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GEOINNOVATION

Bulletin of Nepal Geological Students' Society

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Message from the Head of Department

It is my pleasure to know that Nepal Geological Students' Society, 24th Executive Committee is going to publish its bulletin 'Geo-Innovation Volume-II' soon. I appreciate the continuous effort, dedication and passion of geology students to disseminate their activities and the academic knowledge to the large public. The Central Department of Geology congratulates all institutions and pesonnels who supported for the publication of this bulletin.

Prof. Dr. Khum Narayan Paudayal
18th Shrawan 2080

Ph. No. 4-244047

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Message from the Department Head

I am pleased to learn that Nepal Geological Students' Society (NGSS) is going to publish the second volume of "GeoInnovation: Bulletin of Nepal Geological Students' Society Vol. 2". I know that the publication of this type from the endeavors of students is really a tough job, at the same time it provides the ample opportunities to increase the academic capabilities of the students. In this note, I acknowledge and congratulate the current executive committee of Nepal Geological Students' Society (NGSS), entire editorial board of this publication, the contributors of the articles and all the members of NGSS.

Department of Geology, Tri-Chandra Multiple Campus has been supporting the academic activities of students and endeavors of NGSS. I assure that the department will continue such support in future and suggest NGSS to be more proactive in extending its activities.

I encourage NGSS to widen its academic activities and continue publishing the GeoInnovation by increasing the quality of the papers. I hope the NGSS can help in disseminating the geological knowledge to the wider community and wishes every success in future.

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Subodh Dhakal, PhD

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Foreword

With utmost delight, the 24th Executive Committee presents the second Volume of the Bulletin of Nepal Geological Students' Society (NGSS). This edition showcases the activities carried out by the NGSS in the past year and offers glimpses of the 4th Geo-Science Exhibitions. It covers news and information related to the society, the election of the 25th Executive Committee, a comprehensive list of past Executive Committees, webinars featuring eminent scholars, biographies, and thesis topics of students studying at the Central Department of Geology, Tribhuvan University, and Tri-Chandra Multiple Campus, Tribhuvan University. Additionally, it includes an entrance mock test, sports events, welcome farewell program, old photos of NGSS, and upcoming events. The Bulletin also acknowledges the achievements of current and former NGSS members. Moreover, it contains general and review articles assessed by esteemed senior members of NGSS. Furthermore, the Bulletin offers a variety of popular geology articles of public interest. We believe that both geoscientists and the general public will find these informative.

The Executive Members express their gratitude to all the authors for their contributions to this volume. Likewise, we extend our thanks to all esteemed NGSS members for their continuous cooperation and active participation in the various society activities. On behalf of NGSS, we sincerely appreciate the financial and technical support received from consulting firms, former members' personal donations, agencies, governmental/non-governmental organizations, and industries.

We hope that readers will find this volume valuable and insightful. We always welcome valuable comments and suggestions from society members and well-wishers to further improve the Bulletin's quality. We look forward to receiving continuous support and cooperation in future publications.

Thank you.

24th Executive Committee of Nepal Geological Students' Society

CONTENTS

NGSS NEWS
NEPAL GEOLOGICAL STUDENTS' SOCIETY

ANNUAL GENERAL MEETING HELD

The Annual General Meeting of the Nepal Geological Students' Society was held at the Central Department of Geology, Kirtipur. The program was chaired by Mr. Pawan Kumar Aacharya the president of 23rd executive committee. Mr. Aacharya handed over the office keys and documents to the newly elected president of the society, Mr. Surendra Timilsina.

WEBINAR AND SCIENTIFIC TALK PROGRAMS

The 24th executive committee of the Nepal Geological Students' Society organized five scientific talk programs in collaboration with various organizations. These programs aimed to enhance the knowledge and skills of students as well as career explorations in the field of geology and were conducted online using platforms such as Zoom and Google Meet. The sessions featured participation from professors, professional geologists, graduate and undergraduate students, as well as national and international personnel associated with geology.

STUDENT AWARENESS PROGRAMS

The committee organized student awareness programs in nine government and non-governmental schools in the districts of Kailali, Rupandehi, Chitwan, and Kathmandu. The target audience for these programs consisted of students at the lower secondary and secondary levels. The objective of the programs was to raise awareness among students about geology and geo-disasters. Over a thousand students and their respective teachers participated in the programs.

CAREER COUNSELING PROGRAM

NGSS arranged a career counseling program for fourth-year geology students pursuing their B.Sc. at Birendra Multiple Campus, Chitwan. The program aimed to address the topic of "What to do after completing a B.Sc. in geology." Mr. Surendra Timilsina provided counseling during the session.

FIELD ORIENTATION PROGRAM

The Nepal Geological Students' Society, in collaboration with the TU Society of Exploration Geophysicist Student Chapter (TUSEG), organized a field orientation program at Chovar. The program specifically targeted third and fourth-year B.Sc. students from Tri-Chandra Multiple Campus.The primary objective of the program was to prepare students in advance, equipping them with the necessary knowledge and awareness required for fieldwork. Approximately two hundred fifty individuals, including B.Sc. and M.Sc. students, participated in the program.

M.Sc. ENTRANCE ORIENTATION PROGRAM

The committee organized an orientation program for students who were preparing for M.Sc. entrance examinations in geology and engineering geology. The program was conducted via Zoom, providing a virtual platform for participants. Students who were getting ready for the entrance examination had the opportunity to attend the program and benefit from it.

PYTHON TRAINING PROGRAM

NGSS organized a seven-day physical and four-day online basic Python training at the Central Department of Geology, Kirtipur, specifically designed for M.Sc. geology students. The program was developed by Mr. Biplab Karki and conducted by Mr. Niraj Lamsal. Approximately twelve students participated in the training.

M.Sc. GEOLOGY ENTRANCE MOCK TEST

NGSS, in collaboration with the Central Department of Geology, organized over three online mock tests and conducted two physical mock tests to acquaint students with the examination process and enrich their knowledge. These mock tests aimed to provide students with a simulated exam environment, enabling them to become familiar with the format, content, and time constraints of the actual exams. The collaborative effort between NGSS and the Central Department of Geology ensured that students received comprehensive preparation and support to excel in their examinations.

FOURTH GEOSCIENCE EXHIBITION

NGSS, in collaboration with the Central Department of Geology, organized the fourth Geoscience Exhibition. The program spanned three days and showcased thirty-five stalls. The event attracted a diverse audience of approximately twenty-three hundred individuals, including over eleven hundred school-level students, undergraduate and graduate students of geology from various regions of the country, professional geologists, teachers, professors, and researchers.

The primary objectives of the program were multifaceted. Firstly, it aimed to ignite curiosity among school students about science and geoscience, fostering a passion for scientific exploration. Additionally, it sought to demonstrate the wide-ranging applications and fields of geology to the general public and stakeholders, highlighting the relevance and significance of geoscience knowledge. The exhibition also aimed to raise awareness about geohazards within communities and promote a sense of preparedness. Lastly, the program served as a platform to bring together students, the public, private entities, and stakeholders in a unified effort to promote science and geoscience. The Geoscience Exhibition provided an enriching experience for attendees, offering educational opportunities, interactive displays, and informative presentations. Through this event, NGSS and the Central Department of Geology successfully created a space for knowledge-sharing, community engagement, and the advancement of geoscience awareness.

WELCOME AND FAREWELL PROGRAM

NGSS, in collaboration with the Central Department of Geology, organized a welcome program for the M.Sc. first-semester geology students from the 2079 batch, as well as a farewell program for the students who graduated from the 2074 and 2075 B.S. batches. The program drew participation from over one hundred and fifty individuals. It featured various cultural events and took place in the auditorium hall of TU. The new students were warmly welcomed with flower bouquets, while the departing students were bid farewell with tokens of appreciation and affection.

25th EXECUTIVE COMMITTEE ELECTION

The 24th executive committee successfully organized the election for the 25th executive committee at the Central Department of Geology, held on the date of Bisakh 24, 2080. The election process provided a democratic platform for students to exercise their right to vote and actively participate in shaping the future of the organization. The election served as an opportunity for students to voice their opinions, elect competent leaders, and contribute to the development of the Nepal Geological Students' Society. Through this democratic process, students had the chance to choose representatives who would advocate for their interests, organize beneficial programs and initiatives, and foster a supportive environment for all members.

M.Sc. GEOLOGY FUTSAL COMPETITION

NGSS, in collaboration with the Central Department of Geology, organized a one-day futsal competition at Krinagar Futsal, Kirtipur. Seven teams participated in the event, which aimed to encourage students' participation in extracurricular activities. The program drew the attendance of over a hundred individuals, creating an exciting and engaging environment for both participants and spectators. The futsal competition provided a platform for students to showcase their skills, teamwork, and sportsmanship.

ISSN NUMBER FOR BULLETIN

NGSS has obtained ISSN 2961-1865 (print) and 1873 (online) for both the print and online versions of the bulletin "**GEOINNOVATION**". The purpose of " **GEOINNOVATION** " is to inspire and encourage students to publish scientific articles.

By acquiring the ISSN for both the print and online formats, NGSS demonstrates its commitment to promoting academic publishing among students. The bulletin serves as a platform for geology students to showcase their research, share innovative ideas, and contribute to the scientific community. "Geoinnovation" plays a vital role in nurturing students' scientific curiosity, honing their research skills, and fostering a culture of scientific inquiry within the geology community.

NGSS FOR STUDENTS

NGSS has collected a sum of Rs. 2,59,931 from various organizations and individuals to support the treatment of Mr. Prasan Rai, an MSc geology student who suffered an eye injury. The generous contributions from different organizations and individuals demonstrate the solidarity and support within the geology community. The collected funds will go towards covering the medical expenses and ensuring that Mr. Prasan Rai receives the necessary treatment and care for his eye injury.

नेपाल भौगर्भिक विद्यार्थी समाजका २३ औं कार्यकारिणी समितिका अध्यक्ष श्री पवन कुमार आचार्यद्वारा २४ औं वार्षिक साधारण सभामा प्रस्तुत मन्तव्य

यस नेपाल भौगर्भिक समाजका कार्यसमिति सदस्यहरू,
उपसमिति सदस्यहरू, साधारण सदस्यहरू, सम्पूर्णमा मेरो अभिवादन,

धेरै अगाडिबाट यस समाजको सदस्यहरूको विधान संशोधन गरि त्रिचन्द्र बहुमुखी क्याम्पसको विद्यार्थीहरूलाई मताधिकार प्रदान गरि सम्मानजनक सहभागिता हुनु पर्दछ भन्ने माग थियो । विशेष कारणले यो भन्दा अगाडिको कार्यसमितिबाट यस माग सम्बोधन हुन नसकेको परिस्थितिमा म अध्यक्षको रुपमा निर्वाचित हुन पुँगे । मेरो मात्र नभई यस कार्यसमितिको प्रमुख दायित्व भनेकोनै विधान संशोधन गर्नु थियो । यस कार्य पक्कै सहज थिएन, तर हाम्रो निरन्तर प्रयास र विद्यार्थी, सल्लाहकार, पूर्व सदस्यहरूसँगको अनवरत छलफल र सुझावलाई ग्रहण गरि हामीले विशेष साधारणसभाद्वारा विधान संसोधन गर्न सफल भयौं र सोहिअनुरुप अहिले जुझारु, सक्रिय नवनिर्वाचित कार्यसमितिको गठन भएको छ, जसले हामीलाई उत्साहित बनाएको छ । यस कार्यलाई आधिकारिकता प्रदान गर्न जिल्ला प्रशासन कार्यलयबाट अनुमोदन गर्न पर्ने छ, जुन समय अभावको कारण हामीले सम्पन्न गर्न असमर्थ भएता पनि हामीले सम्पूर्ण कागजातहरू तयार पारेका छौं र हामीलाई विश्वास छ आगामी कार्यसमितिले यसलाई पूर्णता प्रदान गर्नेछ । म अध्यक्ष निर्वाचित हुँदा विभिन्न संकल्प गरेको थिएँ र यस कार्यसमिति यी संकल्पहरूलाई अगाडि बढाउन पर्नेमा एकमत थियो ।

हामीले यस समाजको इतिहासमै पहिलोपटक जियोइनोभेसन नामक नेपाल भौगर्भिक विद्यार्थी समाजको बुलेटिन न्भयष्ललयखबतष्यल ९द्यगर्भितष्ल या ल्भउर्बा न्भययिनष्अर्बा क्तगमभलतकु क्यअष्भतथ० को पहिलो ख्यिगिभ(ज्ञ प्रकाशित गर्न पनि सफल भएका छौं । यस बुलेटिनमा यस समाजले गरेको गतिविधिहरूलाई एबचत(ज्ञ र भूगर्भसँग सम्बन्धित वैज्ञानिक र साधाारण लेखहरू एबचत(द्द मा समावेश गरेका छौं । हामीले जिम्मेवारी सम्हाल्नुपूर्व यस समाजमा भौतिक पूर्वाधारहरूको कमि भएको सन्दर्भमा विभागसँगको समन्वयमा कार्यालयको स्थापना, कम्प्युटर, प्रिन्टर, फर्निचरको व्यवस्थापन गरेका छौं । हामीले अघिल्लो वर्ष हुन नसकेको अडिट र नवीकरण कार्यहरू पनी सम्पन्न गरेका छौं । हामीले यस समाजको स्थापना भएसँग बनेका कार्यसमितिहरूको अभिलेख नभएको कारण, पूर्वसदस्यहरूसँगको छलफलमा यस अघिका कार्यसमितिहरूमा रहेका सदस्यहरूको विवरणको खोजी गरी यस कार्यसमिति २३औं कार्यसमिति रहेको पत्ता लगाउन सफल पनि भयौं । यसको विस्तृत विवरण न्भयष्ललयखबतष्यल ख्या(ज्ञ बुलेटिनको पृ. १९-२१ मा हेर्न सकिन्छ ।

हामीले भूगर्भशास्त्र केन्द्रीय विभाग र त्रिचन्द्र बहुमुखी क्याम्पसमा विभिन्न विद्यार्थीहरूले गरेको शोधकार्यहरू पनि यसै बुलेटिनमा राखेका छौं । यही कार्यकालमा विभिन्न उपसमितिहरूको गठन सम्भवत यस समाजको इतिहासमै पहिलो पटक भएको छ भने स्नातक तह चौंथो वर्षमा अध्ययनरत विद्यार्थीहरूबाट एक जना आमन्त्रित सदस्य राख्ने प्रावधान विधानमा भएता पनि विभिन्न कारणले यस अघिको कार्यसमितिमा सम्भव भएको थिएन र सो कार्य पनि यही कार्यकालमा सम्भव हुन पुगेको छ ।

यस समाजले Stem Foundation Nepal सँगको सहकार्यमा Nepal Geography Olympiad को आयोजना गर्नको लागि उक्त संस्था सँग दुइ वर्षको लागि सम्झौता गरेको छ । यस Olympiad मा प्राविधिक कार्यहरू जस्तै प्रश्नपत्र निर्माण र उत्तर पुस्तिकाको जाँच यस समाजले गर्नेछ र यस Olympiad बाट छानिएका ४ जना विद्यार्थीहरू International Geography Olympiad मा सहभागि हुनेछन् । यस कार्यक्रम यस समाजको अर्थोपार्जनको माध्यम पनि बनेको छ ।

यस समाजले विभिन्न वैज्ञानिक वार्ता कार्यक्रम र अन्तरक्रिया कार्यक्रममा विभिन्न राष्ट्रिय एवम् अर्न्तराष्ट्रिय संगठनहरूसँग समन्वय गरेको थियो । यस समाजले नेपाल विज्ञान शिक्षक संघ, स्टिम फाउन्डेसन नेपाल, र **अर्न्तराष्ट्रिय भूविज्ञान शिक्षा संगठन (International Geoscience Education Organization, IGEO)** सँगको सहकार्यमा काठमाडौँमा अवस्थित युनिग्लोब कलेजमा **"नेपालको विद्यालय तहमा भूविज्ञान शिक्षाको अवस्था"** नामक अन्तरक्रिया कार्यक्रमको आयोजना गरेको थियो । यस्तै **Society for Sedimentary Geology (SEPM)** नामक अन्तर्राष्ट्रिय अमेरिकी भौगर्भिक संस्थासँगको सहकार्यमा एउटा वेबिनारको आयोजना गर्न पनि सफल भएका थियौँ ।

यस समजाले त्रिभुवन विश्वविद्यालय SEG Student Chapters सँगको सहकार्यमा स्नातकोत्तर तहमा अध्ययन गर्न प्रवेश परीक्षा दिन फारम भरेका विद्यार्थीहरूलाई सहयोगार्थ अनलाइन माध्यमबाट ८ वटा नमुना परीक्षाको आयोजना गरेका थियो । यस कार्यको लागि समाजले आफ्नो प्रकाशक समिति (Editorial Board) लाई जिम्मेवारी प्रदान गरेको थियो । कोभिड सङ्क्रमणको अवस्थामा शैक्षिक संस्थाहरू पूर्ण रुपमा बन्द भएको र अनलाईन माध्यमबाट पठनपाठन भएको अवस्थालाई मध्यनजर राख्दै यस समाजले अन्य संस्थाहरूसँगको सहकार्यमा भूगर्भशास्त्र विषयसँग सम्बन्धित रहि १४ वटा विभिन्न वैज्ञानिक वार्ता कार्याक्रम (scientific talk program) हरू अनलाइन माध्यमबाट आयोजना गरेको थियो । उक्त कार्यक्रमको व्यवस्थापन गर्ने कार्यको जिम्मा यस समाजको (Scientific Sub-Committee) लाई प्रदान गरिएको थियो ।

यस समाजले विद्यार्थीहरूलाई सदस्यता पत्र छपाई गरि प्रदान गर्ने कार्यको पनि सुरुवात गरेका छ र यसलाई नै हामीले मताधिकारको महत्वपूर्ण दस्तावेजको रुपमा चित्रण गरेका छौँ । नेपाल भौगर्भिक समाज सँगको सहकार्यमा यस समाजले सहआयोजकको रुपमा दुईवटा अन्तरक्रिया कार्यक्रम Application of Geological Knowledge on Hydropower Sector: Opportunities and Knowledge Gap / Application of Geological Knowledge on Mining Sector: Opportunities and Knowledge Gap अनलाईन माध्यमबाट आयोजना गरेको थियो ।

हामीले नेपालको भूविज्ञानमा उल्लेख्य योगदान पुऱ्याउनु भएका नेपाल भौगर्भिक समाजका संस्थापक सदस्य एवम् पूर्व अध्यक्षहरू: स्वर्गीय श्री विनोद सिं क्षेत्री, डा. रमेश बश्याल र श्री कृष्ण प्रसाद काफ्लेको जीवनी एवम् उहाँहरूको योगदान र प्रकाशनहरूको विवरण पनी बुलेटिनमा समावेश गरेका छौँ । यसको मुख्य उद्देश्य हामी जस्तो विद्यार्थीहरूलाई र नवभूगर्भविदहरूलाई उहाँहरूको योगदान र कार्यहरूले प्रेरणा प्रदान गरोस र उहाँहरूको यस समाजबाट सम्मान गर्नु पनि थियो ।

हामीले स्वतन्त्र विद्यार्थी यूनियनको निर्माण लामो समयबाट नभएको र प्रत्येक विद्यार्थीहरूबाट स्ववियूको नाममा रकमहरू शैक्षिक शुल्कमा समावेश भएको परिप्रेक्षमा उक्त रकम भूगर्भशास्त्रका विद्यार्थीहरूले शुल्क नतिर्ने र यस समाजले विभिन्न शैक्षिक एवम् वैज्ञानिक कार्यहरू गर्दै आएको कारण उक्त रकम यस समाजलाई प्रदान गर्नुपर्ने माग सहितको ज्ञापन पत्र त्रिविको उपकुलपति, शिक्षाध्यक्ष, रजिष्ट्रार र डीनको कार्यालयमा पेश पनि गरेका थियौं। कोभिड महामारीको कारण विद्यार्थीहरूको आर्थिक स्थिति कमजोर रहेको कारण विद्यार्थीहरूको शैक्षिक शुल्क मिनाहा एवम् विभागद्वारा वैज्ञानिक शुल्क निर्धारण गरिनुपर्ने माग राखी सम्पूर्ण विद्यार्थीहरूको हस्ताक्षर संकलन गरि सोही कार्यालयहरूमा अर्को ज्ञापन पत्र पनि बुझाएका थियौं । यसरी नै विद्यार्थीहरूको हकहीतको लागि यस समाज तत्पर भई लागि परेको थियो ।

मैले गरेका वाचाहरू लगभग पुरा भएको मलाई लागेको छ भने केही समन्वयात्मक कार्यहरू विभिन्न निकायको उदाशीनताको कारण सफल हुन सकेन । नेपाल भौगर्भिक परीषद्, सडक विभागमा भूगर्भवीदको

दरबन्दी, स्नातक तहबाटनै भूगर्भशास्त्रको कोर्सको परिमार्जनको मुद्दा उठाई सम्बन्धित निकायहरूसँग सम्न्वय र दबावमूलक कार्य गर्ने योजना बनाएको भएतापनि कोभिड संक्रमणको कारण हामीले उक्त कार्यहरू गर्न असमर्थ भएका छौँ । आशा छ, आगामी कार्यसमितिले यस कार्यको लागि अहम् भूमिका खेल्नेछ र हामीले सुरुवात गरेका कार्यहरूलाई पनि निरन्तरता प्रदान गर्नेछ। हामीले गरेका कार्यहरू यस मन्तव्यमा मबाट पूर्ण रुपमा व्यक्त नभएको हुन सक्छ र यसको विस्तृत विवरणको लागि हामीले प्रकाशन गरेको बुलेटिनको अध्ययन गर्नुहुनको लागि पुनः अनुरोध गर्दछु । अन्त्यमा यस कार्यकाललाई सफल बनाउन विशेष भूमिका खेल्नुहुने यस समाजका कार्यसमिति सदस्य, साधारण सदस्य, सल्लाहकारहरू एवम् पूर्व सदस्यहरूलाई धन्यवाद ज्ञापन गर्न चाहन्छु भने नवगठित कार्यसमितिलाई पनि सफल कार्यकालको शुभकामना प्रदान गर्न चाहन्छु ।

धन्यवाद!!

यस वार्षिक कार्यक्रमका प्रमुख अतिथि नेपाल भौगर्भिक
विद्यार्थी समाजका संस्थापक सचिव प्रा.डा. दिनेश पाठकज्यू,
विशेष अतिथि यस समाजका पूर्व अध्यक्ष डा. भूपति न्यौपानेज्यू,
नेपाल भौगर्भिक समाजका कार्यसमिति सदस्यहरू,
उपसमिति सदस्यहरू, साधारण सदस्यहरू, एवम् उपस्थित सम्पूर्णमा नमस्कार,

म आज अत्यन्तै खुशी छु, आज हाम्रो निमन्त्रणा स्विकार गरी यस समाजका संस्थापक सचिव, नेपाल भौगर्भिक समाजका पूर्व अध्यक्ष एवम् भूगर्भशास्त्र केन्द्रीय विभागका प्राध्यापक डा. दिनेश पाठक हामी माझ उपस्थित हुनु भएको छ र उहाँको हातबाट नेपाल भौगर्भिक विद्यार्थी समाजको बुलेटिन पनि विमोचन भएको छ । यस समाजको इतिहास खोज्ने क्रममा र विभिन्न दस्तावेज संकलन गर्ने क्रममा उहाँलाई यस समाजको दोस्रो कार्यसमितिले वि.सं. २०४९ मा उहाँलाई संस्थापक सचिवको योगदान स्वरूपमा प्रदान गरेको कदर पत्र उहाँबाट हामीलाई प्राप्त भएको छ । यो पत्रलाई हामीले यस बुलेटिनको पृ. १३९ मा समावेश गरेका छौँ ।

आज नेपाल भौगर्भिक विद्यार्थी समाजको स्थापना भएको ३० वर्ष पुगिसकेको छ र यस समाजलाई यस स्थानमा पुर्‍याउन थुप्रै अग्रजहरूको विशेष भूमिका छ र म उहाँहरू सबै प्रति आभारी छु । यस समाजले इतिहासमै पहिलो पटक यस समाजको बुलेटिन प्रकाशन गरेको छ । यसको अलावा हामीले यस समाजलाई आवश्यक रहेको भौतिक पूर्वाधार सहितको कार्यालय स्थापन गर्न सफल भएका छौँ भने राष्ट्रिय र अन्तर्राष्ट्रिय संघ संस्थाको सहकार्यमा ओलम्पियाड, वैज्ञानिक वार्ता कार्यक्रम (scientific talk program) र अन्तरक्रिया कार्यक्रमहरूको पनि आयोजना गरेका थियौँ । यस समाजले आफ्नो पूर्वअध्यक्षहरूसँग पनि अन्तरक्रिया कार्यक्रम गरेको थियो भने यस समाजको विवरण लामो समयसम्म फेला नपरेको अवस्था आफ्नो पूर्व कार्यसमितिमा रहेका सदस्यहरूको विवरण खोज्ने प्रयास पनि गरेको थियो । यसलाई पनि यस समाजको बुलेटिनमा समावेश गरेका छौँ । यस समाजको सदस्यता पत्रको पनि प्रावधान गरेका छौँ । विधान संशोधन अनुरूप २४ औँ कार्यसमितिको गठन भइसकेको छ र केहिबेरमा हामीले हाम्रो पदभार उहाँहरूमाझ हस्तान्तरण गर्दै छौँ ।
हामी अब औपचारिक शिक्षाको लगभग अन्तिम चरणमा छौँ र हामी व्यवसायिक जीवनमा केही वर्षमा जोडिन गइरहेका छौँ । यसै सन्दर्भमा अन्य प्राविधिक विषयहरूमा पेशागत परिषद बनेको छ र नियमन पनि भइरहेको छ । तर दुर्भाग्यवश, लामो समय देखि कुरा उठेतापनि नेपाल भौगर्भिक परिषद् को निर्माण हुन सकेको छैन । यस विषयमा आज भन्दा करिब ५-६ वर्ष अगाडि आजका हाम्रो प्रमुख अतिथि प्रा.डा. दिनेश पाठकबाट नेपाल भौगर्भिक परीषदको आवश्यक्ता सम्बन्धि नेपाल भौगर्भिक समाजको बुलेटिनमा लेख पढ्ने अवसर प्राप्त गरेको थिएँ । आशा छ, यसमा नेपाल भौगर्भिक समाजले आफ्नो दायित्व निर्वाह गरि भौगर्भिक परिषदको स्थापना भई हामीले यसबाट लाभान्वित हुने मौको पाउने छौँ ।

यस समाजले नेपाल भौगर्भिक समाजको कार्यक्रममा आफ्नो उल्लेख्य उपस्थिति जनाउनुको साथै सहकार्य गरि विभिन्न कार्यक्रम जस्तै भौगर्भिक प्रदर्शनी र अन्तरक्रिया कार्यक्रमहरूको पनि आयोजना र सहआयोजना गरेको छ । यस समाज सम्पूर्ण विद्यार्थीहरूको प्रतिनिधित्व गर्ने संस्था भएको र नेपाल भौगर्भिक समाज सम्पूर्ण भूगर्भविदहरूको छाता संगठन भएको परिप्रेक्षमा दुबै समाजहरूको बिच भूगर्भशास्त्र सम्बन्धी विभिन्न विषयहरूमा उचित समन्वय होस् भन्ने कामना सहित हामी नेपाल भौगर्भिक समाजको कतगमभलत धष्लन को रुपमा सामेल हुन चाहेको विषय यहाँ राख्न चाहन्छौँ । यस विषयमा अनौपचारिक तवरमा केहि संवादहरू पनि भएका छन् र यस विषयमा समन्वय गरि

हामीलाई सहयोग गरिदिनुहुनको लागि यस समाजका संस्थापक महासचिव एवम् नेपाल भौगर्भिक समाजका पूर्व अध्यक्ष प्रा.डा. दिनेश पाठकलाई अनुरोध गर्न चाहन्छु ।

अन्त्यमा नेपाल भौगर्भिक विद्यार्थी समाजले सिर्जनशील कार्यहरूलाई आगामी दिनहरूमा निरन्तरता प्रदान गरि यस समाजको गरिमा उच्च राखोस र हामी पनि यस समाजको उत्थान र विकासको लागि सदैव तत्पर रहने वाचा सहित मेरो मन्तव्य यही टुङ्ग्याउन चाहन्छु ।

धन्यवाद ! !

नेपाल भौगर्भिक विद्यार्थी समाजको २३ औं कार्यकारिणी समिति (२०७७/ २०७८) की कोषाध्यक्ष श्री सुजता आचार्य ज्यूको २४ औं साधारण सभामा व्यक्त मन्तव्य

धन्यवाद यस समाजका सचिव ज्यू,
यस सभाका सभा अध्यक्ष ज्यू,
कार्यकारिणी समितिका साथीहरू,
साथै समाजका उपस्थित साथीहरू,

आज म यहाँ गत आर्थिक वर्ष २०७७ / ७८ को एक वर्षको कार्यकालमा गरेको आर्थिक आयव्ययको विवरणहरू पेश गर्न चाहन्छु । यस समाजले सदस्यता शुल्क लगायत बाट रु ५६,४०० उठाएको थियो भने बुलेटिन का लागि रु. १,७०,६३० उठाएको थियो । विभिन्न खेलकुद कार्यक्रमको लागि रु. २४,००० प्राप्त भएको थियो । अन्य स्रोत बाट रु ५००० आम्दानी भएको थियो ।

बुलेटिन प्रकाशनको खर्च रु. १६,४९५० रजिष्ट्रेशन खर्च रु. ५०० अफिस खर्च रु. ८,७५५ कार्यक्रम सञ्चालन खर्च रु.३२,२३० प्रिन्ट स्टेसनरी रु.२२,०८० साधन खर्च रु. १,६०० र अन्य खर्च रु. २,००० भएको थियो ।

यस समाजको गत आर्थिक वर्षको बजेटमा कुल आम्दानी रु. २,५६,०३० ।- (अक्षरुपी दुई लाख छप्न्न हजार र तीस रुपैयाँ मात्र) र कुल रु .२,४०,०२५ (अक्षरुपी दुई लाख चालीस हजार पच्चीस रुपैयाँ मात्र) रहेको छ । समग्रमा हेर्दा यस समाजलाई रु १६,००५ (अक्षेरुपी स्रोह हजार पाँच रुपैयाँ) रहेको छ अन्तमा आर्थिक प्रतिवेदनको सम्बन्धमा कुनै प्रतिक्रिया र सुझावहरू भए सो को अपेक्षा राख्दै मेरो प्रस्तुति अन्त गर्न चाहन्छु ।

धन्यवाद

नेपाल भौगर्भिक विद्यार्थी समाजको २४ औ वार्षिक साधारण सभामा पेश भएका एजेण्डाहरू

१. वार्षिक प्रगति प्रतिबेदन अनुमोदन सम्बन्धमा

उक्त प्रस्ताव माथि छलफल गर्दा कार्यसमितिको तर्फबाट अध्यक्षज्यू द्वारा प्रस्तुत गरिएको आफ्नो कार्यकाल प्रगति प्रतिवेदनमाथि छलफल गर्दा विगतका काम गराइमा केही कमी कमजोरी रहेपनि समग्रमा उल्लेख्य काम गरिएको हुनाले आगामी दिनमा उक्त कमी कमजोरी कम गर्ने गरि उक्त प्रगति प्रतिवेदन सर्बसहमतिले पारित गरियो।

२. आर्थिक प्रतिबेदन अनुमोदन सम्बन्धमा

उक्त प्रस्ताव माथि छलफल गर्दा आर्थिक बर्ष २०७७/२०७८ को यस संस्थाको वार्षिक आयव्यय विवरण लगायतका विषयमा कोषाध्यक्षज्यूबाट प्रस्तुत गरिएको विवरणहरू सर्व सहमतिले पारित गर्दै आगामी दिनमा हरहिसाबका स्रेस्ताहरू पन्जिकरण गर्दै अझ व्यवस्थित हिसाबले राख्न निर्देशन दिइयो।

३. विधान संशोधन सम्बन्धमा

उक्त प्रस्ताव माथि छलफल गर्दा नेपाल भौगर्भिक विद्यार्थी समाजको विधानका केही बुँदाहरूमा संशोधनको आवश्यकता रहेको हुँदा उक्त बुँदाहरू साधरणसभामा छलफल गरी तिन महले फारमका माध्यबाट अध्यक्ष श्री पवन कुमार आचार्यबाट पेश गरियो । दफबार छलफल बाट उक्त बुँदाहरू सर्वसम्मत रूपमा पास गरी नियमानुसार उक्त बुँदा समावेश तीन महले फारम भरी जि.प्र.का काठमाडौँ मा विधान संशोधन कार्य पूर्णताका लागि अगाढी बढ्ने निर्णय गरियो ।

४. अडिट रिपोर्ट पारित तथा अडिटरको नियुक्ति सम्बन्धमा

उक्त प्रस्ताब माथि छलफल गर्दा आर्थिक बर्ष २०७७/०७८ को 'अडिटर' Shree Kumar Suwal & Associates ले प्रदान गरेको ' अडिट रिपोर्ट ' लाई सर्बसहमतिले पारित गर्दै आगामी आर्थिक बर्ष २०७८/०७९को यस सस्थाको 'अडिटर' को रुपमा 'Shree Kumal Suwal & Associates' लाई नियुक्ति गर्ने र निजको पारिश्रमिक कार्यसमितीबाट निर्णय गरि भुक्तानी दिन सक्ने अधिकार प्रदान गर्दै सर्बसहमतिले पारित गरियो।

५. नयाँ कार्यसमिति चयन सम्बन्धमा।

उक्त प्रस्ताव माथि छलफल गर्दा नयाँ कार्यसमिती निम्नानुसारको प्रक्रिया पुर्याई निम्नानुसार चयन गरियो।
मिति २०७८/१०/०४ गते श्री पवन कुमार आचार्यज्यूको अध्यक्षतामा बसेको कार्यसमितिको बैठकले निर्वाचन मण्डलका सदस्यहरुको रुपमा श्री प्रकाश सापकोटा, श्री सुदन कुमार सुवेदी र श्री मनोज थापा ज्युलाई पारित गरको थियो। मिति २०७८/१०/१० गतेका दिन अनलाईन मार्फत चुनाव सम्पन्न गरिएकोमा निम्न उल्लेखित समाज सदस्य निर्वाचित हुनुभएको थियो ।

अध्यक्ष : श्री सुरेन्द्र तिमिल्सिना
उपाध्यक्ष : श्री सुजता विष्ट
उपाध्यक्ष : श्री दिपक राज जोशी
सचिव : श्री रोनित पौडेल
कोषाध्यक्ष : श्री अमृत मरासेनी

सह- सचिव : श्री विशाल पौडेल
सदस्य : श्री सुजन खतिवडा
श्री प्रतिभा पोखरेल
श्री मनिषा थापा
श्री लोक बजगाई
श्री अनुष्का ज्ञावली

५. विविध सम्बन्धमा ।

'विविध' माथी छलफल गर्दा साधरण सभामा श्री भीष्म जोशी, श्री अनिता डल्लाकोटी, श्री सुधन कुमार सुवेदी, श्री प्रतिभा घिमिरेले समाजको विभिन्न भईरहेको क्रियकलापको जानकारी प्रदान गरिदिनुभएको उहाँहरूलाई धन्यवाद ज्ञापन गर्ने निर्णय गरियो । साथै सभामा कार्यसमिति, नवनिर्वाित कार्यसमिति र साधरण सदस्य उपस्थित सबैलाई बिशेष धन्यबाद दिने निर्णय गरियो।

Audit Report-78/79

Shree Kumar Suwal & Associates
Registered Auditor
Panauti-7, Kavre

PAN No.: 301108025
Membership No.:6205
COP No.:2186

Independent Auditor's Report to Stakeholders of Nepal Geological Students' Society

Opinion

We have audited the accompanying financial statements of Nepal Geological Students' Society. (hereinafter referred to as society), which comprise the statement of financial position as at 32nd Ashad 2079 (16th July 2022), the statement of profit and loss, statement of changes in equity and statement of cash flow for the year ended thereon, and attached notes to accounts, including a summary of significant accounting policies.

In our opinion, the accompanying financial statements read with notes to account, present fairly, in all material respects, the financial position of society as of 32nd Ashad 2079 (16th July 2022) and financial performance of society and its cash flows for the year ended on that date in accordance with Nepal Accounting Standards and Companies Act 2063.

Basis for Opinion

We conducted our audit in accordance with Nepal Standards on Auditing (NSAs). Our responsibilities under those standards are further described in the *Auditor's Responsibilities for Audit of the Financial Statements* section of this report. We are independent of society in accordance with the ICAN's Handbook of the code of ethics for Professional Accountants and we have fulfilled our other ethical responsibilities in accordance with the Handbook. We believe that audit evidence obtained by us is sufficient and appropriate to provide a basis for our opinion.

Responsibilities of management and those charged with governance for financial statements

Management is responsible for the preparation and fair presentation of these financial statements in accordance with Nepal Accounting Standards, and for such internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, management is responsible for assessing the ability of society to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate society or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing society's financial reporting process.

Auditor's Responsibilities for Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with NSAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with NSAs, we exercise professional judgment and maintain professional skepticism throughout the audit.
We also:

- Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the society's internal control.
- Evaluate the appropriateness of the accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.
- Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to the events or conditions that may cast significant doubt on the society's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the society to cease to continue as a going concern.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

Report on Other Legal and Regulatory Requirement

We have obtained all information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit. In our opinion, proper books of account as required by Companies Act 2063 have been maintained by society, in so far as appears from our examination of those accounts and the statement of financial position, statement of profit and loss and statement of cash flows dealt with by this report are in agreement with the books of account.

To the best of our information and according to explanations given to us and from our examination of the books of accounts of society necessary for the purpose of audit, we have not come across any case where Board of Directors or any employee of society have acted contrary to the provisions of law relating to accounts, or committed any misappropriation or caused loss or damage to society relating to the accounts in society.

Date: 2079.07.01
Kathmandu, Nepal

Shree Kumar Suwal
Registered Auditor

Nepal Geological Students' Society
Kirtipur, Kathmandu

Statement of Financial Position
As on Ashadh End, 2079
(All amounts are in NPR, unless otherwise stated)

Particulars	Schedule	As on Ashadh End, 2079	As on Ashadh End, 2078
Assets			
Non Current Assets			
Property, Plant & Equipment	1	-	-
Total Non Current Assets		-	-
Current Assets			
Trade and Other Receivables	2	-	-
Prepaids, Loans and Advances	3	-	-
Cash and Bank Balances	4	69,337	17,332
Total Current Assets		69,337	17,332
Total Assets		69,337	17,332
Fund and Liabilities			
Equity			
Fund Balance	6	(153,862)	(169,867)
Total Equity		(153,862)	(169,867)
Non-Current Liabilities			
Loans and Borrowings	7	-	-
Deferred Tax Liability		-	-
Total Non- Current Liabilities		-	-
Current Liabilities			
Loans and Borrowings	8	-	-
Trade Payables	9	223,199	187,199
Provisions	10	-	-
Total Current Liabilities		223,199	187,199
Total Liabilities		223,199	187,199
Total Equity and Liabilities		69,337	17,332
Summary of Significant Accounting Policies	15		

The accompanying notes are integral part of the financial statements.

As per our report of even date

For Nepal Geological Students' Society

President   Treasurer   Secretary

Date:
Place:

Nepal Geological Students' Society
Kirtipur, Kathmandu

Statement of Profit or Loss
For the year ended on 32 Ashadh, 2079
(All amounts are in NPR, unless otherwise stated)

Particulars	Schedule	Current Year	Current Year
Income			
Membership Fees	11	251,030	-
Other Income	12	5,000	27,300
Total Income		256,030	27,300
Administrative Expenses	13	240,025	26,765
Depreciation and Amortization Expenses	1	-	-
Profit /(Loss) from Operation		16,005	535
Financial Expenses	14	-	-
Profit /(Loss) Before Tax		16,005	535
Income Tax Expenses			
-Current Year		-	-
Net Profit/(Loss) for the year		16,005	535
Summary of Significant Accounting Policies	15		

The accompanying notes are integral part of the financial statements.

As per our report of even date

For Nepal Geological Students' Society

President   **Treasurer**   **Secretary**   Auditor

Nepal Geological Students' Society
Kirtipur, Kathmandu

Statement of Cash Flows
For the year ended on 32 Ashadh, 2079
(All amounts are in NPR, unless otherwise stated)

Particulars	Current Year	Current Year
A. Cash Flow From Operating Activities :		
Net Profit	16,005	535
Add:-Depreciation	-	-
Add: Provision for tax	-	-
Operating Profit before Working Capital Changes	**16,005**	**535**
Working Capital Changes :		
(Increase)/Decrease in Current Assets	-	-
Increase/(Decrease) in Current Liabilities	36,000	(3,390)
Less: Tax paid	-	
Cash Generated / (Used) from / for Operating Activities	**52,005**	**(2,855)**
B. Cash Flow From Investing Activities :		
Purchase of Fixed Assets	-	-
Sales of Fixed Assets		
Cash Generated / (Used) from / for Investing Activities	-	-
C. Cash Flow From Financing Activities :		
Increase /(Decrease) in Share capital	-	-
Increase /(Decrease) in Loan Liability	-	-
Interest Paid	-	-
Cash Generated / (Used) from / for Financing Activities	-	-
Net Cash Flow During the Year (A+B+C)	**52,005**	**(2,855)**
Opening Cash & Bank balances & equivalents	17,332	20,187
Net Increase / (Decrease) in Cash or Cash Equivalents	52,005	(2,855)
Closing Cash & Bank balances & equivalents	69,337	17,332

Summary of Significant Accounting Policies 19

The accompanying notes are integral part of the financial statements.

For Nepal Geological Students' Society

As per our report of even date

President

Treasurer

Auditor

Secretary

Shree Kumar Suwal & Associates
Registered Auditor
3000 B
Kathmandu, Nepal

Nepal Geological Students' Society
Kirtipur, Kathmandu

Schedule forming part of Statement of Financial Position as on Ashadh End, 2079
(All amounts are in NPR, unless otherwise stated)

Schedule-1

S.No.	Particulars	Dep%	Gross Block				Depreciation				Net Block	
			Opening	Additions	Disposal/ Transferred	Total	Upto last year	During the year	Disposal/ Deletions	Total	Current Year	Previous Year
	POOL "B"											
1	Computer & Accessories	25%	0.00	-	-	-	-	-	-	-	-	-
2	Furniture & Fixture	25%	0.00	-	-	-	-	-	-	-	-	-
3	Office Equipments	25%	0.00			-	-	-		-	-	-
	Grand Total		-	-	-	-	-	-	-	-	-	-

Shree Kumar Suwal & Associates
Registered Auditor
3000 B
Kathmandu, Nepal

Nepal Geological Students' Society

Nepal Geological Students' Society
Kirtipur, Kathmandu
SCHEDULES annexed to and forming part of Statement of Financial Position for the year ended on Ashad End 2079

TRADE AND OTHER RECEIVABLE — Schedule-2

Particulars	As on Ashadh End, 2079	As on Ashadh End, 2078
Sundry Debtors	-	-
Total	-	-

PREPAIDS,LOANS,ADVANCES & DEPOSITS — Schedule-3

Particulars	As on Ashadh End, 2079	As on Ashadh End, 2078
		-
Total	-	-

CASH AND BANK BALANCES — Schedule-4

Particulars	As on Ashadh End, 2079	As on Ashadh End, 2078
Cash and Bank	69,337	17,332
Total	69,337	17,332

RESERVE — Schedule-6

Particulars	As on Ashadh End, 2079	As on Ashadh End, 2078
General Reserve		
Profit/(Loss) upto last year	(169,867)	(170,402)
Profit (Loss) for the year	16,005	535
Balance Transferred To Balance Sheet	(153,862)	(169,867)

Loans and Borrowings — Schedule-7

Particulars	As on Ashadh End, 2079	As on Ashadh End, 2078
Secured Loan	-	-
Total Borrowed Funds	-	-

Nepal Geological Students' Society
Kirtipur, Kathmandu
SCHEDULES annexed to and forming part of Statement of Financial Position for the year ended on Ashad End 2079

CURRENT LIABILITIES

Loans and Borrowings — Schedule-8

Particulars	As on Ashadh End, 2079	As on Ashadh End, 2078
Total		-

Trade & Other Payables — Schedule-9

Particulars	As on Ashadh End, 2079	As on Ashadh End, 2078
Audit Fee Payable	7,805	7,805
Tds Payable		
TDS on Audit fee	105	105
Other Payable	179,289	179,289
Program Advance received	36,000	
Total	223,199	187,199

Provisions — Schedule-10

Particulars	As on Ashadh End, 2079	As on Ashadh End, 2078
Provision for Tax	-	-
Total	-	-

Nepal Geological Students' Society
Kirtipur, Kathmandu
SCHEDULES annexed to and forming part of Statement of Profit or Loss for the year ended on Ashad End 2079

Revenues — Schedule-12

Particulars	Current Year	Previous Year
Membership fees	56,400	-
Bulletin Advertisement	170,630	-
Sponsorships for Event	24,000	-
Total	251,030	-

Other Income — Schedule-11

Particulars	Current Year	Previous Year
Central Department of Geology, TU	-	14,900
Other Income	5,000	3,000
Donation Received	-	9,400
Total	5,000	27,300

Administrative Expenses — Schedule-13

Particulars	Current Year	Previous Year
Audit Fee	7,910	7,000
Bulletin Expenses	164,950	-
Trophy Medal and Certificate Expenses	-	500
Registration Expenses	8,755	500
Office Expenses	500	
Event Expenses	32,230	-
Printing & Stationery	22,080	1,125
Transportation expenses	1,600	
Other Expenses	2,000	17,640
Total	240,025	26,765

Financial Expenses: — Schedule-14

Particulars	Current Year	Previous Year
Bank Interest	-	-
Total	-	-

Nepal Geological Students' Society
Kirtipur, Kathmandu
For the year : 2078/79

Schedule-15

Other Notes

1 **General Information**
Nepal Geological Students' Societyis a society registered for the welfare of the students associated with Geological Study as a major area of study under Trubhuwan University. This society has been registered under prevalent act and also has affiliation with Social Welfare Council

2 **Significant Accounting Policies**

2.1 **Basis of preparation**

2.1.1 **Statement of Compliance**
The financial statements have been prepared in accordance with the relevant accounting standards except wherever mentioned.

2.1.2 **Basis of Measurement**
The financial statements have been prepared on the historical cost basis except wherever mentioned.

2.1.3 **Functional and Presentation Currency**
The financial statements are prepared in Nepalese Rupees, which is the company's functional currency.

2.2 **Accounting policies**
The principal accounting policies adopted in the preparation of the financial statements are set out below. The

2.2.1 **Trade and other receivables**
Trade and other receivables are stated at their cost.

2.2.2 **Cash and cash equivalents**
Cash and cash equivalents comprises of the cash balance and bank account.

2.2.3 **Taxation**
Provision for income tax has been made as per Income Tax Act 2058. Further, deferred tax has not been calculated

2.2.4 **Trade and other payables**
Trade and other payables are stated at their cost.

2.2.5 **Revenue Recognition**
Revenue is recognized on accrual basis.

Nepal Geological Students' Society
Kirtipur, Kathmandu
For the year : 2078/79

Other Notes **Schedule-15**

2.2.6 Cost of sales
Cost of sales comprises of expenses relating to the works done by Lineworks in regards to the generation of revenue. Such has been considered as expenses of direct nature as they are related to the revenue generated during the year.

2.2.7 Property, plant and equipment
Items of property, plant and equipment are initially recognized at cost. Cost includes the purchase price and other directly attributable costs as well as the estimated present value of any future unavoidable costs of dismantling and removing items.

2.2.8 Depreciation and amortisation
Depreciation on Property, Plant and Equipment has been charged as per the provisions of Income Tax Act, 2058.

3 Contingent liabilities
The company does not have any contingent liabilities or any legal case pending as on Ashad end, 2079.

4 Previous year figures are regrouped and rearranged where necessary.

Nepal Geological Students' Society, 1990

Shree Kumar Suwal & Associates
Registered Auditor
3609 B
Kathmandu, Nepal

FORMATION OF SUB-COMMITTEE OF NEPAL GEOLOGICAL STUDENTS' SOCIETY

Nepal Geological Students' Society formed the different sub-committee to make active participants of the members of the Society in different activities. The executive committee call applications from the members of the Society to apply in sub-committee of their interest in order of their preferences. After receiving the applications, the executive committee nominated the members for the sub-committee from which coordinator and member secretary selection was made.

Nepal Geological Students' Society has nominated the following members in the sub-committee on the basis of application received from the member of the Society and the decision from the executive committee of the Society. The members of the nominated members of the sub-committee area as follows.

Editorial Board of the NGSS

Mr. Sujan Khatiwada	Editor-in-Chief
Ms. Anuska Gyawali	Managing Editor
Mr. Amrit Marasini	Member
Mr. Ashok Thapa	Member
Mr. Ronit Poudel	Member
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Mr. Mahendra Acharya	Member
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Ms. Nikita Upadhaya	Member
Ms. Rojina Chimouriya	Member
Ms. Bindu Thapaliya	Member
Mr. Nagesh Rijal	Member
Mr. Pradeep Devkota	Member

Scientific Sub-Committee

Mr. Deepak Raj Joshi	Coordinator
Mr. Ashok Dhakal	Member
Mr. Ashok Dhungana	Member
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Mr. Prabin Dallakoti	Member
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Mr. Rajan Tiwari	Member
Mr. Ram dhakal	Member
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Mr. Saurav Poudel	Member
Mr. Sujan Raj Pandey	Member
Mr. Suraj Adhikari	Member
Mr. Sushant Prasad Adhikari	Member
Mr. Urusha Gautak	Member

Sports Sub-Committee

Mr. Bishal Poudel	Coordinator
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Mr. Pradip Karki	Member
Mr. Rabin Sapkota	Member
Ms. Rabina Sapkota	Member
Mr. Rajan Tiwari	Member
Mr. Ram Dhakal	Member
Mr. Ramesh Bamjan	Member
Mr. Ramesh Bhattarai	Member
Mr. Sandesh Dhakal	Member
Mr. Sandesh Pandey	Member
Mr. Subash KC	Member
Mr. Sujan Neupane	Member

Mr. Suman Khadka	Member
Mr. Sundar Adhikari	Member
Mr. Suraj Adhikari	Member
Mr. Sushant Prasad Adhikari	Member
Mr. Utsab Bhattarai	Member
Mr. Yogesh KC	Member

Election Committee

Mr. Mohan Raj Shrestha	Coordinator
Mr. Ashok Thapa	Member
Mr. Sameer Luitel	Member

NGSS Membership List

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LIST OF THESIS

List of Masters Thesis from Central Department of Geology in General Geology and Engineering Geology Stream.

Code	Title of Thesis	Name of Student	Year
1	Geology of the Agra Khola (Mahesh Khola Area Central Nepal)	Gopal Man Shrestha	1979
2	Geology of the Dhading area Central Nepal	Devi Nath Subedi	1979
3	Geology of Sopyang-Tistung Area , Central Nepal	Achyut Koirala	1981
4	Geology of Markhu -Tistung Area . Central Nepal	Khagendra Nath Kafle	1981
5	Geology of Barlung Chat-Jugedi Area Central Nepal	Jayandra Man Tamrakar	1981
6	Geolmorphological Evaluation of Banepa Village	Manju Chetri	1993
7	Lithostrarigraphy of Amlekhjanj -Hetauda Area Central Nepal.	Prakash Dash Ulak	1991
8	Historic Landslide of Nepal During 1902 -1990 A D , Extent and Economic significance	Ram Kumar Khanal	1991
9	Geology and Fossil Occurrences of Amlekhganj-Hetauda Area	Lila Nath Rimal	1991
10	Lithostrarigraphic and Structural Characteristic of The Nisti Khola	Ganesh Prasad Dhakal	1991
11	Geology of Amlekhganj Hetauda Area	Anant P Gajurel	1992
12	Landslides in Nepal in the Period 1970 -1980	Mahesh Karmacharya	1989
13	Geology of Malekhu and Adjoining Area	Nir Shakya	1987
14	Geology of Malekhu Area	Rajendra Pradhan	1987
15	Geology of Taruka-Kewal Pur Area	Kaustub Man	1987
16	Ground Water Resource Evaluation of Kathmandu Valley	Ramesh Gautam	1988
17	Estimation of Basement by Electrical Resistivity Survey in Naya Bhanjyang Dhaksi Area Kathmandu	Santa Man Rai	1988
18	Ground Water Resource Evaluation of Kathmandu Valley	Ramesh Gautam	1986
19	Geology of Phalabang Area Central West Nepal	Madan Ratna Manandhar	1990
20	Geology of Malekhu Buri Gandaki Region Dhading Distric	Suresh Dash Shrestha	1986
21	Geohydrology of Terai Region of Saptari Distric Eastern Nepal	Keshav K.C.	1985
22	Geology of Malekhu and Adjoining Area	Tek Raj Pant	1984
23	G. of Triveni-Barahakshatra Area, Sunsari Dhankuta	Subash Chandra Sunuwar	1993
24	Engineering Geol study of the Sildhung Landslide in Lanjujg Distric	Chet bhadur Gurung	1993
25	Petrography of the Siwalik Rocks of the Bardanda Surai Naka Area	Naresh Kaji Tamrakar	1993
26	Hydrological studies in Parts of Dang Valley	Birndra Piya	1993
27	Landforms classification of kathmandu valley	Damayanti Gurung	2048
28	Lithostratigraphy of Surai Naka-Bardada Area With Special Reference to the DhanKhola Area	Raju Gopal Acharya	1993
29	Hydrological studies in Parts of Mahottari Distries Central Nepal	Rajendra Prasad Bhandari	1993
30	Paleomagnetism of Red Sediments of Dubring Formotion Dang Dewakar Paudayal	Dewakar Paudayal	1993
31	Lithostratigraphy of Bardanda-Surai Naka Area with special reference to the Surai Khola Formation	Ghatur Bdr Shrestha	1993
32	Geological Study of Bankas basa Baradanda Area	Sudarshan Pd Adhikari	1993

33	Electrical Resistivity Survey for Groundwater Exploration in Central Chitwan Valley	Khum Narayan Paudyal	1993
34	Landslides of Likhu Khola Area along with the study of Landslides in Nepal	Kiran Kumar Ghimire	1995
35	Geology and Petrography of the Siwaliks of the Sindhulmari Area, Central Nepal	Puskar Nath Ghimire	1993
36	Geology of the Siwaliks of Sarlahi and Sindhuli Districts, Central Nepal	Upendra Ratna Sthapit	1995
37	General Geology of the Timal Danda and its surrounding area, Karve	Yogendra Bdr Kayastha	1995
38	Lithostratigraphy of Bardanda-Ainaka Area with special reference to the Chor Khola Formation	Basant Kafle	1993
39	Geological and Engineering Geological studies of the Agra Khola Basin with a special reference to landslides induced by Disaster of July 19-21, 1993	Churna Bahadur wali	1995
40	Geology and Geochemistry of the Patan-Dhung gad Area	Ajab Singh Mahara	1995
41	Engineering Geological and Geophysical investigations in the Agra Khola Basin	Taka Ram Poudel	1995
42	Engineering Geological studies of Landslidesd induced by Disaster of July 19-21, 1993 the Agra Khola	Prem Bdr Thapa	1995
43	Engineering Geological Studies in the Khimti Khola	Keshar Bdr Kandangura	1995
44	Electrical Resistivity Survey for Groundwater Exploration in Western Part of Dhanusha	Hira lal Moktan	1995
45	Lithological variation and Fossil contents of the Fluvio-Lacustrine Sediments of the Kathmandu Valley	Dipak Ghimire	1994
46	Hydrogeological study of Shallow Aquifer in Parts of Parsa Dist	Surendra Raj Shrestha	1994
47	Springs around the Kathmandu valley	Rajkumar Gambhir Singh	1994
48	Electrical Resistivity Survey for Groundwater Exploration in the Jutpani-Bacchauli Area Eastern Chitwan Dun	Rajendra Pd Khanal	1994
49	Engineering Geological studies of the Butwal Landslides and its Adjacent area	Rabindra Thanpe	1994
50	Lithostratigraphy of Mirchaiya Katari area	Narad Kumar Thakuri	1994
51	Sands inKathmandu valley prospects and problems	Dilip Kumar Sadaula	1993
52	Geomorphological Evaluation of Karra Khola valley Hetauda Chitwan Dun	Shova Singh	1995
53	A detailed paleomagnetic study of the Redbeds of the Dubring Formation, the Lesser Himalaya Dang	Soma Nath Sapkota	1994
54	Engineering Geological and Geotechnical studies of the Bhedetar-Ranke road, between Km 0+000 and Km 15+850 Eastern Nepal	Prathad Baaniya	1999
55	Geomorphological study of Harpan Khola and Phurse Khola valleys of Pokhara Basin, Central Nepal	Rosina Mali	1996
56	Environmental Geological survey along the Bagmati river in Metropolitan Kathmandu city	Jaya Kumar Gurung	1996
57	Engineering Geological and Geophysical investigations in the Dam site of the Khimti	Durga Pd Bashyal	1996
58	Radial Vertical Electrical Soundings to detect underground Tunnels and cavernous fissures around Davis Fall area Pokhara	Rajesh Pandit	1996
59	General geology of the Ampipal Area with special reference to Petrography	Vinod Kr Singh	1996

60	Geological and Engineering Geogical Studies in the Arjun Khola Area	Moti Lal Rijal	1998
61	Geology of Kulekhani Watershed in Central Nepal with Special reference to Landslides and weathering	Mahesh k Regmi	2002
62	Glacial geomorphological analysis of the Everest region for the reconstruction of recent palaeoclimatic	Bishnu Pd Adhikari	1996
63	Geology of the area between the Kakaru Khola and the Sunkoshi River Udaypur dist	Shailesh K Thapa	1999
64	Study of Groundwater from surface aquifer of Kathmandu Valley	Divas Shrestha	1999
65	geology and Structure of the Lesser Himalaya between Pokhara and Kusma	Lalu Pd Paudel	1994
66	Astudy on the Geology of the Suria Naka- Bardanda Area	Aghut R Gautam	1994
67	Geology of the Piuthan area with special reference to the Engineering Geology of the Jhimruk	Sudhir Rajaure	1994
68	Application of Electrical Logging to estimate Hydraulic parameters of aquifer sediments in Northern ground water	Achyut Dangol	2001
69	Engineering geological study and application of bioengineerign system in stablization of landslides of Sindhupalchok Dist	Bam Dev Regmi	2002
70	Landforms in the sediments of Kathmandu valley	Sagar Ratna Bajracharya	1997
71	Environmental Engineering studies in the Kulekhani watershed with special referenceto Hazard mapping around the reservoir	Abha Shrestha	
72	Ground conductivity measurements for the study of the Gokarna landfill site and other areas on the bank of the Bagmati river	Ganesh Nath Tripathi	2000
73	Engineering and Environmental geological study of Kharidhunga Thokarpa Balephi area	Ranjan Kumar Dahal	1997
74	Geology and plant fossils from the Siwaliks of Godawari area	Sharawan Gorkahali	2001
75	Engineering geological studies of th Kali Gandaki A Hydroelectric project area	Suman Panthi	2000
76	Ground water potential from the watershed of Chandragiri limestone	Naresh Sakya	2002
77	Engineerign geological mapping and geological study of the Jiri-Chhange road in Dolakha dist	Arun Dangol	2002
78	Engineering geological and geotechnical study in and around Ilam Hydropower project	Deepak Chamlagain	2000
79	Correlation between Electrical Resistivity measured on the surface with hyraulic parameters of Granular materials in Eastern chitwan Dun valley	Ghan Bd. Shrestha	1999
80	Sedimentation in the Kulekhani watershed and its impact on the reservoir of the kulekhani hydroelectric	Anirudhra Paudel	2001
81	Engineering geological watershed management studies in the kulekhani	Sambha Pd. Lamichanne	2000
82	Geology of the lesser himalaya of Sindhuli Garhi Sulibhanjyang Area	Dinesh K. Napit	1997
83	Geology of Bhaktapur Nagarkot Area	Kausal Ratna Bajhrachraya	2001
84	Engineering geological studies in the Kulekhani	Mahesh Singh Dhar	2000
85	Hydrogeologiccal study in Northern parth of chitwan Dum Valley	Murari Pd. Kharel	
86	Geological study of Arjun Khala Area	Prakash Chandra Paudel	1998
87	Geological Mapping in the Taplejung window panchthar District	Subesh Ghimere	2001
88	Hydrogeological study in southern part of Dang Valley	Birendra Sapkota	2001

89	Hydrological and Envirnmental Engineering Investigation of the Saptakoshi River	Anita Regmi	2001
90	Enveronmental Engineering Investigating Investigation of the saptakoshi	Archana Pradhan	2001
91	The study on the Groundwater Fluctuation and its Hydraulic parameters in the kathmandu valley	Usha Kharel	2001
92	The Comparative water quality Assessment on ground and surface water sources in kathmandu valley	Pramila Subedi	2002
93	Geology and Tecinical analysis of Lower Tertiary coals of Tosh Area	Kabi Raj Paudel	2001
94	Geology of Taplejung area Eastern Nepal	Dibya Raj Koirala	`2002
95	Elatrical Resistivity Investigation and Analog Modeling fhor Reservoir Infilration and Rock Quality	Shayam Hari Ghimere	`2001
96	Engineering Geological and slope stability Studies of Andhi Khola Syangja District	Maheshwor Khanal	2001
97	Stratigraphy Anddepositional Environment of quaternary Sediments Constituting the Eastrin part of Dang valley	Keshab Raj Rijal	2002
98	Geological Mapping and Engineering Gealogical study in the Northern part of the Taplejung	Tej Pd Gautam	
99	Geological studies in the Southeastern part of Taplejung	Chandra Prakash Paudel	2002
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101	Application of Magnetic susceptilty for Sediment Correlation and Deciphering Roadside Polluting in Kathmandu Valley	Ghanashyan Neupane	2002
102	Gealogy of Sundarijal sipaghat area Central Nepal	Rajesh Dhungana	2003
103	Exploration and Caleultion of total Natural Gas Reserve at Teku area	Suchita Shrestha	2003
104	Geochemical Analysis and Reserve Estmation of the Sinduli Limestone Depasit Sukora Udayapur	Paresh Raj Pandey	2003
105	Geology Metamorphism and Mineral Resources of the Dadeldhura Area	Ganesh Raj Joshi	2003
106	Engieering Geological and Geotechnical Stydies of the Tinpile-Banchare dada ROAD	Matrika Pd. Koirala	2003
107	Geology and Petrographic Study of the Area from Chirauneli khola to thulo khola	Ganaynadra Gurung	2003
108	Geology and Grade of Metamorphism of the Gatlechhi Area Dhading	Uddhav K. Mahato	2003
109	Studies on Sedionentology and Molluscan Fossils of the Kathmandu	Ujjwala Bajrachraya	2003
110	Engineering Geological study of the Dipayal -Mellekhsakarlekh Road	Govinda Ojha	2003
111	Engineering Geology and the slope stabilily of Bungmati Landslide in Bungmati	Annanta Man Singh Pradhan	2004
112	Hydrogelogical study of Arsenic Occ	Suman Singh	2004
113	Engineering hydrological study of Kodku Khola in referenceto water supply	Laxmi Devi Maharjan	2004
114	Engineering geological and geotechnical studies of the Phurping-Hetauda road	Damodhr Lamshal	2004
115	Engineering geological and geotechnical studies of Seti-Trishuli storage hydroelectric project Gaighat, Tanahun	Sujan Raj Adhikari	2004
116	Engineeing geological and geotechnical studied of the Phurping-Hetauda road	Srikrishna Lamichanne	2004

117	Soil erosion and environmental geological study of the Kodku khola	Bikash Shrestha	2002
118	Evaluation of Rupathali sand deposit withreference to Mining policy	Arati Chada Pradhan	2004
119	Application of ground penetrating radar for the building evaluation	Dhruba Mishra	2004
120	Engineering geological and geotechnical studies of upper Hewa Khola hydroelectric project, Panchthar	Ganesh Pd. Neupane	2005
121	Geology and landslide hazard mapping in the Thankot to Chalnakhel area	Pardip Paudel	2004
122	Palaeontological investigation of the Siwalik ground along the Chatara-Barahakshetra area	Muan Lamichanne	2003
123	Geomorphological analysis of the Kolpu khola valley	Shana Joshi	1999
124	Geology of the area between the Sunkoshi river and the Kakaru khola Udayapur	Shree Kamal Dwivedi	1997
125	Electrical resistivity measurement on Physical models of sand and cement	Krishna Bd. Basnet	1997
126	Distribution of Fluvio-Lacustrine sediments in Kathmandu valley	Rupak Staphit	1998
127	Electrical resistivity survey for groundwater exploration inNorth central part of Morang	Dushyanta Bhattrai	1997
128	Geology of the Kampughat-Chisapani area Udayapur and Khotang	BishowNath Ray Chaudhary	1997
129	Hydrogeological condition and water quality of deep tubewells in the Kathmandu valley	Sumesh Amattya	1999
130	General geology and petrography of the rockds of Sindhuli Garhi area	Dharma Raj Khadka	1997
131	Engineering geology and geotechnical studies of Kankai storage hydroelectric project, Eastern Nepal	Sunil Kumar Dwivedi	2003
132	Engineerign Geologicl study for the slope instability inChalnakhel VDC, kathmandu vallley	Prakash Dhakal	2003
133	Engineerign geological study for the slope stability of Chobhar landslide in Chobar kirtipur municipality Kathmandu	Amar Bd. Chand Thakuri	
134	Hydrogeological studies in parts of Dang valley	Birendra Piya	1993
135	Hydrogeological studies in parts of Dhanusa	Rajiv Gautam	1995
136	Post project impact studies of Jugeda tubewell irrigation project inJugada area of Kailali	Rajendra Prakash Bhatta	
137	Detail engineering geology and geotechnical studies of upper Tamakoshi	Purushottam Silpakar	
138	Applicability electrical resistivity tomography in the study of the river valleys, Nepal	Dilli Ram Thapa	
139	Study of geology of Tosh area the Northern Dang	Manoj Acharya	2005
140	Geomorphological study and drainage basin analysis in the eastern part of Dang valley	Dipenda Laudari	2001
141	Evaluation of rocks of the Tistung formation for concretea ggregate, southern part of Kathmandu valley, Tikabhairab area	Dev Krishna Maharjan	
142	Study on morphometric characteristics lithology and index properties of the rocks erom from the Chure khola basin	Dharmendra Khakurel	2004
143	Geology and structure of Shivapuri-Ranipauwa area, Central Nepal	Jyotdra Sapkota	2005
144	Stratigrphy and Metamorphism of Shivapuri-Ranipauwa area, Central Nepal	Kushal Nandan Pokhrel	2005
145	Palaeocurrent analysis in quaternary deposits from southern part of Kathmandu valley	Santosh Dhakal	2005

146	Soil erosion in Kahuri watershed and dgeologyog the adjacent area Udayapur	Tara Pd. Bhattrai	2005
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148	Hydrogeological study in south-eastern part of Jhapa district	Ashok Sigdel	
149	Role of rock and soil materials on water storage capacity and quality in eastern part of Jhikhu khola watershed	Smita Kumari Shrestha	1999
150	studies on stratigraphy of Kathmandu valley	Nirma Shrestha	2005
151	Engineering geological study for the slope instability inChalnakhel vdc, Kathmandu valley	Prakash Dhakal	2003
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153	Hydrogeological studies in parts of Bara district	Sanjiv K Sakya	1995
154	Geomorphological analysis of Samari khola watershed of Makawanpur	Binod Tandukar	1996
155	Groundwater studies in the Terai plain of Morang	Tara Niddhi Bhattarai	1998
156	Geological studies around Taplejung area, Eastern Nepal and Landslide hazard mapping of Hangdewa-Hireba watershed	Desh Raj Sonyok	2001
157	Engineering geology and the slope stability of Bungmati landslide in Bungmati	Annanta Man Singh Pradhan	2004
158	Hydrogeological studies in parts of Siraha dist	Khila Nath Dhakal	1998
159	Hydrogeological study inBharatpur area, Chitwan	Shiva Lal Acharaya	2002
160	Studies on geology and mineral resources of kathmandu valley sediments	Suhana Mool	2004
161	Geological mapping and classification of limestone of the Phulchowki area, Central nepal	Diwakar Khadka	2005
162	Study of Seismic Properties of sediments using Pand S wave and their correlation with mechanical properties of soft sediments of kathmandu valley	Om Pradhan	2005
163	Engineering geological study and stability analysis of Shrawan Danda Jyotinagar landslides, ward no 5 Butwal municipality, Rupandehi	Ashish Ratna Sakya	2005
164	Rock mass classification and design of support systems in Middle Marshyangdi Hydroelectric project, Lamjung	Krishna Pd. Uppadhya	2006
165	Feasibility of Rexcharging Aqifer Through rainwater in Patan, Lalitpur	Hitendra Raj Joshi	2006
166	Stratigraphy of Lower Tertiary succession, lesser Himalaya Western Nepal	Pragati Adhikari	1999
167	Geotechinical Investigation of Buddhanagar Bariyarpatti Road and Road trotective Measures	Prakash Jha	2000
168	Quality Assessment and Reserve Estimation and Economic Analysis of Roofing Slate in Thorpa Area Tanahun District	Nawaraj Neupane	2003
169	Petrology of Chapagaun Formation with refrence to Natural Resource of Gravel Southern Part of Kathmadu Valley	Basnata Devkota	2006
170	Engineering Geological Studies of The Gravel Deposits in The Northern Part of Kathmandu Valley	Babukrishna Bhandari	1995
171	Geomorphological Study of Horpan Khola and Phusre Khola Valley of Pokhara Basin, Central Nepal	Rasmi mali	1996
172	Engineering Geological Studies of Mahankal Fan Sundarijalm, Kathmadu Nepal	Sashi Basnet	2001
173	Hydrogeological Studies of Kathmandu Valley	Bipin Lamichane	2006

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176	Evaluation of Chandragiri Limestone as a source of Raw material for Cement Industry in Khopasi Area, Kaverpalanchowk, Central Nepal	Pravat Chadra Neupane	2006
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178	Study on Quality Assessment reserve Estimation in Mining Techniques of Dimension Stone of Khrpa Deposit , Central Nepal	Anita Thapaliya	2005
179	Palentology, Paleoecology and Paleoenvironment of Lukundol Formation	Sudarshan Bhandari	2006
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188	Study on the Feasibility of Establishment of Cement Plane on Chandragiri Limestone, Ramdighat Area, Central Nepal	Pawan Budhathoki	2005
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195	Geological, Geoengineering and Geotechnical Studies of Kulekhani III Hydroelectic Project, Makwanpur District	Kangada Prasi	
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204	Status of Sand Excavation in Northern Part of Kathmnandu Valley with refrence to Spatial Variation of Sand Quality	Mamati Syami Manandhar	2007
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210	Pleistocene Deposits and Environmental Geology of Pokhara Valley	Ramhari Sharma	1995
211	Application of GPR in post construction evaluation amd Monitering	Murari Khatiwada	2005
212	Engineering Geological and Geotechnical Studies of Budhigandaki Hydroelectric Project , Central Nepal	Ravindra Pd. Dhakal	2005
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224	Hydrogeological Studies in the part of Rupendhei District	Anil Bajrachraya	1992
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226	Hydrogeological Study in the Part of Rupendhei District, Western Nepal	Rajesh Shrestha	2008
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228	Location of Buried Geological Structure using Ground Fenetrating Radar in Bardibas Central Nepal.	Suraj Kumar Bajgain.	2008

229	Resistivity Turvey for Rock Quality Invertigation Along the Tunnnel Alignement of the Khimti.	Ganesh Mainali	2000
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234	Glacial Geomorpholpgical Analysis of the Everest Region for the Rrconstrution of Recent Palaeoclimatic Changes	Bishnu Prasad Adhikari	1996
235	Slope Stability Analysis of the Dumrebesi Landslide and Debris flow chitwen District, Nepal.	Satyam Poudel	2007
236	Gealogical and engineering Geological Study of the Dam site Area of Upper Tamakoshi Hydroelectric Project, Dolakha, centra Nepal.	Kumar Khadka	2009
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238	Rock Support Design for the Underground Structures of Upper Tamakoshi Hydroelecric Project Dalakha District, Centraql Nepal.	Kanchan Chaulagai	2009
239	Comparative Hydrogeological Analysis of Lubhoo, Harishi and Thecho-- Chapagaon of Lalitpur Central Nepal -- with Reference to Water Supply Systemm,	Surya Limbu	2009
240	Geology of Tapa- Murkuti Area ,Northeast Dang,West Nepal with Special Reference to Linestone Deposits,	Nam Raj Bhattarai	2009
241	Investigation of Crushed Rock Aggregates for Unbound Pavement from Adeshwar Area. Sitapila VCD, Kathmandu Central Nepal.	Shrawan Khanal	2009
242	Toxic Contamination in the Groundwater of Saptari District and its Health Impact.	Hira Bahadur Gharti Magar	2008
243	Applicability of Different Arrays os Electrical Resisitivity Tomography in the study of Marsyangdi River`	Thakur Prasad Kandel	2009
244	Rock Slope stability of right bank of Dam area, middle Marsyangdi hydro-eliectric project, Lamjung district, central Nepal	Trilok Chandra Bhatta	2006
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255	Geological, Enginerring Geological and Geotechnical Study of Upper Trishuli-3A Hydroelectric project Nuwakot and Rasuwa District Central Nepal	Narayan Krishna Ganesh	2010
256	Geological Mapping and GIS based landslide hazard Mapping of Northern Kavrepalanchok Central Nepal	Ramesh Pandey	2010
257	River dynamics and restoration design of the Nakhu khola	Binod Maharjan	2010
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260	Basin analysis of the Northern part of the Kathmandu Valley, Kathmandu Nepal	Pramod Nepal	2004
261	Engineering Geologgical study and slope stability anlaysis of Thankot Landslide Kathmandu Nepal	Om prakasah paudel	2004
262	Geological exploration of masrang cement Grode Limestone Deposit, chitwan, central Nepal	Pankaj Devkota	2010
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264	Geology, petrography and metamorphism of Kalanki- trishuli area central Nepal	Sobit Thapaliya	2011
265	Landslide Susceptibilty Mapping of the Ghurmi-Dhad Khola area in Eastern Nepal using GIS	Subeg Man Bijukchhen	2011
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267	Geology and structure of the kota Baidi area, Tanahu District, Central Nepal Lesser Himalaya	Deo Kumar Limbu	2011
268	Engineering Geological Study of Chameliya Hydroelectrc project Darchula Far Western Nepal	Dilendra Raj Pathak	2011
269	Geology of Ghurmi- Dhadf Khola area in west Nepal with refrence to strain analysis of Mct zone	Babu ram Gyawali	2011
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274	Geological engineering geological and geotechnical study of the upper Trishuli-2 Hydroelectric project Rasuwa, Central Nepal	Kedar Shrestha	2012
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276	Geology and mineral resource of the Khasaran Watak area, Tanahu district central Nepal, Lesser Himalaya	Lok Bijaya Adhikari	2012
277	Lithostratigraphy,Petrography and metamorphism of Dharan-Mulghat area, Eastern Nepal	Saunak Bhandari	2012
278	Geological Engineering Geological and geotechnical study of the Mai Khola Hydroelectic project,Illam, Eastern Nepal	Puskar Raj Joshi	2012
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284	Landslids Susceptibility Mapping of the Ranipauwa -Jiwanpur Area in central nepal using GIS.	krishna Prasid Dhungel	2012
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287	Vegetation and Climate from the Siwalik Sediments in the Dudhaure khola Section.(Amlekhganj-Hetauda Area)	Bishwa Mani Pokharel	2013
288	Lithology and Structure of the Presiwalik Rock Around Katari-patana Bhanjyang Area.Udayapur District,Eastern Nepal.	Narayan Adhikari	2013
289	Sedimentological Study of Lithological Succession South of the MBT,Hetauda-Sukaura Area,Makawanpur`District,Central Nepal.	Dev Kumar Syangbo	2013
290	Geology Structure and Metamorphism of the Manahari-Taubas Area,Central Nepal.	Laxman Subedi	2013
291	Landslids Susceptibility Mapping of theSeti Watershed Between Bhimad and Damauli,Western Central Nepal.	Gautam Prashad Khanal	2013
292	Hydrogeological study and Well Site Selection Using Geophycal of Bosigaon -Shantibasti Area Kathmandu District Central Nepal.	Sabindra Bahadur Shrestha	2013
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303	Geological Mapping and Soil Erosion Investigation in the Part of Seti Watershed Between Bhimad and Damauli, West Nepal.	Madan Bhattarai	2013

304	Rock mass Characteristics and Kinematic Anilysis of ROCK Slopes of the Lesser Himalaya Thopal Malekhu River area Central Nepal	Jaya Laxmi Singh	2014
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306	Litho- Biostratigraphy of Siwalik Sediments in Arun Khola Area in Nawalparasi and Palpa Districts ,Western.	Yubaraj Lamichhane	2014
307	Geology of Siwalik Succession Binai Khola Area in Nawalparasi and Palpa Districts, Westren Nepal.	Chitra Bikram Tandon	2014
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328	Landslide Susceptibility Mapping of the Juhan-Shantipur area of the Gulmi District,West- central nepal,Lasser Himalaya	Sunil Bikram Thakuri	2015
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3.	Krishna Pudasaini	Engineering Geological Study And Slope Stability Analysis Along Fast Track From Thingan To Chalnakhel (Lesser Himalaya)
4.	Arishma Gadtaula	Susceptibility Mapping of Earthquake Induced Landslides using Weight of Evidence Method in Haku, Rasuwa District, Nepal
5.	Pushkar Bhandary	Engineering Geological Mapping And Slope Stability Analysis of The Fast Track Road Alignment Between Nijhgadh - Kolkhop (Siwalik Group of Nepal, Bara and Makawanpur Districts of Narayani Zone), Nepal
6.	Rabina Hada	Isotopic Analysis of Siraha And Saptari Districts, Western Part of Koshi River for Connectivity Assessment of Shallow And Deep Aquifers
7.	Sanjeeta Pandit	Distribution and Classification of Springs in Bansbari Area of Melamchi Municipality, Sindhupalchowk, Nepal
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9.	Shila Bhattarai	Characterization of Construction Aggregates in the Southern Part of Kathmandu Basin
10.	Harish Dangi	An approach of earthquake-induced landslide hazard mapping: A case study in Nuwakot District, Central Nepal
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11.	Prakash Badal	Landslide Susceptibility Mapping of Birendranagar Municipality, Surkhet by using Statistical Approach (Weightage Evidence Methods)
12.	Radha Krishna Adhikari	Engineering Geological Study of Taprang Landslide (Kaski District, Gandaki Province)
13.	Sushil Neupane	Construction material resource investigation in Kathmandu Valley's southern part and its proper utilization
14.	Sandip Pokharel	Landslide Susceptibility Analysis using Frequency Ratio Method, at Dharche Rural Municipality, Gorkha, Western Nepal
15.	Bibash Parajuli	Cut slope stability assessment of Kaligandaki road corridor in Siwaliks, west central Nepal
16.	Tara Nath Giri	Engineering geological study of Kaligandaki road corridor from Bhakro Khola to Dhadbesi village, Nawalparasi District, west central Nepal (Lesser Himalaya)
17.	Rabi Dhungana	Study of Portal Slope and Tunnel Stability In Mai Beni Hydropower Project, Ilam, Nepal
18.	Lal Bahadur Thapa Singjali	Landslide Characterization and Susceptibility Assessment in Namche-Khumjung Area of Everest Region, Solukhumbu District

19.	Sabin Tiwari	Water-Rock Intereaction and Hydro-Chemical Analysis of Spring Water around Melamchi Area, Sindhupalchok District, Central Nepal
20.	Samir Dhungel	Geomorphological Mapping of Lobuche Area Using Uav and its Application In Engineering Geology, Eastern Nepal
21.	Anil Ghimire	Moraine Dam Stability Analysis of Ngozumpa Glacier in Gokyo Area, Eastern Nepal
22.	Sanjeet Maka	Geomorphological Mapping of Gokyo Village Surroundings and Analysis of Lake Sediments of Taujin Cho Lake with its Engineering Significance
23.	Dinesh Nath	Deep Aquifer Characteristics of Northern Groundwater District in Kathmandu Valley
24.	Bal Krishna Shrestha	Soil Erosional Modeling and Sediment Characteristic of Gokyo Lake and its Surroundings: Engineering Geological Significance
25.	Pranita Pun	Landslide Characteristics and Susceptibility Modelling in Thaha Municipality, Makwanpur District
26.	Bhuwan Awasthi	Recent Trend of Glacial Surface Lowering And Evolution of Supraglacial Ponds in Khumbu Glacier, Everest Region, Nepal
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27.	Bhim Raj Neupane	Engineering Geological Mapping And Rock Mass Classification Along Dumkibas To Barghat Road Tunnel (Part Of Mahendra Highway)
28.	Puskar Thapa	Estimation Of Soil Erosion By Using RUSLE Method (Geospatial Tool) In Thopal Khola Catchment, Dhading District, Central Nepal
29.	Prabin Shrestha	An Estimate Of Safe Angle For Cut Slope Under Different Geology And Rainfall Intensity
30.	Sanjeev Parajuli	Effectiveness Of Using Soil Nail With Semi-Flexible Mat In Comparison With Conventional Slope Protection
31.	Ananta Kafle	Engineering Geological Investigation Of The Turture Landslide Of Burtibang (Baglung District), With Emphasis On Its Failure Mechanism.
32.	Dhurba Tiwari	Geohazard Assessment In Bhanu Municipality Of Tanahun District, Western Nepal

<u>**Welcome and Farewell**</u>


नेपाल भौगर्भिक विद्यार्थी समाज
NEPAL GEOLOGICAL STUDENTS' SOCIETY
Kirtipur, Kathmandu
Welcome & Farewell Program
2080-01-21
Organized by
Central Department of Geology
Tribhuvan University

Glimpses of NGSS Futsal Tournament-2079

Congratulations to the newly appointed head of the Department, Tri-Chandra Multiple Campus, Dr. Subodh Dhakal Sir, on behalf of the student society.

Providing Bulletin of NGGS "GEOINNOVATION Vol-1" to various colleges and library's

Glimpses of the 4th Geo-Science Exhibition

26th to 28th Magh 2079

Students learn about outfits & equipment used and worn by everyday

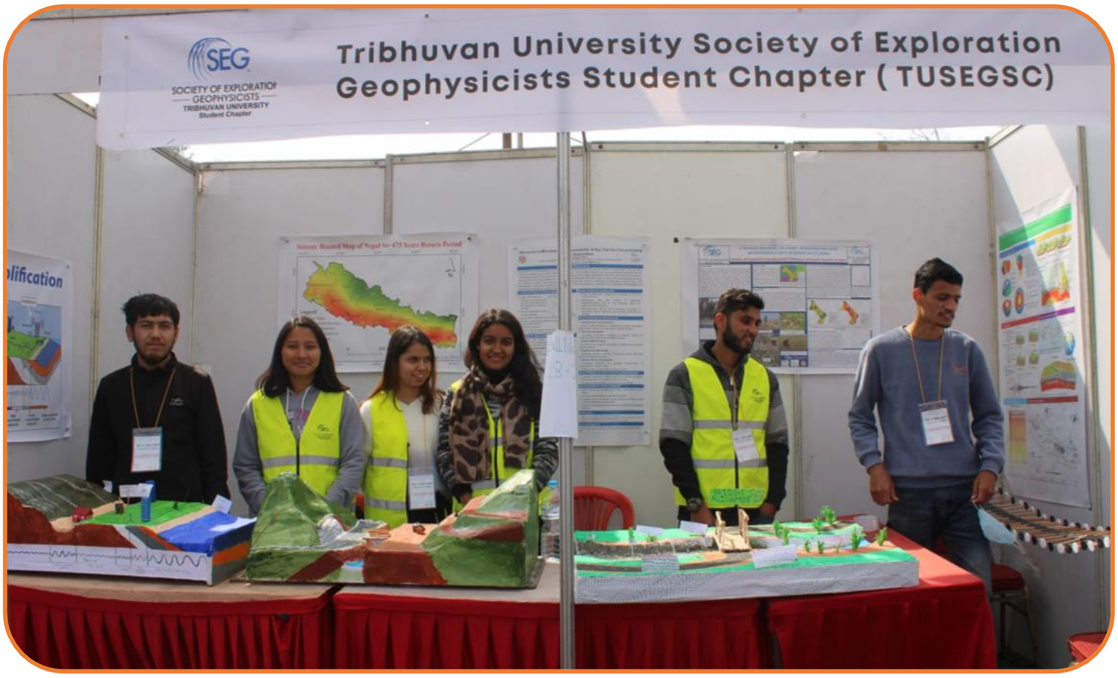
Young Mind learning about mighty worlds of minerals.

First Aid & Health Desk placed in Exhibition.

Prof. Dr. Khum Narayan Poudayal, HOD, Central Department observing and inspecting the exhibition program

Exhibitors showcasing model of Rock Bolting in Tunnel

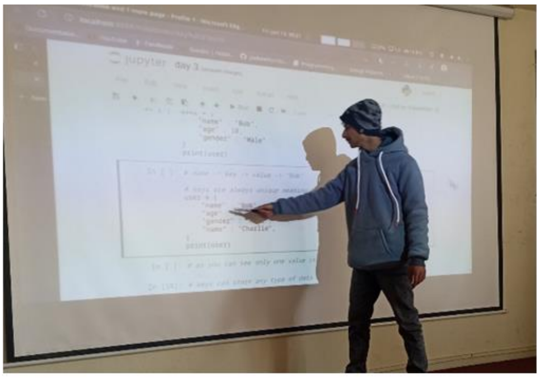
Some of the stalls were showcased during the exhibition.




RIVER MORPHOLOGY MODEL
PREPARED BY:


चौथो भू–विज्ञान प्रदर्शनी
4th Geo-science Exhibition

Glimpses of Closing Ceremony and Certificates Distribution to Presenter, Exhibitor & Volunteers




Seven-day Python training to MSc students organized by NGSS, 2079 Magh


One day field orientation for B.Sc. 3rd year Students on 31st Dec 2022


One day field orientation for B.Sc.4th year Students on 21st Dec 2022


Handing Over the Donation of Rs.2,59,931/- collected via NGSS to our member Prashan Rai whose eye was injured during geology field trip, in the presence of his mother and Head of Department

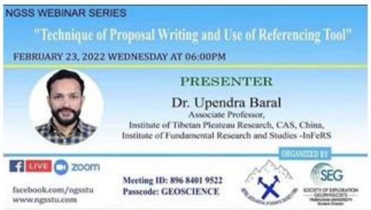
Glimpses of Student outreach program from NGSS where information & knowledge about geology, and disasters we talked.

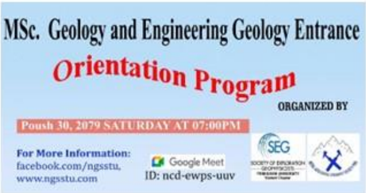
Shree Vaishnabi Secondary School, Kirtipur 2022/06/03

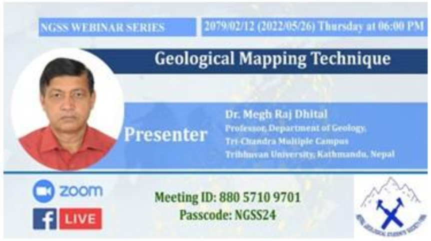

Shree Mangal Secondary School, Kirtipur 2079/04/06

Glimpses of 25th Executive Election, 2080/01/24

Some banners of webinar and online programs organized by NGSS







ARTICLES

EARLY WARNING SYSTEM (EWS) AND WORK TOWARDS DRR IN NEPALESE CONTEXT

- Amrit Marasini, Santosh Sapkota, Ashok Thapa, Amod Acharya

A disaster is an unexpected, catastrophic event that causes damage, disruption, and affect human life, property, and the environment. Disasters can be Natural,man-made or combination of both. Natural disasters include Earthquakes, Floods, Landslides, Hurricanes/Cyclones/Typhoons,, Wildfires, Tornadoes, lightning etc. and Human-made disasters, Industrial Accidents, Terrorism, Technological Failures, War, and Conflict etc.

The impact of such a disaster can be minimized if we can predict the time and scale of the disaster or if we can minimize the element at risk. The early warning system is the process of warning such risk elements before a disaster happens so that we can minimize the loss of life, environment, structures, and finance associated with it. An early warning system (EWS) is the ability to produce and disseminate timely and useful warning information that allows at-risk people, communities, and organizations to prepare and respond effectively and in time to reduce injury or loss.

The most common natural catastrophes that Nepal experiences each year are landslides, floods, glacial lake outburst flooding (GLOF), drought, wildfires, and earthquakes.

Numerous catastrophic threats that the population in the nation faces have severely damaged life and property. Almost every year, Nepal receives 80% of the rainfalls during the monsoon period from June through September, making it highly prone to disasters associated with these floods and landslides, which cause harm to crops or property in one area or another. If we could work more on EWS, we could minimize the impact of these disasters.

In Nepal, the development of early warning systems is in its infancy. At the municipal and national levels, no efficient multi-hazard early warning systems have been built with MEOC(Municipal Emergency Operation Centers) and LEOC (Local Emergency Operation Centers), which are being operated in a few municipality and other are following, but they do lack proper resource, skilled man-powers,, and function are limited but are in right approach towards the DRR . There are some procedures for creating and disseminating hazard-specific alerts and strengthening local communities' response capacities; however, these are project-specific and only apply to a small number of villages. Early warning systems and community-based disaster risk reduction are being worked on by a variety of governmental, non-governmental, and humanitarian groups in Nepal. According to studies, only a small number of organizations have included all four early warning system components in their program interventions.

By delivering timely and reliable information about impending disasters or hazardous events, an early warning system (EWS) plays a critical role in disaster risk reduction (DRR). Its main objective is to inform local people and pertinent authorities so that they can take preventative action is to lessen the effects of disasters and save lives. Effective preparedness and response plans for disasters must include early warning systems.

Nepal's early warning systems include:

Earthquake Early Warning System:
Along with several international organizations and agencies, Nepal has put into place the Nepal Seismic Network (NSN), an early warning system for earthquakes. The system recognizes earthquakes, determines their size and position, and informs authorities, first responders, and the general public via a variety of channels, including mobile apps and sirens.

Flood Early Warning System:
Nepal's Department of Hydrology and Meteorology (DHM) runs flood forecasting and warning systems for key rivers. These systems track rainfall and river levels to forecast impending flooding and send out alerts. The media, governmental organizations, and local communities all share the notifications.

GLOF Early Warning System:
Due to the steep topography and numerous glacial lakes in Nepal, glacial lake outburst floods (GLOFs) are a major threat. In order to spot any indications of a potential outburst, efforts are being made to monitor these lakes and set up early warning systems. These systems entail continuous observation of glacier and lake conditions.

Community-Based EWS:
Local communities in Nepal have frequently built their own early warning systems adapted to their areas' unique dangers and vulnerabilities. These systems incorporate local monitoring, indigenous knowledge, and community-driven response techniques.

Landslide Early Warning System:
A landslide refers to the rapid downward movement of a large amount of earth material, such as soil, rock, or debris, down a slope. The triggering factor for the movement can be triggered by various factors, including heavy rainfall, earthquakes, volcanic activity, human activities (such as construction or mining), and natural geological processes. Landslides can vary in size and severity, ranging from small and localized to large and devastating events occurs, which cause significant damage to building, fractures, and property and even can cause loss of life. Rainfall-induced landslides, also known as rain-triggered landslides, occur when heavy or prolonged rainfall saturates the soil on a slope, reducing its stability and causing the slope to fail and move downward. Landslide Early Warning System (LEWS) should be developed that utilizes sensors like extensometers, soil moisture sensors, and rain gauges to monitor environmental conditions. By communicating timely and reliable information about catastrophe risk, EWS play a vital role in enabling preparedness action as well as a quick response from employees, employers, and national or local authorities, and they can thereby prevent human and financial losses in the workplace. EWS can improve readiness, develop resilience, increase capacity for quick recovery, and decrease vulnerability. As, Nepal always lies in the forefront of disaster and preparedness for the disaster reduction are always seems to be inadequate proper early warning system with cost effective method and technologies which fits the Nepalese diaspora must be implemented and thoroughly researched.

INVESTIGATION AND DESIGN OF GROUTING IN HYDRO POWER PROJECTS

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In previous bulletin (Vol.1) we have already discussed the basic of grouting. The terminologies and general concepts were described in the previous volume. In this chapter we are going to discuss investigation, design and procedure of the grouting. The principle of grouting is to fill all joints, voids, cracks and cavities by pressure through drill holes (bore holes) with a designed mix (cement, water or chemicals). OPC cement is best fit for cement grouting. Accelerator, plasticizer and retarder can be added as per requirement. It is worth to note that grout take may differ during construction than the investigation. It is due to the reasons- mix ratio, pressure applied, fineness of cement, equipment and workmanship.

SITE INVESTIGATION FOR GROUTING:

The main aspect of the site investigation for the grouting is to know about the geology of the area. Geology indicates the lithology, condition of the discontinuities, geo-mechanical properties of rocks etc. Studies carried out in the investigation are as following -

Joints: The main parameters of the condition of joints are persistency, aperture, filling and spacing. In the joint where aperture is wide, it takes higher grout than fine cracks. Following parameters are studied for joints-

Spacing of joints: The spacing of the joint has an important role in grouting. Widely spaced joints take high grout where closely spaced joints take low grout. Chance of collapsing of hole is a problem in closely spaced joints.

Aperture of joints: Separation of joint is also an important parameter in grouting. As the separation is wide, grout penetrates easily and travelling time is also short. In calcareous terrain the bed rock is mostly experienced by dissolution or karst. In such condition the grout flow is fast and take is generally high. In contrast, in igneous rocks such as gabbro or basalt the fractures are very tight and grout take is low.

Persistency of joints: If the persistency is high the grout covers a large area. For low persistence joints, the grout travels a short distance and more drill holes are needed to cover the area to fill the grout.

Inclination of joints: Inclination of the joints matters to grout take. If the joints and drill holes both are vertical, the probability of filling grout in all joints is impossible except drilled one. For the vertical joints, maximum $60^0$of drill hole is suitable.

Uniformity of joints: If the area consists of same joint system, the grouting is uniform. If the area has different lithology, different nature of joints might have existed with variable ratio of take.

Strength of the rock: The strength of the rock matters for the grouting in sense of bearing pressure. If high pressure is applied in a weak and incompetent rock, borehole could be collapsed. Probability of bypass in such holes is high. Bypass is the phenomena where grout comes out from the weak rock disabling the packer. It is difficult to adjust the packer in weak or crushed rocks.

Piping: The process of removal or erosion of material from the joints to ease the permeability is called piping. The filling material between joints should be studied intensively, so that piping in the rock can be avoided. Care should be given if such materials are present between the joints. Soft materials can easily be removed by the water.

Cavities and voids: The cavities and voids take high grout. The generation of holes is mostly common on the calcareous terrain by reaching Vmax (See Vol.1). Identification of such characteristics in the bed rock is essential to design the grout. Difficulties in drilling and grouting can be faced in such areas. Backfilling type of grouting is encouraged in karst and void rock mass. More check holes are needed after completing the grouting activity.

Structure: The presence of fold and faults also affect the grouting process. On the axis of folds the rocks are highly fractured compared to the limbs. The grout take is high in this area and grouting design in such area may differ from other areas. The faults are the weak zone in the rock surface. Materials are comparatively crushed and difficult to grout with low groutability. Breccia can be collapsed or disturbed even in low pressure. Faulted zones are low permeable, so need to be studied precisely.

Geo-hydrology: The presence of ground water and nature of rock both matter in grouting. Some rocks are highly porous but less permeable and low porous but highly permeable and vice versa. Presence of ground water may dissolve the grout and increase the bleeding. Such condition should be studied and the mix is designed as per the presence of sub surface water. The procedure of grouting such as type of mix, spacing and depth of holes, pressure and volume depends upon presence of water table.

Sub-surface investigation: The main investigation to check the sub-surface conditions of rocks such as condition of joints, weathering, infilling, presence of fault and crushed zone, position of water table, hydraulic conductivity, boundary of rock are identified by core drilling. By recovering the core, geologist can get all information to design the grouting area. In such bore holes, core can be recovered and they are investigated by in-situ tests such as bore hole televiewer logging, geophysical logging, water permeability tests etc.

DESIGN OF GROUTING:

For the design of the grout it is necessary to know about the above mentioned parameters related to geology, conditions of the fractures of that area and accordingly it is necessary to fix the required grout pressure, volume, mix and fineness of the cement. A dummy experiment is desired to fix the parameters of grouting. The experimental grouting method is called Grouting Test Panel. Such test panels are based on the lithology and condition of the ground. For the different lithology the volume and pressure might be different depending on the pattern of discontinuities. So, designer should establish different grout parameters for different lithological and joint condition. For example, if the rock mass is marble and inter-bedded with phyllite or quartzite, the probability of high grout take is required compared to monolithic phyllite. Marble may contain karst structure, wide joints or voids. Mudstone exhibits characteristic of low permeability and less fractured than sandstone.

To establish the grouting parameters in an area it is necessary to check the permeability by performing water permeability test (WPT). The WPT test provides the permeability of the area. WPT tests are mostly done in the primary holes. The distance between the primary holes in test panel may vary from12 or 6 meter as per joint or fracture present in the area. The depth is determined as per requirement. The secondary or other generation follow the split spacing method. The secondary is between primary holes and tertiary is between secondary holes.

WTP tests are generally done in primary holes. After analyzing the result of Lugeon values in primary holes, the gout test can be done. Grouting tests are performed in single row, multiple row or circular. Single row of grouting for curtain is an old criteria, so double or multiple rows are done these days. The pressure is determined based on this grout test. The pressure should not be more to behave hydro-jacking or hydro-fracturing. The mix can be changed from the thin to thick. By adopting GIN in panel test, a stable mix 0.7 can be used.

Generalized formula for weak rock condition to determine the pressure applied is-
Pressure Required= Density of rock mass × depth × (max 90% of over burden)

For example, the density of the rock is 2.5gm per cm^3, depth is 20m, and the pressure can be calculated as,

$$\text{Pressure} = \frac{25 \times 20 \times 0.9}{100}$$

=450 kPa, 0.45MPa or 4.5 bar

(Note: 2.5 gm per cm^3 equals to 25kN per m^3)
Note: Average depth should be considered for required grout stage. If the grout stage is between 15 to 20m, the depth should be calculated as 17.5m.

In other way,
As per the grouting practice in the world, the maximum pressure is determined as-
$Pmax\ (bar) = a \times D$

Where, a (bar/m) = Injection factor
D (m) = Depth of the middle part of the grouting stage

Table: Grouting Injection Factor as per Rock Type

Example: For 15 to 20m stage, the middle depth shall be 17.5m. If the rock is slate with moderately weathered, the grouting injection factor is taken as 0.5.

So, Maximum pressure can be calculated as,

Pmax= 0.5×17.5= 8.75 bar

The design of grouting is based on the statistical data. The data is analyzed well to fix the pressure and volume of the grout. An experienced grout expert can determine all the parameters of grouting. Point to be noted "if high water takes during water pressure test, low take in high pressure during grouting, means grout is either thick or fineness of cement is not favorable".
After completing the grout test, check holes need to be done to see the performance of the grouting. Lugeon value less than 1 is best result for the tight permeability.

THE STEPS OF GROUTING HOLE AREA:

Drill the hole as per stage/order specified by designer. For ascending method, drilling of borehole is completed up to the final bottom. For descending method, drilling up to first stage of the hole needs to be completed.
Flush the hole. Flushing the borehole helps to clean the sludge, fragments during drilling and makes the fissures uncoated by drilling slurry.
Install the packer where it is needed.
Check mix, pump and monitoring devices.
Take samples for in-situ testing such as bleeding, viscosity, temperature etc.
Start the grout inside the hole.
Check the monitor for pressure and volume and control by control valves.
After completing the grout in one stage, move the packer for next stage.
After completing total length, hole is backfilled with thick grout.

Rock Type	Grouting Injection Factor (bar/m)
Sound	0.7-1.0
Average	0.5
Weak	0.25-0.35

Throughout the process, bypass from the hole or communication of the hole should be checked. If the hole is blocked, reaming should be done by drill machine. If bypass is frequent due to collapsing, it is plucked and a new hole should be drilled alongside the blocked hole. If each stage reaches Vmax, the grouting of that hole should be suspended and re-grouted after 6 hours because grout cement will have sufficient time to set.

GENERATION OF HOLES:

In a thumb rule, the depth of the hole for curtain should be at least two third of the dam height. Some experienced designers are convinced in half of the dam height if the rock condition is good i.e. if the permeability test result is satisfactory.

The primary hole depth $P_D = 2/3$ H

Where D- Depth of drill hole

H- Dam height

Generally, the designer designs secondary and tertiary holes in between primary holes. So, the primary, secondary and tertiary holes are known as systematic holes. This procedure of locating holes between two primary holes is called split spacing method. The depth of the secondary and tertiary holes should be of same as primary holes. But some designers agree with 0.7 length of primary for secondary hole ($S=0.7P_D$) and 0.4 length of primary for tertiary hole ($T=0.4P_D$). If there is high take in tertiary, generation of new hole is occurred between tertiary holes.

Tertiary holes again generate quaternary, quinary, senary, septenary, octonary etc. If grout take reaches 30-50 liter per meter it generates new hole. The rule to decide the location of newly generated holes follows the split spacing method. After tertiary holes, some designers place generated holes in new alignment at the upstream at a distance of 0.5 to 1.0 m. The depth of generated holes should be deeper (at least 5m) than the stage of maximum takes. For e.g. if quaternary hole is 10m deep and high take is between 5-10m stage, then the generated quinary hole should be 15m deep, that is 5m deeper than quaternary hole. If high grout take is at 0-5m stage in senary, then septenary should be 10m deep.

HYDRO-JACKING AND HYDRO-FRACTURING:

Hydro-jacking is the phenomenon which widens the pre-existing joints by applying excessive pressure. Development of new joint due to high pressure is called hydro-fracturing. Both phenomenons are induced by applying high pressure in the fracture. In both conditions, the grout take is high. During the design phase, the designer performs hydro-fracture test to have an idea about the limit of high pressure to avoid such conditions. If crossing designed pressure, rock exhibits hydro-fracturing which develops new cracks, takes unnecessarily high grout and instabilize the rock condition.

ROLE OF SCIENCE, TECHNOLOGY AND ENGINEERING IN NATIONAL DEVELOPMENT

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ABSTRACT

One of biggest challenge for least developed nation like Nepal is the brain-drain issue. Science, Technology and Engineering are the pillar of development of nation. As we know technology and engineering are the root discipline of science. It is said that 'Development and Destruction are the part of Modernization and Industrialization''. But the destruction can be prevented within footstep of the development via science, technology and engineering. They divide the countries into underdeveloped, developing and developed. Engineering and the development of new technologies are closely tied to science. Science is the knowledge of law, fact and truth to understand the natural world. Engineering acquire and apply scientific knowledge to build, design, and create something that meet society needs that works are majorly concern with the urbanization, communication, transportation and modernization. Technology is the sum of product and processes of all the engineered tool and devices available which are majorly concerned with computer, informational technology, medical and food technology. Science refers to the knowledge of the cause of natural process. Using reason and logic, and other philosophic principles, science examine apparent phenomena and rationalizes a physically consistent explanation. In general world science is used to refer to the collective body of the knowledge as well as process used to establish it. Moreover, science yield natural rather than supernatural explanation for events. Engineering is the process of developing device that accomplish some useful task for humankind. Whereas technology refers to these tool that accomplish a useful task for humankind. The advancement of technology has provided gadget in hand of every people, which have provided communication facilities and entertainment that makes life easier and convenient. Development of nation is said positive impact of country in the scientific, cultural, social, economic and political aspect. Natural resources and human resources are key strategies of fundamental development.

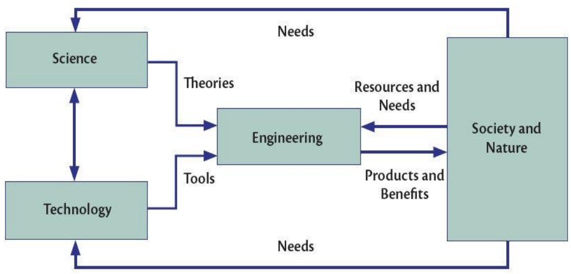
Key Words: Science, Technology, Engineering, Research, government policy, strategies, national development

BACKGROUND

Science has no single origin. Rather, scientific methods emerged gradually over the courses of thousands of years, taking different forms around the world and few details are known about the very earliest development. Modern science is typically divided into Natural science (e.g. physics, chemistry, biology, geology, astronomy) which study the physical world; the Social science (e.g. economics, psychology and sociology) which study individual and societies, and the formal science (logic, mathematics, information and computer science) which study the formal system governed by axioms and rules. Applied sciences are discipline that uses scientific knowledge for practical purpose, such as in engineering, technology, agriculture and medicine sector. Moreover, science can be divided as Physical science (universe, astronomy, mathematics, matter, and computer), Life science or Biological science (botany, zoology, genetics, human biology, nutrition and medicine), Earth science (geology, paleontology, meteorology, oceanography).

In general idiom the term technology refers to the machine and other scientific invention of Human being. In broader sense, it is a pool of technical knowledge, including the scientific discoveries, engineering innovation or knowledge of industrial art or production concept. Broadly technology is applicable of both in terms of ideas and instrument for any type of human activity. It is not useful or applicable for engineering or natural science based endeavors but also for social science and economics. Measurement of technology in economics development simply refers to calculate how much country's growth rate are driven by technology. Engineering is highly diverse sector comprised of various discipline of science and technology. It is the art of applying scientific, mathematical and physical principle, experience, judgement and common sense to construct and design things a specific need and benefit people. There are various type of engineering work such as agriculture, aerospace, civil, mechanical, chemical, electrical nuclear, oceanic, mining, environmental based on physical and natural aspect of science.

RELATIONSHIP AMONG SCI, TECH AND ENGG.



The approach of science, technology and engineering brought progress not only in the entire world. Its development determines to a large extent the socio-economic progress of a country. It is a well-known fact that is directly associated with the modernity and is essential tool for rapid development and progress of a country. A nation development and prosperity is judged to large extent by the status of science and technology. Science and technology hold the key progress and development of any nation. Without proper implementation of science and technology, no nation could grow and all those nations that were labeled as low in growth and have proven where they stand today and all that happened because of the science and technology. The changes induced by science and technology have for the most part benefited mankind although there is many cases where science and technology based on engineering innovation have been used for the detriment of mankind, perused for either and power or both.

Most developed countries have generated new technologies with potential to result a dynamic economic performance. Researcher, as creator of new knowledge must focus on their work on nationality and globally important and competitive areas of research which are multidisciplinary in nature. This means that the result of research must be goal and result oriented, tangible and significant. The technological revolution of 21st century are emerging from new sector, based on micro-processor, bio- technology and Nano technology. To promote the technological advances developing countries should in quality education for youth, continuous skill training for worker and manager and should ensure that the knowledge is shared as widely as possible across society.

No economy in the world can achieve the desired level of growth without support of up to date technical knowledge. When we are talking about the role of technical knowledge in economic development, we are certainly pointing to the technical knowledge that help the entrepreneurs to produce output by utilising the desired level of factor as well as non-factor input. With the given factor of input as entrepreneurs to produce more output if he possess up to date technology. Implying besides other factor more the use of modern technology in the production process. Technology by itself is not harmful to society, but the way society uses technology to achieve specific goal is what result into the negative impact of the technology of the society. Technology has improved transportation as road transport by automobile, air transport by airplane, water transport by ships and speedboats and space transport by rocket spacecraft and satellite. With the development of web technology, the information can be organized in a organized manner and relevant information can be retrieved on supplying search engines. Information technology has proved the digitalization and communication. Technology has improved education and the learning process.

Science contribute new knowledge which serves as a direct source of idea for new technological possibilities. The sources of tools and technique for more efficient engineering design and knowledge base for evaluation of feasibility of design. Research instrumentation, laboratory technique and analytical method used in research as a sources used in design or industrial practice. Practice of research as a source of development and assimilation of new human skill and capability. Creation of knowledge base that become assessment of engineering technology in term of social and environment. Hence the knowledge base that enables more efficient strategies of applied research, development and refinement of new technology for development of nation. It is well known that nation progress is highly correlated to the capacity of country to produce local industrial goods for domestic needs and that industrialization is very much dependent on the country to use science and engineering technology to progress locally found raw material into high tech product and tools for household and other users.

Sometimes Science and Engineering technology being as Curse rather Bless, a switch can destroy the whole world, in invention warhead, nuclear and atomic weapons, space warship thus putting all the world at ruinous peril. We had seen the devastation and destruction caused by atomic bomb in Hiroshima, Japan and now there are more scientific more accurate warheads available that can destroy the whole world within an hour. The invention of chemical and biological weapons has also jeopardized whole civilization that may put the humanity in danger of incurable diseases. The fast development in science and technology has put the balance of nature in great danger. The present day air, water, noise, soil pollution, the gradual global warming has put the existence of the world at stake. With the rapid industrialisation particularly in developed countries has resulted into imbalance in ratio of carbon dioxide and oxygen in the environment.

DISCUSSION AND CONCLUSION

Hence science, technology and engineering use mathematics to analyze data, develop logical, causal and deductive reasoning to solve problems, draw conclusion and establishing causal and logical connection. In today’s world, more often we get to read or listen that developed countries, developing countries, underdeveloped countries or even third world countries. Undoubtedly Science and technology has given the man, much luxury, comfort, material prosperity, but wealth and property is not the be all and end all of the human life.

Our country has ample opportunities in water and natural resources, So Nepal should move ahead in the research of forest, mineral, groundwater, herbal medicine and biodiversity. We are too back in development of nuclear technology, defence technology, development of satellite, biotechnology, nanotechnology, wireless communication. The problem which have the potential to become major bottlenecks to overall growth of the country. Moreover, the impact of science and technology on modern society ranges influence in areas as politics, diplomacy, defence, economy and social capital improvement and many more. The various scientific research, innovation must performed to motivate young scientist, researcher of our country. The majority of the student of science and technology in Nepal, scientist, researchers and professional engineers are willing to go abroad either for better higher education or for better living standard and job opportunities. This suggest that brain drains is individual feature in least developed country like Nepal and government should formulate better policy and create an exclusive department to emphasize on development of science, technology and engineering and a separate budget should allocated for brain pull considering all consequences that can hamper economic growth of country.

स्वच्छ उर्जा, जलवायु परिवर्तन, आर्थिक सम्वृद्दि र आधुनिकरणको छोटो बाटो

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हिमालय पर्वत श्रृंखला को लम्बाइ सरदर २४०० कि.मी. रहेको छ। पूर्वमा नाम्चे बर्वा देखी पश्चिममा नागा पर्वत सम्म यसको फैलावट रहेको छ। भौगर्भिक समयानुसार करिब १५० मिलियन वर्ष अगाडि गोण्डवाना ल्यान्ड जो अफ्रिका महादेशमा समाहित थियो, सो बाट भारतीय उपमहादेश टेक्टोनिक एक्टिभिटी को कारणले सुरुवाती ८० मिलियन वर्ष ४० मि.मि. प्रति वर्ष को गतिमा उत्तर पूर्व सर्दै गयो भने आखिरको ३० मिलियन वर्षमा १५० मि.मि. प्रति वर्ष को गतिमा चलायमान भयो र करिव ५० मिलियन वर्ष अगाडि सो भारतीय उपमहादेश तिब्बत (युरेसिया) सँग ठोकिन पुग्यो र हिमालय पर्वतमाला को जन्म भयो। अहिले पनि करिव ५ से.मि. प्रति वर्ष को औसत गतिमा भारतीय उपमहाद्वीप युरेसिया सँग टकराव दिइरहेको छ। उता युरेसिया भने करिब २ से.मि. प्रति वर्षको गतिमा उत्तरतर्फ धकेलिइरहेको छ। भौगर्भिक अध्ययन अनुसार हिमालयको उचाइ क्रमिक रूपले बढिरहेको र साथ साथै हिमालयको क्षय पनि भइरहेको छ। हिमालयको उचाइ बढ्ने प्रक्रियाको गतिलाई " अपलिफ्ट रेट" भनिन्छ जसको औसत दर ०.४–४ मि.मि प्रति वर्ष रहेको छ भने क्षय हुने प्रक्रियाको गतिलाई " इरोजन रेट " भनिन्छ जसको औसत दर ०.१–३ मि.मि प्रति वर्ष रहेको छ। तर भौगर्भिक दृष्टिले हिमालय एकनासले सबै भागमा अपलिफ्ट र इरोजन हुने सम्भावना रहँदैन। हालको बढ्दो क्रमको जलवायु परिवर्तनले कुनै ठाउँमा इरोजन रेट बढेको पनि देखाएको छ। त्यसैले अपलिफ्ट र इरोजन रेटको औसत मात्रा हिमालयमा देखाउन अप्ठ्यारो अनि अस्वभाविक मानिन्छ ।

नेपाल हिमालयलाई भौगर्भिक तवरले ५ भागमा विभाजन गरिएको छ। पहिलो र सबैभन्दा उत्तरमा " तिब्बतीयन टेथिस जोन" छ। जहाँ पत्रे चट्टानहरू जस्तै चुन ढुंगा, सेल, स्यान्ड स्टोन पाइन्छन्। यो जोन (क्षेत्र) लाई अलग्याउने "थ्रस्ट जोन" हरू रहेका छन जसले हिमालयलाई टेक्टोनिक तवरले वर्गीकृत गरेका छन्। पहिलो तिब्बतियन टेथिस जोन लाई " साउथ तिब्बतियन डिट्याचमेन्ट सिस्टम "ले दोस्रो " हाईयर हिमालय जोन " सँग छुट्याएको छ। हायर हिमालयमा प्राय परावर्तित चट्टानहरू पाइन्छन् जस्तै नाइस, सिस्ट र ग्रेनाइट। यस भागलाई " मेन सेन्ट्रल थ्रस्ट जोन " ले तेस्रो " लेसर हिमालय" सँग छुट्याउँछ यस लेसर हिमालय जोनमा मेटासेडिमेन्ट्री चट्टान पाइन्छन् जस्तै मार्बल, फिलाइट, सिस्ट र क्वारजाइट। लेसर हिमालयलाई " मेन बाउन्ड्री थ्रस्ट जोन " ले चौथो " शिवालिक " सँग छुट्याउँछ। शिवालिकमा कंग्लोमेरेट, सेन्डस्टोन र मडस्टोन जस्ता चट्टान पाइन्छन्। " मेन फ्रन्टल थ्रस्ट जोन " ले शिवालिकलाई तराईको गिट्टी बालुवा पाइने फाँट सँग छुट्याउँछ।

नेपालको भौगर्भिक धरातल निकै उथल पुथल रहेको छ तर साथ - साथै सम्भावनाले भरिपूर्ण रहेको छ। पूर्व देखी पश्चिम सम्म ८६६ वटा नाम दिइएका हिमालहरू छन जस मध्ये २८ वटा हिमशृङखला र १८ वटा उप हिमशृङखला रहेका छन्। जस मध्ये ८ हजार मिटर भन्दा माथिका ८ वटा हिमाल रहेका छन्। नेपालका हिमालहरू बाट १०० भन्दा बढी नदिहरू १६० कि. मी भन्दा लामा तथा १००० भन्दा बढी नदि ११ कि. मी. भन्दा लामा बग्ने गरेका छन्। यी नदिहरू मध्ये सप्तकोसी, सप्तगण्डकी र सप्तकर्णाली प्रमुख नदि हुन।प्रचुरमात्रामा जलविद्युत सम्भावना बोकेका यी नदिहरूमा १ मेगावाट भन्दा ठूला १०७ वटा जलविद्युत सञ्चालनमा रहेका छन्। जसबाट १९२०.२७९ मेगावाट उत्पादन भइरहेको छ र ३६ वटा जलविद्युत अध्ययनको प्रक्रियामा रहेका छन् जस बाट ९२३० मेगावाट उत्पादन गर्न सकिनेछ। खानीको प्रचुरता जस्तै युरेनियम, सुन, काइनाईट, गार्नेट, सिसा तथा निर्माण सामग्री जस्तै गिट्टी बालुवा, चुनढुंगा, मार्वल, फलाम, तामा र पेट्रोलियम पदार्थ आदि भएको देश, जलविद्युतको असामान्य क्षमता भएको देशमा वर्तमान स्थिति जलवायु परिवर्तनको रहेको छ जसका मुख्य कारण उच्च्व तापमान वृद्धि, प्रदुषण र वनजंगल फडानी हुन्। हिमालहरू अनपेक्षित ढंगले पग्लिनु, अनावृष्टि र अतिवृष्टि हुनु जसका कारण कृषि प्रधान देशमा उत्पादन अनुकूलता घट्नु विभिन्न बालिजन्य रोग निम्तनु र प्राकृतिक तथा मानव सिर्जित विपद् जस्तै बाढी, पहिरो, आगलागी र महामारी का घटना वर्षे पिच्छे बढ्नु जलवायु परिवर्तनले नेपालमा गरेका प्रत्यक्ष असरहरू हुन। एक अध्ययनका अनुसार खुम्बु हिमनदीमा एभरेस्ट आधार शिविर

नजिक वार्षिक १.४ मिटर सम्म हिउँ पग्लिने गरेको छ र यस हिमनदीमा विभिन्न हिमतालहरू वर्षेनी बढ्दै गइरहेका छन् । जसका कारण ति हिमताल फुटेर हुनसक्ने जोखिम र हिम पहिरोको जोखिम जलवायु परिवर्तनले हो भनी नकार्न सकिदैन । वार्षिक ३० मिटर प्रति वर्ष सम्म हिमनदीहरू खुम्चिरहेका छन् र असामान्य तापक्रम वृद्धि ०.०६ डिग्री सेन्टिग्रेड यस हिमालय क्षेत्रलाई बढी प्रभावित गरिरहेका छन् । अनेक राजनीतिक कालखण्ड मा प्रवेश गरेर नेपाल अहिलेको लोकतान्त्रीक पद्धतिमा पुगेको छ । यस उपलब्धिलाई संस्थागत गर्न र स्वाभिमानी बन्न जलवायु परिवर्तनले चुनौति र अवसर दिएका छ । चुनौतीहरू पार लगाउदै अवसरहरू खोज्ने पद्धति अपनाउन जरुरी छ । अहिले विश्वभर स्वच्छ उर्जाको प्रयोग बढी रहेको छ । नेपाल जलविद्युत, सौर्य र वायु उर्जाको प्रचुरता भएको भाग्यमानी देश मानिन्छ । तुरुन्तै विद्युतीय ऊर्जाका कलकारखाना खोल्नका लागि अध्ययन गर्न जरुरी छ । अबको युग स्वच्छ ऊर्जामा जाने पक्का पक्की भई सकेको छ । विद्युतीय सवारी साधन निर्माण गर्न र उपयोग बढाउन तर्फ नेपाल सरकारको ध्यान केन्द्रित हुनु पर्ने देखिन्छ । हामीले उचित स्रोत साधन जुटाएर कलकारखाना स्थापित गर्न सके नेपालमा बेरोजगारीको समस्या हल गर्न टेवा पुग्ने, देश आत्मनिर्भरता तर्फ अगाडि बढ्ने र स्वच्छ उर्जाको प्रयोगले कार्वन नेगेटिभ देशको रुपमा उदय भई संसार सामु उदाहरण बन्न सकिनेछ । कुनै समयमा नेपाल बाहिरी संसार भन्दा ५० वर्ष पछि परे झै लाग्थ्यो अति कम विकसित देश माननीयको नेपाल यस युगमा सही कदम चाले आर्थिक क्रान्ति ल्याउन सक्ने देश हुनेछ । नेपाल सौर्य किरणको तवरले ३.६ देखी ६.२ किलो वाट आवर प्रति मिटर २ प्रति दिन सौर्य उर्जा पाउने गर्छ । त्यसैले सौर्य क्षमताका दृष्टिले पनि सम्भावना प्रबल रहेको देश नेपाल हो । आवश्यक अध्ययन गरी विद्युतीय र सौर्य ऊर्जालाई स्थायीकरण गर्दै देश लाई जलवायु परिवर्तनको चपेटा बाट हट्न मद्दत पुग्नेमा जो कोही विस्वस्त छन । नेपालको इतिहासमा पहिलो पटक काठमाडौँ र ढोरसिङ् जोड्ने रोपवे सन् १९२२ मा सुरु भएको थियो। र पछि कुल ४२ कि मि लम्बाइ सहित सन् १९६४ मा हेटौँडा सम्म बिस्तार भएको थियो। सन् १९७५ मा चिनियाँ सरकारको सहयोगमा काठमाडौं उपत्यकामा विद्युतीय ट्रलीबसहरू सञ्चालनमा आएका थिए । ट्रलीबसहरू सन् २००१ सम्म काठमाडौं र भक्तपुर बीचको १३ किलोमिटरको बाटो सफलतापूर्वक सञ्चालन गरेको थियो र व्यवस्थापन समस्याका कारण बन्द भएको थियो। पछि सन् २००३ मा आंशिक रूपमा फेरि खोलियो तर सन् २००८ मा फेरि बन्द भयो। त्यसैगरी सन् १९९५ मा स्थानीय रूपमा सफा टेम्पो भनेर चिनिने बिजुली तीन -पाङ्ग्रे गाडीहरू, पहिलो पटक युएसएआइडीको सहयोगमा सञ्चालनमा ल्याइएका थिए। आज, ७०० भन्दा बढी सफा टेम्पो सार्वजनिक रूपमा २८ विभिन्न रुटमा सार्वजनिक यातायातको माध्यमको रूपमा सञ्चालन छन्। सफा टेम्पो बाहेक, पछिल्ला वर्षहरूमा धेरै तीन पाङ्ग्रे रिक्साहरू पनि चलिरहेका छन्। नेपालका सडकहरू, विशेष गरी तराईका भूभागमा अवस्थित सहरहरूमा यी रिक्साहरू सञ्चालनमा रहेका छन्। यि मध्ये केही ई- रिक्सा नेपालमा एसेम्बल गरिन्छ भने अरु भारत वा चीनबाट आयात गरिन्छ। नेपालको १५ औं पञ्चवर्षीय योजनामा पेट्रोलियम आयात घटाउनु, चार्जिङ स्टेसनहरू स्थापना गर्ने र बिजुलीको पहुँच र उपयोग बढाउन अध्ययन गरिने कुरा लेखिएका छन्। वातावरणमैत्री सवारी साधन तथा यातायात नीतिले सन् २०२० सम्ममा विद्युतीय सवारी साधनको हिस्सा २० प्रतिशतमा पुऱ्याउने, यातायात क्षेत्रबाट हुने वायु प्रदूषण कम गर्ने जस्ता लक्ष्य राखेको छ। नेपालको राष्ट्रिय रुपमा निर्धारित योगदानहरूमा सन् २०२० सम्ममा २०% ईभी (विद्युतीय सवारी साधन) वृद्धि हुने उल्लेख गरेको छ भने वातावरणमैत्री सवारी साधन तथा यातायात नीतिले सन् २०२० सम्ममा २०% ईभीको लक्ष्य राखे पनि पुरा भएको देखिदैन। नेपालको विकासको ढोका विद्युतीय सवारी साधन र उपकरणका कलकारखानाले खोल्न सक्छ। जलविद्युतमा भइरहेको विकास र उर्जा खपत बढाउनका साथै पेट्रोलियम पदार्थ ले निम्त्याएको ब्यापार घाटा लाई न्यूनिकरण गर्न पनि कलकारखानाले महत्वपूर्ण योगदान गर्ने छ। भौगर्भिक दृष्टिले खाइलाग्दो यो देशलाई विकासको नयाँ उचाइमा पुर्याउन विद्युतीय, सौर्य र वायु जस्ता स्वच्छ उर्जा सम्बन्धित नीतिहरूलाई गहन अध्ययन गरि खुकुलो र आकर्षक बनाउँदै विदेशी लगानी भित्र्याउनु र स्वदेशी लगानी प्रबर्द्धन गर्न जरुरी छ ।

REVIEW ARTICLES

A REVIEW OF ARSENIC CONTAMINATION IN GROUNDWATER OF NEPAL AND ITS HEALTH EFFECTS

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ABSTRACT

In present times, arsenic contamination has emerged as a major health and environmental issue in Nepal, especially in the districts of the Terai region. The households in the area are primarily dependent on groundwater for drinking and other purposes. Various studies have shown that a large number of the population has been using water with arsenic concentration >10 µg/L and even higher than 50 µg/L in some areas, which exceed the permissible limit set by the World Health Organization (WHO) as well as the country. This paper reviews the status of arsenic in groundwater and recommends proper measures to be adopted in mitigating the effects of its contamination on human health.

Key Words: *Arsenic, Groundwater, Contamination, Mitigation*

INTRODUCTION

Arsenic is a versatile element with an atomic number 33 and atomic mass of 74.916, which lies in Group VA of the periodic table. It is widely distributed in nature, ranking 20^{th} in natural abundance and 12^{th} in the human body (Mandal & Suzuki, 2002). Arsenic occurs in three forms: organic, inorganic and arsine gas, with two oxidation states, viz. trivalent and pentavalent of inorganic arsenic. Inorganic arsenic is found to be more toxic than organic arsenic (WHO, 2000).

Arsenic is found naturally in rocks and soil, with the primary source being volcanic activity. It appears primarily in the form of sulfides in association with the sulfide ores of minerals. Most rocks contain 1-5 ppm of arsenic and trace amounts can also be found in soils and other elemental media (WHO, 2000). However, major sources of arsenic contamination in air and water are anthropogenic sources that include activities like petroleum refining, use of wood preservatives, leather tanning operations, industrial smelting, and agricultural use of herbicides and pesticides (Shakoor et al., 2015). According to new research, the alluvial sediments that are deposited by rivers chained from the Himalayas are the major source of arsenic in groundwater in the Terai region of Nepal (Shrestha, 2012).

Since ancient times, arsenic has been considered a plant and animal poison, and it has been linked to a variety of health complications and death in large doses. Arsenic and its compounds are regarded as carcinogenic to humans by the International Agency for Research on Cancer (IARC). WHO has set the limit of arsenic in drinking water to 10µg/L in its 'Guidelines for drinking-water quality'. But this standard is currently not feasible in the context of Nepal, which has set its limit at 50µg/L. The particular reason for this circumstance is the lack of knowledge, implementation, economic consideration, and technical unavailability (Thakur et al., 2010).

Currently, arsenic contamination has become a critical issue worldwide, especially in Southeast Asia. Higher concentrations of arsenic in drinking water have been reported in several countries including Argentina, Chile, Bangladesh, China, Japan, India, Mongolia, Nepal, the USA, etc. (Thakur et al., 2010). The problem in Nepal is reported to be limited to the Terai region where 29% of tube wells have arsenic concentrations exceeding the WHO standard, with approximately 0.5 million people at risk of consuming water with >50µg/L arsenic concentration (Shrestha, 2012).

TESTING METHODS OF ARSENIC

Field-based and laboratory-based analytical methods are used to measure arsenic concentrations in samples. Arsine gas is formed when any metal arsenide reacts with strong acids. Arsenic kits are used in field-based methods that use bromide (HgBr2) indication paper to detect the presence of arsine gas. Most arsenic test kits rely on the reduction of inorganic arsenic to arsine gas (AsH3) using zinc metal and hydrochloric acid. The arsenic kits available in Nepal are AAN Kit (Japan), E-Merck Kit (Germany), NIPSOM Kit (Bangladesh), AIIHPH Kit (India), ENPHO Kit (Nepal), Modified AAN Kit (Nepal), Hach EZ (USA), Wagtech Arsenator (UK).

Analytical laboratory methods work more or less based on the same principles. The sample is simply acidified and sprayed into argon plasma. The high temperature of the plasma atomizes and ionizes all forms of arsenic. Atomic absorption spectrometry (AAS), Inductively coupled plasma (ICP-AES) and (ICP-MS), Atomic fluorescence spectrometry (AFS) Anodic stripping voltammetry (ASV) and Spectrophotometry are some of the methods used for arsenic testing. AAS-HG is the most commonly used technique in Nepali laboratories and is based on the atomic absorption measurement of arsenic generated by the thermal decomposition of arsenic (3+) hydride. Alternately the, silver diethyldithiocarbamate spectrometric method (SDDC) and spectrophotometry have also been used (Panthi, 2006).

PREVALENCE IN NEPAL

Arsenic contamination in Nepal has not been observed in the hilly and mountainous regions but is an emerging concern in the Terai region, where approximately 47% of the country's population resides and 90% of them are dependent on groundwater. Studies conducted by several individuals and organizations in 25 districts (Figure 1) reported concentrations of arsenic in groundwater in the range of 10-50µg/L with few samples having >50µg/L arsenic concentrations (Thakur et al., 2010).

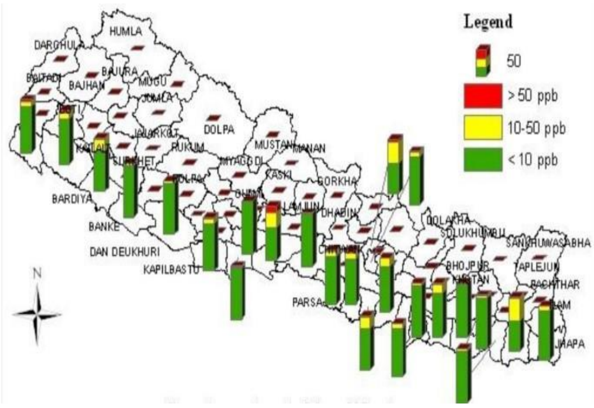

Figure 1: Groundwater arsenic map of Nepal showing proportion of arsenic contaminated samples found in various districts of Nepal (from Thakur et al., 2010)

High concentrations of arsenic in groundwater have been reported from south-western and south-eastern districts, which share border with India Districts like Saptari, Sunsari, Siraha, Sarlahi, Rautahat, Bara, Nawalparasi, Rupandehi, Kapilbastu, Banke, Kailali, and Kanchanpur have become major concerns in recent times. These districts have reported arsenic concentration larger than 50µg/L (Shrestha, 2012). 69% of the tube wells have arsenic concentrations of less than 10g/L, 31% have concentrations greater than 10 g/L and 8% have concentrations greater than 50g/L A population of 2.29 million is expected to rely on water containing 10-50 g/L arsenic and 0.37 million on water containing more than 50g/L arsenic. Minimum concentrations have been reported from Ilam, Palpa and Chitwan districts with maximum concentrations obtained in the range of 10-50µg/L (Kohnhorst, 2005).

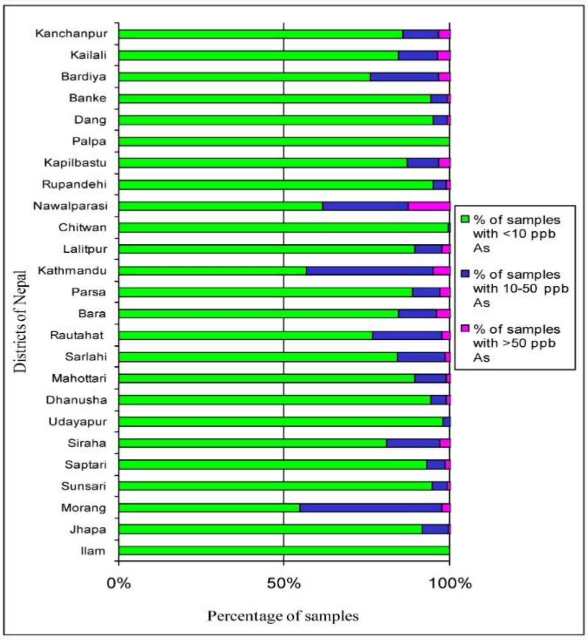

Figure 2: Percentage of arsenic contaminated samples in various districts of Nepal (from Thakur et al., 2010)

Nawalparasi is the most affected district in terms of arsenic contamination, with arsenic concentrations measured higher than 50µg/L. Ramgram Municipality and Panchnagar VDC of Nawalparasi have been identified as highly affected, showing >50µg/L of arsenic in about 63% of the tube wells (Panthi et al., 2006). Arsenic concentrations in two rural villages of Nawalparasi district, Goini and Thulo Kunwar, were reported to be in the range of 104-1702 g/L and 4-972 g/L, respectively, in a detailed study. (Ahmad et al., 2004). Morang district has reported 10-50µg/L and >50µg/L arsenic concentration in46% and 2% of the tested samples, respectively. Jhapa and Udaypur have reported arsenic concentration in the range of 10-50µg/L (Thakur et al., 2010).

To summarize findings from various studies, a concentration of arsenic concentration lower than 10µg/L is reported in 89.8% of the samples of groundwater and 10-50µg/L and >50µg/L in 7.9% and 2.3% of the groundwater samples respectively (Thakur et al., 2010). The summary of district wise arsenic concentration is presented in a bar graph (Figure 2), and the total concentration in Nepal is presented in a pie chart (Figure 3).

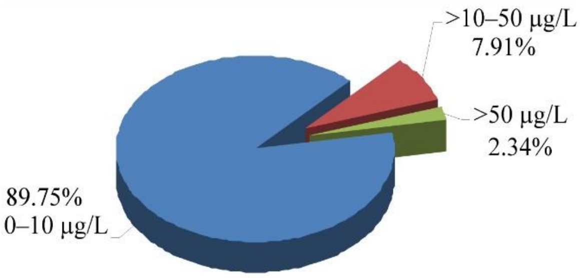

Figure 3: Overall arsenic concentration in the groundwater of Nepal Overall arsenic concentration in the groundwater of Nepal (from Thakur et al., 2010)

HEALTH EFFECTS OF ARSENIC

The primary source to exposure of arsenic in the human body is ingestion, which occurs through the digestion of contaminated food and water. Other means of exposure are inhalation and dermal exposure. Acute arsenic poisoning shows immediate symptoms like vomiting, abdominal pain, and diarrhea which is then followed by numbness, tingling of extremities, and death in extreme cases. The long-term effects of arsenic are developed after exposure for more than 5 years showing symptoms like pigmentation changes, skin lesions, and hard patches on the palms and soles of the feet (hyperkeratosis). Adverse effects of arsenic exposure include skin, bladder, and lung cancer, as well as developmental effects, diabetes, pulmonary disease and cardiovascular diseases.

National studies on the health effects of arsenic contamination have yet to be conducted in Nepal. So far, studies have been conducted in 3 districts; Nawalparasi, Bara and Parsa by the Department of Water Supply and Sewerage (DWSS) and Nepal Red Cross Society (NRCS). The studies reported that the individuals exposed to higher levels of arsenic contamination showed the presence of arsenic-related dermatosis (skin disease) in 1.3 to 5% of the population (Shrestha, 2012). Symptoms of the early stages of arsenic poisoning (melanosis) and mild stage of arsenic poisoning (keratosis) were observed in the palms, trunks and soles of the feet of the patients. The study of Goini and Thulo Kunwar villages of Nawalparasi district by Ahmed et al. revealed melanosis in 95.6% and keratosis in 57.8% of the patients. 3.3% of the village population showed symptoms of leucomelanosis (black and white spots on the back of the legs and trunk). The patients were seen to be affected by bronchititis, gastroenterotitis, peripheral neuropathy, gangrene of limbs, precancerous skin lesions, and cancer (Ahmed et al., 2010). A detailed analysis of the severity of effects of arsenic on health

needs to be done in all the affected areas to estimate the condition of the individuals.

MITIGATION MEASURES

Prevention of further exposure is the most important action to be taken in the affected areas. WHO has recommended numerous options to reduce levels of arsenic in drinking water:

Substitution of high arsenic sources like groundwater with low arsenic sources like rainwater and treated surface water

Identification and differentiation of low and high arsenic sources, such as painting high-arsenic content tube wells red and low-arsenic content tube wells green

Dilution of high-arsenic water with low arsenic water

Installation of arsenic removal systems using technologies of oxidation, coagulation, precipitation, adsorption, filtration, ion exchange, and membrane techniques.

The most common prevention measures used in Nepal are the use of alternate sources of water mainly by rainwater harvesting, filtering of contaminated water by 3-kalasi filter, and prevention of contamination through the implementation of an efficient waste disposal system (Shrestha, 2012). However, detailed studies and effective prevention and mitigation measures as well as communication strategies to develop public awareness of the dangers and practical mitigation technologies for individuals need to be implemented by the government bodies for effective prevention of arsenic related problems in the country.

CONCLUSION AND RECOMMENDATION

Groundwater has always been the primary source of water in the Terai region. The presence of arsenic in groundwater in concentrations of 10-50µg/L and >50µg/L has proven to be a serious issue that is only increasing in the present times. A large number of the population has been affected by serious health issues caused by exposure of arsenic in their bodies. Districts especially located around the Indian border, have reported a serious issue of arsenic contamination. However, proper planning of prevention, mitigation and awareness are yet to be done to tackle the rising issue by the government of Nepal.

This actively demonstrates that actions need to be taken at the policy level to assess the scale and emergency level of arsenic contamination at the national level. Following the identification of the contamination, proper measures to safeguard the health of the exposed population must be implemented by both the government and private authorities. The magnitude of the issue is bound to grow in the future if proper measures are not taken in the present. Accordingly, the involvement of international agencies and participation of the government, as well as private and industrial sectors to address the problems, is of utmost urgency for the purpose of saving millions of lives in the country.

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AN OVERVIEW TO MAPPING OF LESSER HIMALAYAN AUGEN GNEISS ALONG KHIMTI- DOLAKHA AREA, TO UNDERSTAND ITS NATURE AND FIELD RELATION.

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ABSTRACT

The geological mapping carried out along the Khimti- Dolakha area identifies four lithological unit that implies for the lithostratigraphy given by Schelling (1992) as Ramechhap Group, Dolakha Phyllite, Melung-Salleri Augen Gneiss and Khare Phyllite from bottom to top. Drainage pattern in the study area is characteristics of lithology and exhibit two patterns i.e. trellis and dendritic pattern. The Melung-Salleri Augen Gneiss shows wide distribution throughout the study area and separate sharp and irregular contacts having both concordant and discordant field relation. The augen structure and S-type ptygmatic fold of quartz veins in gneiss shows top to the southwest sense of movement. Also, the gneissic bodies are characterized by banded variety and resemble biotite grade of metamorphism. The overall metamorphism of the study area increases towards the northeast. The Khare Phyllite succession comprise abundant gray schists with various interbeds of quartzite and carbonates. The major structure is an open synform The synform forms within flanks of Melung-Salleri Augen Gneiss whose core lies in overlying Khare Phyllite.

Key Words: *Melung-Salleri Augen Gneiss, Drainage pattern, Field relation, Synform, Metamorphism.*

INTRODUCTION

The Himalaya is the young, active and fragile mountain range, formed by the intense continental collision, large scale thrusting and folding, polyphase metamorphism and magmatic intrusion (Gansser, 1964; Valdiya, 1998). Tectonically, the Nepal Himalaya is subdivided into five major tectonic zone namely the Indo-Gangetic Plain, the Siwalik, the Lesser Himalaya, the Higher Himalaya and the Tibetan-Tethys Himalaya from south to north (Fuchs & Frank, 1970; Gehrels et al., 2003; Stöcklin, 1980; Upreti & Le Fort, 1999).

This study focuses on the Lesser Himalayan rock sequence predominantly exposed within Okhaldunga Window (Lombard, 1953, 1958 ; Hagen,1959) in East Nepal. The study area lies in within Dolakha and Ramechhap District of Bagmati Province covering an area of nearly 450 sq.km. The area is easily accessible through motorable road. The study area is characterized by wide occurrence of augen gneisses bodies (Ishida & Ohta 1973; Schelling & Arita 1991; Schelling 1992) as around Khimti–Mainapokhari area which has been correlated with Melung-Salleri Augen gneisses (Schelling, 1992). Several authors have reported Melung-Salleri Gneiss to be equivalent of Ulleri Augen Gneiss at the base of MCT footwall which is interpreted to be of volcano-sedimentary origin (Pecher & Le Fort, 1977; Schelling, 1987). From the various radiometric dating conducted by different researchers in past, they found that magmatic age of Ulleri Augen Gneiss is the equivalent to the Precambrian depositional age of Kuncha Formation i.e 1.74 Ga (Kohn, Paul, & Corrie, 2010).

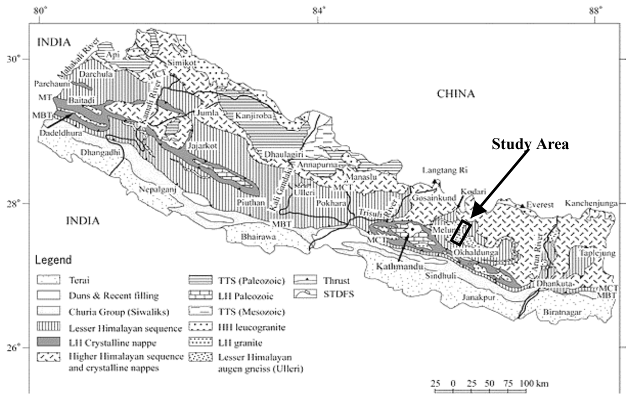

Figure. 1: Geological map of Nepal (Upreti and Le Fort, 1999)

Earlier works by the Ishida (1969) around Tamakoshi- Dudhkoshi region has outlined the basic lithological framework of the study area. Initial works of Ishida (1969); Ishida & Ohta (1973) has subdivided the study area into several formations assigned to the Midland metasediment group. Later, Schelling (1992) reported corresponding litho-units as described by Ishida and Ohta (1973). Likewise, Dhital (2015) works around Namdu-Gairimudi area has distinguish the different lithological units along with augen gneiss defined as 'Maina Pokhari Gneiss' which is equivalent to Melung Formation (Ishida, 1969). Besides, there have been various works carried out to characterize petrography, occurrence and structure of the area in the past (Schelling, 1987, 1992; Regmi & Arita, 2008; Dhital, 2015). but, present approach of study is concerned with the, 'Geological Mapping along Khimti-Maina Pokhari Area and its cross-section', to understand the basic lithology, structure, drainage pattern in different litho-unit, field relation of gneiss bodies with country rocks and metamorphism of the surrounding area.

METHODOLOGY

Topographical map (Topo-Sheet No. 2786 05A, 2786 05B, 2786 05C, 2786 05D, 2786 09 A and 2786 09 B), geological maps, various research articles, journals, books and thesis were reviewed during desk study to conduct the field work and data collections. Likewise, LANDSAT-9 OLI, satellite images were used to understand and delineate lithology contrast, linear feature or breakage along study area through surface raster analysis tool (Hill shades, Slopes, Aspect and Curvature) using ArcMap 10.8. During field work, Google Earth aided the route selection while Field Move app was used to locate GPS location and measure attitude of beds/foliation. However, geological equipment like Brunton compass, geological hammer, chisel, measuring scale, dil.HCL, diary, marker, sampling bags and mobile camera were widely adapted in field work. Also, Dips 6.0 was used to demarcate the axial trace, trend and plunge of major fold axis reported (Figure.2).

DRAINAGE

Tamakoshi River is the major river of the area flowing from north to south. Khimti Khola, Gopi Khola, Khani Khola, Dholi Khola are other important tributaries.

Generally, drainage pattern is formed due to stream erosion in geologic time which is characteristics of its lithology, structure and topography. In the present study area, drainage patterns vary with lithological variation within schist-gneiss terrain and phyllite terrain. Two distinguishable drainage patterns can be interpreted from the map (Figure. 3). Among them, one is recognizable within Augen Gneiss (Figure.3) with bands of mica schists interbedded at places resembling swift alteration of hard resistant rock and least resistant rock to results in trellis pattern. Likewise, dendritic pattern is resembled at NE portion of map (Figure.3) by tributaries of Gopi Khola, Khani Khola such that the area lies within the reach of homogenous lithology of dominant schist and a synform axis passing through nearby Gopi Khola. Besides, dendritic pattern has also been developed within phyllite and metasandstone on the SE part and within Augen gneiss at NW part of the study area.

GEOLOGICAL SETTING

The study area extending from Charikot in the west, Khawa in the east, Maina Pokhari in the north and Khimti bazar in the south lies within the west portion of the Okhaldunga Window, East Nepal (Lombard, 1953, 1958 ; Hagen,1959) belonging to Midland Metasediment Group (Ishida & Ohta, 1973) of Lesser Himalayan Series. There are four lithological unit mapped in the area each separated by the augen gneiss. Ishida (1969) and Ishida & Ohta (1973) have demarcate augen gneiss unit within two thrust namely, Jiri Thrust to the north and Midland Thrust to the south. However, this present study deals with mapping of lithological unit of Khimti-Mainapokhari area that builds upon the previous lithostratigraphy given by Schelling (1992) for Eastern Nepal. The lithostratigraphic correlation is shown in Table1. The geological map is shown in Figure. 3.

Ramechhap Group

The Ramechhap Group (Schelling, 1987, 1992) within study area form the southern most lithological unit. The rocks of this group surrouding Khimti area consists of thinly foliated, green-grey pelitic phyllite interbedded with medium to thick beds of fine to medium grained, grey metasandstone. Elongated, stretched quartz veins are evident for deformation. The strata dips homogenously towards northeast between 40º to 55º, with strike varying from N55ºW to N85ºW.

The thickness of this succession along Tamakoshi exceeds 2000m extending southward to Sun Kosi Fault (Schelling, 1987) from overlying Melung-Salleri Augen Gneiss at or near the confluence of Tama Koshi and Khimti Khola forming northern upper boundary. The Ramechhap Group (Schelling, 1987) has been correlated with Okhaldunga Formation (Ishida, 1969) and Kuncha Formation (Stöcklin, 1980)

Melung- Salleri Augen Gneiss

The Melung-Salleri Augen Gneiss (Schelling,1992) covers the wide part of the map area (Figure 3). It overlies Ramechhap Group to the south with a sharp lithological contact (Figure 4a) and topographic break at around confluence of Tama Koshi and Khimti Khola and is overlain by Khare Phyllite to the northeast.

Foliated, stretched and banded variety of mica gneiss with characteristics augen structure (Figure 4b) resemble this unit. The composition of augen is mainly K-feldspar but sometimes as rounded quartz ball with matrix of quartz, feldspar and mica. The size of augen reach up to 8 cm. The augen structure are rotated while quartz veins are folded into S-Z type due to ductile deformation. The augen size decreases away from the contact and deficits at places being exposed as banded gneiss. The gneiss exhibit strongly lineated mica minerals and augen structure.

Also, gneiss exhibits dominant schistosity interbedded with chlorite-biotite, grey schists. Massive beds of banded gneiss interbedded with schist and quartzite are evident from northeast elongation. Moreover, small euhedral-hexagonal crystals of quartz (0.2 to 2 cm) have been reported from banded gneiss or migmatite that show intense ductile deformation (Figure.4c)

The main foliation is a like parallel to foliation of underlying Ramechhap Group rocks and overlying Khare Phyllites. The strata dips gently between 9º to 35º and forms a flank for synform with overlying Khare Phyllite as core, around Maina Pokhari-Bhirkot area. The synform is a gentle east plunging open fold with E-W trending axial trace. Dips 6.0 plot of synform interpreted the trend to be 91° and plunge to be 5° which is shown in Figure 2. This synform is equivalent to Nayapul- Mirge synform (Ishida, 1969; Ishida and Ohta, 1973). The Melung-Salleri Augen Gneiss (Schelling, 1987, 1992) has been correlated with Melung Formation (Ishida, 1969) and Ulleri Augen Gneiss (Pecher and Le Fort, 1977).

Khare Phyllite

The Khare Phyllite (Schelling, 1987, 1992) has been mapped in the northeast, east and central portion of the study area (Figure 2). It overlies Melung-Salleri Gneiss around Hawa, Gairimudi, Mirge area forming a core of synform.

Dark gray to gray chlorite-biotite-garnet pelitic schists with intercalated bands of parallel laminated pale-yellow quartzite (Figure. 4e) and/or white calcareous rocks is prominent characteristics of the unit. Lamination in quartzite is parallel to dip of the bedding. A small band of continuous black graphitic schist is evident at around Khawa and south of it. This graphitic schist band attains to be a marker horizon and correlates equivalent to Jiri Formation (Ishida, 1969; Ishida and Ohta, 1973). There are prominent deformed, squeezed, lenticular thick quartz veins and prominent minor folds within the unit. The strata gently dip between 8° to 20° forming a core of a synform within schist while dips inclined between 60° to 70° for quartzite and calcareous rocks at southern end of the unit.

Moreover, east of Khawa dada, the high grade metamorphic mineral; staurolite has been reported within medium beds of fine-medium grained grey schists.

Dolakha Phyllite

The Dolakha Phyllite (Schelling, 1987, 1992) forms the northern most lithological unit mapped in present study. It is overlain by Melung-Salleri Augen Gneiss to the south. It comprises of light grey to green-grey pelitic and psammitic phyllite. The pelitic phyllite are thinly foliated and interbedded within thin to medium beds of fine to medium grained metasandstone. The phyllite beds surrounding Dolakha Bazaar express well developed schistosity. The pelitic schist contain biotite- garnet near Dolakha whereas phyllite succession further north shows metamorphic grade of sericite-biotite. The Dolakha Phyllite (Schelling, 1992) correlates with Dolakha Formation (Ishida, 1969 and Ishida and Ohta, 1973). The Dolakha Formation may be a highly metamorphosed part of Okhaldunga Formation (Ishida, 1969).

Table 1: Lithostratigraphic correlation between previous studies in the study area.

Lithostratigraphy of present study based on Schelling (1987, 1992)	Lithostratigraphy after Ishida (1969) and Ishida and Ohta (1973)	
Khare Phyllite	Jiri Formation Jiri Thrust	Midland Metasediment
Melung-Salleri Augen Gneiss	Melung Formation Midland Thrust	
Dolakha Phyllite	Dolakha Formation	
Ramechhap Group	Okhaldunga Formation	

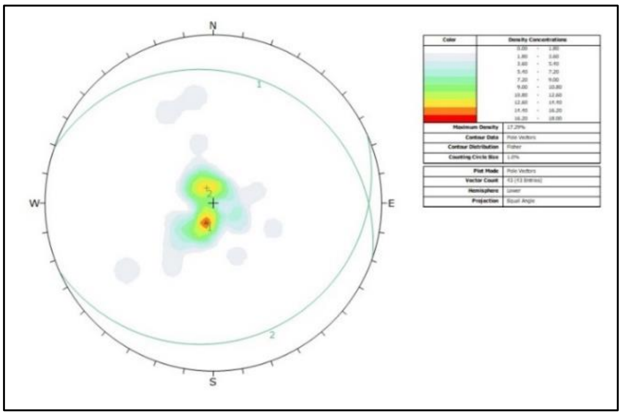

Figure 2: Stereographic plot of Nayapul-Mirge Synform (Ishida,1969), observed at vicinity of Bhirkot- Namdu area.

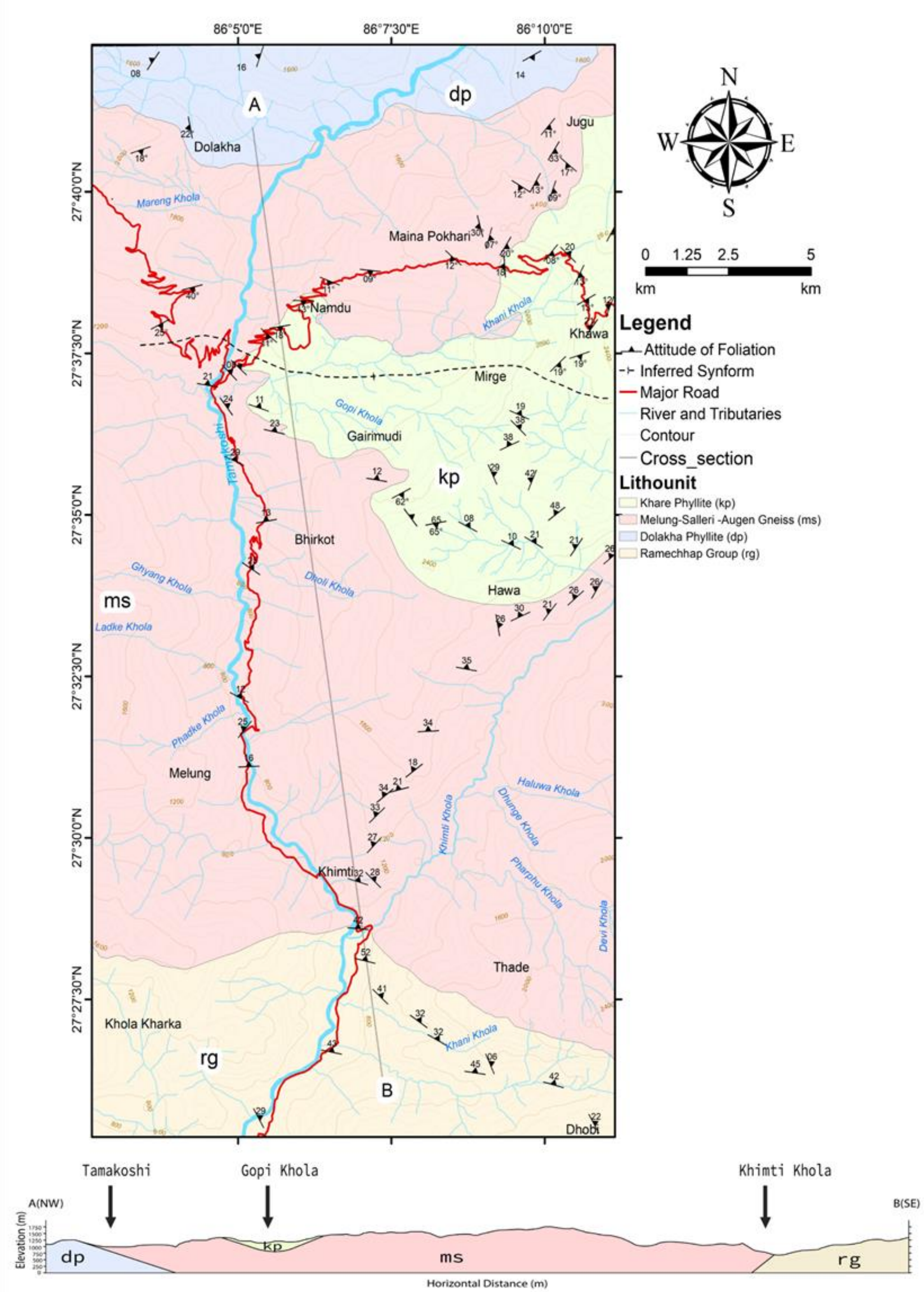

Figure 3: Geological Map of Khimti-Dolakha area and its geological cross-section along line A(NW)-B(SE). (Modified after Schelling, 1992; Dhital; 2015)

Figure 4: Field photographs of different rockunits and structures exposed along the Khimti-Dolakha Road section. A) Sharp contact between overlying Mellung-Salleri Augen Gneiss and underlying phyllites of Ramechhap Group. B) Augen structure and deformed quartz veins in gneisses along Khimti-Jiri Road east of Hawa. shows top to the south sense of deformation.C) Migmatite texture banded variety gneiss exposed along the village road section of Khimti- Chyama motor road. D) Lithological contact between Augen Gneiss and black-brown mica schist exposed east of Hawa. E) Medium beds of jointed dolomite (Calcareous rocks of Khare Phyllite) near Jormaney along Hawa-Gairimudi gravel road.F) Medium beds of parallel lami-nated quartzite exposed near Gairimudi village.

Distribution and Field Relation of Melung-Salleri Augen Gneiss with Country Rocks

The Melung-Salleri Augen Gneiss within study area exhibit wide distribution of continuous unit exposed from confluence of Tama Koshi-Khimti Khola at south to Dolakha Bazaar at the north. The major distribution of gneissic bodies occurs in the vicinity of Charikot, Maina Pokhari, Bhirkot, confluence of Gopi Khola and Tama Koshi. NE of Maina Pokhari, the gneiss forms massive banded gneiss outcrop narrowing in a band extending northward. Moreover, gneisses exhibit large augen structure (up to 10cm) and intense schistosity at proximity of contact while the upper portion around Charikot-Bhirkot exhibit a banded variety of gneiss.

In contrast to distribution, the Melung-Salleri Augen Gneiss shows sharp contacts with underlying phyllites of Dolakha Phyllite and Ramechhap Group and overlying schists, quartzites and carbonates of Khare Phyllite. Overviewing the orientation and attitude of the rock layers, it can be distinguished that both concordant and discordant field relation of gneiss with country rocks are evident in the study area. At the vicinity of confluence of Tama Koshi and Khimti Khola where phyllites of Ramechhap Group are overlain by Augen Gneiss such that their foliation run subparallel to each other with a consistent orientation in between NE-NW direction and dip at similar inclined angle, descriptive for concordant relation. However, the field relation of gneiss unit with phyllitic schist of Dolakha Phyllite resemble discordant as evident from inconsistent orientation of strata though both strata dip gently.

Moreover, Melung-Salleri Augen Gneiss exhibit both concordant and discordant relation with rocks of Khare Phyllite. Inconsistent orientation can be observed along Hawa-Gairimudi, northeast of Maina Pokhari to distinguish discordant relation whereas concordant relation with Khare Phyllite is evident from Namdu- Gopi Khola area foliation within gneiss is subparallel to schistosity and have consistent orientation with gently dipping strata.

Metamorphism

The metamorphism under Ramechhap Group increases towards north near the sharp contact (Figure. 3a) between underlying phyllite and overlying augen gneiss. Sericite-chlorite grade metamorphism is evident that resemble lower greenschist facies in the phyllites directly under Melung-Salleri Augen Gneiss (Schelling, 1987). The Melung-Salleri Augen Gneiss exhibit biotite grade metamorphism whereas metamorphic mineral like chlorite- biotite- garnet are dominant within Khare Phyllite that exhibit high grade of metamorphism. The metamorphic grade reaches up to staurolite grade within Khare Phyllite exposed on the way Jiri from Khawa Dada. Likewise, Dolakha Phyllite exhibit sericite-chlorite-biotite grade metamorphism with or without garnet mineral resembling medium to high grade metamorphic event. The Melung-Salleri Augen Gneiss, Khare Phyllite and Dolakha Phyllite exhibit green schist facies-epidote amphibolite facies (Ishida, 1969). Hence, the grade of metamorphism is characteristics of each litho-unit such that overall trend of metamorphism increases towards the northern portion of the study area.

DISCUSSION

Ishida (1969) reported the boundary between Melung Formation and the Okhaldunga Formation or Dolakha Formation to be a large thrust (namely, Midland Thrust) dipping towards north east which is likely to be due to occurrence of Melung-Salleri Augen gneiss at low structure level. Likewise, Jiri Thrust has been marked to separate overlying Jiri Formation from underlain Melung Formation (Ishida, 1969 and Ishida and Ohta, 1973). Schelling (1992) reported no evidences to suggest thrust contacts between Melung-Salleri Augen Gneiss and overlying Khare Phyllite, but left possiblities for Melung-Salleri Augen Gneiss to be underlain by thrust fault.

The gneiss exhibit augen structure resembling mantled feldspar porphyroclast and S-type ptygmatic fold of quartz veins(Figure 4b) which are good indicators of shear sense movement such that they exhibit top to the southwest sense of movement. The rotated feldspar porphyroclast have undergone brittle deformation while quartz shows ductile deformation such that brittle-ductile deformation is evident in Melung-Salleri Augen Gneiss. Moreover, the southwest sense of convex up of augen structure is promient to the trend of Himalayan orogeny and exhibit overthrusting of higher sequence while, northeast directed sense of convex down resemble underthrusting of lower sequence (Schelling, 1987). Under these circumstances, there could be possibilities of Melung-Salleri Augen Gneiss to be underlain by thrust fault. If accepted then it would represent 40km of shortening within the Lesser Himalaya (Schelling, 1987). These augen gneiss are at the footwall of MCT such equivalent to Ulleri Augen Gneiss of central Nepal, whose occurrence is in dispute of, either volcano-sedimentary origin (Pecher & Le Fort, 1977; Le Fort and Rai, 1999) or as emplacement of felsic magma as intrusive porphyritic granite that later metamorphosed and deformed to augen gneiss (Regmi and Arita, 2008; K.C and Paudyal, 2019). However, the present study narrows down to understand the nature and field relation of gneiss with country rocks rather than picking out its structural importance and origin.

Apart from discussion above, the present study approach to realize different drainage pattern with lithological variations. The raster analysis tools provide preliminary insight on larger pattern of draiange and lithological variations though field observation and evidences are of importance for mapping. Moreover, a descriptive analytical approach of looking at consistency of stratal orientation from map is put forward to delineate the field relation of gneiss with country rock.

CONCLUSIONS

The rock exposed along the Khimti- Dolakha area can be mapped into four lithological unit namely, Ramechhap Group, Dolakha Phyllite, Melung-Salleri Augen Gneiss and Khare Phyllite stratigraphically aligned from bottom to top (after Schelling, 1992). The Dolakha Phyllite is thought to be highly metamorphosed part Ramechhap Group of rocks.

The drainage pattern in the area is charecteristics of lithology and slope of the area such that gneissic terrrain with interbedded schist shows trellis pattern while uniform phyllite-schist terrain exhibit dendritic pattern.

The Mellung-Salleri Augen Gneiss exhibit sharp and irregular contacts with surrounding country rocks and resemble both concordant and discordant field relation. The southern part exhibit concordant relation while NNE part gneiss shows discordant relation. The gneiss variety are of banded type and augen type in the area. The augen structure and ptygmatic fold of quartz veins in gneiss shows top to the south sense of movement that coincides with the trend of Himalayan orogeny. The gneiss reaches upto biotite grade metamorphism whereas the overlying schist attains upto garnet grade which suggest inverted gradient metamorphism in the study area.

The Melung-Salleri Augen Gneiss forms flanks for gently east plunging open fold of E-W trending axial trace around Namdu-

Bhirkot area which is overlain by Khare Phyllite forming the core of synform. This synform has been reported as Nayapul-Mirge Synform (Ishida, 1969).

Moreover, Khare Phyllite comprised of grey schists, quartzites, carbonate rocks and black graphitic schists lacks detail mapping, whereas petrography and metamorphic zonation map of overall study area misses out which delimits the further understanding of the study area.

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RADIOACTIVE METHODS OF MINERAL EXPLORATION

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ABSTRACT

Radioactive method is the advanced methods for minerals prospecting. The radioactive element generates the different radioactive rays which mostly used to mineral exploration. All the igneous, sedimentary and metamorphic rock consist Uranium and Thorium in different proportion. There two radioactive elements are widely used in mineral prospecting and exploration. The U/Th bearing pegmatites, veins and skarn deposit is explored by the radioactive elements. The decay of potassium alteration is sufficient to gold exploration. The gamma ray spectrometry detect the uranium mineralization, ore grade estimation, gold deposits, porphyry copper deposits, and VMS deposit, and kimberlite phase and facies classification in diamond exploration.

Key Words: *Uranium, Pegmatite, Kimberlite*

INTRODUCTION

Background

Radioactive minerals are those minerals which contains radioactive elements. The radioactive element emits alpha rays, beta rays and gamma rays. The radioactive minerals are Uraninite, Aotunite, Andersonite, Phosphuranylite etc. The radioactive elements are Thorium, Radium, Actinium, Radon, Lead, Bismuth, Uraium, Thalium etc. The radioactive elements are associated with all igneous, metamorphic and sedimentary rock in very small amount. These elements are mostly used in dating of rock and minerals. The fundamental geochemistry of radioactive elements has emits the radiation of alpha, beta and gamma rays. The identification of new minerals, its exploration process is carried out by the use of radioactive elements. The radioactive minerals and the property bearing minerals are prospected and explored by this technique.

Objective

The objectives are,

- To know about the presence of radioactive elements in different rock type
- To elaborate the exploration technique of radioactive minerals.

METHODOLOGIES

The research included only secondary data which was collected from the different literature and published unpublished text, journal and books. The data are reliable and most include the research based data. The methodology is concluded in the flowchart given below.

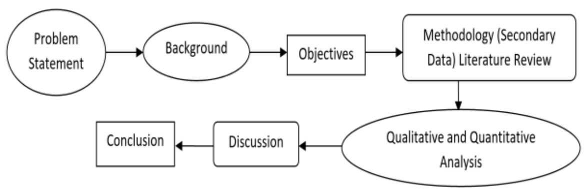

Figure 1: Flowchart of the Methodology

RADIOACTIVE METHODS OF MINERAL EXPLORATION

Radioactive Elements

Radioactive elements are made up of atom whose nuclei are unstable and give off atomic radiation as part of a process of attaining stability. The ratio of neutron/ proton estimate the stability of the nucleus. If the neutron and proton number is same then, there atoms containing elements are stable. As the atomic number increases, proton no increases the repulsion with neutron increases. From this the ratio is stable nuclei increases with increasing atomic number. From the periodic table, the different radioactive elements are studied.

Occurrence of radioactive elements a case study of Uranium and Thorium in different type of rocks

Radioactive minerals that contain radioactive elements U, Th and rare earth metals occurs in all three types of rocks, sedimentary, metamorphic and igneous rocks. The sediments and sedimentary rocks as in sandstone, quartz pebbles, and pyrite bearing conglomerates are good hosts for the radioactive minerals. The metamorphic rock Phyllite, Schist (Low temperature less than 350 degrees Celsius) infested with metasomatic alteration addition of the volatiles like water, carbon-dioxide, Florine, Chlorine within structurally weak zones are the suitable location for the radioactive minerals. In Igneous rocks the radioactive minerals usually concentrated in plutonic and volcanic rock which includes granitoids-pegmatite and rhyolites respectively, Geochemical prospecting for Th and U deposits – R.W. Boyle, Elsevier, 1982.

Minerals exploration methods by radioactive element

The radioactive minerals are mostly used in the mineral exploration. The Uranium and Thorium usually present in trace amounts measured in ppm and are relatively mobile and immobile elements in surface conditions. The Uranium, Thorium are used in direct mineralization as a primary target. Dickson and Scott (1997) provided a review of the application of Air brone gamma ray spectrometry data to exploration for a variety of mineral deposit types in Australia, including granophile Sn, W, and Mo porphyry Cu–Au, Au and strata bound poly metallic deposits. They noted that radioelement distributions associated with each type of deposit are varied and complex.

Table 1: Radioactive element from periodic table

Radioactive Elements	Atomic No.	Most stable Isotope	Radioactive Elements	Atomic No.	Most Stable Elements
Technetium	43	Tc- 97	Fermium	100	Fm- 257
Promethium	61	Pm- 145	Mendelevium	101	Md- 258
Polonium	84	Po- 209	Nobelium	102	No- 259
Astatine	85	At- 210	Lawrencium	103	Lr- 266
Radon	86	Rn-222	Rutherfordium	104	Rf- 267
Francium	87	Fr- 223	Dubnium	105	Db- 268
Radium	88	Ra-226	Seaborgum	106	Sg- 269

Actinium	89	Ac- 227	Bohrium	107	Bh- 278
Thorium	90	Th- 232	Hassium	108	Hs- 269
Protactinium	91	Pa- 231	Meitnerium	109	Mt- 282
Uranium	92	U- 235	Darmstadtium	110	Ds- 281
Neptunium	93	Np- 237	Roentgenium	111	Rg- 286
Plutonium	94	Pu- 244	Copernicium	112	Cn- 285
Americium	95	Am- 243	Nihonium	113	Nh- 286
Curium	96	Cm- 248	Flerovium	114	Fl- 290
Berkelium	97	Bk- 247	Moscovium	115	Mc- 290
Californium	98	Cf- 251	Livermorium	116	Lv- 293
Einsteinium	100	Es- 252	Tennessine	117	Ts- 294

Table 2: Concentration of U &Th in igneous rock

Rock Type, Igneous Rocks	Th(ppm)	U(ppm)	Th/U
Ultrabasics (Peridotite, Dunite, etc.)	0.1	0.02	5
Kimberlites	12	4.5	2.6
Lamprophyres	15	5	3
Basic intrusive and extrusives (Gabbro, Basalt, etc.)	3	0.6	5
Intermediate intrusive and extrusive (Diorite, Andesite etc.)	5	2	2.5
Acidic intrusive and extrusive (Granite, Rhyolite etc.)	15	4.5	3.3
Alkali rich Syanite, alkali Granites etc.	Upto 100	Upto 100	1

Table 3: Concentration of U and Th in Sedimentary Rocks

Rock Type, Sedimentary Rocks	Th(ppm)	U(ppm)	Th/U
Arenites and rudites (Sandstone, Arkose, Greywacke)	5	1.5	3.3
Lutites (Shales, Argilites)	12	3.5	3.4
Sapropelites (Carbonaceous Pyritic Shales, Oil Shales)	Upto 20	Upto 1200	-
Sapropelites (Lignite, Coal)	Upto100	Upto1000	-
Precipitates (Limestone, Dolomite, Siderite)	1	1.5	0.6
Precipitates (Chert, cherty iron formation)	3	2	1.5
Evaporites (Anhydrites, Gypsum)	0.2	0.1	2

Phospherites (Oceanic)	Upto12	Upto300	-
Tuff (Intermediated and acidic composition)	6	3	2

Table 4: Concentration of U and Th in Metamorphic Rocks

Rock Type, Metamorphic Rocks	Th (ppm)	U (ppm)	Th/U
Quartzite, Meta-conglomerate, Meta- greywacke	5	1.5	3.3
Quartz- Pebble Conglomerate	435+	2000+	-
Marble and Crystalline Dolomite	1	0.5	2
Phyllite, Slate, meta- argillite	10	2.5	4
Schists (Igneous Percentages)	6	2	3
Schists (Sedimentary Percentages)	10	2	5
Amphibolites (Igneous Percentages)	2	0.5	4
Greenstone (meta- Andesite and Meta- Basalt)	2	0.5	4
Gneiss and Granulites	10	3	3.3
Serpentinites	0.1	0.02	5
Hornfels (Sedimentary Percentages)	10	2	5
Skarns (Sedimentary Percentages)	15	3	5

An understanding of the effects of K alteration, varying degrees of in situ weathering and local lithologic variations on these radioelement distributions is required to properly evaluate the effectiveness of Air borne gamma ray spectrometry data as an exploration technique

a. Direct Methods

The direct detection is the most direct application of Air borne gamma ray spectrometry in mineral exploration for uranium. The direct application has been described in different publication IAEA (1976, 1979), Killeen (1979), and Darnley et al. (1977). The potential of uranium mineralization is directly estimated from the U/Th ratio R.W. Boyle, Elsevier (1982). The AGRS data for U (ppm), Th (ppm), and U/Th over pegmatite-style uranium mineralization from the Bancroft area, Ontario for abundant U- and Th-bearing pegmatite, veins, and skarn-type deposits show the enrichment of U and Th. Shives et al. (1995), Clark et al. (1966).

b. Direct Detection: U and Th as Trace Elements

U and Th often serve as pathfinder or indicator elements for a number of other commodities, including REEs, Li, Cs, Be, Nb, Ta, and Zr, which are concentrated in some types of pegmatites, granitic intrusions, carbonatites, and alkalic complexes. In these situations, the U and Th concentrations may not be sufficiently high to warrant extraction but occur as associated trace elements at sufficient concentrations to produce a distinctive radioelement signature. Killeen et al.(2015). Thomas et al. (2011) reviewed geophysical methods, including AGRS that have proven effective in the search for intrusion-hosted REE deposits. AGRS examples include complex pegmatite (Bernic Lake, Manitoba), alkaline–per alkaline intrusions (Strange Lake, Quebec/ Labrador, and Thor Lake, Northwest

Territories), and carbonatites (Allan Lake, Ontario).

c. Indirect Detection: Alteration Mapping

The potassium alteration for the poly metallic minerals deposit, gold deposit, shear hosted Au deposit (Dube´ and Gosselin, 2007). Potassium alteration in the form of biotite, K-feldspar, and sericite is also diagnostic of poly metallic, iron oxide Cu–Au deposits (Corriveau, 2007).

d. Mineral Exploration by Gamma Ray

The applications of natural gamma ray logs in mineral exploration include

-Direct detection of uranium mineralization and ore grade estimation,

-Mapping alteration associated with mineralization (e.g., in gold deposits, porphyry copper deposits, and VMS deposits), and

-Mapping characteristic prospective lithologies (e.g., kimberlite phase and facies classification in diamond exploration).

RESULT AND CONCLUSION

The major radioactive minerals are Uranium and Thorium which are present in all types of rocks in valuable percentages. The Uranium Thorium ratio gives the proportion of presence of it. The presence of these element helps in the other mineral exploration by radioactive methods. The Air brone gamma ray spectrometry is most used method of mineral exploration. The U/Th bearing pegmatitie, veins and skarn type deposits show the enrichment of U and Th. The potassium alteration is used to detect the polymetallic mineral deposit, shear hosted and Au- deposit. The diamond exploration in kimberlites also explored by gamma ray spectrometry. So this method is widely used for the exploration of valuable minerals.

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PRESENT CONDITION AND SUGGESTED MITIGATIONS OF JYOTINAGAR LANDSLIDE

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ABSTRACT

This paper elaborates the present condition of sliding mass in Jyotinagar area, Butwal and possible mitigation measures for the landslide. The landslide was originated from Shrawan Dada and few houses and public buildings were also damaging in the past years. Landslide is seeming to be occurring in the rainy seasons and small landslide also seems originating inside the large body of landslide day by day. The landside presents in Lower Siwalik Group, which consists of a mudstone, sandstone and marl at a varying proportion. Most of the bed were interbedded to each other but thickness was different. The sediment found in this section was deposited by fluvial system. Similarly, the material on the slope seems very loose and highly fractured rock found on the top most of the landslide. Large scarp, Tensional crack, sagging and bulging topography, Drunken trees were the indication of active landslide. Similarly, high infiltration from the infiltration test also shows the landslide in active phase. To give the best and suitable mitigation measures for the landslide was the main motto of the research.

Keywords: *Landslide, Infiltration test, Mitigation*

INTRODUCTION

The usually rapid downward movement of a mass of rock, earth, or artificial fill on a slope are landslide (Bazar, 2019). Reason for an occurrence of landslide can be various. Landslides due to excessive rainfall are one of them. Upon that, in the Siwalik area occurrence of landslides is very high due to the varying physical and chemical properties between alternatively bedded sandstone and mudstone and rainfall directly enhances those differences. In addition, various factors play important role for their occurrence.

The Jyotinagar landslide lies in Rupandehi district-Butwal sub-metropolitan city-ward no.03 Laxminagar and Jyotinagar (figure1). The landslide was originated from the Shrawan Danda. In past Jyotinagar landslide was activated in 2055-Bhadra-20. Due to this landslide few houses and public buildings were got damages. Every year, monsoon period is possibility of the large to small scale landslide. After several events of landslide over there, various civil engineering structures were seeming built but these structure does not seems effective. The lateral extension of this landslide is about 4 km. This landslide also referred to as Shrawan Danda landslide. A left flank of landslide lies in Laxminagar and at right flank lies in Jyotinagar.

The landslide originated from the Shrawan Danda. This landslide was occurred during the rainy season 2078-Bhadar-11 and Ashoj-04. Due to this landslide more than 55 houses were affected among them 15 houses were completely damages, 30 houses were partially damages and 12 houses bear simple damages. Furthermore, one school (Janajyoti

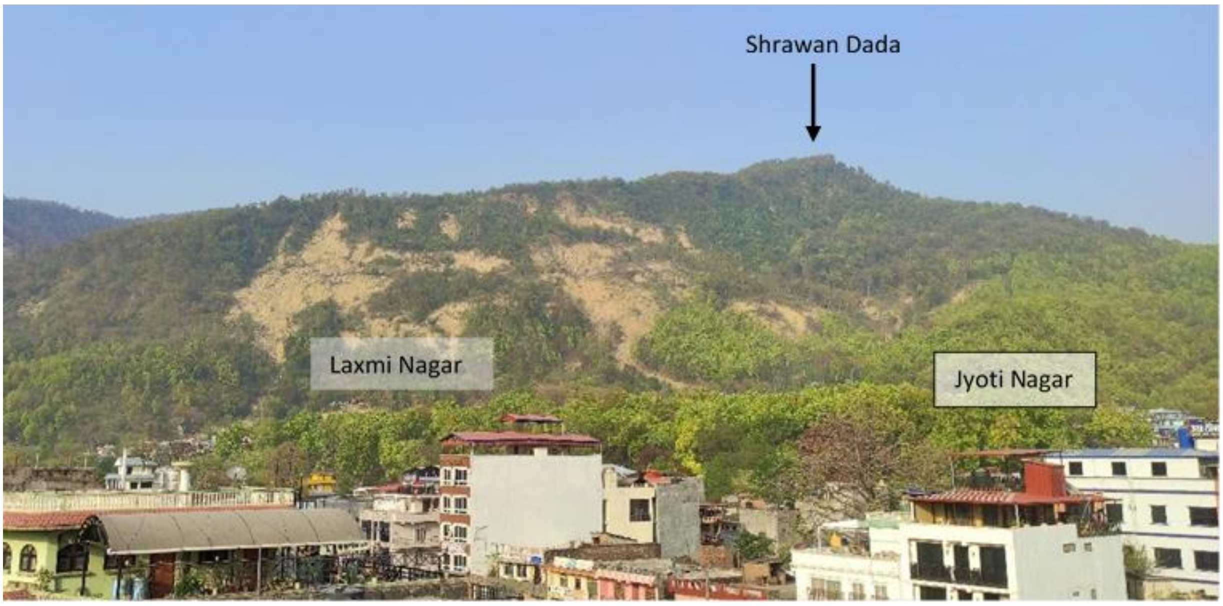

Figure 1 Photograph of Jyotinagar Landslide from Butwal city

Primary School buildings, compound and local drinking water project were damages).

GEOLOGY AND HYDROLOGY OF THE AREA

Landslide occurred in Jyotinagar lies in the Lower Siwalik Group, which consists of a mudstone, sandstone and marl at a various proportion. Most of the bed were interbedded each other but thickness was varying. The sediment found in this section was deposited by fluvial system. The materials on the existing slope were very loose. So, the permeability of the materials is too high. In landslide area, at top most part rock is heavily fractured which allows the infiltration of the rainfall water. Due to this reason surface runoff seems very poor. At the middle portion of this landslide loose materials get eroded due to surface runoff water so there formed number of a small-scale to large-scale gullies.

In the areas where ground movement occurred, there was no any kinds of drainage systems. So, the overall drainage system is haphazardly distributed. At the middle portion of landslide there seems number of a gullies flowing directly (straight) towards south. At top of the landslide there was no any sign of the surface runoff in the past which indicates the materials lies at top has high permeability than the other parts of landslide. In context of the hydrology at different parts of landslide there exists small seepage zone. In some parts small lake like water body also observed during the field visit.

PRESENT CONDITION OF THE LANDSLIDE

The lateral extension of this landslide, whose left flank is Laxminagar and right flank is Jyotinagar, is about 4 km. This landslide also referred to as Shrawan Danda landslide. Observations along the prefixed route over the landslide mass indicate devastating damages to local habitat and interesting mechanism of large-scale landslide. Characteristic features of large-scale landslide such as tensional cracks, sag ponds, tilted trees and electricity poles, unexpectedly bulged masses; low lands etc. are clearly observable (Figure3) (Figure4) (Figure5).

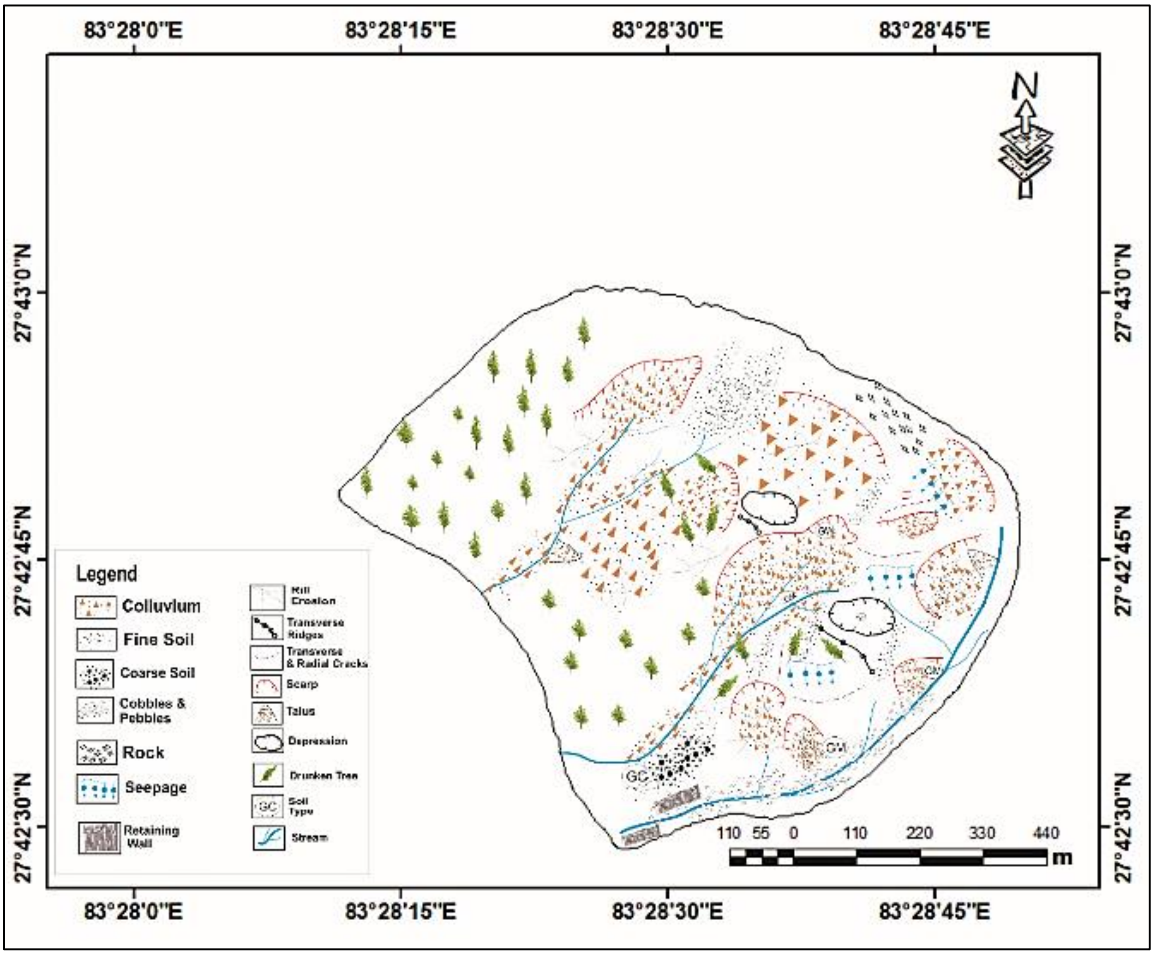

Figure 1 Different evidences found during the field visit

The conditions of the landslide at present seems very poor in sense of stability. At different portion of the sliding mass impact of external environment makes much weaker and unstable. At the left flank of landslide there observed several tensional cracks (all were in open conditions). Then, the number of drunken trees and tilted pole indicating the continuous mass from the slope. The number of a hanging mass of slope materials also observed at the middle and top portion (crown). Seepage of the groundwater were clearly seemed at different portion of the landslide. At middle part most of the materials is ready to fail in the different forms. At right flank of the landslide number of the tensional cracks were observed and the most of the slope materials were disturbed. Then the several erosional landforms were also observed. At the middle portions, the gully erosion was mostly dominant. Several tensional cracks (Parallel to movement direction) can be observed at the both flanks of landslide (Figure3a). At the top most part, the bulging of landmass forms large pond where rain water can be collected and ultimately enhance the possibility of failure in upcoming days.

Infiltration test shows average infiltration over the landslide. The measurement of infiltration test is tabulated (Table1). The result shows that the average infiltration rate was 0.056 cm/sec.

Table 1 Measurement of infiltration test

Radius of Pipe (cm)			5.25	Flow, $Q_f = \Delta H * V_p$ $I = (Q_f/A)/\Delta t$	
Depth of Liquid (cm)			9		
Area (A) (cm^2)			86.59		
Volume of water, (cm^3)			1000		
Volume of pipe, V_p (cm^3/cm)			111.11		
			Flow Readings		
Reading Time (sec)	Time interval, Δt (sec)	Elevation, H (cm)	ΔH (cm)	Flow of water, Q_f(cm^3)	Infiltration rate, I(cm/sec)
0	0	9			
1	1	8.8	0.2	22.22	0.257
5	4	8	0.8	88.89	0.257
10	5	7.8	0.2	22.22	0.051
15	5	7.5	0.3	33.33	0.077
20	5	7.3	0.2	22.22	0.051
25	5	6.8	0.5	55.56	0.128
30	5	6.5	0.3	33.33	0.077
60	30	6.2	0.3	33.33	0.013
120	60	5.8	0.4	44.44	0.009
180	60	5	0.8	88.89	0.017
240	60	4.5	0.5	55.56	0.011
300	60	4	0.5	55.56	0.011
360	60	3.6	0.4	44.44	0.009
420	60	3.1	0.5	55.56	0.011
480	60	2.7	0.4	44.44	0.009
540	60	2	0.7	77.78	0.015
600	60	1.6	0.4	44.44	0.009
900	300	0	1.6	177.78	0.007
Average Infiltration Rate, I in cm/s					0.056

Figure 2 Cracks parallel to movement and present sag pond at the top portion

Figure 3 Drunken trees and gabion wall inside the landslide mass

Figure 4 Tilted poles and gabion wall in the landslide area

IMMEDIATE ACTION NEEDED

Immediate action is most important so that stability of failed landmass is confirmed until long term stability designs are made and implemented. Based on the landslide mass, shape of landslide type of soil and depth of the soil the different actions are carried out immediately. After observation of the landslide following immediate action are needed to control the large-scale mass movement.

Drainage management of surface and sub-surface is the most immediate action at first stage. Several scientific and creative attempts such as using the pipes from which surface runoff water can drain out.
Adequate instrumentation is needed for regular monitoring of the landslide.
Public awareness about the cause of landslide is not by presence of large tree on slope.
Need to carry out geophysical survey to identify the depth of slide surface, thickness of saturated soil (if soil present) and information of groundwater.

RECOMMENDATION AND MITIGATION MEASURES FOR LANDSLIDE STABILITY

At first surface and subsurface water management work is needed.
Need to prepare the risk map of the landslide area. For that the co-operation of government is needed.
In area before any kind of engineering construction there need to study about the stability of slope.
In landslide area the surface water management model is need to utilize to mitigate the surface drainage.
In this area from the municipality level there need to make land use act. Up to stabilization of slope around the risk area further developmental work is need to stop.
At toe of landslide where creeping is still seems active Rock-fill buttresses wall can be used by this toe creates the counterforce which can resists the failure.
The rate of gully erosion on slope seems too high so to control these various bioengineering practices can be used. For this landslide dry seeding seems best.
In between Laxminagar and Jyotinagar area there seems huge mass of slope materials seems creeping for that large diameter piles can be used at the toe of landslide.

CONCLUSION

Inside the landslide area many small scales landslide was found active. The landslide mass was huge and different structures were present over there like drunken trees, tilt electric poles, cracks parallel to movement which tell the landslide is still active and can damage the structures and lives below the landslide. Material in the landslide was loose and fractures also present in the rocks found in the landslide. Similarly, the infiltration test also shows high infiltration in the soil which also indicates the activeness of the landslide. For the solution and protect the peoples and structures below the landslide perfect plans should be implemented regarding the mitigation. To mitigate this largescale landslide action from government level should be needed. As above mentioned, slope mitigation and protection work should be done. At present conditions some engineering practices seems wrong such as trenching at top for drainage, and gabion wall on sliding mass are needed to stop for further construction. Community awareness about landslide should be done.

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PETROGRAPHY AND GEOCHEMISTRY OF CHARNOENDERBITE AROUND THANA-GYANGARH, BHILWARA DISTRICT, RAJASTHAN INDIA.

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ABSTRACT

Charnoenderbite are observed in the medium to high-grade terrains of Thana-Gyangarh area. These charnoenderbite are the result of the metamorphism of pre-existing mafic igneous rocks under medium to high grade P-T conditions and consist essentially of Pyroxene (Opx + Cpx), plagioclase$_{(An40-50\%)}$, K-feldspar, and hornblende, biotite, quartz are also present. Their igneous parentage is evident from a combination of features including field relations, mineralogy, petrography, as well as distinct chemical feature. Geochemically, these charnoenderbite are tholeiitic, show association with non-orogenic environment and shift to subalkaline derivatives with progressive differentiation. It is also clear that the parent magma for these rocks was highly evolved in nature. Present study includes petrography, geochemical characters to elucidate the petrogenetic history and origin of the charnoenderbite.

Key Words: *Charnoenderbite, Petrographic, Petrochemistry, Thana-Gyangarh, India*

INTRODUCTION

Granulites are uncommon at the earth surface (Heier and Adams 1965, Heier 1965, Lambert and Heier 1968). Charnoenderbite are hypersthene-bearing granitic rocks which are the pivotal components of the lower continental crust in many high-grade terrains (Le Maitre 2002). Charnoenderbite have been reported from the majority of the continents, mainly within the high-grade belt and their petrogenesis is still controversial (Bhattacharya, 2010). Authors considered them as a product of deep-seated melting during collision. Charnoenderbite are formed by either anhydrous felsic magma deposited in the lower crust or by intensive dynmothermal metamorphism of an arenaceous protolith up to granulite facies along with dehydration (Gupta 1934, Touret and Huizenga 2012). When the orthopyroxene-bearing granitic orthogneiss frequently appears as veins and patches in the host of biotite or hornblende-bearing gneisses, they are termed as incipient charnockite (Hansen et al., 1987, Frost and Frost, 2008, Newton and Tsunogae 2014, Lee et al 2021, Wang et al. 2021). The investigated region lies between 74°5' to 74°10' and longitude 25°38'20" E to 25°42'36" E covering an area of about 133 square kilometres in the ancient gneissic complex (Heron, 1935 and 1953) of the Proterozoic age (Buick et al. 2006). Thana-Gyangarh area of Rajasthan is predominantly granulite (Charnoenderbite) rather than pelitic granulite/paragneiss which are surrounded by augen gneiss, migmatite and amphibolite contributing to main litho unit of the gneissic complex.

In central Rajasthan there is a NE-SW trending belt (~ 100 km long) in which enclaves of granulite facies rocks outcrop discontinuously amidst amphibolite facies rocks of the BGC (BGC-II of Gupta, 1934) from Sandmata in the southwest to Ajmer in the northeast. This belt, known as the Sandmata granulite complex, contains granulite facies metapelites and metabasites as well as charnockite-enderbite suites (Joshi et al., 1993; Sharma, 1995; Roy et al., 2005; Thomas, 1995, 2005, Saha et al., 2007, Thomas & Sujata, 2008, Thomas & Neeraj, 2011, Thomas & Lalu, 2014, Neeraj & Thomas, 2015, Thomas et al., 2018, Thomas et al., 2019 and Thomas & Rana, 2020).

Present study reveals that rocks of Thana-Gyangarh area is dominantly Granulite (Charnoenderbite) composed of orthopyroxene + clinopyroxene + K-feldspar + plagioclase + garnet + quartz + biotite + hornblende, Al-rich pelitic gneiss, garnet bearing and garnet-free amphibolite, gneisses and schist of Banded Gneissic Complex occur as massive and in boulder form. Small scattered bodies of metanorite occur within the SGC which intruded the complex in the waning stages of granulite metamorphism (Sharma et al., 1987; Thomas and Sujata, 2005). At one place, near Gyangarh village, norite is observed included within the intrusion of granodiorite-charnockite comagmatic series dated at 1723 Ma (Sarkar et al., 1989). These rock associations and field relationships are very similar to that of the Sandmata area (Joshi et al., 1993) and reflect a high pressure granulite complex

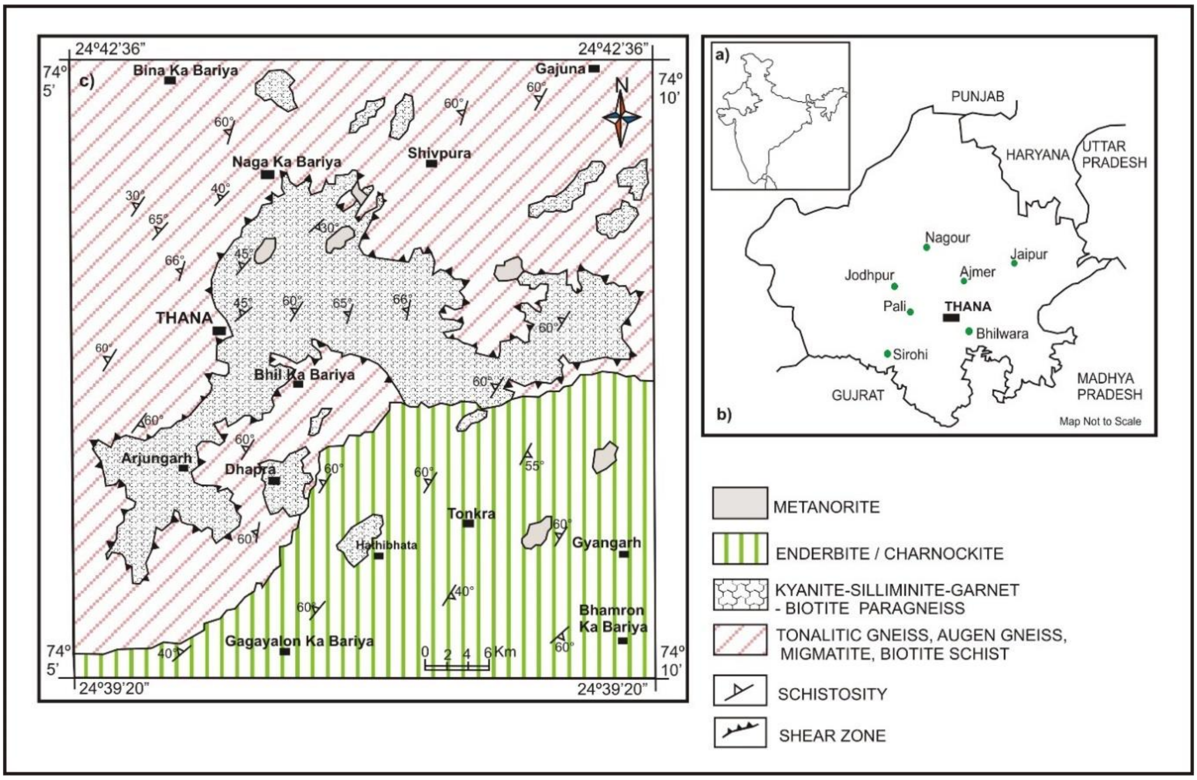


Figure 1: Geological Map showing lithology and structural elements of Thana-Gyangarh area, Bhilwara district, Rajasthan (Thomas, 1991).

LITHOLOGY AND FIELD RELATION OF ROCKS.

Granulite (charnoenderbite) being the important component on the regional scale they are surrounded by gneisses and migmatites of the Banded Gneissic Complex (BGC). Texturally the granulite ranges from massive to crudely foliate and often occurs in boulder shape, commonly in and around Gyangarh village. Pyroxene (Opx + Cpx), plagioclase, K-feldspar are the main constituent of these Charnoenderbite along with hornblende, biotite and quartz. The charnoenderbite are medium to fine grained, brownish to dark ash-grey in colour, at times showing waxy or greasy lustre. Generally, the foliation is discernible and is the result of the variation in grain size and mineral composition. The enderbite are often foliated and gneissic because of the lenticular shape of bluish quartz. Pyroxene and feldspar grains are conspicuously equivalent while the garnets occur as thin elongated crystals and often as porphyroblasts.

"Aluminous enclaves" which are compositionally kyanite-garnet-sillimanite-biotite granulite occur as small bands within these charnoenderbite near the Hathibata village. The garnet amphibolite also occurs as small patches within the enderbite usually north and northwest of Gyangarh village. The contact between the host rock and aluminosilicate bearing rock as well as that between the host rock and the garnet amphibolite is sharp, suggesting that during the tectonic and metamorphic events the migration of material was highly restricted. Hornfels occurs at the contact of metanorite, near the village Hathibata and Gyangarh. It also occurs as small bands in enderbite due to thermal effects of rocks showing hornfelsic texture.

On the basis of field and mineralogical criteria, it becomes obvious that the charnoenderbite rocks of Gyangarh area are intrusive into the surrounding granulite facies of rocks showing two stages of metamorphic events (Thomas, 1995, 2005).

PETROGRAPHY

The hypersthene-bearing granitic rock has been referred to as charnockite (c.f. Howie and Subramanian, 1957). These acid to intermediate granulite rocks are intrusive in nature but they are generally massive and in boulder form in the area, and are responsible for the thermal effect on the adjoining gneisses in the Gyangarh region.

Megascopically charnockite are dark grey due to predominance of grey and bluish quartz with waxy lustre, dark grey perthite, hypersthene and plagioclase. Microscopically in charnockite most of the gains are coarse and equant, showing granoblastic texture. Relic textures contain hypersthene as isolated crystals adjacent to or within biotite. Reaction rims of biotite around hypersthene against k-feldspar are common which in turn are surrounded or enclosed in garnet porphyroblasts. The different parageneses recorded in these rocks are:

Hypersthene – biotite - garnet - k-feldspar – quartz – plagioclase- hornblende ± magnetite (Sample no. H90/5)

Hypersthene – biotite – K-feldspar – quartz – plagioclase (Sample no. R87/256).

Hypersthene – garnet- biotite- hornblende-k-feldspar-plagioclase-quartz ± magnetite (Sample no. R87/464)

Hypersthene – garnet- clinopyroxene-quartz-hornblende- -plagioclase- biotite- k-feldspar (Sample no. R87/312)

Microscopic description

Hypersthene occurs in close intimation with biotite with preferred orientation. Small isolated hypersthene crystals are embedded in some biotite which in turn is surrounded by garnet porphyroblasts. The orthopyroxene seems to have originated during the early stage of M_2 (Delhi) metamorphism, later due to changing physical conditions (Probably during cooling) it converted to biotite.

Orthopyroxene + Garnet + K-feldspar = Biotite + Quartz + Water

Garnet

Garnet is usually seen as high relief, euhedral to subhedral porphyroblasts sieved with all the minerals of the hypersthene-bearing gneisses. In some domains secondary garnet rims around biotite or ilmenite/magnetite.

Biotite

Biotite is a common constituent of the charnockite rocks in the region, and shows intergrowth with hypersthene. Biotite is strikingly reddish brown, highly pleochroic and contains ilmenite inclusions.

K -feldspar

K-feldspar is microperthite, usually a string perthite. Its contact with hypersthene is marked by a rim of biotite, suggesting that k-feldspar also has inclusion of quartz.

Quartz

Quartz always occurs as elongated or amoeboid grain. Undulatory extension is common. Symplectic intergrowth with biotite is noticeable. Inclusion of Quartz within garnet are frequently observed.

Plagioclase

The composition usually falls between An_{33} to An_{45} amongst the opaque minerals ilmenite and magnetite deserves mention.

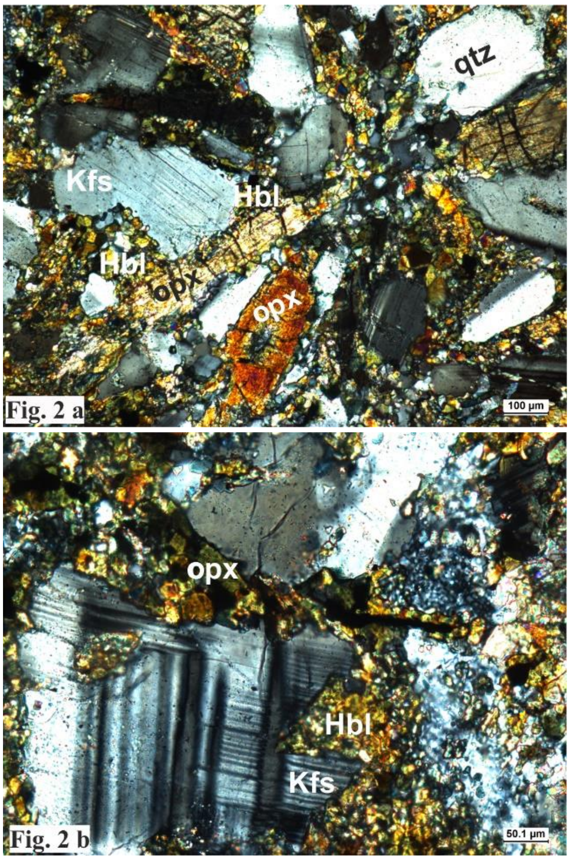
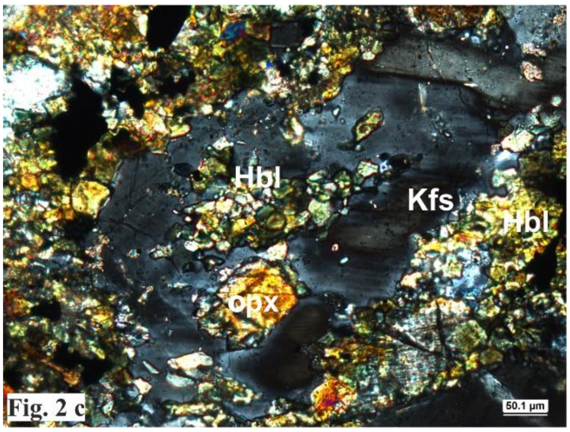


Figure 2a: Photomicrograph showing blastophitic texture and a reaction rim of hornblende around hypersthene (relics), suggesting the reaction:

Hypersthene + plagioclase = hornblende + quartz.



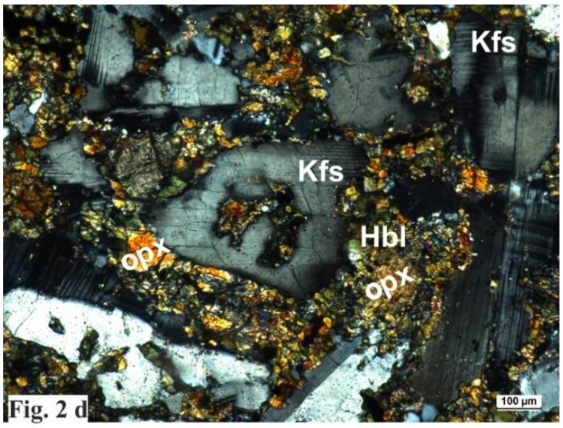


Figure 2b: K-feldspar showing exsolution perthite texture formed by exsolution due to cooling of a grain of alkali feldspar with a composition intermediate between K-feldspar and albite.

GEOCHEMISTRY AND PETROGENESIS OF CHARNOENDERBITE

ANALYTICAL TECHNIQUES

The major oxides for ten selected samples of charnoenderbite from Thana-Gyangarh are were analysed by AAS at Wadia Institute of Himalayan Geology, Dehradun.

Results of the ten selected charnoenderbite rocks for major oxides are presented in Table.1. The rocks of different assemblages show clear chemical differences. The SiO_2 and Al_2O_3 content varies from 53.33 to 71.96 % and from 10.29 to 16.68 %, respectively. In all the ten selected-samples the SiO_2 content is > 53%. The average Na_2O and K_2O content in the charnoenderbite stands 1.553 % and 3.1755 %, respectively. The average K_2O/ Na_2O ratio of these rocks is 2.066. TiO_2 content of the rock varies from 0.13 to 2.93 %. The average FeO/MgO ratio of these rocks is 2.5

***Table.1: Major element analysis (in wt %) of Charnoenderbite from Thana-Gyangarh area, Bhilwara, Rajasthan*.**

Ref. No.	1	2	3	4	5	6	7	8	9	10
Sample No.	R87/282	R87/312	R87/314	R87/335	R87/432	R87/453	R87/464	91/609	94/837	94/836
MAJOR ELEMENTS										
SiO2	59.98	53.33	60.03	59.55	53.52	54.02	65.14	49.88	65.69	71.96
Al2O3	13.9	21.3	16.68	15.34	15.45	16.23	14.71	12.88	14.08	10.29
Fe2O3	2.06	2.96	2.92	2.6	2.08	1.28	1.44	-	-	-
FeO	7.33	6.37	7.83	11.28	8.56	6.93	5.91	12.74	6.94	8.27
MgO	1.01	1.21	1	1	5.44	1.22	1	14.78	2.86	2.38
CaO	7.85	3.64	5.6	4.02	8.69	2.97	5.6	8.31	6.19	4.94
Na2O	2.2	1	2.4	1.25	2.8	1.7	2.4	0.69	0.64	0.45
K2O	3.6	5.28	4.1	4.2	0.4	6.4	3.9	0.17	0.53	
MnO	0.124	0.045	0.07	0.07	0.124	0.05	0.07	0.25	0.09	0.21
TiO2	1.285	0.87	1.56	1.33	1.39	1.51	0.46	0.13	2.93	1.48
P2O5	-	0.43	0.73	0.71	0.12	0.87	0.27	-	-	-
TOTAL	99.339	96.435	102.92	101.35	98.574	93.18	100.9	99.99	99.97	99.98

Table 2. CIPW norms and Niggli values of charnockite/enderbite from Thana area, Bhilwara, Rajasthan.

Ref. No.	1	2	3	4	5	6	7	8	9	10
Sample No.	R87/282	R87/312	R87/314	R87/335	R87/432	R87/453	R87/464	91/609	94/837	94/836
CIPW NORMS										
Quartz	15.26	15.18	14.65	20.38	6.83	9.4	21.19	2.21	38.78	49.21
Orthoclase	21.29	31.25	24.24	24.85	2.39	37.86	23.07	1	3.11	
Albite	18.6	8.44	20.28	10.58	23.68	14.36	20.28	5.82	5.4	3.83
Anorthite	17.38	15.57	22.57	15.79	28.36	9.73	17.79	31.53	30.72	24.52
Corundum		8.21		2.93		2.92			1.18	0.55
Diopside	18.64		0.84		11.62		7.26	7.92	0	
Hypersthene	2.74	10.91	11.53	18.97	11.8	12.3	7.76	43.19	15.16	19.07
Magnetite	2.99	4.29	4.32	3.78	3.02	1.86	2.09	0	0	0
Ilmenite	2.45	1.66	2.96	2.52	2.61	2.87	0.88	0.24	5.62	2.81
Apatite		1.01	1.71	1.68	0.27	2.02	0.64			
Olivine								19.33		
NIGGLI VALUES										
Al	27.02	41.55	31.55	32.54	23.72	35.27	32.04	15.06	31.82	26.99
Alk	14.61	14.39	15.88	19.66	7.9	21.17	17.79	1.54	3.68	1.94
C	27.74	12.94	19.3	18.4	24.26	11.75	22.17	1.54	25.49	23.6
Fm	30.64	31.12	33.27	29.4	44.12	31.8	27.99	65.66	39.01	47.46
K	0.518	0.777	0.53	0.622	0.105	0.713	0.516			
Mg	0.162	0.194	0.145	0.352	0.479	0.213	0.196	0.672	0.423	0.336
Ti	3.59	2.17	3.76	2.15	2.72	4.19	1.28	0.19	8.45	4.95
P		0.597	0.289	0.112	0.132	1.33	0.42	0	0	0
Si	197.89	176.88	193.07	247.76	139.48	199.6	240.79	99.26	252.48	320.98

The CIPW norm indicates the silica saturated nature of the charnoenderbite. As per the CIPW norm calculated, the normative quartz varies from 2.21 to 49.21% while the plagioclase content varies from 9.73 to 31.53%. As per the alumina saturation index, the Al/ (Na+K) vs. Al/(Ca+Na+K) plot, Figure.3 after Shand 1943 shows that all the samples of charnoenderbite of Thana-Gyangarh area falls within a meta to peraluminous field. Charnoenderbite points fall in the tonalite to quartz monzonite field in the normative Ab-An-Or diagram after O'Connor 1965, Figure.4.

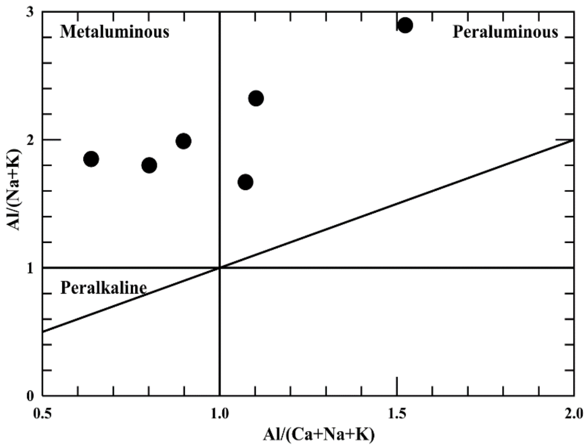


Figure 3: Al/(Na+K) versus Al/(Ca+Na+K) plot for Charnoenderbite after Shand, 1943.

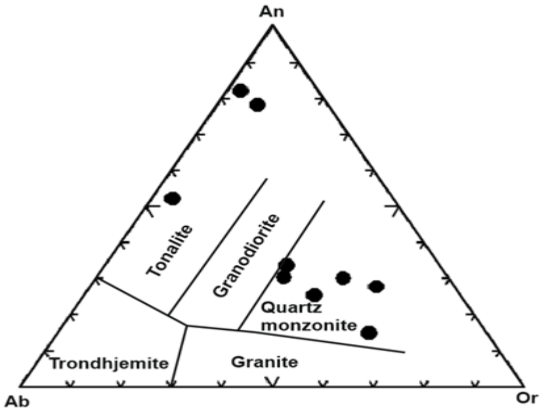
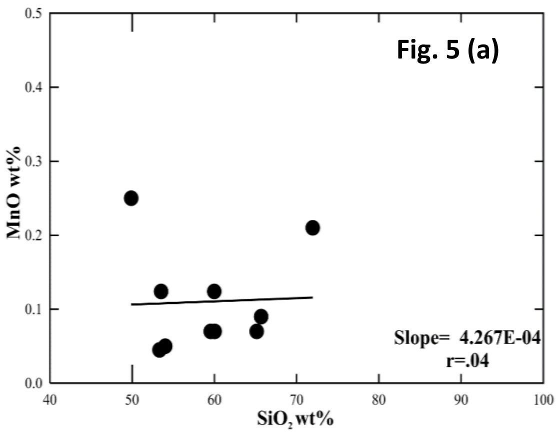
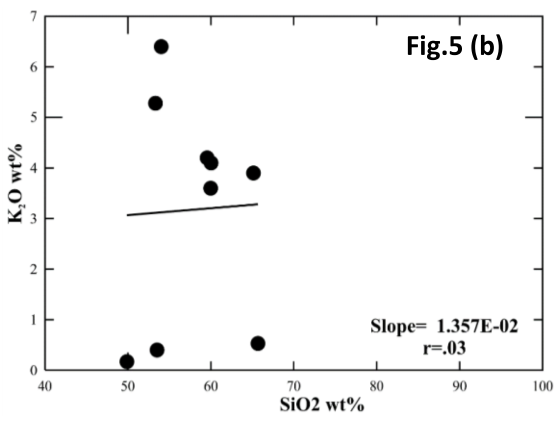
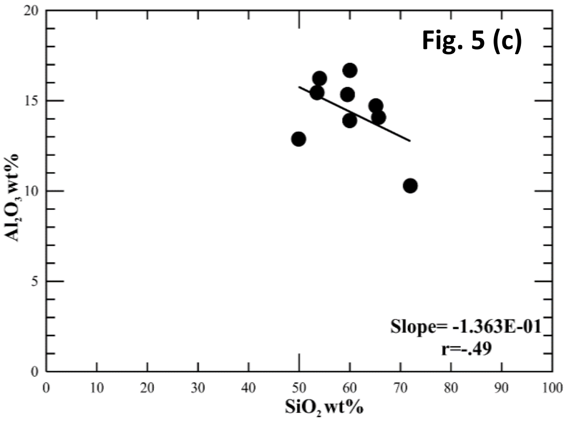


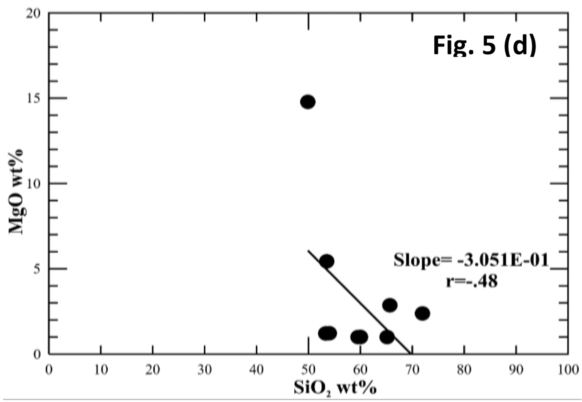
Figure 4: Ab-An-Or diagram for charnockites after O'Connor (1965). The combined fields for granodiorite and quartz monzonite comprise the adamellite field.

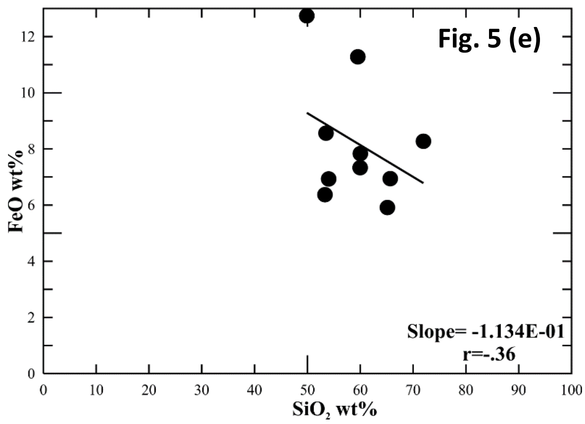
The Harker variation diagrams between SiO_2 and others major oxides (FeO, MgO, Al_2O_3, MnO, Fe_2O_3, K_2O, Na_2O, and CaO; Figure 5a to 5h) shows good correlations which indicates coherent behaviours of element during different processes of metamorphism.

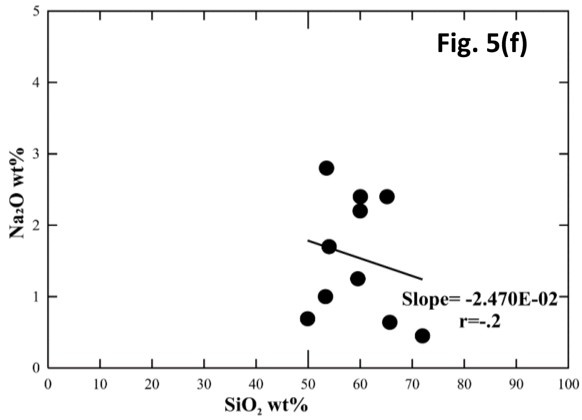


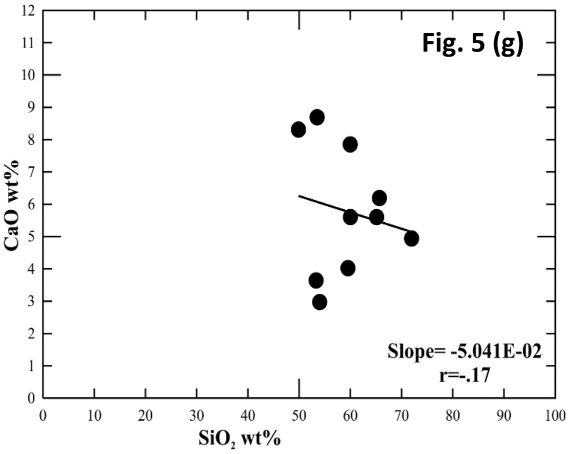












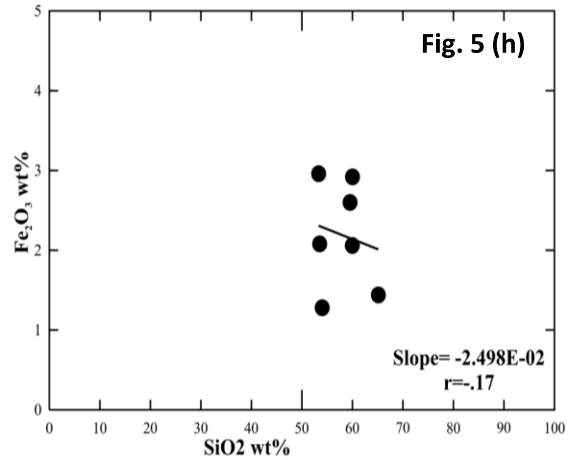


Figure 5 (a-h): Harker variation diagram for charnoenderbite

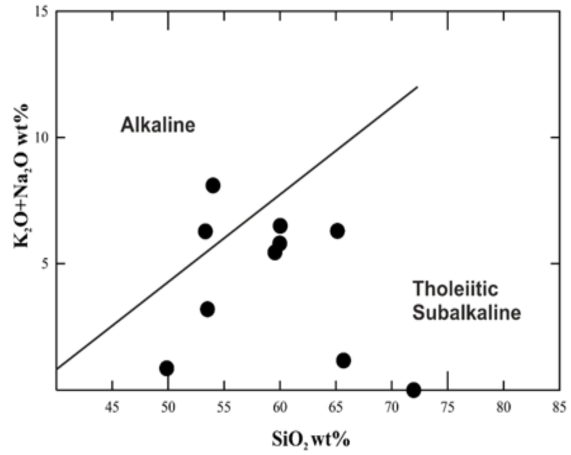


Figure 6(a): SiO2 wt% vs Na2O+K2O wt% diagram after MacDoland and Katsura (1964)

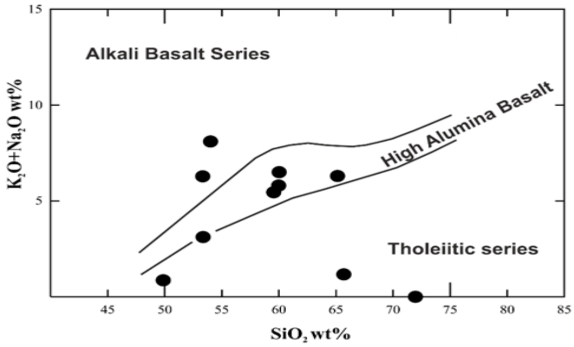


Figure 6(b): SiO2 wt% vs alkali wt% after Kuno (1966)

The plots between SiO_2 wt% vs Na_2O+K_2O wt% after MacDoland and Katsura (1964) Figure.6a and SiO_2 wt% vs alkali wt% after Kuno (1966) Figure.6b indicate tholeiitic to subalkaline nature.

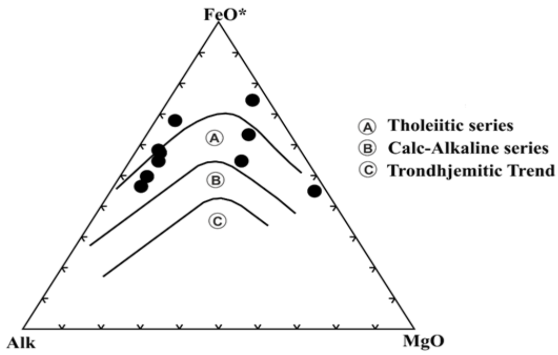


Figure7. FeO-Alk K2O+Na2O)-MgO diagram after Irvine and Baragar (1971).

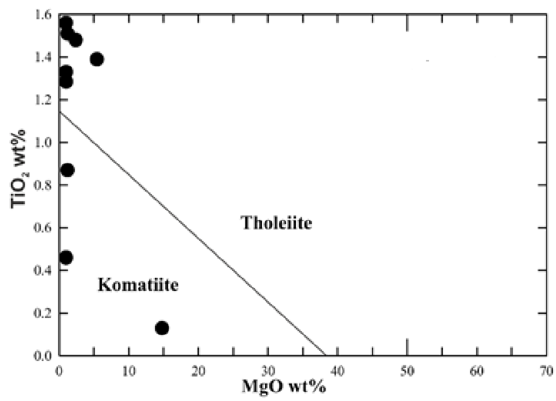


Figure 8. TiO2 wt% vs MgO wt% diagram after Arndt et al. (1977)

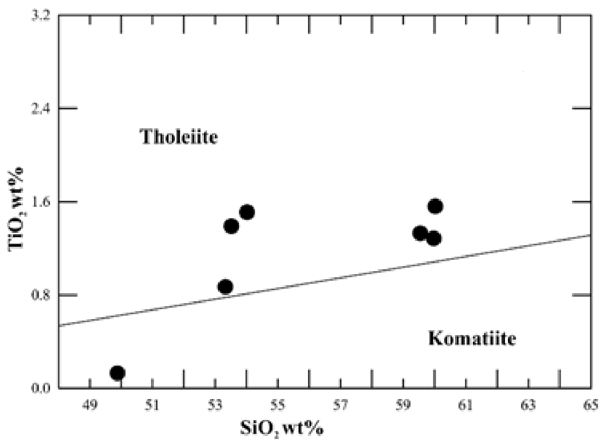


Figure 9. TiO_2 wt% vs SiO_2 wt% diagram after Arndt et al. (1977)

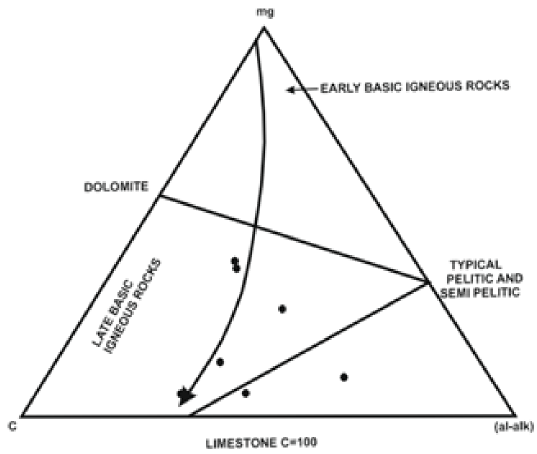


Figure 11. Niggli mg + C + (al-alk) diagram after Leake (1964)

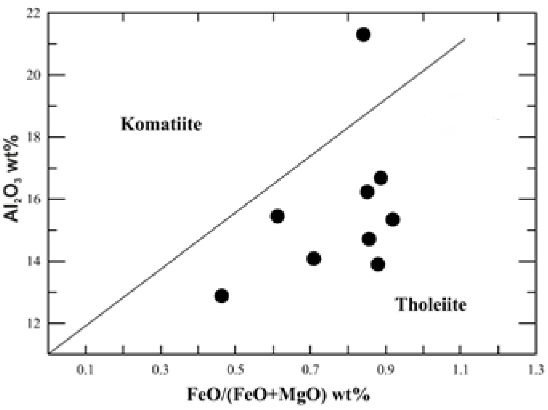


Figure 10. Al2O3 wt% vs FeO/(Feo+MgO) wt% diagram after Arndt et. al. (1977)

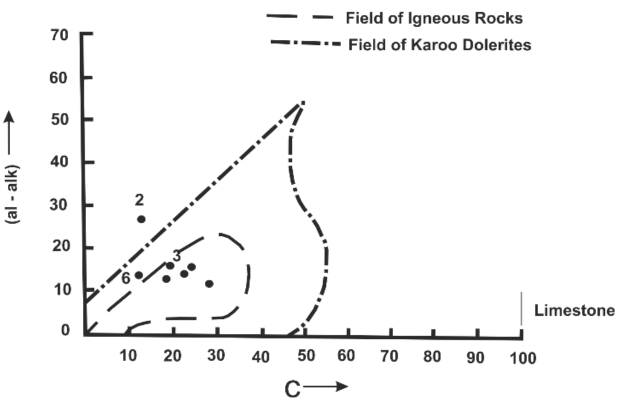


Figure 12: Plots of Niggli C Vs (al-alk) diagram after Leake (1964)

The plot between FeO + (Na_2O + K_2O) + MgO (Figure.7) after Irvine and Baragar (1971), plot between TiO_2 wt% vs MgO wt% diagram after Arndt et al. (1977) Figure.8, and MgO Vs TiO_2 (Figure.9) and Al_2O_3 Vs FeO/(FeO + Mg) diagram after Arndt et al. (1977). (Figure. 10) diagrams, also shows tholeiitic percentage for the charnoenderbite.

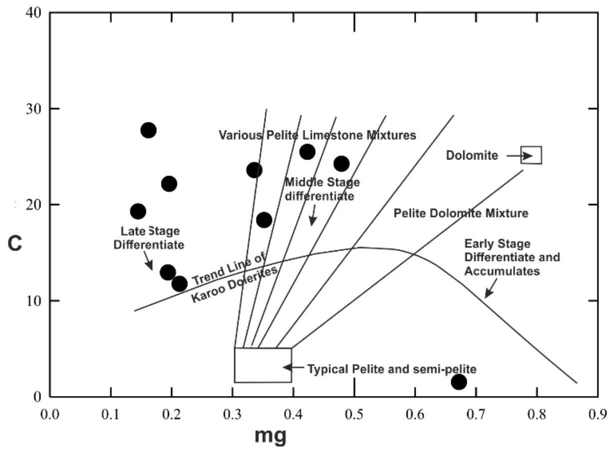


Figure 13: Niggli mg against C plot for the amphibolites trends of Karoo dolerite after Leake (1964).

The plot of the charnoenderbite with Niggli mg against c (Figure.13), display a composition which is comparable with middle to last stage differentiation trends of karoo dolerite. This, plus the plot of mg + C + (al-alk) recalculated to 100, after Leake (1964) also fall on the middle to last stage differentiation trend (Figure.11). These plus the Niggli (al-alk) Vs C values plotted (Figure.12) after Leake (1964), support an igneous parentage for the charnoenderbite.

CONCLUSION

Based on the above discussion, the following conclusions can be draw:

Field and mineralogical studies suggest that the charnoenderbite rocks of Gyangarh area are intrusive into the surrounding granulite facies of rocks showing two stage of metamorphic events Thomas, 1995 & 2005). They occur as massive and in boulder form surrounded by gneiss, migmatites amphibolite and are the result of metamorphism of pre-existing mafic igneous rocks like gabbroid (gabbro/dolerite) under medium to high grade P-T conditions.

Petrography suggests that the charnoenderbite include orthopyroxene + clinopyroxene + K-feldspar + plagioclase + quartz + biotite + hornblende appears to be derived from igneous source.

Geochemically, these charnoenderbite are tholeiitic, show association with non-orogenic environment and shift to subalkaline derivatives with progressive differentiation. The different plots of these charnoenderbite clearly support an igneous parentage for the charnoenderbite.

INTEREST OF CONFLICT

The author declares that there is no conflict of interest regarding the publication of this article.

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ROCKS OF NEPAL USEFUL FOR STATUES, MONUMENTS AND TEMPLES

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ABSTRACT

Rocks from Nepal have been used for centuries to create carved stones, statues, and temples. Not only do they provide the strength and stability needed to build the structure, but they can also be carved to create beautiful works of art. These rocks have become an important part of Nepalese culture and identity and are used in a variety of ways, from carving designs to creating large sculptures. The rocks are also used in the construction of temples and other religious structures. They stand for centuries, withstanding the test of time and various weather conditions, and represent the culture and lifestyle of the people. There are a variety of different types of rocks used in temple construction, each with its unique properties and symbolism.

This research explores and identifies the various uses of rocks from Nepal and the importance of these rocks in the construction of religious monuments. The most common type of rocks used in the construction of statues and temples in Nepal are limestone, marble, granite, basalt, quartzite and sandstone, with limestone and sandstone being the most commonly used rock for temple construction. These rocks are used in their natural form as well as in carved form. Various factors that make these rocks unique from other rock types and how they are used in the construction of temples and other religious structures are discussed. Close observation of the different rock types and the reason behind their uses in the construction are analyzed.

Key Words: *Carved stones, temples*

INTRODUCTION

Statues and temples are some of the most iconic monuments in the world. They stand for centuries, withstanding the test of time and various weather conditions, and represent the culture and lifestyle of the people.

Nepal is a beautiful landlocked country situated between India and China. It is known for its beautiful landscapes and stunning mountains, but it is also home to some of the most beautiful temples in the world. The uniqueness of these temples lies in the fact that they are made up of rocks and woods, also known for their abundance of carved rocks. These rocks have been used for centuries to create carved stones, statues and temples.

Nepal has a long history of using these rocks for such purposes and they have become an important part of the country's culture and identity. It has a rich cultural heritage and is home to some of the world's oldest and most stunning temples.

When it comes to the construction of such heritage sites, rocks are an integral part of the process. From the foundations to the walls, rocks are used in all aspects of temple building. They give the temple its strength and stability, and many times, they are intricately carved to create beautiful works of art. Throughout history, different types of rocks have been used for different purposes in the construction of temples. These temples are constructed using carved stones that are hand-crafted by local artisans. The art of stone carving has been a traditional practice in Nepal. The unique these temples have become a cultural symbol of Nepal.

The types of rocks used in temple construction can vary from region to region. In some cases, rocks are carved into specific shapes to give a particular look and feel to the temple. In other cases, rocks are used in their natural form. Rocks can also be used in combination with other materials to give a unique look to the temple.

AIM AND OBJECTIVES

This present study is aimed to find the types of rocks used in building different Statues, Monuments and Temples and the reason behind their uses for those specific purposes.

RESULTS

The carved rocks used to create the Nepalese temples are unique in their own right. They feature detailing that is unlike any other type of stone. Every temple is different, and no two are alike. This makes them a popular tourist attraction and a great way to explore the history and culture of Nepal.

Kathmandu Durbar Square, Patan Durbar Square and Bhaktapur Durbar Square are the major places located in the Kathmandu valley where one of the most iconic carved rock temples and statues are located. The temples located in those areas are believed to be more than 500 years old and are adorned with intricately carved sculptures of Hindu gods and goddesses. Dominantly sandstone and limestone are used for the construction of monuments in those locations. Unique Shiva lingam made up of quartzite is also found in the Jaggan Narayan temple of Patan Durbar Square (Figure.2). Various structures as well as fossils can also be observed in the rock blocks. Statues made up of joining various blocks as well as statues made up of single blocks are also observed (Figure.3).

Figure 1: Intricately carved sandstone in the Krishna temple, Patan

Figure 2: Shiva lingam made up of quartzite found in the Jaggan Narayan temple, Patan

Figure 3: Statues made up of carved rocks (a) Lion statue carved from a single limestone block (b) Elephant statue carved by joining metasandstone blocks

Figure 4: Entire wall including windows and door as well as the roof made with carved sandstone in the Chyasin Dewal temple of Patan Durbar Square

Figure 5: Fossil observed in the limestone found in the statue of Patan Durbar Square

Kakrebihar is a Hindu and Buddhist temple located in the Surkhet valley in Karnali province as both the statue of Buddha and Hindu gods like Ganesh, Shiva and Saraswati are found in this temple (Figure.7). Sandstone is dominantly used in the construction of these statues as well as the temple.

Figure 6: Ashoka pillar made up of carved sandstone at Lumbini

Figure 7: Kakrebihar temple made up of sandstone in Surkhet valley (source: Gaurav Dhwaj Khadka)

Ashoka pillar inside the Mayadevi temple in western Nepal is also a stone-carved pillar that is six meters in height and constructed by carving sandstone (Figure.6). This pillar is said to be the earliest stone carving structure within Nepal i.e., 3rd century.

The largest statue of God Vishnu carved in Budhanilkantha is over five meters long and is built from a single block of basalt (Figure.8).

Figure 8: Lying statue of God Vishnu made up of basalt at Budhanilkantha

A combination of carved rock along with metal can also be observed in various locations. The big bell of Patan Durbar Square named Taleju bell is one of the architectural marvels (Figure.10). The giant ancient bell is hung between two big carved sandstone pillars. Similarly, King Yoga Narendra Malla's statue made up of metal is beautifully placed on top of a carved limestone huge pillar at Patan Durbar Square (Figure.9).

Figure 9: Metal statue placed on the top of carved Limestone ahead of Krishna temple, Patan

Figure 10: Metal bell hung in between two big carved sandstone pillars at Patan Durbar Square

DISCUSSIONS

Rocks play an important role in the construction of temples. When it comes to the construction of temples, the use of rocks and stone has been the most popular choice of architects and designers. Different types of rocks have been used in different regions around the world. These materials have been used in the construction of temples, churches and other religious and spiritual buildings. Not only do they provide the strength and stability needed to build the structure, but they can also be intricately carved to create beautiful works of art. From granite to marble, sandstone to limestone, there are a variety of different types of rocks used in temple construction, each with its unique properties and symbolism.

The art of stone carving and the construction of temples using carved stones is an important part of Nepalese culture. These temples are not only beautiful, but also represent the cultural heritage of Nepal. It is a practice that has been passed down from generation to generation, and it is a tradition that is still practiced today. These rocks are often carved into specific shapes and Figures to give a unique look to the temple. The rocks are also often polished to give a smooth finish. The use of rocks and stones in temple construction has various benefits, including durability, cost-effectiveness, and spiritual and symbolic meaning.

The process of stone carving is a complex and time-consuming task. It requires a great deal of skill and precision to create the intricate designs and patterns that are used in the construction of these temples. The process begins by selecting a large stone block that is suitable for carving. This block is then cut into smaller sections, which are then carved into the desired shape using chisels and other tools. Once the stone is cut and shaped, the artisan begins to carve the intricate designs and patterns into the stone. This process is done by hand and requires a great deal of skill and patience. The artisan must ensure that all the details are precise and that the design flows naturally. Once the carving is complete, the stones are polished to give them a smooth finish. The final step in the process is to assemble the stones into the desired shape. This is done by carefully placing the stones together and securing them together.

The type of rock used in temple construction can have a great impact on the overall look and feel of the building. Different rocks can be carved into statues, used to form the foundations of the temple, and even used to bring good luck and protection. The various factors that make these rocks unique include their hardness and durability, which make them ideal for carving and construction. They also have a distinctive texture and color, which can be used to create unique and beautiful designs. The most common type of rocks used in the construction of statues and temples in Nepal are Limestone, marble, granite, basalt, quartzite and sandstone, with limestone and sandstone being the most commonly used rock for temple construction. These rocks are used in their natural form as well as in carved form.

Limestone is a sedimentary rock made up of calcite, which is a mineral that can be used as a rock-building material. Limestone is a very common rock in Nepal and is found in many places around the country. Limestone has a hardness of 3.5 on the Mohs scale and can be easily carved into all kinds of architectural shapes.

Granite is the most popular material for statues and temples, due to its hard and durable nature. It is also resistant to weathering and has a wide range of color options. Granite is often craved in intricate designs, making it an ideal choice for creating statues and temples.

Sandstone is a sedimentary rock that is made up of quartz along with different amounts of other constituents. It is a hard rock that is durable and can stand up to harsh weather conditions. Sandstone is also often used in temple construction. This type of rock is softer than granite, making it easier to carve, but it is still strong and durable. It is often used to create designs and sculptures, as well as to form walls and foundations.

Marble is a metamorphic rock that is made up of calcite and is usually white or light in color. Marble is slightly softer than granite, but it is still strong enough to withstand the elements and maintain its beauty over time. Marble has a beautiful, glossy finish, making it perfect for creating sculptures and designs as it has unique veining and color patterns.

These rocks are spread throughout the Himalayas. The middle part of the Siwalik is mainly composed of sandstone along with some of the stratigraphic units of the Lesser Himalaya. Quartzite, granite and limestone belongs geologically to the Lesser Himalayan zone. Marble is dominantly found in the northern portion of the Lesser Himalaya as well as in the Higher Himalaya zone.

Overall, hard rocks are the best materials to use for making statues and temples. They are able to withstand the elements and maintain their beauty for generations. Hard rocks like granite, marble, and limestone can be carved into beautiful designs. These materials are perfect for creating statues and temples that will stand the test of time. We also found that the rocks are often carved into specific shapes and Figures to give a unique look to the temple. This includes carved statues, pillars, and walls. The rocks and stones are also often polished to give a smooth finish.

There are rocks that are specifically chosen for their spiritual and symbolic meaning. These rocks can be carved into statues or used to form the foundations of the temple. For example, in Hindu temples, rocks from the holy river like Kaligandaki are often used to form the foundations of the temple. This is said to bring good luck and protection to the temple

The rock carving process is also an important source of income for many artisans in Nepal. The process is labor-intensive and requires a great deal of skill and patience. The artisans that practice this craft can earn a decent living and provide for their families.

CONCLUSION

The use of rocks and stones in the construction of temples has been around for centuries. Overall, there are many different types of rocks used in statues and temples, each with its unique properties. Marble, granite, sandstone, and limestone are the most used types of hard rock used in Nepal due to their availability, durability, weatherability, and ability to be carved into intricate stone sculptures. These rocks are used in both their natural form and in carved form. The rocks are often carved into specific shapes and Figures to give a unique look to the temple. This includes carved statues, pillars, and walls. The rocks are also often polished to give a smooth finish. The rocks and stones are durable and can stand up to harsh weather conditions. They are also easy to carve and shape, which makes them ideal for temple construction.

Additionally, the use of rocks and stones in temple construction is cost-effective. Rocks and stones are readily available and are relatively inexpensive. This also makes them an ideal choice for temple construction.

In conclusion, the use of rocks in temple construction is a tradition that has been around for centuries. These rocks as an important part of Nepalese culture and identity. They are seen as a symbol of the country’s history and heritage and are valued for their beauty and uniqueness. The intricate carvings of the temple make it a unique sight in Nepal. It is a must-visit for anyone visiting Nepal and is a great way to experience the beauty of the carved rock of Nepal.

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IMPORTANCE OF GROUNDWATER POTENTIAL MAPPING

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ABSTRACT

The use of groundwater resources can be delineated due to the consequences of rapid population growth and global environmental change. This article Figures out the state of art on groundwater potential mapping, a technique based on geographical database (GIS) that has major development in recent year using parameters such as; lineament density, geomorphology, lithology, soil type, texture, slope, rainfall, land use and its weighted value potential map and groundwater potential index (GWPI) can be prepared. This mapping helps to understand the groundwater condition, distribution of the specific area and helps to utilize the groundwater resources in effective way for the sustainable development.

Key Words: *Groundwater, Groundwater potential mapping, Geographical Information System, GWPI, Lineament density*

INTRODUCTION

Groundwater is the water located beneath the ground surface, filling the pore space between grains in bodies of sediments and clastic sedimentary rocks, filling cracks and cervices in all types of rocks. It is stored in and moves slowly through geological formation of soil, sand and rocks called aquifers. Groundwater is the largest sources of useable fresh water in the world. It makes up about 20% of the world's fresh water supply, which is about 0.61% of the entire world's water, including ocean and permanent ice.

Groundwater potential mapping describes the presence of groundwater in aquifer to enhance the sustainable management of groundwater resources in the specific area which is followed by the analysis in term of groundwater flow pattern, quality and its sustainability. This mapping helps to Figure out how aquifer are connected to the surface water bodies, groundwater flow system and how the quality of groundwater are changing through the decade of time. This mapping can be performed by studying geomorphology, lithology, soil type, texture, slope, drainage density, rainfall, land use of the specific area.

Geomorphology

Geomorphology is the study of landforms of an area which gives the information about the description and genesis of its landform which depends upon the evolution of geological formation. Geomorphological study describes the erosional and depositional landforms. Geomorphological factors have the highest weight in a potential mapping because it plays the important role in the storage and movement of groundwater at specific area.

Geology

Geology describes the Earth materials which include lithology, structures and processes acting on it, which is most important factor in groundwater potential mapping. As the groundwater occurrence depends on the permeability, porosity and conductivity of different rock types. These are important in terms of reflecting aquifer status, which shows groundwater storage. The collected geological information is given weighted value in attributed table of ArcGIS and made ready for the groundwater potential zone delineation.

Lineament Density

Lineament density are the linear, curvilinear features of beddings, joints, fractures, faults and topographic linearity and formations which can be easily observed in the satellite image. It is an important geological feature that shows rainfall penetration into the ground. It can be extracted by an automatic processing line tool in PCI_Geomatica_2017 software, and further processes of editing and watershed classification job can be done in ArcGIS spatial analyst tool environment. In areas where lineament density is high, groundwater feeding is higher; in areas where density is low, groundwater feeding is less. Therefore, high value weights are given for high-density lineaments and less value for low-density lineaments.

Slope

The slope is an essential parameter in groundwater investigation which describes the variation of altitude/elevation in a certain area. As slope ratio increases, surface flow increases, and infiltration into the ground is less. The slope map can be prepared with the help of ArcGIS and weighted can be given in the attribute table depending on its effect on groundwater potential occurrence.

Rainfall

Rainfall (precipitation) is one of the most important groundwater parameters which controls groundwater potential. Annual rainfall data can be collected from Department of Hydrology and Meteorology (collected in mm) and reclassified as very poor, poor, intermediate, good and very good.

Soil type and texture

Soil is an important parameter that influences rainfall infiltration into the ground. The rate and amount of infiltration vary depending on grain structure. Soil texture generally influences the moisture content in the soil, infiltration rate, hydraulic conductivity, and soil permeability, the grain size of the soil, and the specific composition of the soils, which in turn plays an important role in recharge potentiality. The soil type and texture of the study area was given individual weightage and became ready for GWPZs delineation.

Land use

It has the significant role in the runoff, infiltration, and groundwater recharge capacity of any watershed or sub basin. Land use/cover is projected, and given weightage in the attribute table of ArcGIS and prepared for groundwater potential delineation.

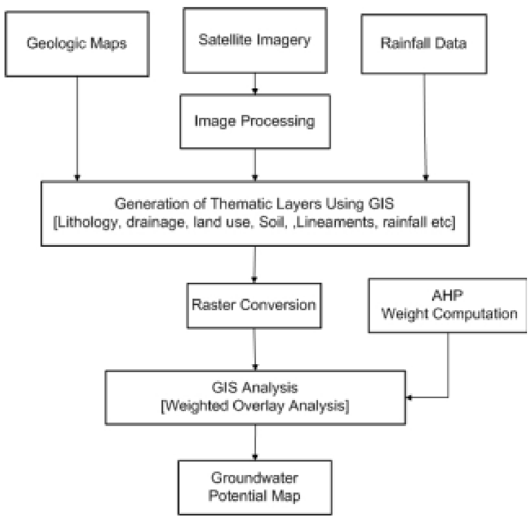

Figure 1: Methodology Diagram for Groundwater Potential Mapping

These parameters have been overlaid in Gis to determine the groundwater potential zone of the area. The groundwater potential index can be determined according to the AHP method as follows:

GWPI = Sr.Sw + LDr.LDw + Gr.Gw + GMr.GMw + LUr.LUw + STr.STw + Rr.Rw + DDr.DDw

where GWPI is groundwater potential index, S is Slope, LD is lineament density, G is geology, GM is geomorphology, LU is land use, ST is soil type, R is rainfall, and DD is drainage density. In addition, subscripts r and w refer to the rating and weight of the parameter, respectively.

OBJECTIVE

The main objectives of this article are:

- To establish an understanding of groundwater potential mapping to enhance the sustainable management.
- To figure out the importance of groundwater potential mapping in present context which will gives the quick identification and information for better utility.

METHODOLOGY

The necessary information for the article were collected from various sources such as books, various websites, articles published in journals etc.

FIELD INVESTIGATION AND DATA COLLECTION

Since the study is based on the secondary data, not any direct field was carried out for the purpose of article. All the information is collected from different sites through internet, journals etc.

DISCUSSION AND CONCLUSION

Groundwater is important source of water for agriculture, municipal and industrial use but these days due to human activities like excessive pumping groundwater is being depleted day by day. Therefore, to improve our understanding of groundwater resources issues, it is important to have a better understanding of the role that groundwater plays in the overall ecosystem of this region. To minimize the excessive use, the distribution of groundwater throughout the area should be known properly. Therefore, groundwater potential mapping helps to understand the groundwater condition, distribution of the specific area and helps to utilize the groundwater resources in effective way for the sustainable development.

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MINERAL RESOURCES IN BAGMATI PROVINCE

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ABSTRACT:

Bagmati province lies in the central portion of Nepal and covers an area of 20,300 sq.km. The province is enriched with various mineral resources that if explored, exploited, and utilized can generate self-sufficient revenue and budgets. Makwanpur, Ramechhap, Dhading, Dolkha, Sindhupalchowk, Sindhuli district have reported 'sub-economic' to 'economic' deposits whereas other districts report 'showing' or 'occurrence' A few placer deposits of gold are reported from Trishuli River. Non-metallic minerals are abundant with stratified deposits of limestone, dolomites, slates, magnesite, talc, clay, graphite, dimension stones like granites, slates, marble, quartzite, and coal and natural gas (methane). Ganesh Himal region shows occurrence of lead and zinc along with Ruby and Sapphire. Also, several semi-precious stones like Aquamarine, Tourmaline and Quartz crystal are associated with pegmatite veins. Though there are limitation due to harsh topography, lack of roadways, less interest from government, lack of investors nor sufficient research, but overcoming the problem with collaboration of local, awareness and interest from government can lead to prosperity of Bagmati Province for mineral resources.

Key Words: *Mineral Resources, showing, occurrence, exploration, exploitation.*

BACKGROUND

Minerals are naturally occurring inorganic solids, of definite chemical composition and atomic arrangement. These natural elements have become resources for humans as people perceive a use for it (Stanford & Moran, 1978). But not all minerals can be termed as a resource, to be a resource, it must be feasible, economic, and available under technical and cultural conditions (Paudel, D.P., 2019). Recent studies emphasis that mineral resources abundance has adverse consequences for economic growth (Wright and Czelusta, 2003). This suggests that, enriched with mineral resources and its exploitation, a nation tends to have higher industrial development and increased GDP.

Nepal lies in the center of 2400km Himalayan belt with vast natural resources including water, minerals, forests, agricultural & medicinal plants. Among these, mineral resources have been less explored and exploited. Nepal has over 200 years long history of indigenous mining activities as there is abundance of minerals required for industry including the most abundant limestone, copper, iron, lead-zinc, cobalt, coal, talc, red clay, granite, marble, gold, and precious & semi-precious stones, along with construction materials including aggregates, sand, gravel, dimension stones, decorative stones, paving stones and roofing slates (ESCAP1993; DMG, 2004; Kaphle,2020). All these resources are being explored, controlled, managed, and mined

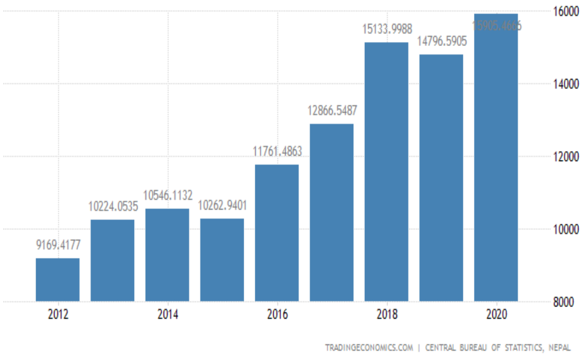

Figure 1. GDP from Mining in Nepal (Source: CBS,2020)

under the Department of Mines and Geology (DMG). GDP from Mining in Nepal increased to 15905.47 NPR Million in 2020 from 14796.59 NPR Million in 2019 (CBS, 2020) (Figure 1).

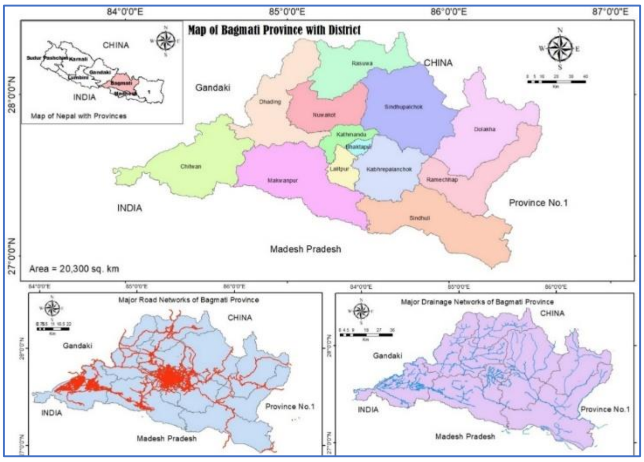

Figure 2. Map of Bagmati Province with major road networks and drainage.

After the adoption of Constitution of Nepal in September of 2015, Nepal has been divided into seven- provinces. The federal system has imposed the exploration and exploitation of mineral resources to each province for improved economic growth but there has been some dispute over mineral resources along boundaries region and cases of illegal mining activities. This article emphasizes mineral resources within the region of the Bagmati Province, the history of mining activities and future aspects of mineral exploration and exploitation. Moreover, the report carries an importance to the development of mineral resources in Bagmati Province to highlight problems and suggest solutions in generalized context.

OVERVIEW OF BAGMATI PROVINCE

Bagmati Province (Figure.2) is in central region of Nepal and includes the national capital Kathmandu. It occupies an area of 20,300 sq. km. i.e., 13.79% of the total area of the country. Geologically, the Bagmati Province can be divided into three major tectonic zones from south to north namely, the Siwalik Group, the Lesser Himalayan Zone and the Higher Himalayan Zone respectively bounded by major thrust of Himalaya**.** Moreover, the province has been explored and researched for mineral resources more than any other province but still, several voids are to be filled. Talalov reported many base metals from the central Nepal, and he considered the deposits are structurally controlled and are related to magmatic intrusions and are of skarn type (ESCAP, 1993). Makwanpur, Ramchhap, Lalitpur, Dhading, Rasuwa and Dolakha district report distribution of various mineral resources, showing and occurrence at the province evident from old prospects and mines in the region. There are vast deposits of dolomite, granite, limestone, quartzite, talc, and zinc for which federal government licenses have already been issued for mining and exploring. Some 45 mining licenses have been issued to various private miners in the province as per fiscal year 2018/19 (DMG,2019).

MINING HISTORY

Since ancient times, our ancestors had made use of mineral resources for their day-to-day activities by making tools, utensils, pottery, jewelry, temples artifacts with old school mining methods. Small scale historical iron, copper, lead, zinc, cobalt, nickel mines and placer gold panning in the major rivers and many slate, quartzite, dolomite and limestone quarries were operational in many districts (Kaphle, 2020). Old working pits, adits, smelting places, scattered slag and remnant of mine materials stand as solid proofs of such mining activities in the past. In many cases the name of the village is derived after the mines e.g., Taba Khani, Falam Khani, Shisa Khani, Sun Khani etc. (Kaphle, 2020). One of the best examples of abandoned mines in the Bagmati Province are the Iron mine of Those, Ramechhap. Other example includes, Dhusa copper mine in Dhading, Kharidhunga

Magnesite Quarry of Dolakha, Nepal Metal Company based on lead and zinc of Ganesh Himal and several other prospects. One will find amusing to know the fact that, Nepal was once the exporter of iron and copper to Tibet and Cobalt to India (Kaphle,2020). Much of the mineral resources exploitation held during Rana regime, but after 2007 B.S. mining activities were gradually closed because of change in the policy of

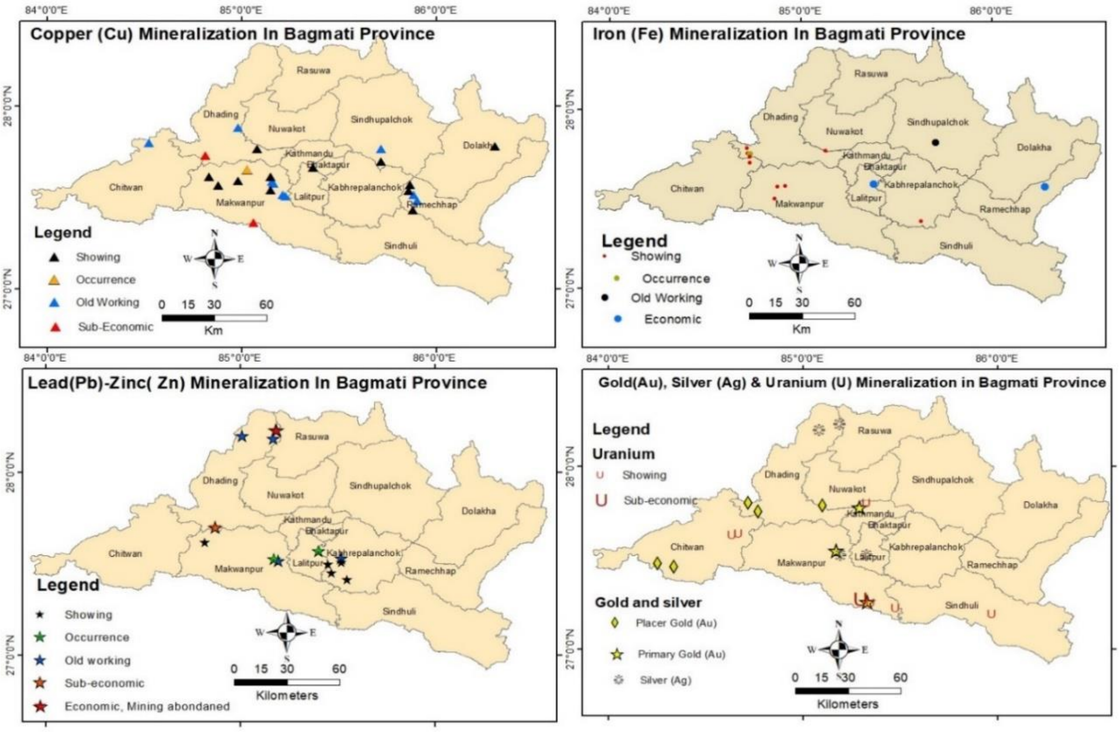

Figure 3. Major Metallic Mineral Deposits of Bagmati Province with present status. a) Copper, b) Iron, c) Lead and Zinc, d) Others (Source:DMG,2004).

new government, unavailability of charcoal for smelting, technical difficulties in mining at depth etc. Another cause for a pause of mineral exploitation is due to cheaper cost in importing mineral resources than extracting in harsh terrains. At present, most of the mineral resources utilization of the province is found to be associated with limestone quarries for cement industries, dimension stones excavation and construction aggregates from riverbed. Very few metallic minerals are being exploited while the gemstones market has found an illegal way of trading. It has been weakness of state government and federal government to develop mineral resource plans to exploit them and stop illegal mining activities.

MINERAL RESOURCES

A descriptive approach has been attained to further clarify the mineral resources of Bagmati Province based on their uses and their present status of development or future possibilities. The approach is given way by the literature from various authors, publication of ESCAP,1993 and various publication of 'Mineral Resources of Nepal' by DMG. Accordingly, DMG has divided the minerals into six sub sectors as: metallic, non-metallic, fuels minerals, gemstones, decorative stones, and construction minerals for easy access to exploration and exploitation.

Metallic Minerals

Bagmati Province is long known to have metallic mineral deposits such as copper, iron, lead- zinc, gold and silver have been extracted to make tools, weapons, and utensils (Figure 5). Also, several other metallic deposits like cobalt, antimony, arsenic, tin and tungsten, chromium, bismuth, mercury, molybdenum, and uranium are found to have deposits in Bagmati Province. About 20 metallic minerals are found in Bagmati Province. Among 20 minerals, only the important and economic deposits are discussed more in detail while others are shortly introduced.

Copper (Cu): Copper is the principal traditionally mined mineral of Bagmati Province. Copper is widely used in electrical industries for copper wires, also for making coins, alloys, utensils, and crafts. Copper is associated with the mineralization of chalcopyrite in large stratigraphic units. Along with chalcopyrite, there are several malachite and azurite coatings associated (ESCAP, 1993). The major copper deposits in the Bagmati Province are known from the Kalitar, Ipa-Baraghare, Agra Khola (Makwanpur), and Dhusa, Deurali (Dhading). There are several showings of mineral deposits like in Kalphu, Chibhar, Makhu, Shansa Pakha, etc. The major old workings are known from the Dhusa and Kalitar deposits.

Iron (Fe): Iron has been extensively mined in the Bagmati Province in the past. Those Iron mine is one of the oldest mines of Nepal. At present none of the iron mines are in production in Bagmati Province. Lot of iron showing has been reported from the province but not much detail study has been done. Some of the probable and possible mines that can be operated at economic scale are the Phulchauki Iron Deposit (Lalitpur), Those Iron Deposit (Ramechhap), and Jirbang at Chitwan (Kaphle, 2020;. ESCAP, 1993).

Lead and Zinc (Pb-Zn): Lead and Zinc are another important metal that have been mined since old days. Many lead resources occurred at the surface in the Lesser Himalayan region had been worked out extensively by the ancient people (DMG,2004). Pb-Zn are mostly located in dolomitic rocks of the Lesser and Higher Himalaya. Some of the economic lead-zinc deposit of Bagmati Province are known from Ganesh Himal (Dhading/ Rasuwa), Labang-Khairang (Makwanpur), and Phulchauki (Lalitpur) (Sah and Paudyal, 2019; Escap, 1993).

***Gold and Silver*:** Gold and silver are metals used for making ornaments, jewelry, coins, electroplating and many other purposes. Gold is found in Bagmati Province as both primary and placer deposit. Primary gold has been reported from the Halchok in Kathmandu, Damar and Chandi Khola in Makwanpur while placer deposits are planned from the Trishuli River, the Buri Gandaki, the Reu Khola, and the Marodi Khola. Similarly, few silver deposits have been reported as occurring or showing but no economic deposit have been reported. Silver is found in the Ganesh Himal, Baraghare associated with lead and zinc while few showing are noted from the Thosne Khola (Lalitpur) and the Manjit Khola (Dhading) (Kaphle, 2020; D MG, 2004).

Uranium: Uranium is a radioactive element that has been of interest as it releases immense radiation that has been used to produce energy though nuclear reactors.. Bagmati Province is also blessed with uranium deposit as showing, occurrence to sub economic concentrations. Great concentration of uranium can be found in the Tinbhangale (Makwanpur) in sandstone of the Middle Siwalik and the Upper Siwalik. Other deposits are reported from the Chandi Khola, the Chiruwa Khola (Makwanpur), the Mardar Khola, Panpa Khola (Chitwan), pegmatites from Jagat, and the Gagalphedi in Shivapuri area (DMG, 2004).

Non- Metallic Minerals

Non-Metallic minerals have a huge category which can be characterized as chemicals, fertilizers, abrasive, and refractory as one category while gemstones, decorative stones, construction materials and fuels differ to other categories. Bagmati Province is even richer in non-metallic resources. Nonmetallic minerals such as talc, magnesite, mica, limestone, dolomite, graphite, ochre, and clay have their abundance in Bagmati Province (Figure6).

Talc: Talc is one of the requirements for cosmetics and chocolates factories. Bagmati Province has significant deposits of talc being one of the potential resources to uplift the economy. Occurrences of talc bands, lenses, veins, and pockets are known in association with magnesite, dolomite and chloritic talc schists in different parts of Lalitpur, Dolkha, Sindhupalchok, Dhadhing, Chitwan and Makwanpur districts. Talc of Kharidhunga (Dolakha) is the largest deposit of the Bagmati Province and was mined before but the mine is not operating at present. There are several other occurrences of deposit like: deposit of Phalpu (Dolkha), Sallerkali, Dari, Phulping (Sindhupalchok) and deposits of Bandar Khola, Maldung (Dhading). These deposits are potential resources to exploit for coming years.

Magnesite: So far two occurrences and one economic deposit of magnesite is reported in the province. Phalpu (Dolkha) and Phulping (Sindhupalchok) are major occurrences while old mining works of Kharidhunga Magnesite Deposit of Dolkha is of profound quality with MgO content of 88 to 96%. The Kharidhunga Deposit is confined to the Nawakot Group in the Jhiku Carbonate Beds as developed in graphitic phyllite. The deposit is economic, but production has been limited for the past 20 years.

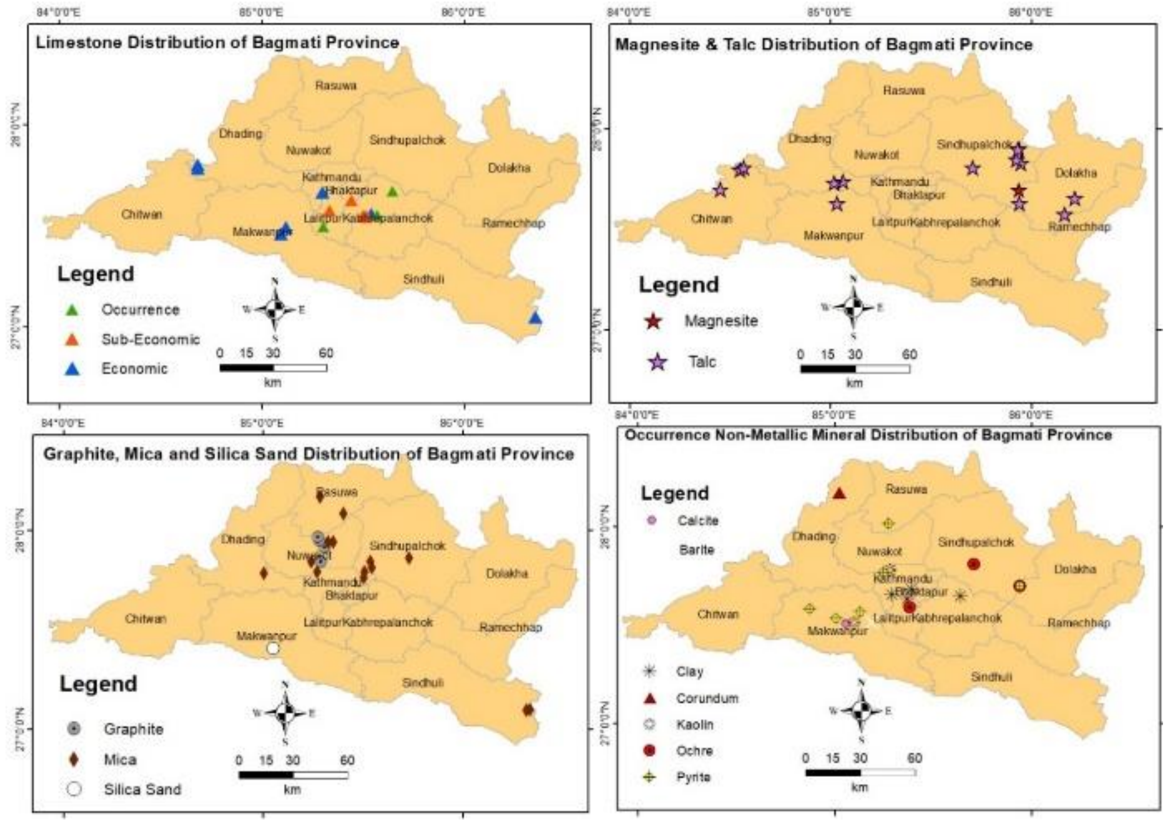

Figure 4: Non-Metallic Mineral Distribution of Bagmati Province (Source: DMG, 2004)

Silica Sand: A great reserve of 11.9 million tons of sand suitable for making glass and sandpaper has been reported from Karra

Khola, Makwanpur. Bagmati Province can take advantage of deposit in manufacturing of glass, bottles and abrasives.

Limestone: Limestone has been in use since ancient times for white washing of household and tanning of leather. Later, limestone found its way in cement industries and lime industries. At present, in Bagmati Province there are over 10 limestone quarries based on cement industries. Some proven and active limestone quarries are the Bhaisedovan-Okhare Deposit (Makwanpur), Majuwa, Jogimara-Beldanda (Dhading), Maruti-Kakaru deposit (Sindhuli), Rossi Limestone (Kabhre), and Chobhar, Lele (Lalitpur) (DMG, 2004; ESCAP ,1993). As per DMG 2018, annual production of limestone in the overall country was 6,621,614.96 million tons.

Mica: There are several showing and occurrence of mica deposits in pegmatites of Higher Himalayan crystalline. Few excavations and small-scale mining have been reported from Goganpani (Dhading), Lamagaon, Dandagaon (Nuwakot). Other occurrences are known from Nibuwagoan, Sepagaon, Kipche (Sindhupalchok), Godikhag (Rasuwa), Hattikharkha, Okhreni (Sindhuli).

Ochre: Few deposits of ochre have been reported from Kharidhunga (Dolkha), Phulchoki (Lalitpur) and Gorati (Sindhupalchok) of the Bagmati Province.

Clay and Kaolin: Most of the clay uses are reported from the Kathmandu valley. The likes of Thimi, Chobhar, Pachmane have significant clay deposits which have been used by potters and brick industries. Kaolin deposits are in Pachmane (Kathmandu) and Palung (Makwanpur) in the province.

Graphite: Graphite resources are keen to Nawakot district of Bagmati Province. The location of the deposit is Kharentar, Marthum Pass, Yaijo and Patibhanjynag. The later deposit of graphite has old workings.

Gemstones

The occurrence of gemstones is known mainly from the Higher Himalayan regions of Bagmati Province. Recorded gems in Bagmati Province are aquamarine/beryl, ruby-sapphire, quartz crystal and tourmaline. Jagat, Panchmane, Kagtigaon in Kathmandu; Baguwa, Tarkeghyang, Nibuwagaon in Sindhupalchok are some known localities for beryl (Figure 7). Gem quality, small crystals of red ruby and blue sapphire are known from Chumar, Ruyil, Shelghar, Pola, Shongla in Ruby valley, Dhadhing (Basset, 1984) and Lari, Ganesh Himal area in Rasuwa (Kaphle, 2011). Gem quality crystals of tourmaline are reported from pegmatites of Langtang valley (Rasuwa). The economic grade of rock crystals is known from pegmatite veins in Ralika (Nuwakot) and other deposits are

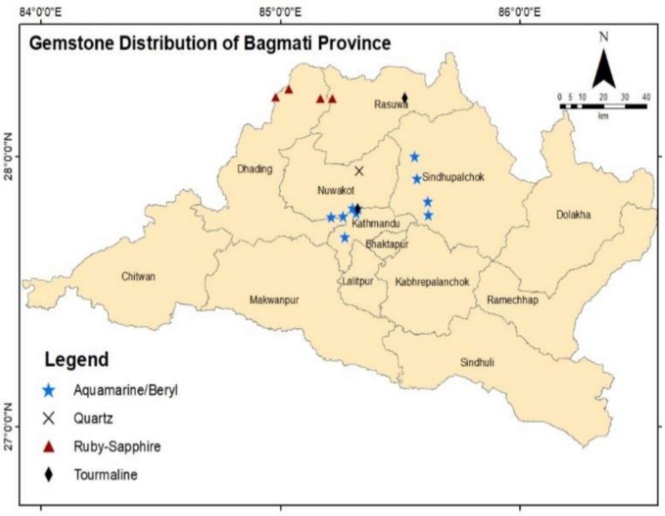

Figure 5: Gemstone Distribution of Bagmati Province (Source: DMG, 2004)

known from Dhading and Rasuwa (ESCAP ,1993; DMG, 2004).

Dimension Stones and Construction Materials

There are several occurrences and deposits of decorative stones and construction materials available from riverbeds and bed rock. They are the most visible resource of the country (Sah and Paudyal, 2019). Bagmati province is enriched with these resources as there are great rock bodies of slates, quartzites, marble, granite and metabasite intrusion (Figure 8). Similarly, there is an abundance of construction aggregates.

Slate: Slate is a widely distributed rock in Bagmati Province with several old and present workings. Slate has been used as roofing or facing stone. Slate occurrence and quarries have been reported from Gaighat (Chitwan), Benighat, Listi, Gajuri (Dhading), Agra Khola, Palung (Makwanpur), Belkot (Nuwakot), Melamchi, Sikharpur, Golche (Sindhupalchok), Bigu (Dolkha), Those (Ramechhap) and Ghatte Khola (Kabhre).

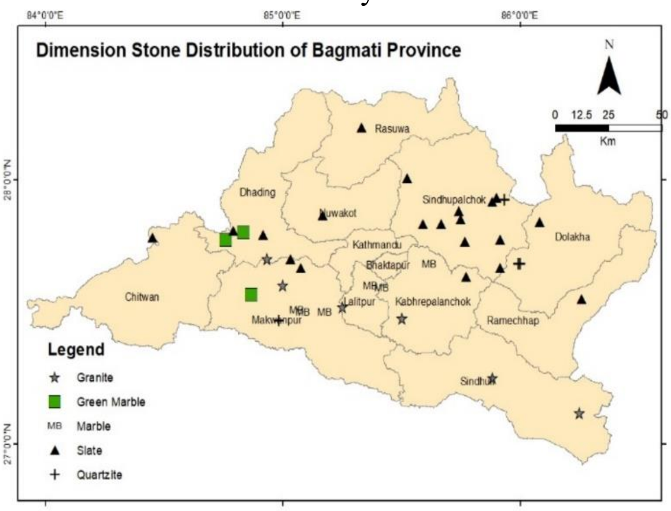

Figure 6:5 Dimension Stones Distribution of Bagmati Province (Source: DMG, 2004)

Quartzite: Quartzite is used as dimension stone and decorative stones. Quartzites are mostly reported from the Lesser Himalaya Zone. Major deposits are reported from Kharidhunga, Lakuri (Dolkha), Rashimadi (Makwanpur), Kodari (Sindhupalchok) and Dhading district.

Marble: Pink, gray and white colored marble deposit (1.63 million ton) is in Godavari, Lalitpur. Based on this deposit Godavari marble industries (Pvt.) Ltd. was established. Its annual production capacity was about 80,000m^2 of polished marble slabs. It was producing annually about 50,000m2 to 70,000m2 polished marble slabs, chips and aggregate as biproducts (Kaphle & Jnawali,1994. Other deposits are associated with Budichaur, Bhimsen and Bhaisedovan Marble in Makwanpur district.

Granites: Granite intrusion are abundant in the Lesser Himalaya and Higher Himalaya of Bagmati Province. Agra Khola, Ipa, Palung and Tistung granites have great potential for making granitic slabs as decorative stones or kitchen slabs. Also, Ulleri Augen Gneiss can also be used to make slabs as feldspar augen shape makes attraction. Coarse grained, massive granites are used as decorative and dimension stones. 3 prospecting licenses are issued by DMG (2018) but not a single granite quarry is in production.

Construction Aggregates: Most of the rivers of Bagmati Province flowing through lesser Himalaya and Siwalik are abundant with gravel and sands. The riverbed gravels are widely used because they are loose, uncemented and found in different shapes and sizes. All of these are used for different construction aggregates.

Fuel Minerals and Thermal Springs

There are few reports of fuel minerals like coal and gases from the Kathmandu (Figure 9) Valley sediments beside it, there are few lignite coal and peat in Siwalik Group of rocks.

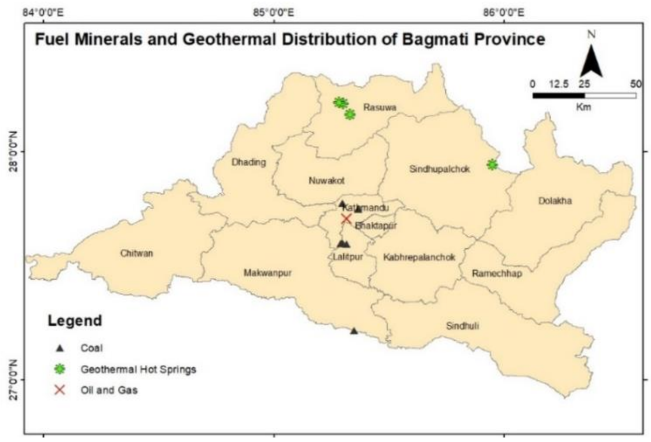

Figure 7: Fuel Minerals and Geothermal Springs Distribution of Bagmati Province (Source: DMG, 2004)

Quaternary Coal of Kathmandu Valley: The fluvio-lacustrine sediments of Kathmandu valley have reported large number of carbonaceous materials from impure peat to lignite coal seams. The lignite coal seams are reported from Lukundol, Gorkarna, and Dhukuchhap.

Kathmandu Valley Gas: Natural gas occurs in fluvio-lacustrine sediments of Kathmandu Valley. Several gas leakages from the subsurface have been reported from time to time in Valley. The total reserve of natural gas is expected to be around 300 million cubic m. The gas mainly consists of methane which has been proven for domestic use.

Hot Springs: Mostly geothermal are found to be associated with Main Central Thrust and confined to the banks Trishuli and Bhote Koshi Rivers of the Province. Geothermal Hot Springs are reported from Chilime, Lamde Khola and Parang of Rasuwa and from Kodari (Tatopani) of Sindhupalchok (DMG, 2004). Hot spring in Kodari have been used as tourist attractions and people take hot water bath to heal skin diseases and pain due to arthritis, etc.

IMPORTANCE OF MINERAL RESOURCES IN ECONOMIC DEVELOPMENT OF THE PROVINCE

Mineral resources could play an important role in the economic development of the Bagmati Province. The province is rich in mineral resources, but poor in an inability to extract them. If mineral resources can be developed and utilized, different benefits can be achieved. The mineral-based industries can promote industrial development in the Bagmati Province. The mineral-based industries provide employment opportunity to the people. The Central Bureau of Statistics (CBS) has projected that the economic growth rate of Bagmati will increase by 6.7 percent in the current fiscal year 2078-79. Bagmati Province is estimated to contribute 36.9 percent to the gross domestic product (GDP) with the highest amount of Rs 1.79 trillion. But the contribution of mining/ quarrying sector in the Bagmati Province's GDP is less than 3 percent (CBS, 2022).

There are good prospects for developing mines in Bagmati Province. The extraction of minerals such as natural gas and coal in Kathmandu Valley can reduce the growing energy demand of province/ country. Based on available mineral items such as limestone, iron, and copper, industries like chemical fertilizer and agricultural tool industries develop which promotes agricultural development. Granite slabs from various parts of the province are potential resources for economic development of minerals. Development of infrastructures and human capital for mining purposes could enhance the expansion of other non-mining related industries. The shortage of capital for exploration and exploitation of mineral resources in Province has become greatest problem.

PROBLEMS IN EXPLORATION AND EXPLOITATION OF MINERAL RESOURCES IN BAGMATI PROVINCE

There are many mineral resources in the Bagmati Province but very few have been exploited to its full potential. The state government and federal government don't seem to have keen interest in exploration and exploitation of possible mineral resources. Mineral exploration and mining activities are mostly done by private investors, that too has been limited to limestone quarrying by cement industries, sand and gravel excavation from riverbeds, clay extraction for potteries and few granites, marbles slabs extraction. Besides the non-metallic resources, metallic resources are not much exploited due to their difficulty in mining, processing, and marketing strategies. Most of the old copper, iron lead-zinc workings have been abandoned due to their large cost, complex geological controls, disseminated ores, lack of investors, transportation, and infrastructures.

Roadways are limited in the higher part of the province. The locals on the higher part of the province are hard to cope with, while illegal mining of gemstone is abundant. Further, it is not only the people but lack of more systematic geological understanding of mineralization is also the cause. We are constrained to lack different types of geological maps at different scales, lack of techniques and concepts of exploration of minerals, lack of studies in mineral genesis and lack of concept for exploration of disseminated ores. However, limitation can be overcome with more detailed research, dedicated work of geologist, investors, other parties like locals, transportation facilities and awareness to importance of mineral resources for development of both state government and overall country.

CONCLUSION

There are several 'showing, occurrence, subeconomic and economic' ranks of mineral resources with their own significant contribution to the Bagmati Province. Bagmati Province has been enriched with mineral resources along the Lesser Himalaya Zone as there are several metallic, industrial, dimensional and construction minerals or rocks present. Abundant deposits of metallic minerals are in Dhading, Ramechhap, Makwanpur, and Lalitpur Districts. Moreover, Kathmandu Valley, within Lesser Himalaya has reported lignite grade coal deposits and natural gas (methane). Higher Himalaya are quite promising for precious and semiprecious stones, marble and metallic minerals. Among the districts of Bagmati Province, Makwanpur, Ramechhap, Dhading and Dolkha district have great resources, but other district also has several abundances of certain minerals.

Bagmati Province has a great abundance of possible and potential mineral resources, but it is not easy to exploit and utilize mineral resources as there are several limitations and problems to be faced. The major problems are lack of research, dedications, lack of investors, rugged terrain, disseminated ore bodies, lack of concept, techniques and equipment and limited transportation aside urban areas. Future exploration, exploitation, and utilization of mineral resources with proper laws and regulation can be beneficial for Bagmati Province to generate great revenues for further development. Enriched with several great mineral deposits, Bagmati Province has a great future ahead as exporter of mineral resources with the likes of Kharidhunga Magnesite-Talc Deposits, Those Iron Deposits, Ganesh Himal Lead-Zinc and Ruby, Godavari Marbles, and construction aggregates.

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SPRING INVENTORY IN THE LOWER REACHES OF BARUWA RIVER, EASTERN NEPAL

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ABSTRACT

The Spring inventory was conducted in the eastern Siwalik Hills of Udayapur, Nepal where 54 springs were inventoried along the lower reaches of the Baruwa River. Hydrogeological characteristics, such as geology, slope, aspect, elevation, rock and soil distribution, landuse, geomorphology, and spring discharge were utilized to access the condition of springs in the study area. The study showed that 43% of the spring sources were found under natural conditions, i.e., open spring whereas 11% of them were of spring box type. Similarly, the other 37% spring were recorded as a concrete structure or tank while 7% was determined to as stone spout. The majority of springs are found in areas with depressed terrain and low elevations of 100–200 m with a flat to mild slope. Also, about 44.44% water spring water source has been decreased 3.7% are completely dry and 50% remains constant. Most of the springs are fed by annual precipitation and those located near the river valley are supported by (river) water course.

Key Words: *Spring, Hydrogeological Parameter, Siwalik, Baruwa River, Eastern Nepal*

INTRODUCTION

Spring is a natural resource that occurs when subsurface water seeps out of rocks, sediments, or soils and flows onto the earth's surface or into a body of surface water (Ogunbode & Ifabiyi, 2017). Spring is a dynamic flow in response to changes in climate, topography, geology, and geomorphology (Mays & Todd, 2005; Pitts & Alfaro, 2001). In complex rockey terrain occurrence of spring is closely related to geology (Pacheco & Alencoão, 2002). While in the Himalayas, spring occurrence is controlled by topography, rainfall, and land use/land cover type (Agarwal, Bhatnaga, Nema, & Agrawal, 2012; Mahamuni & Kulkarni, 2012; Tambe et al., 2012). Despite being unimaginably little in comparison to rivers and lakes, spring flows constitute an important part of the hydrological cycle. Springs also act as additional groundwater quality and quantity indicators to monitoring wells or water wells. A high degree of natural good quality of water can be found in Springwater.

Springs are the main source of water for locals in the mountainous region of Nepal. Many individuals obtain drinking water directly from springs. Groundwater occurrence is typically determined by hydrogeological factors such geology, slope, aspect, land use, rock and soil distribution, geomorphology, etc. The lower portions of the Baruwa River in some parts of Triyuga Municipality is carried out as the study area (Figure 1). Erratic rainfall, seismic activity, and ecological degradation associated with land-use change for infrastructural development are impacting mountain aquifer systems.

Water supplies are currently under significant stress and are particularly scarce in Nepal's central mountain area (Wester, Mishra, Mukherji, & Shrestha, 2019). The unavailibility of water has become an obstacle to local livelihood and their effort to reduce poverty in the villages of the mountain region. The surface water is contaminated by practices including dumping untreated household sewage and sludge, agricultural chemicals, and solid wastes, as well as encroaching on riverbanks to illegally harvest resources from riverbeds (Gurung et al., 2019). Despite being the primary source of water resource, very little/limited study or research has been done on spring resources of mountainous region in Nepal. A longer-term impact database with information on groundwater, hydrology, groundwater supply, and distribution would be necessary to address the issue of water availability, supply, and distribution. This study was created to produce knowledge on the mapping of groundwater spring sources using geospatial techniques in the watersheds of western Nepal, taking this issue into consideration. The Study area was focused on the Triyuga Municipality of Udayapur District (Figure 1). The Baruwa watershed covers an area of 329.647 Square Kilometres.

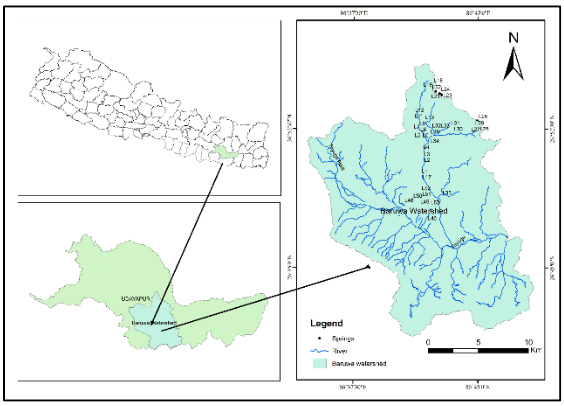

Figure 1: Political map Nepal and Udayapur District showing study area.

MATERIALS AND METHODS

The present study was conducted in March-April, and data were collected through fieldwork. The instruments used for collecting data were a geological hammer, burton compass, GPS (Garmin 64s), dilute hydrochloric acid (HCL), and water discharge measuring device. The procedure used in field methodologies used is presented (Figure 2)

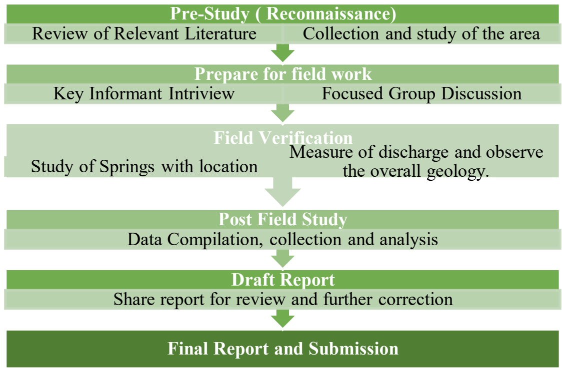

Figure 2: The flow chart shows the steps used in the Analysis of Spring inventory composites.

The spring inventory conducted in the field to determine the spring type, the rock type along with discharge measurement whenever possible. With the use of a bucket and timer, the volumetric method was used to measure the discharge rate of the spring. Questionnaire survey was done to collect further information about the spring and their uses.

GEOLOGY

Geology is the primary factor in groundwater occurrence and movements, depending on the formation of porosity and permeability. The infiltration capacity of the surface or near-surface layer is controlled by the erosion and weathering conditions of rocks and types of lithology, joint and fracture conditions, rock hardness, and orientation of rock strata. The geology of the study area dominantly comprises the Siwalik, Lesser Himalaya, and Higher Himalaya (Dhital, 2015). The Lower Siwaliks cropping out in this area are predominantly of interbedded red, purple, green, brown, and orange mudstones and grey, greenish grey, and purple sandstones (Dhital 2015). The Recent Deposits consist of unconsolidated gravels to fine sand and silt particles, and pore spaces between the grains easily allowed water to infiltrate subsurface strata. These recent deposits were found on the river terrace of Baruwa Khola.

RESULT AND DISCUSSION

This study assessed the existing water availability, uses and its impacts on watershed hydrology in Baruwa watersheds. The primary focus of the study was to locate and map existing spring sources and their status in terms of water discharge, uses, and their discharge trend. A total number of 54 springs (Figure 3) were spread across the Baruwa Watershed.

The springs in the study area mostly Depression, Fracture, Contact, and Karst springs which are either perennial or seasonal. Water discharge in the majority of the springs was found to be decreasing when compared with the flow of over past years. The water flow has decreased in approximately 44.44% of the springs. The water flow remains unchanged in 50% of the springs. In 1.85% of the springs, water flow has increased as compared to previous and 3.7% completely dried up.

Types of Spring

Spring results from an aquifer being filled to the point that the water overflows onto the land surface. Most of the springs in that study area flow annually through the Baruwa River, while few dry periodically. Based on spring classification of (Bryan, 1919), 70% are depression springs, 24% are fracture springs, and 6% are Karst springs (Figure 4).

The depression types of springs are distributed chiefly in the alluvial deposits, consisting of gravel to sand particles overlying the bedrocks.

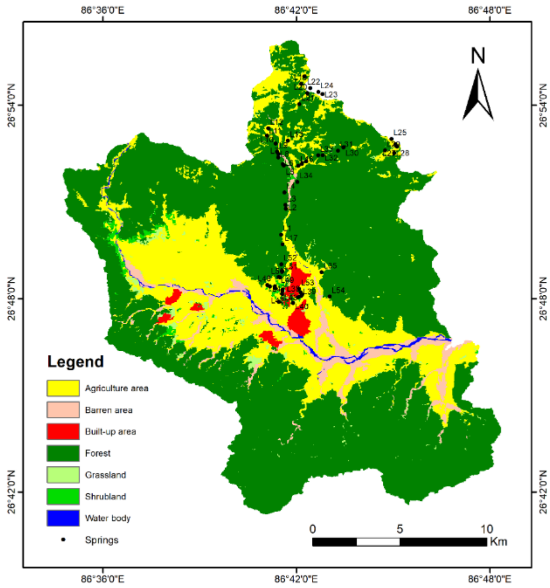

Figure 3: Landuse map of Baruwa Watershed showing the location of spring at Baruwa Watershed.

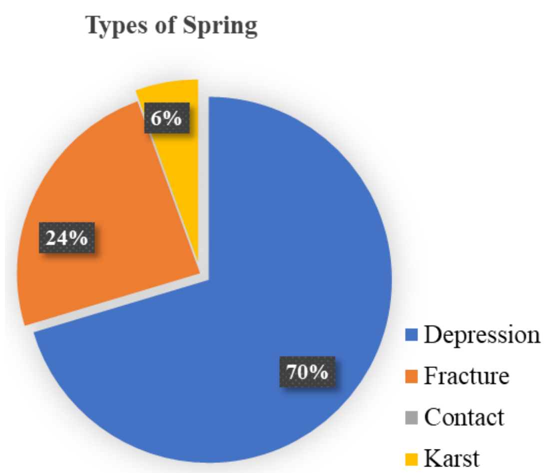

Figure 4: The Figure shows the different types of spring with a percentage value.

The jointed and bedding plane of impervious rocks is represented by a fractured spring. The karst spring could be in limestone and dolomite terrain when the movement water dissolves and carry away.

Landuse

The landuse map was prepared from the DEM produced by the Department of Survey. Seven landuse classes have been identified in the area: agriculture land, forest, grassland, shrubland, built-up area, water body, and barren land. A total of 52%

of spring is located in the forest, 39% in Agriculture land, 4% in grassland, and 5% in Shrubland (Figure 5).

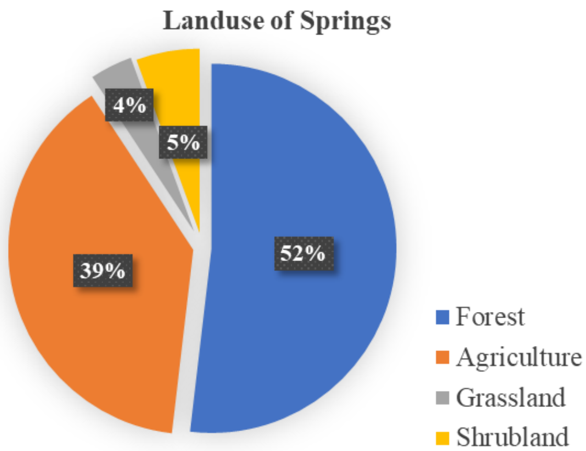

Figure 5: Pie diagram showing the percentage covered by Forest, Agriculture, Grassland, and Shrubland in the study area.

The majority of the area is comprised of forest and agricultural land. The cultivation lands are an excellent site for groundwater percolation due to porous soil, but it depends on soil type. Forest and grassland are classified under good groundwater prospects keeping in mind that these areas are generally water percolation through loose soil due to the primary root zone on the soil.

Condition of Springs

The condition of the spring at the source was analysed in Figure 6. About 43% of the springs are open springs, 37% are concrete tanks, 11% are Spring boxes, 7% are stone spouts, and 2% are wells. Generally, capturing water from an open spring is the most common and inexpensive process used since ancient times in the mountain areas, but the available spring can be polluted with waste products, bacteria, and soon. However, in recent years, villagers have constructed concrete structures or tanks to store spring water.

Springs are the only dependable source of water supply in the villages as not all villages have access to an improved water supply system. In the past, springs provided sufficient water for their basic requirements, and local people observed that the rainfall has drastically declined over the past two decades. However, in recent years, villagers have been facing a water shortage, and their springs are not producing sufficient water for their day-to-day activities.

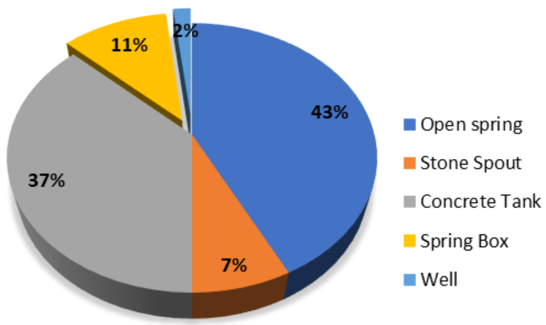

Figure 6: Conditions of the mapping springs in the watershed.

The underlying causes of water scarcity includes over growing population pressure, landuse changes, infrastructure development, increased water demand, the introduction of modern technology, and the negative impacts of climate change.

As depicted in Figure. 7, the flow from many springs has lessened. The findings revealed that the flow from approximately 44.44% of springs has reduced. 3.7% are completely dried, 50% remain constant, and 1.85% increase.

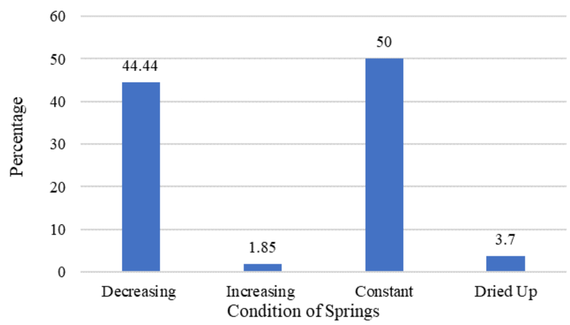

Figure. 7: Historical trend of Spring in the Baruwa watershed.

Similarly, due to increasing transportation facilities, people made it an easy method to use water. They had to travel a long distance to bring water previously, but the people of this area made water storage concrete tanks and collected water using pipes from the distant river and distributed it to all the Hamlet. Figure. 8 shows that about 28% of springs are not used today, and other remaining 72% of population don't depend entirely spring water.

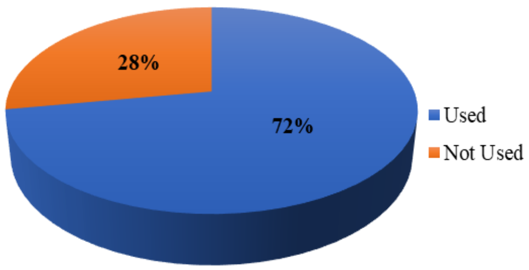

Figure. 8: Condition of spring water used in the village.

The people don't manage the waste, and no proper sanitation was used to keep Springs clean because of the availability of water tap at the house. It doesn't say all the people don't have the problem of water in this area.

Discharge of Spring

Measuring spring flow is another way of characterizing a spring's overall condition. The rate of water flow from the spring will vary with the seasons. It is necessary to measure the spring's flow at the end of the dry season to determine its potential reliable yield. A flow above 0.1 litres per second is sufficient to fill a 20-litre container in just three minutes, an acceptable waiting time. A good daily yield of about 3000 litres can be expected from such a spring, enough water for about 150 people. If the flow is only 0.05 litres per second, water storage tank of one cubic meter should be made to supply the same capacity populations. This enables the spring's flow over 24 hours to be stored, allowing enough water to be provided at peak demands and throughout the day to meet intermittent needs utilizing a tap in the structure. If the flow is 0.5 litters per second or more, the source would be suitable to supply multiple outlets or a piped gravity scheme

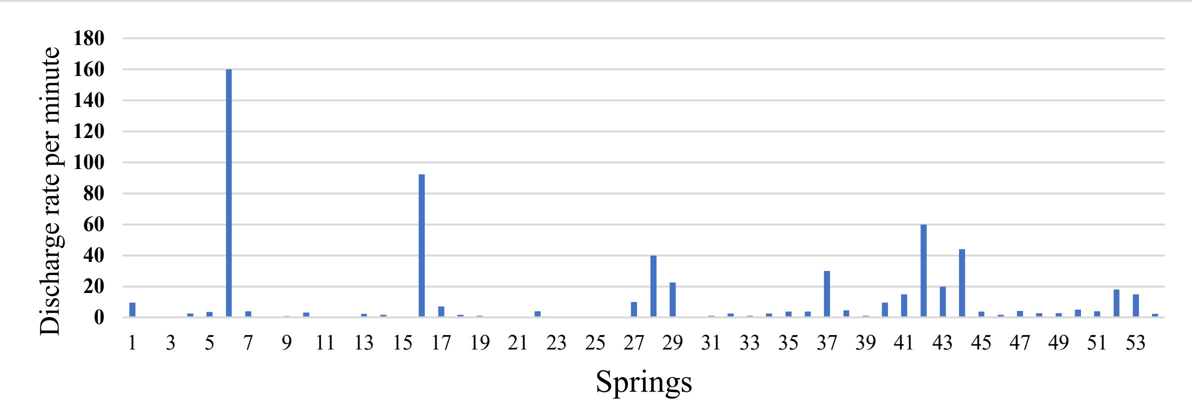

Figure. 9: Line Graph shows the measured 54 springs discharge of water in Baruwa Watershed

In the given study area total discharge measured is 49 out of 54 springs, and five springs discharge cannot be calculated. The measured maximum discharge is 160 litres per minute, and the minimum discharge is 0.53 litres per minute (Figure. 9). The highest release of 160 l/m can be an excellent water source for the future growing population in community. There are other few springs whose discharge is greater than 50 liters per minute. Managing this Spring can solve the problem of water for the growing population that community.

The spring discharge is the effect of geology, soil, vegetation, and soil. The area calculation of 54 discharges is very low and possible for small communities.

Water level of spring is in decreasing trend as per the locals. Since the springs are not sufficient to meet local demand, villagers explore other options to meet their water demand. Some of the initiatives that villagers are employing include piped water from distant spring sources. In some areas, the problem of water has become so acute that people use turbid river water to meet their water needs.

DISCUSSION AND CONCLUSION

The study mapped a total number of 54 springs in Triyuga Municipality. About 43% of the spring sources were found in natural conditions, i.e., open springs. 11 % of the spring source is ponds. 37% of the spring source is directly collected into concrete structures or tanks. Only 2% of the spring source is wells. As discussed earlier, water resources are becoming increasingly scarce in the study area. The shortage of water for drinking and other domestic purposes, especially during the dry periods, is of particular concern. In 44.44 % of the springs, water flow is decreasing. According to the local people, the water flow has reduced significantly as compared to 10 years ago, and about 3.7% of the spring sources have dried up in the watersheds. The decreasing tendency of rainfall amount complemented people's perceptions and, most importantly, the significant year-to-year variation of rainfall affects the spring sources every year at a different severity. Besides the variation of rain, other potential factors like excessive unplanned road construction, vanishing of traditional ponds, lakes, and wallows tectonic movement, and concreting and piping of sources also contributed to the drying springs (Gurung et al., 2019).

Despite the rapid drying of springs, the study found that in some parts, villagers access spring water without implementing adequate protection measures. The Springwater is very unhealthy and doesn't use the action of sanitation, and there is a lack of proper awareness about the use of water. The current water resources management strategy must be reviewed at the watershed scale to prevent this mass exodus from the villages and improve their water quality.

Similarly, the study shows that people stop using the spring water in many parts of the study area because of adequate and easy transport of water using the pipe. They made water storage tanks and distributed them to all the villagers. About 28% of the spring of this study area was not being used. In 72%, the people don't depend entirely on spring water because water availability through the pipe. A location such as Ratamate, Khabu of Triyuga Municipality, faces quite a scarcity of water problems.

Most of the springs are located in depressed topography, and elevation ranges from 100-200 masl with the flat-gentle slope in the spring inventory. The spring of that area considered in the present study shows that the spring is fed by precipitation from a mountain range to valley floors and the base of mountains. The present study represents the field condition of groundwater occurrence, and it can be used for detailed exploration of groundwater, which meets the demand for water in that area. Based on the current findings, the following future activities are recommended:

a. Immediate need for a watershed-level springs' restoration program with a participatory approach focusing on local communities, local government, and other stakeholders for the sustainability and upscale of good practices.

b. Building capacity of local communities, local governments, and other stakeholders to understand the multiple values of springs and the protection of watersheds.

c. Local government and communities should consider the values of watersheds before construction of any liner infrastructure.

d. The need to develop and mainstream the watershed management plan at the local developmental government plan.

e. Traditional lakes, ponds, and wallows are excellent ecological services for rechanging the downstream springs, and so on. Therefore, protecting such lakes, ponds, and wallows is crucial.

f. The spring protection measured has not been practised in some springs. A protective structure providing stability and may be made of concrete or masonry with a seal to prevent surface water from leaking is necessary.

g. A ditch, known as the interceptor drain, diverts surface water away from the spring box and prevents contamination due to infiltration from the surface, and use of the fence, keeps animals out of the spring area.

h. Improve the spring yield, clean the spring eye or source bed of debris, remove blockages to water flow into the spring, and remove overgrowth of vegetation. Simple improvements up-slope from the spring eye, such as surface drains or berms placed to slow the movement of runoff waters, permitting more rainwater to seep into the soil, can improve the aquifer that feeds a spring, thus improving spring yield.

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ROLE OF ATMOSPHERE IN THE GEOMORPHOLOGICAL PROCESSES: A CASE STUDY IN CHANDRAGIRI, KATHMANDU

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ABSTRACT

Like many other factors, the atmosphere has been playing an important role in the evolution of Earth's landforms. However, little research has been done to explore how it is making its involvement in geomorphology. This paper derives from the study of the geology, geography, climate, weather, and geomorphological processes of Chandragiri municipality. It will present and discuss findings from the collected data by establishing the relation between the morphological processes with the atmosphere. The study has demonstrated that the frequent and effective processes operating now are exogenic; weathering, erosion, and deposition, most of which aren't possible without the involvement of the atmosphere.

Key Words: *Atmosphere, Climate, Geology, Geomorphological processes*

BACKGROUND

Introduction

The surface of the Earth is an ever-changing feature. The motion of water (including ice) and wind over long periods shape the Earth's surface, which acts to level mountain ranges. Rivers and glacial ice transport soil and break down rock, depositing the material in sediments or taking it to the sea in solution.

Geomorphology is the scientific study of landforms and their evolution on the earth. Not just the earth, but sometimes other bodies as well. It includes the origin and evolution of topographic and bathymetric features enhanced by various processes occurring at the surface or near the surface. Changes are driven by several forces such as tectonic, fluvial, storm, aeolian, glacial, groundwater, climate, and tsunamis.

The earth's atmosphere is the layers of gases held by its gravitational pull that surrounds the earth. It indirectly participates in the modification of landforms: therefore, this cannot be directly observed and understood. The contemporary practice involves the observation of landfeatures and seeks the understanding that why the landscape looks the way they do. A relevant study was carried out in Kali Gandaki valley, analyzing the geomorphic events and their triggers (Bell et al., 2021). It emphasized the various forces like precipitation, temperature, anthropogenic forces, vegetation, etc. triggering the event. It remains interesting what kind of involvement the atmosphere makes in those events. So, research emphasizing the role of the atmosphere was carried out in the Chandragiri area of Kathmandu, Nepal where many geological studies have been conducted but the impact of the atmosphere hasn't been studied till now.

Objectives

Following research objectives would facilitate the achievement of the aim.

Extracting the weather and climate information of the Chandragiri area.

Analyzing the surface nature, landscapes of the Chandragiri area, and geomorphological processes prevailing there.

Synthesizing both sets of information to establish if correlation points exist between geomorphological processes, climate, and atmosphere.

MATERIALS AND METHODS

The analysis of the topic is dominantly done over the primary data. Observations of ongoing natural processes were used, generalizations from past experiences, general understanding, secondary sources such as journals, documentaries, related articles, and electronic media, as well as published secondary data. A camera and GPS were used to collect some data. For the collection of the data, considering the accessibility, Chandragiri area was selected. It consists of diverse land features like steep slopes, gentle slopes, and valley. The study covered the altitude ranging from 1,338 meters to2,550 meters.

RESULTS

Weather and climate information of the Chandragiri area

Chandragiri lies in the subtropical climate zone. According to the Climate and Weather Averages in Kathmandu, Nepal, (n.d.), the weather reports collected from 2005 to 2015 (Table 1), the climate of Kathmandu is warm, muggy, and partly cloudy during the wet season; but is comfortable and mostly clear in the dry season. They found the average annual precipitation is 1,154.7 mm.

Table 1: All year climate and weather average in Kathmandu, 2005 to 2015 (Climate and Weather Averages in Kathmandu, Nepal, n.d.)

High Temp (°F)	86
Low Temp (°F)	38
Mean Temp (°F)	67
Wind Speed (km/h)	5
Pressure (mmHg)	63.64
Humidity (%)	67
Precipitation (mm)	96.2

Geography and geology of the study Area

Chandragiri rests as a western part of Kathmandu valley, an intermontane basin. It has a predominantly hilly terrain with both gentle and steep slopes. It does share a good fraction of its area with Kathmandu valley.

The study area lies in the Sub-Himalayan tectonic basin. Hence, Sub-Himalayan rock hills surround the basin containing the Lacustrine and river deposit. The characteristics of geology distributed in the study area are tabulated (Table 2).

Table 2: Geological characteristics of the study area

Location	Geology
Chandragiri hill	Limestone, partly siliceous, medium to thick-bedded.
Baad Bhanjyang	Highly jointed and fractured sandstone and phyllite.
Dahachowk and Indrathan	Weathered whitish grey soil at the surface.
Srijanachowk and Balambu	River and lake sediments: Black-brown clay, silt, gravel.

Photograph 1: Erosion and deposition by Triveni River at Dahachowk.

Geomorphological process

Table 3: Geomorphological processes: their causes, occurrences, and effects on geomorphology

Geomorphological Processes			**Location**	**Causes**	**Effect**
Exogenic	Weathering	Physical	Chandragiri hill, Baad Bhanjyang, Indrathan	Temperature fluctuation, frost action	Medium
Exogenic	Weathering	Biological	Chandragiri hill, Purano Naikap, Indrathan, Baad Bhanjyang	Vegetation, burrowing animals, fungi microorganisms, etc.	Medium
Exogenic	Weathering	Chemical	Chandragiri hill	Due to the reaction of limestone with rainwater.	Low
Exogenic	Erosion	Running water and groundwater	Mostly Dahachowk (Figure1) to Naikap	Surface runoff on slopes, Balkhu river, and its tributaries.	Medium
Exogenic	Erosion	Wind	Thankot, Dahachowk	High-velocity wind entering through Nagdhunga (West to East)	Low
Exogenic	Erosion	Mass wasting	Chandragiri hill (C), Baad Bhanjyang (B), Dahachowk hill (D)	Steepness, weathering,wind, Rainfall, road traffics, etc.	Medium at B, Low at C and D.
Exogenic	Deposition	Running water and groundwater	Mostly Dahachowk (Figure1) to Naikap	Surface runoff on slopes, Balkhu river, and its tributaries.	Medium
Exogenic	Deposition	Wind	Not observed significantly.		Low
Exogenic	Deposition	Mass wasting (talus and scree)	Chandragiri hill, BaadBhanjyang, Dahachowk	Resulting from weathering and erosion	Medium
Endogenic: Most of them are very slow. Earthquake occurs, but infrequently.					

Diverse geomorphological processes were observed during the field study. All these processes prevail due to the geography, and characteristics of geology distributed over the area. Observed processes are detailed in the Table-3 above.

DISCUSSIONS

The geology of the Chandragiri area and the climatic and weather condition it suffers, give rise to diverse geomorphological processes. Critical analysis of the collected data shows that the evolution of landform taking place over the Chandragiri area is greatly affected by the exogenic processes.

Different types of erosion, deposition, and weathering are the dominant factors responsible for geomorphology. Due to the pressure gradient of gas, the wind blows carrying small particles from one location to another. Saltation and suspension are the major mode of sediment transport caused by wind action, however, comparatively, this action is less significant than other. Running water (flood, surface runoff), occurring due to rainfall, which is formed in the atmosphere, eats away rocks and loose material and deposits later.

These processes are leveling the surface over time, wearing away mountains, and filling in low spots. Landslides later covered with vegetation (life, existing and protected by the atmosphere), caving, and subsidence is locally observed processes resulting in surficial alternation. The occurrence of these processes and their intensity varies depending on the climatic and weather condition it experiences, which exist due to the presence of the sheer atmosphere.

Likewise explained above, this is what the whole earth's surface has been experiencing from the beginning of its life resulting in a very different appearance than other planets. Discussing the moon, it doesn't seem to change dramatically. Craters and other formations on its surface appear to be lasting forever (NASA Science Earth's Moon, 2021). Moon's surface hasn't evolved a lot as there is no erosion or deposition as of the Earth. All the influence of foreign bodies that it has on its surface always stays there. There is no rain, no wind, and no life since there is no atmosphere.

CONCLUSIONS

The climate of the Chandragiri area is generally warm and temperate. The geology consists of thin to thick-bedded limestones, highly jointed and fractured sandstone, and phyllite. Weathered soil, gravel, silts, and clays too are part of it. Effective geomorphological processes occurring are physical and biological weathering, erosion, and deposition due to running water, mass wasting, and wind. Relating all these events, climate, and weather to the atmosphere, when overviewed, all of them are highly influenced by the atmosphere. As a result, the atmosphere surrounding the Earth is solely responsible for the majority of geomorphic processes and features. However, geomorphic processes influenced by the atmosphere vary depending on altitude, weather, climate, and many other factors in other parts of the world.

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HYDROGEOLOGICAL CONDITION OF PARSAGADHI MUNICIPALITY, PARSA DISTRICT, NEPAL

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ABSTRACT

Parsagadhi Municipality lies in southern part of Indo-Gangetic plain i.e. Terai, which is underlain by thick quaternary alluvium deposits. Geologically, the area lies in Middle Terai and Quaternary Alluvium deposit. It consists of mainly Clay, Silt, Coarse Sand, Gravel, Pebble, Cobble and Boulder. Parsagadhi Municipality area is more potential for groundwater recharge as well as discharge zone due to low elevation and shallow water table of area and possesses rich groundwater potential. Which can be used for the large scale irrigation in this area. Artesian condition occurs in some part of the study area. The primary data and secondary information was collected in filed. The secondary information and primary data collected in the field and interpretation based on the satellite imageries had been carried out to extract relevant information and update the geological map of the area. Also the Water Quality index shows the quality of the drinking water as well as irrigation of the study area. From 51 samples of the area the quality of the groundwater was determine. As per WQI results, 1.96% of the groundwater samples are in excellent quality, 5.88 percent samples are in good quality, 54.9 percent have poor quality, 35.29 percent sample are in very poor quality and remaining 1.96 percent are unsuitable for drinking. and correlated with Nepal Drinking Water Quality Standard (NDWQS) and WHO.

INTRODUCTION

Hydrogeological condition of the study area defines the groundwater quantity as well as quality of an area. During, hydrogeological investigation of the area, groundwater potential of the area is determined. The geologically study area consist of Middle Terai and recent alluvium deposits. The study area consists of silt, gravel, pebble, boulder of southern part of Indo-Gangetic Plain. The groundwater is the major source of water for drinking and irrigation purpose. (Itihara, 1972).The groundwater in the study area is considered as a reliable and sustainable source of water supply as it is abundantly available in the region. (Pathak, 2016)

STUDY AREA

Parsa district is divided into 14 local levels. Parsagadhi Municipality is part of it. Which belongs to central terai region of Nepal. It lies in the north part of Parsa district headquarter, and surrounded by Birgunj and Parsa Wildlife Reservoir in north, Birgunj Metropolitan City in south, Belwa VDC in east and Sakhuwa Prasauni VDC in west. The total area of the Parsagadhi Municipality is 99.69 square kilometers. It has extended east west with 8.6 kilometers and north south with 16.2 kilometers. The topographical base map that completely cover the study area of Parsa district at scale of 1:25000.

Majority of the population of Parsagadhi Municipality are engaged in agriculture, which main source of income. Economic condition of the people of Parsagadhi Municipality is moderate. The location of the study area shown in Figure 1

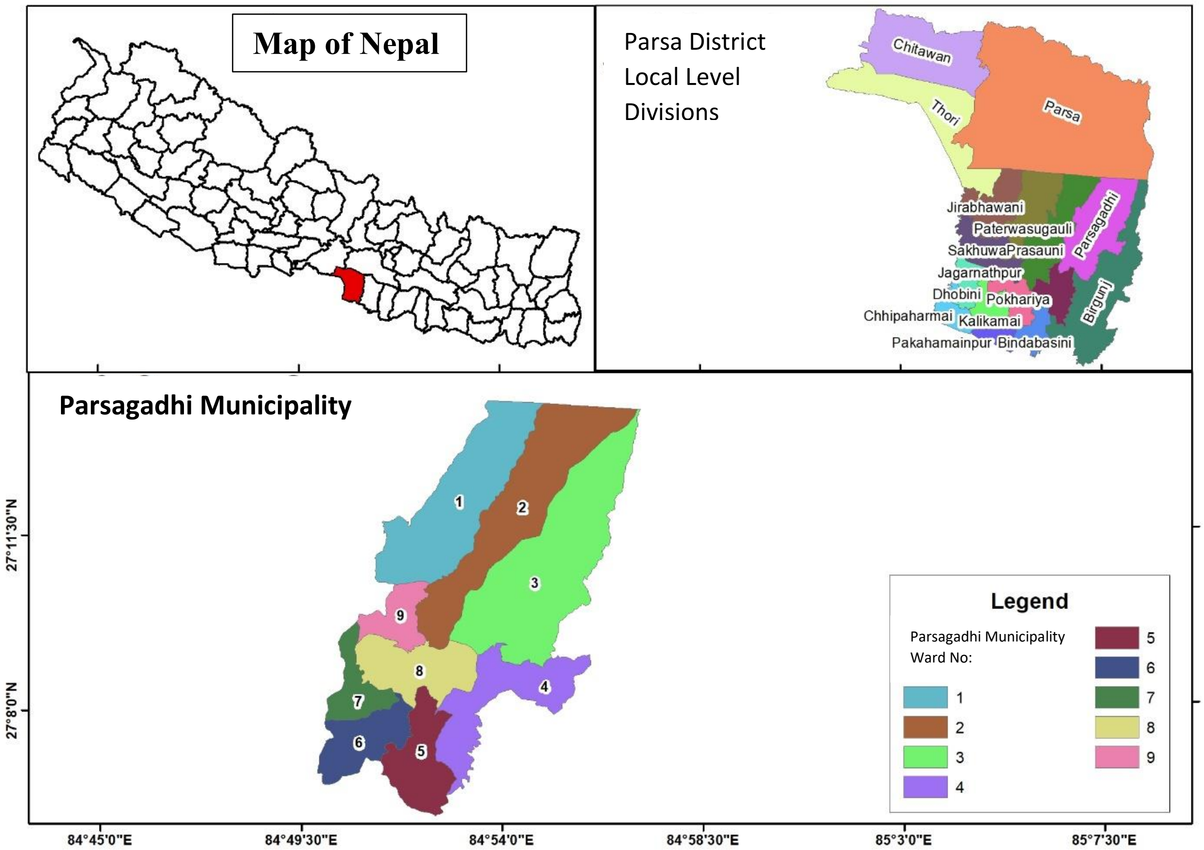


Figure 1 Location Map of Study Area

TOPOGRAPHY AND DRAINAGE

The topography of the study area is generally plain area gently sloping towards the south part of the area. The minimum elevation of the area is 61m above M.S.l. which observed in southern part of the area and maximum elevation is 194m above M.S.l, observed northern part of the area. The study area is cover with alluvium deposit in the flat Terai plain.

The major river that run through the study area originate in the Siwalik Zone (Mahabharat Mountain Range) and flow from north to south across the Terai Plain. Some of the major rivers from east to west of the study area are Bhedaha Khola, Aamoda Khola, Dokar Khola, Phanti Khola, Harpur Khola, Megha Khola, Dora Khola, Singiyani Khola, Tilabe Khola, Phpkaha Khola and Aragorana Khola respectively.

GEOLOGY

Geologically, there are mainly two Formations which are the Middle Terai and the Recent Alluvium Deposits (Quaternary Deposit) (DMG, 1984).

The Middle Terai consists of sand, silt and clay whereas the Recent Alluvium Deposits consists of sand, gravel, pebble, Cobble and Boulder. The Geological Map of study area shown in Figure3.

SUB SURFACE GEOLOGY

The subsurface lithology is composed of fine sand, coarse sand, silt, silty clay, loam, sandy loam with intercalation of clays as well as detritus of quaternary age. There is relatively uniform distribution of sediments in the underlying alluvial deposits and the sequence shows little change in lithology. The lithology is determined by the Drilling Followed by Borehole Survey.

types. Data can be generated directed from filed and laboratory are primary source and data other than primary are secondary source of data. To fulfill the mentions

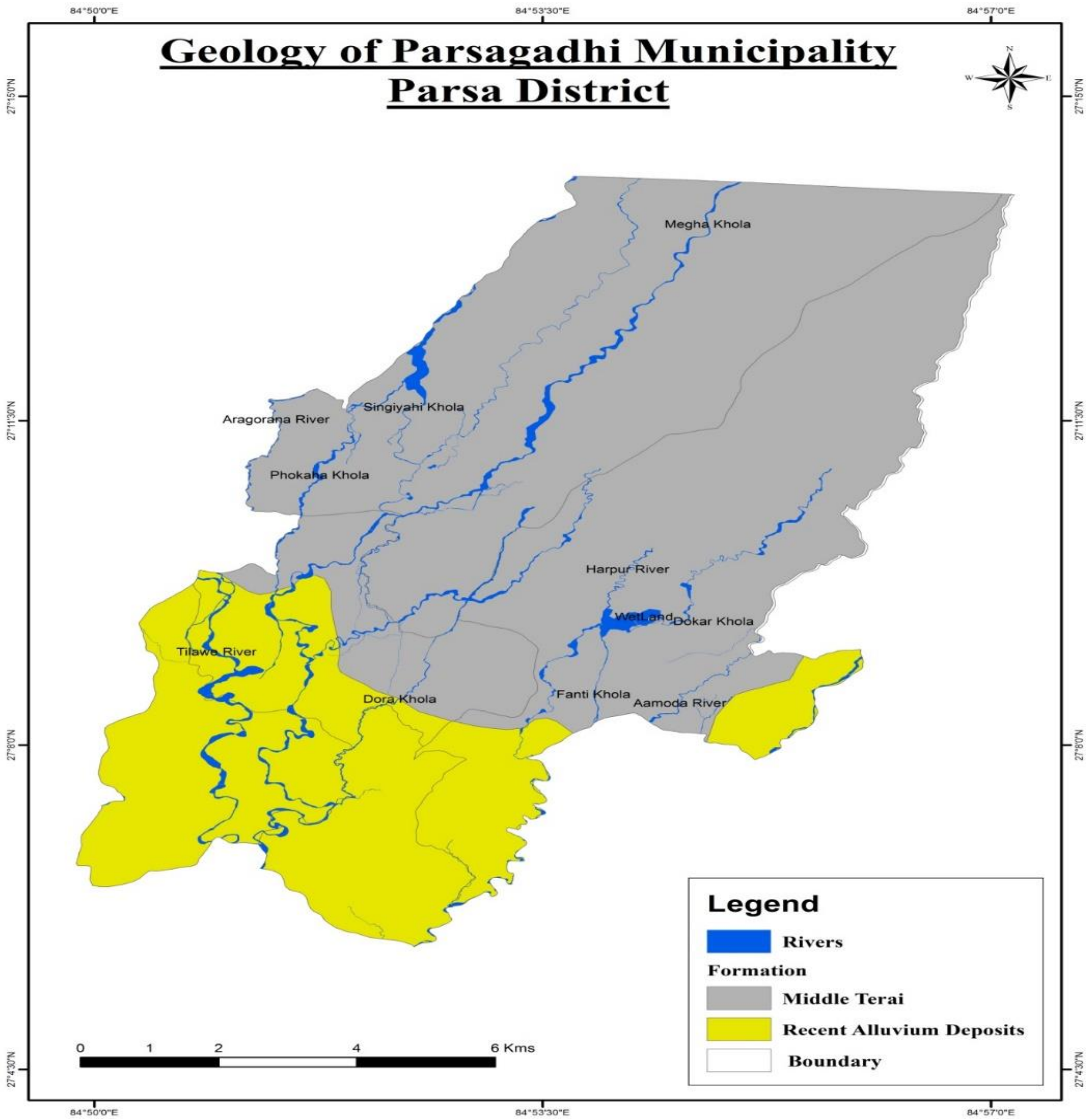


Figure.2 Geological Map of Study Area

OBJECTIVE

The major objectives of this research is to determination of hydrogeological condition of study area which relates to determination of groundwater potential, Water Quality of the area.

METHODOLOGY

The methodology used to collect of data from source as primary and secondary data

objectives of the research, the following methodologies area applied.

During the study various data were collected from the topographic map of the area at 1:25a000 provided by Department of Survey and geological map provided by Department of Mines and Geology while secondary data were collected from previous report and journals. The field survey was conducted for the collecting primary data and sampling for the laboratory study. In-situ test was conduct for pH of the groundwater using PH meter and also sample was collected in the clean sample jar (500 ml) and analysis it within 24 hours in laboratory. Nitrate, potassium, phosphate was determined by drinking water test kit and the presence of organic matter was determined in laboratory.

After measuring all the physio-chemical parameters, the obtained values were compared with National Drinking Water Quality Standard (NDWQS), 2005 and World Health Organization (WHO) standards.

Data were analyzed by the help the software ArcGIS and Rock Works which were used to interpret the data collected. The groundwater potential zone was delineated by using ArcGIS and remote sensing method, the different thematic layer like geology, geomorphology, land use land cover, drainage density, slope etc., were prepared in ArcGIS. Also data were calculated and analysis in given below method for Water Quality Index.

WATER QUALITY INDEX (WQI)

The drinking water quality index (WQI) was calculated. Like the other indices systems, which relates a groups of water quality parameter to a common scale and combines then into a single number in accordance with a chosen method of computation. The preferred use of the WQI is to assess trends in water quality for management purpose, but it is not intended as an absolute measure of population level of actual water quality. (Srivastava, 2007). Application of WQI is a useful method in assessing the water quality. WQI was calculated considering all those eleven physio-chemical parameters using NDWQS-2005 and WHO standards by following the formula given by Brown (Brown, 1972) as follows and the status of water quality was classified as per (Chatterjee, 2002).

$$WQI = \sum_{n=1}^{n} \mathrm{Wi} \times \mathrm{qi}$$

Where,

The unit weight factor (Wi) is calculated as Wi = 1/5 = 0.2

The quality rating qi is determined as follows:

$$qi = \frac{100\,(Vo - Vi)}{(\mathrm{Si} - \mathrm{Vi})}$$

Where,

Vo = Observed value of the nth parameters at a given sampling station

Si = Standard permissible value of nth parameter

Vi= Ideal value of the nth parameter in pure water

All the ideal values (Vi) are taken as zero for the drinking water except for pH = 7.0. The unit weights

RESULT AND DISCUSSION

The interpretation of water depth and water quality parameter helps to find out the current status of water level and the variation of physiochemical characteristics of groundwater of Parsagadi Municipality. The quality of groundwater gives the idea of suitability for drinking domestic, agricultural and industrial purposes.

GROUND WATER CONDITIONS

The study area consists of the alluvium deposits sediments which is the higher potential for groundwater presence. The quantity of the groundwater is available more than enough. So the study area consists of higher amount of groundwater use for drinking purpose, irrigation and fish farming. There are also lower ground water table in which observed the artesian well in the study area and mostly shallow well in the area. The porous and permeable pediment deposits from the main large aquifer system in this area. The aquifer system is multilayer in

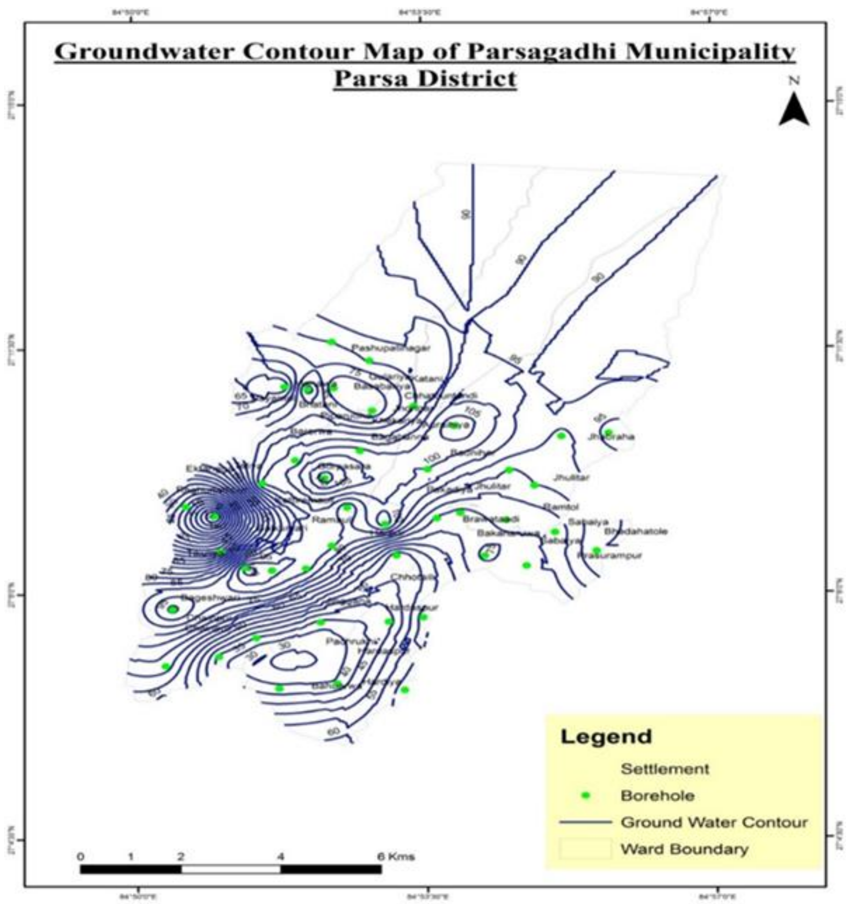
nature, as commonly found in alluvial deposits. Groundwater condition is under unconfined or water table types in shallow aquifer and leaky or semiconfined in deeper aquifer. Based on the drilling data. Perched water table condition also present in places.

GROUNDWATER POTENTIAL ZONE

To delineation of groundwater potential zone there are different thematic layer was prepared in the ArcGIS with the help of different primary and secondary data. It is used to determine of the groundwater condition and examine groundwater recharge zone. The various thematic layer which used to determine groundwater potential zone is given by: Groundwater level, geology, geomorphology, land use and land cover, slope, drainage density and soil texture.

Groundwater Level or Static Water Level

Ground Water level of the study area are mostly in shallow zone. It also determined the artesian zone many place but some place like Tikuliya, Chainpur located at south east and southern part. Water level of the area varies from 0m to 48.7m from the surface level, these area consists of shallow static water level.



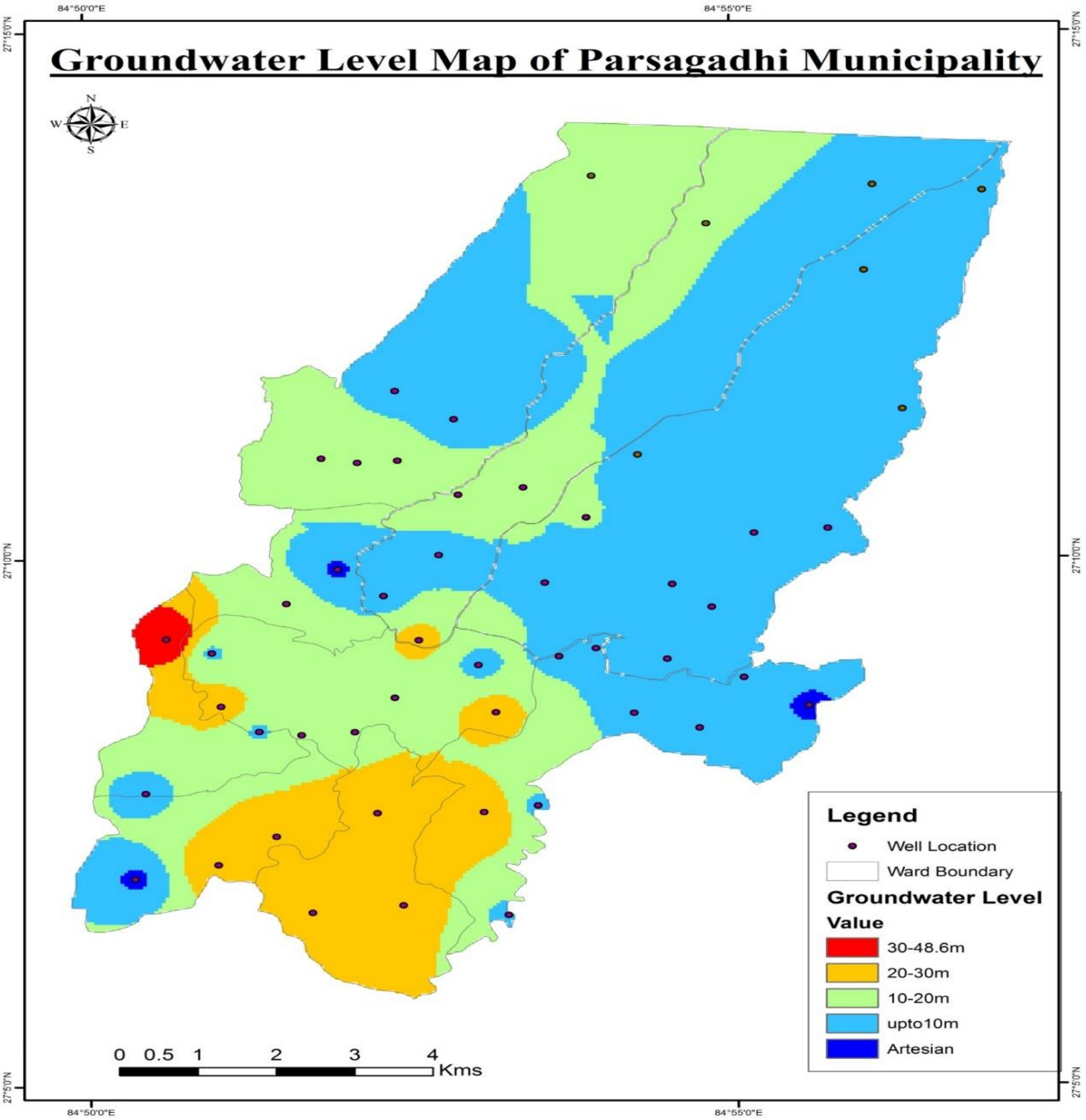


Figure.4 Groundwater Level map of Study Area

Geology

The geology of the study area lies in the southern part of Indo-Gangetic Plain, mainly composed of alluvium deposits. Geologically, the area consists of two formations i.e. Middle Terai and Recent Alluvium Deposits (Quaternary deposits) (DMG,1984). Sand, silt and clay found in Middle Terai and Recent Alluvium deposits consists of sand, gravel, pebble, cobble and boulder.

Geomorphology

The geomorphology of the study area consists of three different land type which are Flood Plain, Alluvium Deposits and Flat Land. The geomorphology of the are shows the plain area of Terai.

Land Use Land Cover

Land use land cover of the area are important for the estimation of recharge in groundwater (infiltration) and surface runoff. In the study area, the land use land cover was categorized into 8 different divisions which are agricultural land, industrial area, forest, commercial land, river and lake area, residential area, cultural land and public land which gave idea for the potential of infiltration of precipitation water. Porous or permeable land, such as soils with high sand content or vegetation, facilitates infiltration.

Slope

Slope angle and length affects runoff generated when rain falls to the surface. Hill slope orientation affects the microclimate of a place. As the slope of the surface increases, so does the local sun angle up to point. As the local sun angle increases, the intensity of heating increases, causing warmer surface temperatures and, likely, increased evaporation. Orientation of the hill slope is certainly important too. Those slopes which face into the sun receive more radiation than those facing away. Thus inclined surfaces facing into the sun tend to be warmer and drier, than flatter surfaces facing way from the sun. From the slope map it could be revealed that Parsagadhi Municipality has little ranges of slope. It is almost flat and most of the area has less than 1% slope. However, the slope ranged from less than 1% to 5%

Drainage Density

Drainage Density is the density of the water flow or surface flow of water which is affect to the groundwater potential as well as recharge of groundwater. The higher the drainage density, also the higher of runoff therefore the decrease in infiltration. So during delineation of groundwater potential zone drainage density is inversely affected. In the study area the drainage density is higher in the central part where as the lower drainage density is observed in northern part of the study area.

Soil Texture

Soil texture is another important part for the groundwater potential delineation which gave the proper information about the surface as well as subsurface details which directly affect to groundwater recharge. The study area consists of Silty Loam, Loam and Loamy Sand soil texture which can observe in given Figure below

Groundwater Potential Zone Map

From the above 7 thematic layers, the groundwater potential zone map was prepared which can delineate the groundwater potential zone. In the study area, the higher potential can be observed in the southern part of the study area section and lower potential for groundwater is central section of the study area.

WATER QUALITY INDEX (WQI)

In the present study, the application of WQI gives a comparative evaluation of water quality at different sampling locations. Out of 51 samples, 1.96percent of the groundwater samples are in excellent condition,5.88 percent samples have good quality, 54.9 percent have poor quality, 35.29 percent sample are in very poor quality and remaining 1.96 percent are unsuitable for drinking. The WQI distribution of sampling wells the study area is presented below in Figure 13 and table 2.

The different water quality status of the sampling wells can be attributed to the factors like septic contamination, agricultural percolation, construction and demolition activities and direct influx of rainwater in the open wells. And, seasonal fluctuation in water quality might be because the monsoonal water influx and the dilution effect.

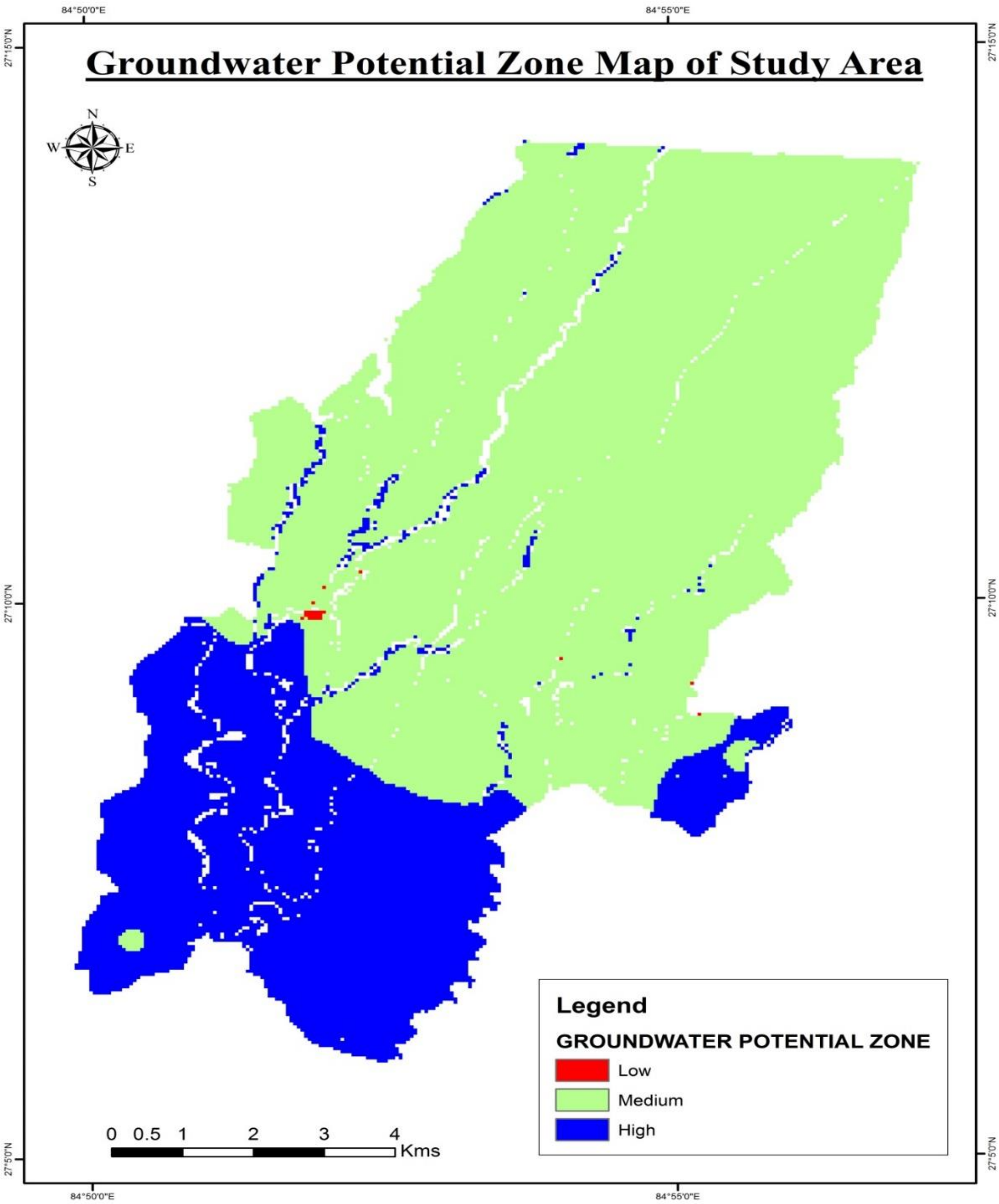


Figure.5. Groundwater Potential Zone of Study Area

Table 2 WQI of Samples

S.N.	WQI Range	Water Quality Status	No. of Samples	Percentage(%)
1	0-25	Excellent	1	1.96
2	26-50	Good	3	5.88
3	51-75	Poor	28	54.90
4	76-100	Very Poor	18	35.29
5	100 and above	Unsuitable For Drinking	1	1.96
		Total	51	100

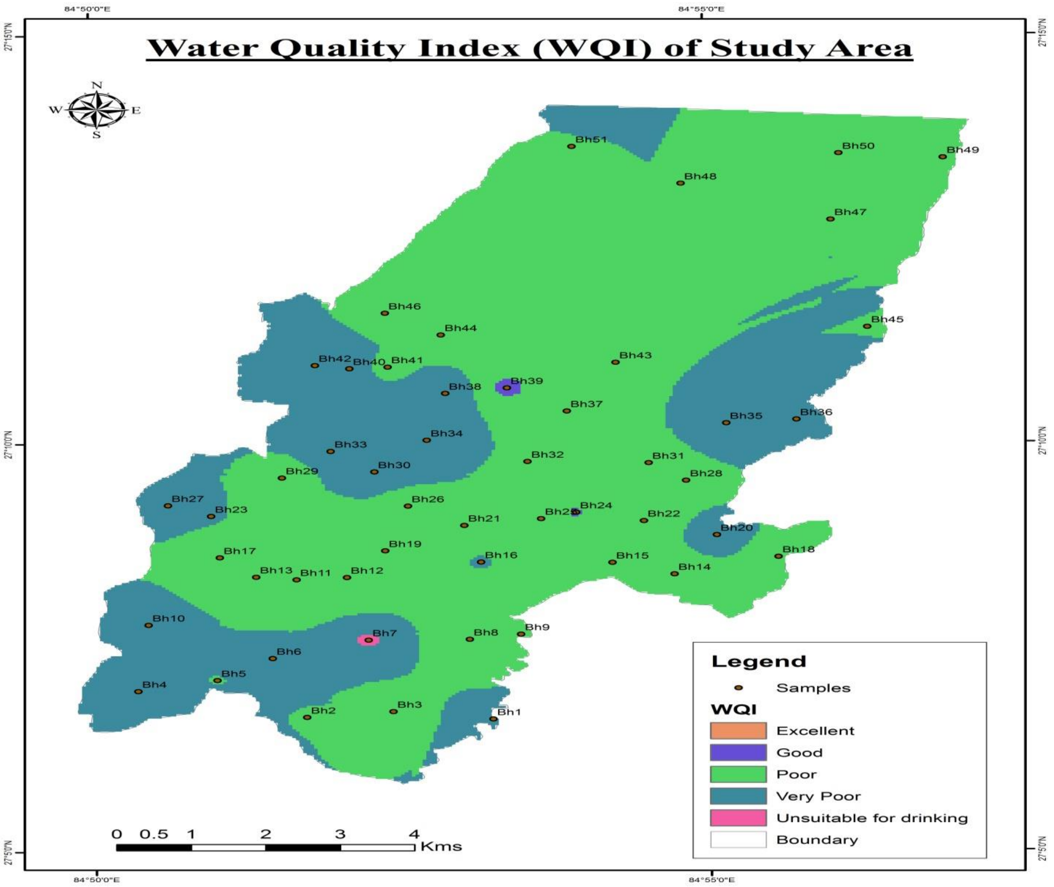


Figure.6 WQI of Study Area

CONCLUSION

Hydrogeological condition was carried out in Parsagadhi Municipality, Parsa distrct. The area consists of Middle Terai and Quaternary alluvial deposits. The objectives of hydrogeological condition of the area was to determine the ground water potential zone, water quality and hydrogeological condition of the area. From 51 samples of the area the quality of the groundwater was determine and correlated with Nepal Drinking Water Quality Standard (NDWQS) and WHO.

Groundwater is under unconfined or water table types in shallow aquifers and under semi-confined or leaky confined conditions in deeper aquifers. Perched water table conditions also present in places.

Using the primary and secondary data in ArcGIS, the groundwater potential map, various thematic layer such as ground water level, geology, geomorphology, land use and land cover, slope, drainage density and soil texture are used to determine the ground water potential zone.

Water level of the study area varies from 0m to 48.7m from the surface level so area is shallow static water level. Most of the study area determine the artesian zone. Flood plain, alluvium deposits and flat land are major geomorphology of the area. Slope map from the Parsagadhi municipality has almost flat with less than 1-5% slope. Drainage density is higher in the central part where as the lower drainage density is observed in northern part. Silty Loam. Loam and Loamy Sand Soil area major texture of the study area. From the Ground water potential zone map, higher potential zone lies in southern part and lower potential groundwater is in central part of study area.

As per WQI results, from the 44 samples 1.96% of the groundwater samples are in excellent quality, 5.88 percent samples are in good quality, 54.9 percent have poor quality, 35.29 percent sample are in very poor quality and remaining 1.96 percent are unsuitable for drinking.

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MEDICAL GEOLOGY: A MISSING FIELD IN NEPAL

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ABSTRACT

Medical geology is the combined field of various disciplines of sciences like geology, ecology, medicine, biology, hydrology, and many more that deals with the relationship between natural geological factors and living organisms. The principal goal of medical geology is to study the basic laws of the influence of the geological environment on human health. Many minerals and elements which are in the background value of the earth's crust do not harm the environment, however, the elevated value of these elements shows the health impacts on all living beings. An attempt is made to gather such information related to medical geology from the perspective of human health in this study. Globally medical geology is an emerging field but in Nepal, it is still the missing field to study and research. The impacts of drinking water contamination in Terai communities are found severe. Both keratosis and melanosis problems are reported in the community of Terai, however, health workers and the local community know very little about the impacts of arsenic. Similarly, many Nepalese communities are suffering from guitars which may be due to a deficiency of iodine. These are very few examples and the causes of heart diseases, and cancer that may be the cause of geological environment. Studying the field of medical geology is already late in Nepal. A multidisciplinary and collaborative study and research are essential among geologists, biologists, ecologists, geographers, medical scientists, and planners to overcome the health issues related to the geological environment.

Key Words: *Medical geology, geogenic materials, keratosis, and melanosis*

BACKGROUND

Rocks and minerals comprise the fundamental building blocks of the planet and contain the majority of naturally occurring chemical elements. Many elements are essential to plant, animal, and human health in small doses but elements, which are considered as being truly beneficial to human and animal health, may also lead to debilitating diseases if ingested in large doses. The list of essential and toxic elements in the periodic table is shown in Figure 1. Most of these elements are taken into the human body via food, water, and air. Rocks, through weathering processes, break down to form the soils on which crops, and animals are raised. Drinking water travels through rocks and soils as part of the hydrological cycle and much of the dust and some of the gases contained in the atmosphere are of geological origin. Hence, through the food chain and through the inhalation of atmospheric dust and gases, human health is directly linked to geology(Selinus, Finkelman, & Centeno, 2010). Paracelsus (1493–1541) defined the basic law of toxicology, namely **"All substances are poisons; there is no element which is not a poison. The right dose differentiates a poison and a remedy"**. Medical geology is the science dealing with the relationship between natural geological factors and health in humans and animals. It is an ancient but re-emerging field of geology. The Commission on Geological Sciences for Environmental Planning defines medical geology as "the science dealing with the influence of ordinary environmental factors on the geographical distribution of health problems in man and animals. Although it is defined in different terminology, the scientific term for this field is "hydrobiogeochemoepidemiopathoecology" and it was first established in 1990 by the International Union of Geological Sciences.

Although this is an emerging field in earth science, the concept of medical geology has been introduced during a medieval time when Hippocrates and Aristotle first recognized the relationship between human diseases and the earth's elements. It is a rapidly expanding field concerned with the relationship between natural geological factors and human and animal health, including understanding the influence of environmental factors on the geographical distribution of health problems. This branch of geological science brings together geoscientists and medical/public health researchers to address health problems caused or exacerbated by geological materials. Geological material may have a natural cause that may directly or indirectly impact human health. The geogenic materials that are naturally hazardous to human health are called geogenic contaminants(Bundschuh et al., 2017). Some examples of geogenic contaminants are as, F, Mn, Be, Cd, Hg, Pb, Rn, Se, and U.

Iodine Deficiency Disorder (IDD) cause mental impairment and leads to hypothyroidism. In 1965 AD the Government of Nepal had first conducted a survey of goiter which is caused due to lack of iodine in the body, and it was found that the goiter rate was high as 55 percent in children above 13 years. Then the government of Nepal implemented the National Iodine Deficiency Disorder control program from 1997-2002 and from 2013-2017 to achieve optimal iodine nutrition in Nepal.

Arsenicosis is an important non-communicable disease resulting from the ingestion of groundwater containing unsafe level of arsenic. During 2001-2004, governmental and non- governmental organizations had conducted a survey regarding an arsenicosis in six different districts of Nepal which includes Nawalparasi, Bara, Parsa, Rautahat, Rupandehi and Kapilvastu. The arsenic contamination in tube wells of these districts ranges from 2.1% to 25.7 %. The prevalence of arsenicosis was on average 2.2% and varied from 0.7% in Kapilvastu district to 3.6% in Nawalparasi district. In the community-based study, the highest prevalence (18.6%) of arsenicosis was found in Patkhouli village of Nawalparasi, where 95.8% of tube wells were contaminated with arsenic. The prevalence of arsenicosis was higher in older age groups (>50 years) of both the sexes. Males suffered more from arsenicosis than females (odds ratio: 2.50, 95% confidence interval 1.80 -3.47). Skin manifestations such as melanosis and keratosis were the common symptoms of arsenicosis. Most patients were identified in the early or mild stage of the disease. (Maharjan, Shrestha, Ahmad, Watanabe, & Ohtsuka, 2006)

The research gap on the field of medical geology in Nepal are:

Nepal is agricultural country but still the importance and effects of geogenic materials to the crops has not been subject to the interest of concerned authority. People use Himalayan black salt *(Birenun)* as a medicine of stomach problems and black bitumen *(Silajit)* is used to cure so many diseases but still their geochemical analysis is lack. Trace elements are called the micronutrients which are heavily needed for plants but still is the missing subject. The impact of radioactive elements presents in the rock which are used for different purposes are not studied which may cause people to the direct exposure of radiation. There is direct relation between the water hardness and human health. The combination of geology and hydrology of a river catchment is important in determining the hardness of water (Selinus et. al., 2010).

METHODOLOGY

For the preparation of this article, all the available books, literature, and research papers related to medical geology have been reviewed and analyzed in detail. Further, available materials on the internet have been studied.

The methodological process followed for the preparation for this article is shown in the following flow chart:

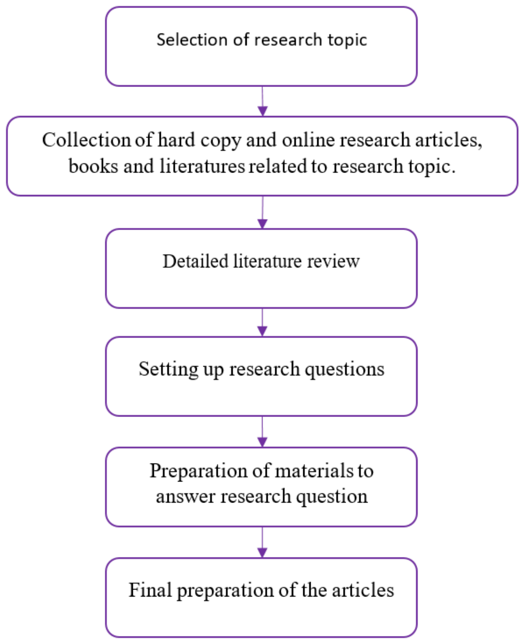

Figure 1: Flowchart showing the methodology for the preparation of this research articles

RESULTS

The result of this research article is discussed on the following sub-topics.

Scope and Importance of Medical Geology

The scope and range of medical geology include (Bunnell, Finkelman, Centeno, & Selinus, 2007)

(1) Identifying and characterizing natural and anthropogenic sources of harmful materials in the environment.

(2) Learning how to predict the movement and alteration of chemical, infectious, and other disease-causing agents over time and space.

(3) Understanding how people are exposed to such materials and what can be done to minimize or prevent such exposure.

Importance of medical geology in Nepal

Some research shows that asbestos contaminated talc on rice in the diet is the carcinogen which is responsible for the high incidence of Japanese stomach cancer, in our country also large amount of polished rice is imported from the India but the polishing materials are still unknown.

Huge portion of the mountainous terrain is occupied by the igneous rock in Nepal, this rock may be the potential sources of the geogenic contaminants like trace elements, rare earth elements and radioactive elements but the importance, impact and effect of these elements to the living organism of the country is still unknown. For example, huge portion of the igneous rock called nepheline syenite which has a high potentiality of having radioactive elements like Uranium is distributed in a place called *Aapipal, Gorkha*. Also, some detrital uranium is reported from the sandstone beds of the Siwalik which are used in the construction materials. But still the impact of uranium to the public has not been studied yet.

Case Studies

Some emerging global issues regarding medical geology and its importance (Dissanayake & Chandrajith, 2009) are described in detail below:

More than 30 million people in China alone suffer from dental fluorosis caused by the excess of fluoride in drinking water. This is clearly related to the geochemistry of the groundwater among some other factors. Many countries, such as South India, Sri Lanka, Ghana, Tanzania among others also have very high incidences of dental (and in some cases) skeletal fluorosis.

Nearly 1 billion people (notably in developing countries) suffer from Iodine Deficiency Disorders (IDD) caused by the lack of iodine in the diet. These diseases include epidemic goiter, cretinism, and fetal abnormalities among others. The relationship between the geochemistry of iodine in the rocks, soil, water, sea and atmosphere on the incidence of IDD is one of the most interesting research studies that is now creating global interest among scientists.

Arsenic is a toxic and carcinogenic element present in many rock forming minerals including iron oxides, clays and in particular sulphide minerals. When this arsenic gets into the groundwater through oxidation and subsequently into the human body through drinking water, serious health hazards can occur. Well documented cases of chronic arsenic poisoning are known in southern Bangladesh, West Bengal (India), Vietnam, China, Taiwan, Chile, Argentina, and Mexico. Skin diseases are the most typical symptoms of chronic exposure to arsenic in drinking water, including pigmentation disorders; hyperkeratosis and skin cancer, but other renal, gastrointestinal, neurological, hematological, cardiovascular, and respiratory symptoms can also result. The study of the medical geochemistry of arsenic is now being recognized by several governments as a priority area of study.

Recent evidence indicates that cancer, after heart diseases, is the leading killer in many industrialized societies and is largely due to environmental factors. A large number of causative factors which have been isolated are in one way or other environmental. A good example from developing countries that affects millions of poor people is the contamination of drinking water by nitrogenous matter such as human and animal wastes, nitrogen containing fertilizers etc. The common diseases caused by this are stomach and esophageal cancer and methaemoglobinaemia ('blue baby' syndrome), caused by excess nitrates. The passage of these chemical species from the environment into the food chain and into the human body is mostly geochemical and the medical geochemistry of cancer has developed into an intriguing field of research (Dissanayake and Weerasooriya, 1987).

Podoconiosis or non-filarial elephantitis, named and characterized by Price (1988) affects large populations in Ethiopia, Kenya, Tanzania, Rwanda, Burundi, Cameroon, and the Cape Verde Islands. The most interesting feature observed was that the affected areas were consistently associated with red clay soils. Analysis of lymph nodes from diseased tissues showed the presence of micro particles consisting predominantly of aluminum, silicon, and titanium. It was suggested that the pathological agent is a mineral from volcanic bedrocks, probably the amphibole eckermanite (Harvey et al., 1996). In this case too, the importance of research into medical geology is obvious.

One of the most intriguing yet, not very well-defined aspects is the geochemical correlation between the incidence of cardiovascular diseases and the water hardness in the areas concerned. In several Countries and areas, a negative correlation has been observed between water hardness of the country or region and its death rate due to heart diseases (Masironi, 1979). Even though a causal effect still cannot be ascribed to this geochemical correlation, the effect of trace elements in drinking water on heart diseases is worthy of serious study. It is of interest to note that such a negative association between water hardness and cardiovascular pathology is evident in both industrialized and developing nations.

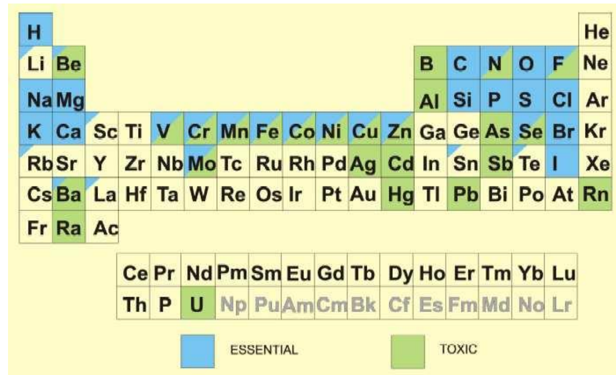

Figure 2: The periodic table of elements showing those elements essential to human health and those considered or known to be toxic or undesirable. Note that some elements fall in both categories, others are possibly essential for living organisms (Source: Groundwater Geochemistry and Health, 1996)

The most common pathways and exposure of the geogenic contaminants are (Selinus et al., 2013):

Volcanic emissions

Radon in air and water

Arsenic in ground water and the environment

Fluoride in natural water

Whereas the emerging issues regarding medical geology in the modern era are:

Water hardness and health effect

Bioavailability of elements in soil

Selenium deficiency and toxicity in the environment

Soil and iodine deficiency

Animal and medical geology

Some of the geological sources of health hazards are:

Natural and anthropological redistribution of metals

Distribution of elements through rocks, soil and water

Deficiency of essential elements in the geo-environment

Use of geologic materials having toxic elements for domestic use

The geogenic elements affect the human body through a different mechanism which include normal allergy to chronic diseases. Some of the major effects of the geogenic elements on the human body are:

Alteration or incorrect expression of genetic material by mercury, and mutations of DNA by reactive oxygen species like arsenic, chromium, nickel.

Disruption non genetic components like direct binding to inhibition of enzymes, proteins and other essential substances. For example, Cadmium and Mercury can inhibit the activation of vitamin D thus preventing Ca^{2+} and Mg^{2+} mechanism.

Table 1: Table showing the diseases associated with excessive intake of elements. (Modified Randive 2013)

S.N.	ELEMENT	SOURCE	ASSOCIATED DISEASES	PERMISSIBLE LIMIT
1.	Mercury	Dust in atmosphere, volcanic eruption, salt spray, geyser thermal liquid gaseous release from mantle	Inactiveness	0.001 mg/lt.
2.	Cadmium	Flying dust, volcanic eruption, sea water spray, cement industry	Joint pain, softening of bones, skeletal deformity, lung cancer prostate cancer	0.01 mg/lt.
3.	Fluorine	Leaching of rocks, volcanic ash, bentonite, flying dust	Yellowish of teeth, skeletal deformation	1.5 mg/lt.
4.	Lead	Coal burning,	Lung cancer, neurological disorder	0.05 mg/lt.
5.	Arsenic	It is absorbed on clay, oxides, iron, and manganese	Liver disease, cancer of skin and lungs ulcer, blood deficiency.	0.05 mg/lt. $(AsO_4)_3$ is toxic

Table 2: Table showing the diseases associated with deficiency of elements. (Modified Randive 2013)

S.N.	ELEMENT	ASSOCIATED DISEASE	CAUSATIVE FACTORS	PERMISSIBLE LIMIT
1.	Selenium	Bone disease, Arthritis, cancer, cardiovascular failure	Deficiency of selenium in food chain	0.01 mg/lt.
2.	Zinc	Dwarfness, infertility, delay in filling up the sores, loss in resistance, impaired taste and smell	Deficiency in agriculture produce due to low zinc content in the soil.	0.5 mg/lt.

3.	Copper	Anemia, skeletal defects	Heart ailment, deficiency of blood, disorders of nervous system, defects in bones.	0.05 mg/lt
4.	Chromium	Disturbances in the glucose metabolism, kidney problem, diabetic problem, cholesterol disorders.	Released through industrial effluents of tanneries.	0.01 mg/lt.
5.	Magnesium	Depression, disease of nervous system, skeleton malfunction, dysfunction of gonads	Deficiency in food intake	30 mg/lt.
6.	Iodine	Goiter	Excessive calcium in water sinks iodine and does not allow to go in the drinking water for human use.	0.3 mg/day
7.	Fluorine	Dental caries dental and skeletal (Fluorosis)	Deficiency of fluorine (<0.5 mg/lt)	0.5 to 1.2 mg/lt.
8.	Sodium	Coma	Deficiency in food intake	0.9 mg/day
9.	Iron	Anemia	Deficiency in food intake	0.3 mg/lt
10.	Molybdenum	Mouth and esophageal cancer	Deficiency in food intake	2.8 mg/day

D. Medical geology vs Aayurbedic concept

In Ayurveda, Rasa Shastra is the discipline that describe use of minerals for cure of diseases. Among all the inorganic substances used in Ayurveda, the most important is mercury. Other substances have been categorized into the *Maharasha, Uparasa and Sadharana.(Randive, 2013)*

The ***Maharasha*** is the substance of great importance which includes *Abhraka* (mica), *Vaikranta* (tourmaline), *Makshika* (chalcopyrite), *Vimala* (pyrite), *Shilajitu* (black bitumen), *Sasyaka* (blue vitriol), *Chapala* (selenite?), and *Rasaka* (zinc ore). The incinerated mica is used in diseases like diabetes mellitus, dermatoses, tuberculosis, asthma, cough, anemia, colitis, epilepsy and hysteria etc. Similarly, black tourmaline is used for fever, skin disease, leprosy, piles, tumors and ascites, chalcopyrite for hyperacidity, dermatosis bleeding disorder etc, black bitumen for urinary stone, bronchitis, chronic digestive disease, obesity and cough, zinc ore strengthens body tissues, asthma, diarrhea, and tuberculosis.

The *Uparasa* is a substance which means the substance of the secondary importance which includes *Gandhaka*(sulfur), *Gairika*(hematite), *Kasisa* (melanterite), *Kankshi*(Alum), *Heratala*(Orpiment), *Manashila*(Realgar).

The sulfur ointment is used for wound dressing, its antimicrobial property is used in skin diseases like scabies and dermatoses, and hematite is used for purification of cow's milk and to mitigate vomiting and hiccups. Similarly, alum is used to arrest the bleeding, eye drops from alum is used for eye diseases, ortiment is used for treating gout, syphilis, and gonorrhea.

The *Sadharana Rasa* is the ordinary or common substance it includes Gauripashaha (arsenolite), ammonium chloride, Hingula(cinnabar).

Arsenolite is used for scorpion bite and syphilis and cinnabar is used to mitigate diseases like dibetes, skin diseases, fever, and hepatitis.

The other examples of mineral sources used for medicines are like chalk for blood disorder, eyes diseases, talc for abdominal pain, heart diseases, cough, dysentery and gypsum for bile disorder, hyper acidity etc.

DISCUSSIONS AND CONCLUSIONS

The field of medical geology is directly or indirectly linked with wide circles of readers and researchers like geologists, doctors, biologists, ecologists, planners, and all others who deal with the task of life and health protection. Authors have no knowledge of medical science; however, an attempt is made to indicate the importance of geological environment to the human health. The geological environment refers to relief, soil, and other loose materials, and basic rocks and soil substrates. Several studies have shown that there is direct relation between the heart disease and the geochemical environment (Keller, 1985). Communities who drink with relatively soft water for a longer time have a higher rate of heart diseases. Similarly, there should be a link between cancer and the geochemical environment. The deficiency of iodine is supposed to be one of the causes for the breast cancer. Agricultural, industrial, and mining activities have released hazardous and toxic materials into the environment. These materials have been associated with bone disease in people, metabolic disorder in cattle, and other biological problems (Keller, 985).

Arsenic contamination in groundwater of Terai is an emerging issue for Nepal. There exists a significant contamination of arsenic in shallow wells of almost all districts of entire Terai region. Elevated concentration of arsenic has been recorded from sulphide ore and other arsenic containing minerals (Paudyal, 2011). Health problems related to arsenic are already visible in some Terai communities of Nepal. Both keratosis and melanosis problems are reported in the community of Terai, however, health workers and local community know very little about the impacts of arsenic (Sah et. al, 2003; Pandit and Paudyal, 2011, Bhusal and Paudyal, 2014).

Medical geology is still the missing field in Nepal despite of having its great importance and scope. As it seems compulsory to aware people about the relation between health and geology, the subject should be included in the curriculum from the school level as well as some chapters in the curriculum of graduate and post-graduate syllabus of geology. Detailed research about the impact of geogenic material to the living organism should be done by geologist collaborating with medical institutions, ecologist, biologists, environmentalists, geographer, hydrogeologists, planners, and many more related fields.

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A REVIEW ON GEOLOGY IN AND AROUND BABINA, DISTRICT JHANSI, UTTAR PRADESH (INDIA): WITH REFERENCE TO LITHOLOGY & FIELD RELATION

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ABSTRACT

Craton are a stable part of the earth that record all the past geological processes, Bundelkhand craton is one among the Archean craton in northern block of peninsular India which preserve the imprints of early crustal evolutions. The craton hosts two Archean supracrustal complexes, namely the (i) Central Bundelkhand greenstone Belt (Babina, Mauranipur) and (ii) Southern Bundelkhand greenstone Belt (Girar, Madaura). The Babina area is part of Central Bundelkhand greenstone belt (78º25 to 78º50 E and 25º10 to 25º16 N) covering an area of about 160 square Kms situated in the Jhansi District, Uttar Pradesh has been selected for the detailed geological mapping at scale of 2 cm equals to 4 kms. The subduction-accretion tectonic setting which result in the formation of Tonalite Trondhjemite Granodiorite gneiss, E-W trending greenstone belt which consist of Banded Iron Formation, felsic volcanic, amphibolite, mafic, ultramafic having angular relationship with granites, NE-SW to NNE-SSW trending quartz reefs and NW-SE mafic dykes marks the stabilization of craton. The area had suffered multiple phases of intrusion, deformation, metamorphism, faulting reflected in different rock types. This paper is based on the literature review, lithology and filed relation.

Key Words: Review, Bundelkhand Craton, lithology, field relation.

INTRODUCTION

The Archean craton preserves the imprints of prevailed geological processes which led to formation and crustal evolution of juvenile Earth, which is still a subject of focus throughout the world. The Bundelkhand craton, one among the Archaean nuclei along with Aravalli cratons in the northern part and central tectonic zone which separates southern part, which is integrated with the Dharwar, Bastar, Singhbhum craton, all constitute to form the Indian Shield (Basu 2007, Ramakrishnan and Vaidyanadhan, 2010). The petrologic evolution of all five cratons was similar, with a long period (850–250 Myr) of episodic TTG magmatism abided by a short time period (100–30 Myr) of granitoids diversification (A- Type granite, K-rich anatectic granites, and sanukitoid) with markers of both mantle and crustal origin, hydrothermal and basic intrusion activity in later stage mark the stabilization of cratons (Dey and Moyen, 2020). And large bodies of granite and its related massive eruptions are the world's greatest magmatic products, with a dual character that is homogeneous at large scales but spatial and temporal variation at small scales (Burgisser and Bergantz 2011). Bundelkhand craton rests over an area of about 30,000 km^2 in the vicinity of central India. It includes portions of Uttar Pradesh and northern Madhya Pradesh and is positioned between 24^{O} N to 27^{O} N latitude & 77 ^{O} 30' E to 81 ^{O} 24' E longitudes. On the east, west, and south, Bundelkhand craton is bordered by the rocks of the Vindhyan Supergroup. The southern-western part is recognized by small outcrops of Deccan basalt, while the northern part is buried beneath the Indo-Gangatic alluvium. Lithologically, Granite, Tonalite Trondhjemite Granodiorites gneisses (TTG), supracrustal complexes, felsic volcanics, quartz reefs trending NE-SW and mafic dykes swarms trending NW-SE are the main components of the Bundelkhand Craton. The craton includes two E-W to ENE-WSW trending Greenstone belts which are engulfed by felsic volcanics, gneisses, and granites. The present study attempts to investigate and understand the geology of the area on the basis of field work and previous studies of the Babina area, district Jhansi, (U.P.). The investigated area is composed of TTG gneisses, Granites, Schist, Quartz reef, Dykes and Supracrustal rocks in which Banded Iron Formation is sandwiched between metamorphosed basic rocks and low grade metamorphic felsic volcanics sedimentary rocks. These rocks suffered and stored the imprints of metamorphism and deformation.

REGIONAL GEOLOGY

Being the prominent Archean nuclei in the northern part of the Indian shield across the north of Son–Narmada lineament the Bundelkhand craton hosts Paleoarchean TTGs, Mesoarchean gneisses (3551–3270 Ma) and Neoarchean granites (2583–2516 Ma) extensively exposed over an area of > 30,000 km2 (Mondal et al., 2002; Kumar et al., 2010; Joshi et al., 2013; Saha et al., 2016, Kaur et al., 2014, 2016). The Northern portion is over lain by Quaternary Indo-Gangetic alluvium and Paleoproterozoic low grade metamorphic rocks of Bijawars envelopes with angular unconformity from south and southeast. Meso to Neo Proterozoic Vindhyan Supergroup had overlain with angular unconformity to the southeast, south, southwest, and west (Sarkar et al., 1996, Singh et al., 2007; Ramakrishnan and Vaidyanadhan, 2010) (Figure. 1). Medlicott, 1958, was first to suggest the occurrences of granite, greenstone, dykes, quartz reef. The Bundelkhand Craton composed of the oldest basement of polyphase deformed TTG gneisses, associated with supracrustal rocks of greenstone belts. (Slabunov and Singh, 2015, Singh et al., 2019b, 2021). Two greenstone complexes can be recognized in the Bundelkhand craton, namely the (i) Central Bundelkhand Belt (Babina, Mauranipur) and (ii) Southern Bundelkhand Belt (Girar, Madaura) which vary in age, grade of metamorphism, texture, structure, etc. (Singh and Slabunov, 2015, Singh et al., 2019b). The Central Bundelkhand greenstone complex contains different tectonostratigraphic assemblages TTG gneisses, granodiorite, sanukitoid metamorphosed mafic and ultramafic, metasedimentary, banded iron formations (BIFs), and felsic volcanics. (Basu, 1986, Mondal et al., 2008, Ramakrishnan & Vaidyanadhan, 2010, Singh & Slabunov, 2015, Saha et al., 2016, Verma et al., 2016, Joshi, et al., 2017, Singh et al., 2018, 2019, 2020). Petrography, petrogenesis, geochronology and structural studies of Archean age TTG gneisses, low to medium grade metamorphosed greenstone belts and Archean granites had a markable contribution in understanding the geological process during geological time worldwide and in the Bundelkhand craton.

The basement rock TTG gneisses show polyphase deformation and have angular relationship with the granites, biotite gneiss and greenstone belt comprising of low to medium grade metamorphic rocks composed of Banded Iron Formation, mafic to ultramafic and volcano sedimentary rocks (Mondal et al., 2002, Ramakrishnan & Vaidyanadhan, 2010, Kaur et al., 2014, Singh and Slabunov, 2015, Saha et al., 2016, Singh et al., 2018, 2019, 2020). As in other cratons TTG rocks of Bundelkhand craton are low Al and high Al types and are evolved between diorite and granite in which less evolved have tholeiitic affinity while more evolved have calc-alkaline affinity which is further divided into potassic group (with enrich source) and sodic group (depleted hydrated basalt source and display more fractionated REE pattern) (Mohan et al. 2012). Melting of Eoarchean crust with or without crustal assimilation generated Paleoarchean TTG gneisses and a Neoarchean TTG gneiss generated as a result of partially melting of deep seated mafic crust with minor assimilation of Eoarchean to Paleoarchean crustal material and both TTG gneiss were developed under subduction zone by basaltic crustal melting with fluid interaction from subducting slab. (Mohan et al., 2012; Singh et al. 2021). Before regional granitization during the Archaean, the entire area suffered two phases of sedimentary-volcanic activity (Prakash et al. 1975). In situ zircon 2544 ± 25 Ma (LA–ICP–MS U–Pb ages) and Archean sanukitoid of the Bundelkhand Craton and their whole rock chemistry and Sm-Nd isotopic composition are concurrent with high-K anatectic granites (2544–2583 Ma) and is involved with subduction-related activities, followed by slab breakoff, which occurred prior to the accretion-collision events (Batuk & Slabunov, 2019, Singh, et al., 2019).

In the greenstone belt of Babina and Mauranipur, ultramafic- mafic are associated with metasedimentary rock are syngenetic to post genetic to oldest TTG intrusion and are relics of oceanic crust that may have been intruded in the subduction-related environment (Malviya et al., 2006, Singh and Slabunov 2015, Singh et al. 2019b). Outcrops of a composite body of ultramafic-mafic rocks which contain mainly peridotite, pyroxenites and are Komatiitic-tholeiitic in composition occur in and around Baragaon, Dhaura, Babina villages (Singh et al., 2019). The trace and major geochemistry of mafic and ultramafic rocks was carried out by Singh et al (2019). Balaram et al., 2013 carried out geochemistry of ultramafic rock on the basis of a platinum group of elements suggesting komatiite-peridotite related composition for source rock. Thomas et al., (2019), Vishwakarma et al., (2020), Mohanty et al., (2019) carried out the mineral chemistry of mafic and ultramafic complexes of the Bundelkhand craton and explain the tectonic history of the region.

Granitoids extensively cover a large part of the craton, their intrusion into the greenstone belts sequence marks major geological events for cratonization. Jhingram, 1958 classified granites of the craton into different types and later Saxena, 1961, Prakash et al., 1975, Kumar et al., 2010, Joshi et al., 2013, Saha et al., 2016, Kaur et al., 2016 worked on granites of different area of Bundelkhand craton. On the basis of geochemical character, colour index, and mineralogy Zainuddin et al., 1992, Mondal et al., 1996 classified granite into Hornblende granite, Biotite porphyritic and foliated granite, coarse and fine grain leuco granite. Monzogranite, diorites, granodiorites, and syenogranites make up the majority of the granitoids in the Bundelkhand craton. Granitoid diversification on the basis of geochemistry and mineralogy (A- Type granite, K-rich anatectic granites, and sanukitoid) are markers of both mantle and crustal origin (Sukanta Dey et al., 2020). The mantle wedge and crustal material partially melted during Precambrian convergent subduction to form the 2.5 Ga high-K granitoids and Anatectic granitoids were generated as a result of the melting of the continental crust, while sanukitoid and hybrid granitoids were generated in the mantle, with the latter showing larger crustal contributions. Joshi et al., 2022

The quartz reefs forming ridges of width around 50-60m and length of about 30-40 km trending NNE-SSW to NE-SW are the characteristic feature in Bundelkhand craton. Kinematic model to the geometry of quartz reef and dykes was developed by Rhoday et al. 1995. Studies were carried out on the character & distribution of Quartz reef on the basis of remote sensing Prakash et al., 2013. The formation of quartz reefs is the result of the uplifting around 1.9-1.8 Ga as a result of compression induced by collision at western margin of Columbia Supercontinent and associated with intense tectonically controlled hydrothermal activities during 1866 ± 12 Ga (Slabunov and Singh, 2022). Rout et al., (2017), (2022) carried out fluid activity and fluid inclusion studies and suggest that three possible water condition which controlled overall fluid activity of quartz reef i.e. low temperature-high saline which resemble metamorphic fluid, second moderate temperature-moderate saline represent a magmatic fluid through fluid rock interaction and low temperature-low saline may be part of meteoric fluid interacted with moderate salinity fluid. The geochemistry, geochronology of the quartz reef was attempted for tectonic implications and suggested that Quartz reef intruded in brittle ductile shear zones marks the end of hydrothermal activity as the result of maximum NE-SW to NW-SE compressive stress and associated with pyrophyllite-diaspore and polymetallic sulphide mineralisation (Roday et al. 1995, Pati, et al., 2007).

Table 1: Stratigraphy of the area.

Tectonic-Unit	**Litho- Units**
Mafic Dykes (1800-1600)	Dolerite, Gabbro
Quartz Reefs (2300-2000)	Quartz veins and reefs, quartzite.
Granitoids (2500-2300)	Coarse to medium to fine grained granite, biotite granite, hornblende granite.
Newer Metamorphic Group (NMG) (3200-2600)	Metavolcanics Banded Magnetite Quartzites, mafic and ultramafic, Quartzites.
Older Metamorphic Group(OMG) (3500-3300)	Tonalite-Trondhjhemite-Gneiss (TTG), gneiss, amphibolite.

Rao et al., 2005, Pradhan et al., 2012 and Radhakrishna et al., 2020 suggest fine grained mafic dyke dissects the craton in two phases with nearly in same petrogenetic evolutionary pattern trending NE-SW 1.98 Ga to 2.20 Ga (U-Pb ages) NW-SE. These dykes are narrowing linear and discontinuous, displaced sinistrally and dextrally as a result of regional deformation (Ghosh and Acharya, 2006). The dykes are doleritic; lamprophyres in composition having sharp contact with host rock but show no signature of reaction with country rock (Basu, 1986). Pati et al., 2008 carried out petrological geochemical characteristics, Pradhan et al., 2011 did paleomagnetic studies and Deb and Bhattacharyya, 2018 studied their geochemistry, interaction with felsic granitoids. NE-SW trending dykes are emplaced around ~ 20-2.1 Ga marking stabilization of craton, they are low-Ti tholeiitic, depletion in HFSE (High Field Strength elements) and enriched in LREE (Light rare earth elements) composition and mafic-ultramafic rock composition range from subalkaline through andesite to dacitic (Mondal et al., 2001, 2008). As a result of the interaction of upwelling mantle melts with metasomatized subcontinental lithospheric mantle, the dyke magmas inherited a variety of enriched compositions (Radhakrishna et al., 2020).

METAMORPHISM

The Bundelkhand area reflects three phases of metamorphism along the Bundelkhand tectonic zone and in the western part of the craton. Being the part of Ur supercontinent along with other unified cratons Bundelkhand craton undergone the crust forming process around 3.6 Ga. 2.8 Ga ultrahigh pressure (12-20 kbar) eclogite facies metamorphism from corundum bearing white schist (Saha et al., 2011, 2016) correlated with subduction process, Neoarchean 2.7 Ga metamorphism by accretion-collision events, metamorphic event related to 2.55-2.50 Ga subduction-accretion reveal poor and infrequent imprints, the youngest Paleoproterozoic rifting was associated with (1.9–1.8 Ga) prehnite-pumpellyite-facies metamorphism (Saha et al., 2011, 2016, Joshi et al., 2017, Sibelev, et al., 2021). Previous study reveals that mafics and ultramafic rocks suffered regional metamorphism which grade from greenschist to amphibolite facies, stability of biotite at pressures between 3.5 and 8.5 kbar suggests that these rocks developed during retrograde metamorphism. (Nasipuri et al., 2019,) Around Girar, Baraitha, and Badwar villages, outcrop of low-grade metamorphosed volcano-sedimentary rocks are exposed ranging from quartzite with bands of haematite magnetite to amphibolite facies marked by mafic, amphibolite and ultramafic rocks. Mineral assemblages such as garnet, sillimanite and cordierite marks granulite facies metamorphism in the western part of the craton. (Singh and Dwivedi 2009, Saha et al. 2011, 2016,).

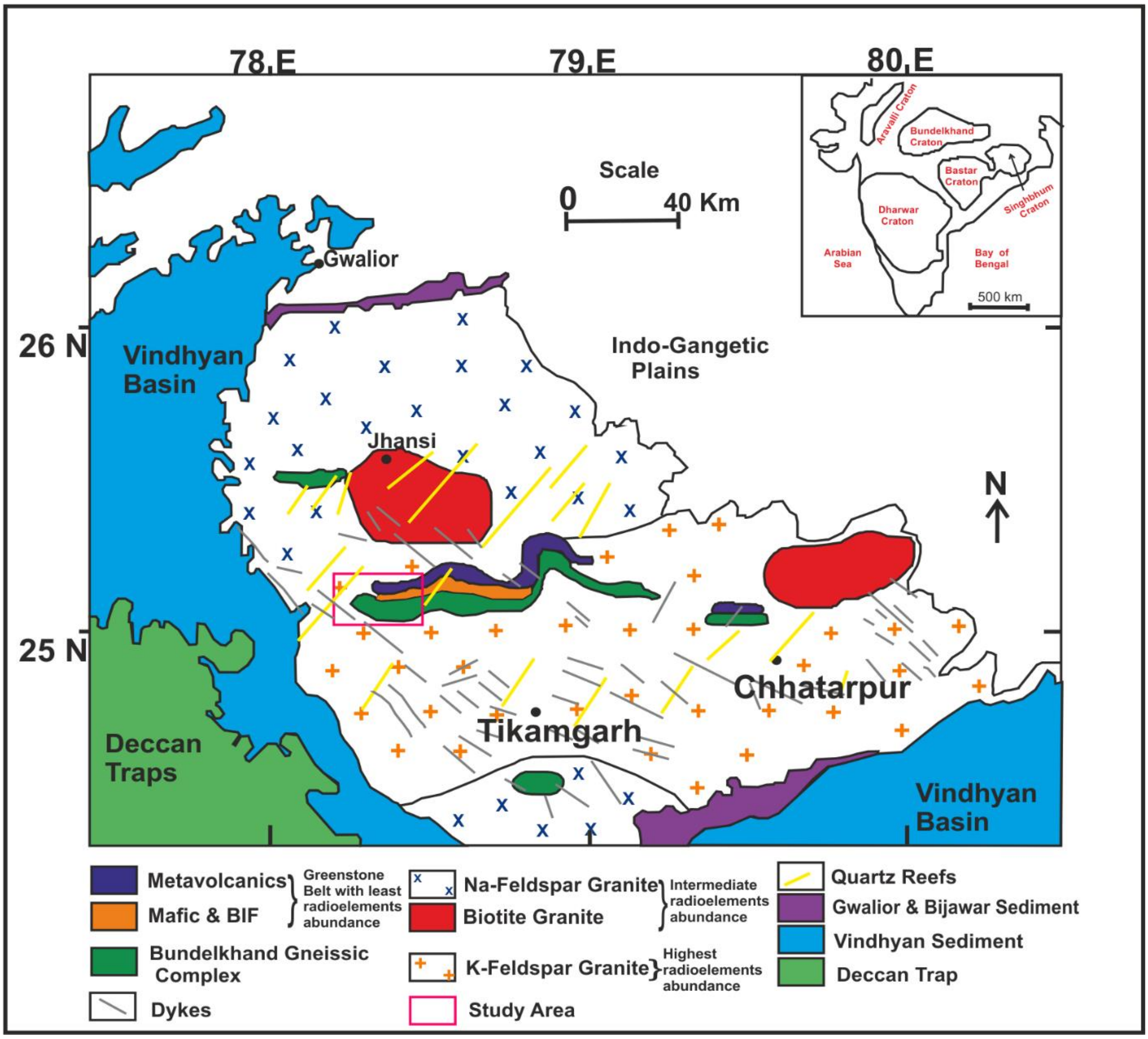

Figure 1: Regional Geological Map showing different lithologies and study area of Bundelkhand Craton (modified After Thomas et al., 2019, Singh et al.,2019)

Table 2- Geochronology of rocks of the Bundelkhand craton

Locality	Rock Type	Age	Method	Reference
Babina	TTG gneisses	2706 ± 7.4 Ma	(LA-ICP-MS)	Verma et al., (2016)
	TTG gneisses	2706 ± 11 Ma	(LA-ICP-MS)	Singh et al., (2021)
	TTG gneisses	3440 ± 3 Ma	(LA-ICP-MS)	Saha et al., (2016)
	TTG gneisses	3532 ± 7 Ma	(SHRIMP)	Nasipuri et al., (2019)
	TTG gneisses	3503 ± 99 Ma	(Rb-Sr)	Sarkar et al., (1996)
	K-rich granite	2556 ± 23 Ma	(LA-ICP-MS)	Singh et al., (2021)
	K-rich granite	2546 ± 3 Ma	(SIM U-Pb)	Joshi et al., (2017)
	K-rich granite	2516 ± 38 Ma	(LA-ICP-MS)	Verma et al., (2016)
	K-rich granite	2525 ± 25 Ma	(LA-ICP-MS)	Kaur et al., (2016)
	Granodioritic gneiss	2358 ± 46 Ma	(LA-ICP-MS)	Kaur et al., (2016)
	Quartzite-BIF-Pelitic sediments	2733 ± 30 Ma	(Th-U-Pb EPMA)	Saha et al., (2011)
	Felsic volcanics Dacite/Rhyolite	2542 ± 17 Ma	(SHRIMP)	Singh and Slabunov, (2015)
		3140 Ma	(Nd Modal age)	Singh and Slabunov, (2016)

	Felsic volcanics Dacite /Rhyolite Mafic-Ultramafic Mafic-Ultramafic Quartz reef	3440 ± 163 Ma 3440 ± 163 Ma 1866 ± 11 Ma	(Sm-Nd isochron) (Nd Modal age) (SHRIMP)	Singh et al., 2019 Malviya et al., 2006 Slabunov et al., 2017
Mauranipur	TTG gneisses TTG gneisses TTG gneisses TTG gneisses TTG gneisses K-rich granite K-rich granite Felsic volcanics Dacite /Rhyolite Mafic-Ultramafic	3551 ± 6 Ma 3297 ± 8 Ma 3220 ± 79 Ma 3394 ± 8.6 Ma 3422 ± 39 Ma 2578 ± 22 Ma 2545 ± 10 Ma 2810 ± 13 Ma 4.5-3.4 Ga	LA-ICP-MS LA-ICP-MS Ion probe LA-ICP-MS LA-ICP-MS SIMU-Pb LA-ICP-MS SHRIMP Nd Modal age	Kaur et al., (2014) Mondal et al., (2002) Saha et al., (2016) Verma et al., (2016) Singh et al., (2021) Joshi et al., 2017 Verma et al., (2016) Slabunov and Singh, (2019) Malviya et al., (2006)
Jhansi	K-rich granitoid K-rich granitoid K-rich granitoid Granodioritic gneiss Sanukitoids Sanukitoids	2560 ± 7 Ma 2531 ± 21 Ma 2529 ± 8 Ma 2551 ± 7 Ma 2568 ± 12 Ma 2578 ± 13 Ma	SIMU-Pb LA-ICP-MS LA-ICP-MS LA-ICP-MS LA-ICP-MS LA-ICP-MS	Joshi et al., (2017) Verma et al., (2016) Kaur et al., (2016) Kaur et al., (2016) Singh et al.,(2019) Singh et al., (2019)
Mahoba	TTG gneisses TTG gneisses TTG gneisses TTG gneisses K-rich granitoid K-rich granitoid Granodioritic gneiss Mafic-Ultramafic Mafic-Ultramafic	3346 ± 10 Ma 3310 ± 2 Ma 3285 ± 6.7 Ma 3270 ± 3 Ma 2549 ± 13 Ma 2482 ± 7 Ma 2566 ± 11 Ma 3249 ± 5 Ma 4.2-3.4 Ga	LA-ICP-MS SIMU-Pb LA-ICP-MS Ion probe LA-ICP-MS Ion probe LA-ICP-MS Ion probe Nd Modal age	Singh et al., (2021) Joshi et al., (2017) Verma et al., (2016) Mondal et al., (2002) Kaur et al., (2016) Mondal et al., (2002) Kaur et al., (2016) Mondal et al., (2002) Malviya et al., (2006)
Karera	K-rich granitoid K-rich granitoid Sanukitoids Granodioritic gneiss	2563 ± 6 Ma 2563 ± 11 Ma 2559 ± 7 Ma 2561 ± 11 Ma	Ion probe LA-ICP-MS SIM U-Pb LA-ICP-MS	Mondal et al., 2002 Kaur et al., 2016 Joshi et al., 2017 Kaur et al., 2016
Dhala	K-rich granitoid	2553 ± 6 Ma	SHRIMP	Pati et al., 2010
Bansi	K-rich granitoid K-rich granitoid Felsic volcanics Dacite /Rhyolite	2554 ± 3 Ma 2539 ± 7 Ma 2517 ± 7 Ma	SIM U-Pb LA-ICP-MS Ion probe	Joshi et al., (2017) Kaur et al., (2016) Mondal et al., (2002)
Lalitpur	K-rich granitoid K-rich granitoid Granodioritic gneiss	2564 ± 42 Ma 2592 ± 10 Ma 2546 ± 6 Ma	LA-ICP-MS (Ion probe LA-ICP-MS	Kaur et al., (2016) Mondal et al., (2002) Kaur et al., (2016)
Girar	TTG gneisses Quartzite-BIF-Pelitic sediments Quartzite-BIF-Pelitic sediments	3205 ± 12 Ma 3432 ± 9.7 Ma 3290 Ma	LA-ICP-MS LA-ICP-MS Nd Modal age	Kaur et al., (2016) Slabunov and Singh, 2019 Slabunov et al., 2017

TECTONIC HISTORY AND MORPHOTECTONICS

The Satellite imageries clearly depict that the entire craton is dissected by E–W, NE–SW, NW–SE, N–S trending shear fractures/joints (Basu 2007), and lineaments NE-SW to NNE-SSW. The reactivation of the Son-Narmada Lineament in the Archean and Paleoproterozoic periods was reflected in all tectonic processes in the Bundelkhand craton, resulting in the development of intracratonic small to large scale shear zones. ~2.8 Ga ultrahigh pressure (12-20 kbar) eclogite facies metamorphism from corundum bearing white schist (Saha et al., 2011, 2016) correlated with subduction process, Neoarchean 2.7 Ga metamorphism by accretion-collision events, metamorphic event related to 2.55-2.50 Ga subduction-accretion reveal poor and infrequent imprints, the youngest Paleoproterozoic rifting (Saha et al., 2011, 2016, Joshi et al., 2017, Sibelev, et al., 2021). Quartz reef trending NE-SW are mainly associated with wink granitoids and have crosscutting relationship with mafic dykes trending NW-SE and are result of the late stage of cratonization. This is intruded by NE–SW trending intrusive giant quartz reefs of km scale long and tens of meters wide and the extensive NW–SE trending dolerite dyke swarms along with less abundant dykes in other orientations (Pati et al. 2008; Mohan et al. 2012; Bhattacharya and Singh 2013). Regional compressive tectonic setting gave rise to deformation D1 and D2 during which TTG gneisses, amphibolite, and schist were deformed and folded and (2.57-2.5 Ga) granitic intrusion took place in D3 along fracture and shear planes (Bhatt and Singh, 2019)

Prakash et al., (2016, 2017) attempt Morphotectonic and morphological analyses and suggest extensional tectonic systems trending NE-SW to NNE-SSW, (following general trend of quartz reef intrusion), NW-SE (trend of dyke intrusion), ENE-WSW, E-W and N-S. The lower order streams of the Bundelkhand craton flows in NE-SW, NW-SE and E-W following structural deformation result of fractures, lineaments, and faulting which are major controlling tectonic trend and reflect that these tectonic trends were active in the Late Pleistocene period. The drainage patterns were probably first governed by almost E-W oriented tectonic zones, then by NW-SE and NE-SW trends zones. Dendritic drainage patterns may be seen across the landscape, with certain spots displaying trellis and centripetal patterns.

RADIO ELEMENTAL AND GEOPHYSICAL STUDIES

Radio elemental studies suggest that the southern part of the central tectonic zone is dominated by Neo-Archean K-rich calc-alkaline pink granitoids with high radioelement abundance, whereas the northern part above the central tectonic zone is composed of Neo-Archean Na-rich calc-alkaline grey and biotite granitic with moderate radioactive elements reflecting a different magma source (Figure.1), is associated with the greenstone belt, which has the least radioelement abundance and is the older in age (Ray et al., 2016). Later Podugu et al,. (2017) studied the heat flow, production, and crustal temperature of Bundelkhand craton and observed low heat flow (mantle heat flow 12-22 mWm^{-2}) and variable upper crustal temperature (290ºC-420 º C) in which granitoids average heat production contribute around 4.0 ± 2.1 (SD). The northern region of the Bundelkhand Craton has a single high resistivity layer that extends to a thickness of about 60 km, whereas the southern region has three layers of low resistivity that extend to a thickness of 60 km, indicating that the Bundelkhand Craton does not extend south beneath the Vindhyan (Agrawal et al., 1994, Gokarn et al., 2013). Bundelkhand tectonic zone separates the high gravity anomaly zone from low gravity north zone (Nabakumar and Kumar, 2018). Kumar et. al., (2010) they did magnetic susceptibility (MS) mapping of felsic magmatic rocks of central Bundelkhand craton and suggested that granites series represent different redox conditions intrinsic to magma source and later partially altered by hydrothermal and tectonic processes. Chopara et al., (2018) estimated thermal conductivity (TC) of Pink-granite 2.95 ± 0.09 $Wm^{-1}K^{-1}$ with density 2.64 ± 0.02 g cm^{-3} and porosity 0.21 ± 0.05 %, Biotite granite having TC 2.95 ± 0.04 $Wm^{-1}K^{-1}$ with density of 2.67 ± 0.02 g cm^{-3} and porosity of 0.18 ± 0.04 %, Sodic-granite TC 2.95 ± 0.04 $Wm^{-1}K^{-1}$ with density 2.67 ± 0.002 g cm^{-3} and porosity 0.18 ± 0.01 %. TTG gneisses with TC 3.08 ± 0.13 $Wm^{-1}K^{-1}$, density 2.65 ± 0.02 g cm^{-3} and porosity of 0.08 ± 0.02 %.

ECONOMIC POTENTIAL

In terms of mineralization and economic potential, Bundelkhand area is endowed with Granite building stone, diaspore pyrophyllite, Banded Iron Formation of Hematite and Magnetite and also metals like Molybdenite, base-metals, primary gold, doubtful nickel mineralisation, PGE, uranium not up to cut-off grade but had been reported within the different stratigraphic-tectonic environments recognised in this area (Singh and Goyal, (1972), Prakash et al., (1975), Sharma, (1980), Pati et al., (2014), Farooqui, & Singh, (2010), Bhattacharya et al., (2011), Rawat et al., (2018)). Rhyolite-hosted uranium mineralization (Kumar et al., 2013) in the Dhala structure, which is still a topic of debate in the area that either it is formed by volcanic explosion of Plinian type (Jain et al., 2001) or due to impact which is reflected by presence of Cr, Ir and Os (Pati et al., 2008, 2017, 2019, Li et al., 2018).

LOCAL GEOLOGY OF THE STUDY AREA

The investing area comes under the toposheet No. 55K/8 and 55K/12, which lies in the vicinity of central Bundelkhand craton. The geology of the area is represented by the outcrops of porphyritic medium to coarse grained granites which dominate the area, in the south of Babina outcrops of deformed TTG gneisses, hornblende-biotite gneisses, older mafic enclaves, amphibolite, banded iron formations, mafic-ultramafic, metavolcanics are exposed, the NE-SW trending quarts reef intruded in the older lithologies, and rare outcrop of dykes are exposed in the area. The E-W trending greenstone belt which is part of supracrustal rocks in the area, consist of BIF, amphibolite, felsic volcanics and mafic rocks which extends from Babina to Prithvipur area and shows angular relationship with TTG gneisses and other lithounits.

ROCKS TYPES

Granites: The study area consists of fine, medium to coarse-grained, hard compact granite. They show intrusive and Angular relationships with TTG gneisses and supracrustal rocks. The large phenocryst of K-feldspar can be seen twisted and distorted in some outcrops.

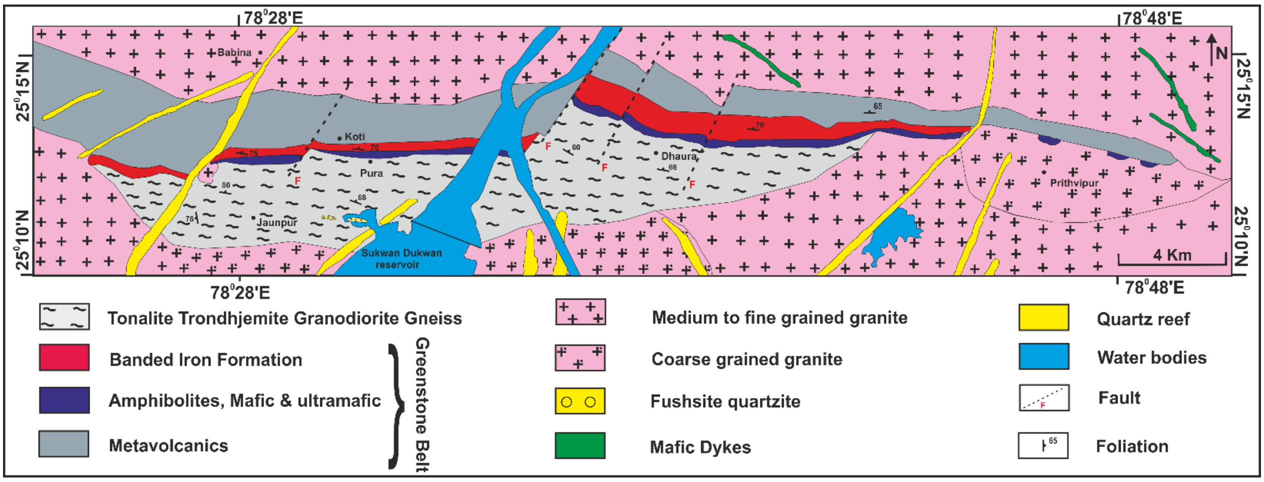

Figure 2: Geological map of study area (modified after Vishwakarma et al., 2020)

Quartz, feldspar, biotite, and hornblende can be identified by naked eyes. Pink granite consists of orthoclase feldspar, quartz, and biotite. Granites host some minute mineralization of chalcopyrite at places. (Figure 11, 12, 13, 14,15 and 16). Despite the lack of a regional control, local pressures, and small shear zones may be the cause of foliations in granites of few areas. WNW-ESE is the regional foliations trend in the area.

Gneisses- Gneiss in the study area are greyish to dark in colour medium to fine grained composed of partially recrystallized alternate light quartzo-feldspathic and dark colored bands of biotite and muscovite due to regional metamorphism in the area. These bands are deformed and preserve all the signature of suffered multiple stress and deformation of three generations and reflect in coaxially folding of previous formed tight folds and rootless folds near Lakhar Devi temple and way to Sukwan-Dukhwan Dam (Figure 3, 4, 5 and 6). The rotated porphyroblast of feldspar grain wrapped by dark colour minerals aligned in the least stress direction giving rise to the S plane of deformation. The gneissosity bands vary in their strike and thickness from place to place due to deformation. The gneissic bands hold some older mafic enclaves which are deformed can be seen opposite Lakhar Devi temple, Babina.

Amphibolite: Amphibolite are found adjacent to the TTG and BIF around 100 meter towards east near the Koti area. They are dark greenish colored, medium grained hard and compact rocks (Figure 7). Prismatic grains of amphiboles can be identified with the naked eye. They are found in the patches in the TTG rocks in some areas.

BIF- BIF is the part of the supracrustal rocks of the Bundelkhand craton. The red colour discontinuous hill locks trending ENE-WSW to ESE-WNW moderate to steep dipping (60°– 85°) northward with alternate bands of magnetite, hematite, and quartz. These bands are folded and deformed at places (Figure 9 and 10). They are sandwiched between meta-felsic volcanics, quartzite on the northern side and amphibolite, granites on the southern side.

Quartzite- Quartzite with high iron content is found associated with E-W trending

Banded Hematite Quartzite having angular relationship with TTG gneisses at Babina. Fuchsite quartzite showing hint of foliation in small sheets of mica in it. The presence of chromium mica imparts the greenish colour to it (Figure 8). The outcrop is well identified near the Sukwan-Dukhwan Dam. The protolith sandstone had suffered medium to high metamorphism in the area which graded them up to greenschist facies in Bundelkhand Craton.

Dykes-The area is dissected by numerous dykes intruded in the country rock trending NW-SE. The dykes are dark colour, fine grained, dense, compact and devoid of vesicles or amygdule. These dykes are exposed in isolated outcrops having crosscutting relationships with the quartz reef and different rock units in the study area. The intrusion of dykes is associated with the last phase of deformation that results in the shearing and marks the final stage of stabilization of Craton. The caught-up patches of granite (Figure 17) are preserved in the dyke behind the Lakhar Devi Temple which reflects those dykes are younger than the granite in which they are intruded.

Quartz reefs-The residual liquid rich in fluid of granitic magma intruded in the country rock in the form of Quartz reefs trending nearly NE-SW direction resulting in the second last phase of deformation in craton (Figure 18). These quartz reefs are the prominent structure running high above the ground throughout the area having cross cutting relationships with the granites, gneisses, and BIFs. The area possesses two generations of quartz veins; the early formed vein matrix is composed of non-transparent massive quartz and has a crosscutting relationship with the late formed vein matrix, which is composed of profuse semi-transparent veins. At places these veins host mineralization of micaceous hematite with metallic luster, chalcopyrite, bornite which encountered during the field.

FIELD PHOTOGRAPHS

Figure 3: Biotite gneiss showing alternate banding of light and dark coloured minerals forming S-C planes.

Figure 4: TTG Gneiss showing folding and minor faults in the band.

Figure 5: Mafic gneiss showing alternate folded banding of light and dark colours minerals.

Figure 6: Enclaves of older relic in the younger gneiss near Lakhar Devi Temple, Babina.

Figure. 7: Amphibolite rocks consisting of grains of tremotite and actinolite.

Figure. 8: Fuchsite quartzite part of greenschist facies rocks showing hints of foliation in small sheets of green colour chromian mica.

Figure. 9: Banded Iron Formation which is part of Greenstone belt of Babina area.

Figure. 10: Banded Iron Formation which is folded and deformed in the East of Dhaura area.

Figure. 11: Contact between coarse grained pink granite and grey granite in Jaunpur area.

Figure. 12: Coarse grained granite showing rounded grains of feldspar.

Figure. 13: Porphyritic coarse grained pink granite with large phenocryst of k-feldspar.

Figure. 14 Fine grained grey granite with a dark patch of mafic minerals.

Figure. 15: Porphyritic medium grained grey granite consisting of phenocryst of feldspar of greater than coin size.

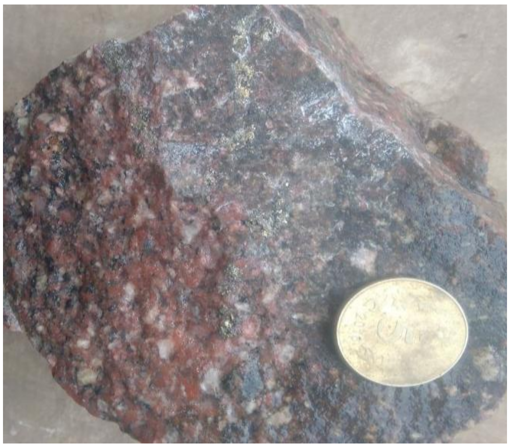

Figure. 16: Porphyritic medium grained pink granite showing stains of chalcopyrite near prithvipur area.

Figure 17: The caught-up patches of granite are preserved in the dyke behind the Lakhar devi Temple.

Figure 18: Quartz reefs trending in NE-SW direction intruded in the Bundelkhand granites.

Figure 19: The granite get sheared and fractured along trending E-W shear zone around Babina and result in the

Figure 20: The mafic gneiss suffered two generation folding and get deformed dur to compression .

DISCUSSION

Babina area which is the part of Central Bundelkhand craton consists of different lithology. The study area is mapped and lithological map prepared. The TTG gneiss is metamorphosed and deformed which trend E-W and dipping towards North to North East direction. The Greenstone belt consist of Banded Iron formation, felsic volcanics, amphibolite, mafic and ultramafic units, granite varies from fine to coarse grained pink to grey colored porphyritic nature. Sanukitoid, anatectic granite, with NE-SW trending Quartz vein and NW-SE trending dykes marks the last stage intrusion and stability of craton.

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INTEREST OF CONFLICT

There author declare that there is no conflict of interest regarding the publication of this article

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A REVIEW ON ASSESSMENT OF GROUNDWATER QUALITY IN FAR-WESTERN KAILALI DISTRICT, NEPAL

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ABSTRACT

The study area lies in Bhajani and Chuha VDC_s in Kailali district. A total number of 24 water samples were collected and various water quality parameters were assessed from groundwater in the study area. Various parameters like color, PH, turbidity, TDS, EC and hardness were used for water quality analysis. Some of the heavy metals such as Al, Cd, Pb, Fe, As were found that indicates risk to the community. Mainly the study is focus on arsenic concentration as the Kailali is one of the major contaminated district in terms of Arsenic. The result of water quality analysis was compared to the national standard values.

Key Words: Groundwater, Water quality, NDWQS, WHO, Permissible limit, Metal concentration.

INTRODUCTION

Groundwater is commonly understood by mean water occupying all the voids within a geologic stratum (Mays & Todd, 2005). It is stored in and moves slowly through geologic formation of soil, sand and rocks called as aquifer. Groundwater is a significant water supply source of domestic, municipal, irrigation, self-industry purposes (Zekster, 1998). Groundwater contributes 75% of overall drinking water in the world. It is the major source of drinking water in Nepal. Around 90% of the people in Terai region depends upon groundwater as their primary source of portable water (Kayastha, 2015). Anthropogenic activities are the major cause of groundwater pollution in Nepal as well as in the world.

Several tests have been conducted on groundwater quality in Nepal. The groundwater quality is based on physio-chemical, biological contamination analysis. The study area lies in the Terai region, and it is mainly focused on the arsenic contamination. In the terai region of Nepal about 1.8% of total tested tube wells have concentration of arsenic above the natural standard (50 ppb) for drinking water (Detection, Management and Surveillance of Arsenicosis in Nepal, 2009).

The study was conducted in Bhajani and Chuha VDC_s Kailali District, terai region of Far Western Nepal. Kailali district lies from 28°22´ N & 29°05´ N latitude and from 80°30´ E to 81°18´ E longitude. The study area is lies in Chure Hills underlying by Bhabar region in northern and plain land in southern part. In northern region coarse sand, silt and sandstone is dominant. In middle Bhabar region gravel, sandy loamy, cobble, boulder, pebbles are found dominant. And similarly, fine sandy loamy soil is found in southern terai region. The study area (Figure-

1) has subtropical, cool temperate climate with maximum and minimum temperature of 44°C & 23.5°C.

OBJECTIVE

The study is focused on groundwater assessment.
To identify the physical, chemical, biological parameters that affect the water quality of that area.
To inform the public about the water contamination and its risk on their health and livelihood.
To identify the dominancy of chemical elements on the location.
To identify the major utilization purpose of water.

Figure-1: Location of Bhajani and Chuha of Kailali district (Gurung et al., 2015)

MATERIAL AND METHOD

Desk study is applied for this article. As this article is written based on the secondary data, authors of this original paper used various field and laboratory methods for water quality analysis.

For the quantitative determination of different physio-chemical parameters:12 samples from handpump from Chuha; 9 samples from handpump, 2 from taps and one from reservoir from Bhajani were collected. A total number of 24 water samples were collected in March 2014 (Gurung et al., 2015). The physio-chemical parameters measured in the field were pH using calibrated pH meter (Eco Sense pH.10A), Electrical Conductivity (EC) and Total Dissolved Solid (TDS meter). For the detection of fecal coliform in water samples a presence-absence test (P/A test kit) developed by Environment & Public Health Organization ENPHO, Nepal was used.

For laboratory analysis water quality parameters were chosen as prescribed by Nepal Drinking Water Quality Standard (NDWQS) (NDWQS, 2005). For cation, water samples were collected in pre-acidified 125ml plastic container. Concentrated HCl was used as preservation for Arsenic, while nitric acid was used in other cation Calcium(Ca), Iron(Fe), Manganese(Mn), Aluminum (Al), Copper(Cu), Lead(Pd), Chromium(Cr). For anion, water samples were collected in non-acidified 500ml plastic container for sulphate, nitrate, chloride and fluoride. The obtained result was compared with the NDWQS.

RESULT AND DISCUSSION

Different parameters sech as color, pH, turbidity, TDS, ES and Total hardness were within the permissible limits of the National Standard Table-1, Table-2 (Gurung et al., 2015). The values obtained for the different physical parameters measured in Bhajani and Chuha along with the major factors affecting that parameter is shown in (Table-3). The correlation graph between EC & TDS

Bhajani (a) and Chuha(b) in Figure-2 (Gurung et al., 2015). This shows that EC is affected by TDS. In Bhajani high pH 7.6 in sample BR6 and low pH 6.56 in BP4; high hardness 454 mg/l in BR2H and low hardness 194 mg/l in BP2. In Chuha, CR6 has a high pH, while CR2 & CP1 has a low pH.

The concentrated of the anion in all samples were within the permissible limit prescribed by the NDWQS. Nitrate was present below the detection limit in 20 samples (Table-1 & Table-2). A sample CR2 had a relatively high sulphate concentration (33.69 mg/l). A sample CR3 had a relatively higher concentration of chloride (30 mg/l) which; could be attributed to contamination of the groundwater wastewater. The concentration of different cation in water samples were in order of Ca>Al>Fe>Mn>Zn>Pb>As>Cu>Cd>Cr in Bhajani whereas the order in Chuha it was Ca>Al>Fe>Mn>Zn>As>Cu>Pb>Cd>Cr.

Major dominancy of elements in the Water Sample in the Study Area

In all the samples, concentrations of Ca, Zn and Cr were within the permissible limit of the NDWQS, beside these as, Cr and Pb concentrations in samples from Bhajani and Cu and Cr concentrations in samples from Chuha were within the permissible limit. The concentration of *Aluminum* exceeded the national standard in twenty-two samples from Bhajani and Chuha, *Iron* in eighteen samples from Bhajani and Chuha, *Manganese* in nine samples from Bhajani and Chuha, *Lead* in four samples from Bhajani and Chuha, *Arsenic* in two samples from Bhajani and Chuha and *Cadmium* in one sample from Bhajani exceeds the prescribed limit.

Table 1: Water Quality result (Bhajani)

Parameters	Unit	Sample ID												NDWQS
		BP1	BP2	BP3	BP4	BP5	BP6	BR1T	BR2H	BR3H	BR4T	BR5H	BR6	
Turbidity	NTU	2	<1	<1	<1	3.5	<1	2.1	4.0	2.1	1.8	3.8	3.2	5 (10)
pH	-	7.3	7.1	6.62	6.56	6.57	6.82	7.3	6.65	6.67	7.3	7.04	7.6	6.5-8.5*
Color	TCU	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	5 (15)
Taste and Odour	**	**	**	**	**	**	**	**	**	**	**	**	**	**
TDS	mgL^{-1}	422	388	403	537	410	453	291	671	628	290	242	292	1000
EC	μScm^{-1}	843	779	803	1073	821	910	579	1340	1260	581	485	585	1500
Hardness	mgL^{-1}	210	194	260	230	410	360	256	454	362	196	224	206	500
Ca	mgL^{-1}	60.1	52.9	87.4	66.5	129.1	103.4	59.3	139.5	136.3	58.5	82.6	56.9	200
Cl	mgL^{-1}	3	5.5	9	12	1	44	2.0	122	8 6	4.0	6.0	4.0	250
Fl	mgL^{-1}	0.21	0.23	0.23	0.28	0.22	ND (<0.05)	0.17	0.12	0.09	0.18	0.16	0.17	0.5-1.5*
NH_3	mgL^{-1}	1.94	1.51	1.22	1.51	1.51	1.72	0.19	2.15	0.92	0.18	0.56	0.19	1.5
NO_3^{-1}	mgL^{-1}	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	16.07	ND (<0.05)	16.13	19.09	ND (<0.05)	ND (<0.05)	ND (<0.05)	50
SO_4^{-2}	mgL^{-1}	0.35	0.18	1.4	0.7	1.05	28.07	5.97	95.44	85.62	3.33	4.39	0.18	250
Fe	mgL^{-1}	0.17	0.47	0.18	0.37	1.85	0.85	0.21	0.32	0.95	0.18	1.04	0.61	0.3 (3)
Mn	mgL^{-1}	0.56	0.78	0.92	0.6	0.45	0.91	ND (<0.05)	0.23	0.23	ND (<0.05)	0.75	0.08	0.2
As	mgL^{-1}	ND (<0.005)	ND (<0.005)	ND (<0.005)	ND (<0.005)	ND (<0.005)	ND (<0.005)	ND (<0.005)	ND (<0.005)	ND (<0.005)	0.008	ND (<0.005)	ND (<0.005)	0.05
Cd	mgL^{-1}	ND (<0.003)	ND (<0.003)	0.003	0.003	ND (<0.003)	ND (<0.003)	ND (<0.003)	0.004	0.003	ND (<0.003)	ND (<0.003)	ND (<0.003)	0.003
Cr	mgL^{-1}	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	0.05
Cu	mgL^{-1}	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	1
Zn	mgL^{-1}	0.06	0.13	0.05	0.07	0.17	0.14	0.08	0.07	0.09	0.08	0.18	0.11	3
Pb	mgL^{-1}	ND (<0.01)	ND (<0.01)	ND (<0.01)	0.016	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)	0.01
Al	mgL^{-1}	ND (<0.05)	3.35	0.88	7.02	5.9	7.88	1.47	4.58	5.88	2.78	10.50	7.88	0.2

** unobjectionable; ND: Not detected; ( ): Maximum limit

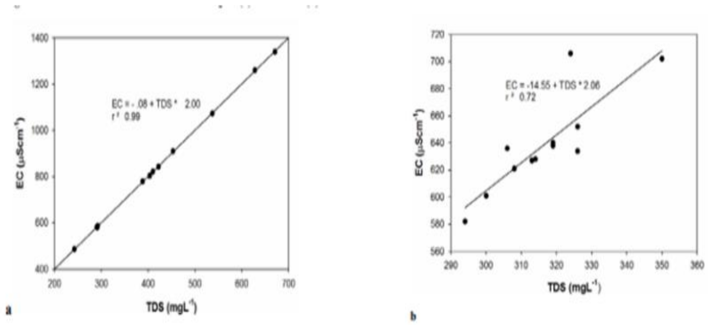

Figure 2. Correlation between EC and TDS Bhajani (a) and Chuha (b).

Table 2: Water quality results (Chuha)

Parameters	Unit	Sample ID												NDWQS
		CP1	CP2	CP3	CP4	CP5	CP6	CR1	CR2	CR3	CR4	CR5	CR6	
Turbidity	NTU	3.5	78	16.4	11.0	42.0	75.0	2.8	3.3	12.4	6.6	7.4	7.2	**5 (10)**
pH	-	5.9	6.99	6.91	6.85	7.01	6.94	6.03	5.9	6.99	6.96	6.97	7.05	**6.5-8.5***
Color	TCU	<2	<5	<5	2	<10	<10	2	<2	<2	<2	<2	<2	**5 (15)**
Taste and Odour	**	**	**	**	**	**	**	**	**	**	**	**	**	**
TDS	mgL^{-1}	306	314	350	319	326	308	319	324	300	313	294	326	**1000**
EC	μScm^{-1}	636	628	702	638	652	621	640	706	601	627	582	634	**1500**
Hardness	mgL^{-1}	326	304	344	312	328	324	330	364	316	316	292	320	**500**
Ca	mgL^{-1}	90.6	93.0	118.6	93.0	102.6	100.2	97.0	112.2	97.8	93.8	97.8	84.2	**200**
Cl	mgL^{-1}	3.0	1.0	30.0	1.0	1.5	2.0	2.0	8.0	1.0	2.0	1.0	1.0	**250**
Fl	mgL^{-1}	0.21	0.58	0.22	0.26	0.27	0.23	0.09	0.19	0.26	0.27	0.19	0.24	**0.5-1.5***
NH_3	mgL^{-1}	0.49	0.57	0.50	0.38	0.89	0.56	0.60	1.59	1.31	0.66	1.63	2.76	**1.5**
NO_3^{-1}	mgL^{-1}	ND (<0.05)	ND (<0.05)	3.66	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	ND (<0.05)	**50**
SO_4^{-2}	mgL^{-1}	0.53	33.69	11.23	2.11	12.63	7.72	1.40	5.79	3.68	4.04	2.81	4.91	**250**
Fe	mgL^{-1}	1.58	0.91	0.96	0.80	0.22	5.28	1.68	1.42	1.65	1.93	6.54	1.15	**0.3 (3)**
Mn	mgL^{-1}	0.08	0.16	0.52	0.08	ND (<0.05)	0.31	0.20	0.07	0.08	0.11	0.12	0.10	**0.2**
As	mgL^{-1}	ND (<0.005)	ND (<0.005)	ND (<0.005)	ND (<0.005)	0.007	0.052	ND (<0.005)	ND (<0.005)	ND (<0.005)	ND (<0.005)	0.019	ND (<0.005)	**0.05**
Cd	mgL^{-1}	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	0.003	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	ND (<0.003)	**0.003**
Cr	mgL^{-1}	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	**0.05**
Cu	mgL^{-1}	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.02)	0.02	ND (<0.02)	ND (<0.02)	ND (<0.02)	0.02	ND (<0.02)	**1**
Zn	mgL^{-1}	0.18	0.37	0.06	0.06	0.03	0.05	0.12	0.06	0.11	0.11	0.14	0.08	**3**
Pb	mgL^{-1}	0.012	0.015	ND (<0.01)	ND (<0.01)	ND (<0.01)	ND (<0.01)	0.022	0.012	0.017	0.012	0.014	ND (<0.01)	**0.01**
Al	mgL^{-1}	4.11	6.02	0.12	1.44	4.03	2.64	4.70	3.99	4.59	4.61	5.28	4.00	**0.2**

Table-3: Physical parameters measured in Bhajani and Chuha

Parametrs	Bhajani	Chuha	Factors affecting the parameters
Turbidity	<1-4 NTU	>2.8-78 NTU	In surface and groundwater inert clay or chalk particles precipitation of non soluble reduced iron and other oxides. High turbidity is a disease causing organisms, medium for microbial growth.
Color	<2TCU	<2-<10TCU	Humic acid, fluvic acid, metallic ions such as Fe, Mn, suspended matter, industrial waste impart color to natural water bodies.
pH	6.96±3.5	6.71±0.47	Presence of organic and inorganic solutes together with reaction of CO2. In terai high bicarbonate, low sulfate and nitrate in GW are responsible for neutral to alkaline.
TDS	242-671	294-350	TDS <600 mg is considered as good and drinking water significantly increasing. Higher TDS significantly health impacts to peoples with hyper tension and diabetes.
EC	485-1340 µs/cm	582-706 µs/cm	It measures the total amount of dissolved minerals and ions in water, that indicate the presence of Na, K, Cl, Sulfate.
Hardness	280.17±91.32mg/l	292-364 mg/l	It is cause by variety of dissolved polyvalent metallic ions Ca, Mg and other cation Al, Ba, Fe, Mn, Zn. It shows the Ca Concentration in samples.

The concentration of Arsenic was lesser than the average Arsenic level in the tube wells of Kailali district previously reported at 0.062 mg/l. Kailali has been categorized as one of the six districts worst hit by Arsenic contamination in Nepal. In this study only two samples were known to contain the concentration exceeding the permissible limit indicating spatial variation in the concentration. A number of anthropogenic activities such as urbanization use of fossil fuel also can bring about an increase in the concentration of different ions and heavy metals in groundwater.

The result of contamination of water in the study area is due to the presence of faecal coliform. 3 samples from Bhajani and 3 samples from Chuha have indicated faecal contamination in the water wells. The possible causes of faecal contamination of the GW are improper sewage disposal practices like pit latrine, soakage pit system. As per Nepal Drinking Water Quality Standard (NDWQS) and WHO (2011) guidelines, water is considered acceptable if the total coliform count is zero in 95 percent of the samples. Faecal contamination of water bodies is an indication of presence of pathogenic organisms.

Utilization of Water in the Study Area

In these locations drinking water parameters from groundwater are assessed. The groundwater was tapped from the aquifer using hand-pumps dug at household level and water pipe supply from deep boring reservoir. The average depth of tube well in Bhajani was 41.29± 18.01 feet and 48.917± 11.02 feet in Chuha.

The locals of these area were found to consume the groundwater directly without any treatment. They were aware of the health implications of arsenic contamination in water. However, they have not adopted any measures to address this issue. The community perceives that there is no scarcity of water in their VDC.

CONCLUSION

The study was carried out to assess the groundwater quality of Bhajani and Chuha VDCs of Kailali district in Far Western Nepal. Many of the water quality parameters are within the permissible limit and some of the parameters exceeds the permissible limit by NDWQS. Only two samples of Arsenic were exceeding the permissible limit indicating spatial variation in the concentration. The concentration of Aluminum exceeded the national standard in twenty-two samples. Iron exceeds in eighteen samples. Similarly, Lead exceeds the permissible limit in four samples. The study implies there is high health risk to the community due to these heavy metals' concentration in water samples.

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GEOCHEMICAL PROSPECTING OF SECONDARY MINERALS

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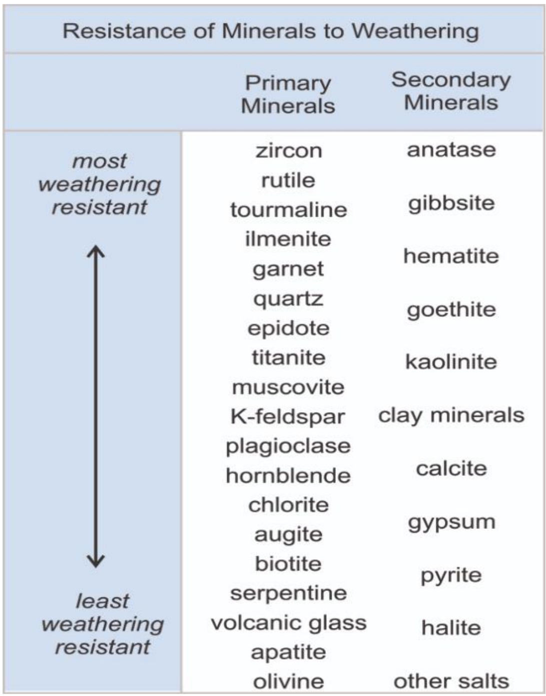
ABSTRACT

Geochemical methods such as Pedogeochemistry (soil sampling), Lithogeochemistry (rock sampling), Sampling of fluvial sediments, Sampling of heavy minerals, Hydrogeochemical sampling, Geochemistry of radiogenic isotopes, Geochemical sampling of glacial sediments. Vegetation sampling Gas sampling are used for prospecting of minerals and in this paper major of the above mention methods are described. These methods are applicable for prospecting of primary and secondary mineral deposits.

Key Words: *Geochemical method; Prospecting; Secondary minerals*

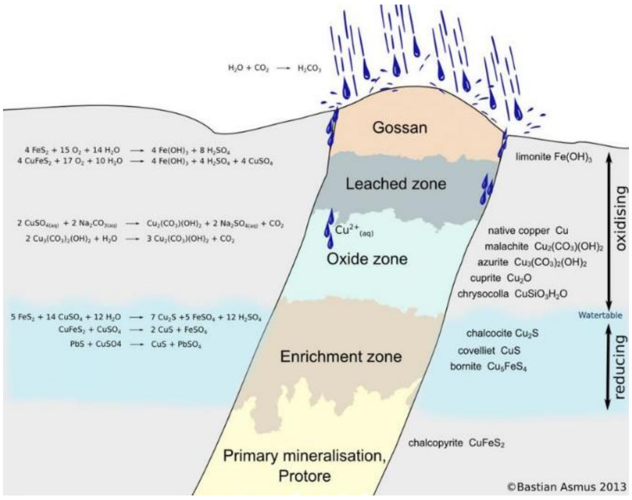
INTRODUCTION

Prospecting is the first stage of the geological analysis (followed by exploration) of a territory. It is the search for minerals, fossils, precious metals, or mineral specimens. Traditionally prospecting relied on direct observation of mineralization in rock outcrops or in sediments. Modern prospecting also includes the use of geologic, geophysical, and geochemical tools to search for anomalies which can narrow the search area. Once an anomaly has been identified and interpreted to be a potential prospect direct observation can then be focused on this area. It is mainly concerned with studying the enrichment or impoverishment of certain chemical elements in the vicinity of mineral deposits.



Geochemical prospecting is done by systematic measurements of one or more chemical parameters, usually at trace concentrations, of naturally occurring materials in the Earth's crust. The types of samples that are collected include rocks, soils, gossan, river or lake sediments, groundwater, surface water, steam or gases, and vegetation. The redistribution of chemical elements on or near the Earth's surface due to weathering, transport, sedimentation, and/or biological activity is classified as secondary geochemical dispersion. The secondary geochemical dispersion halo comprises the dispersed remnants of mineralization, caused by surface processes of chemical and physical weathering and the redistribution of the primary patterns. The halo can be recognized in samples taken from soil, rocks, sediments, vegetation, groundwater, and volatiles, at a distance of meters to tens of kilometers.

Mineral deposit is a mineralization (referring to an area of the crust where ores were deposited) of sufficient size and grade (concentration), which under favorable circumstances could be exploited with economic benefits, which has sufficient reserves. Secondary minerals are substances that are formed from the alteration of primary minerals. That means; secondary mineral forms when primary minerals undergo chemical and geological alterations such as weathering and hydrothermal alteration. A mineral deposit formed when a primary mineral deposit is subjected to alterations through chemical and/or mechanical weathering. Secondary deposits are divided into three groups: sedimentary rocks, secondarily enriched mineral deposits, and residual or detrital mineral deposits.



When rock minerals undergo a transformation process due to the change of temperature and pressure (such as metamorphism and weathering), the newly created stable minerals are known as the secondary minerals. For example, clay minerals are secondary minerals produced during the process of weathering. Usually, the formation of secondary minerals begins near the site where primary minerals are being attacked, perhaps even originating as coatings on the crystal surfaces

METHODOLOGY

Geochemical prospecting methods:

In general terms, they can be classified into the following types depending on the sampling stages, the nature of the terrain, the signal associated with the mineralization, the type of analytical instrumentation available, and finally, the time and cost allowable for the program.

Pedogeochemistry (soil sampling).
Lithogeochemistry (rock sampling).
Sampling of fluvial sediments.
Sampling of heavy minerals.
Hydrogeochemical sampling.
Geochemistry of radiogenic isotopes.
Geochemical sampling of glacial sediments.
Vegetation sampling.
Gas sampling.

Soil sampling

Soil is the unconsolidated product of weathering. It is usually found at or near its source of formation such as residual soils. It can be transported over long distances, forming alluvial soils. It is widely used in geochemical prospecting and often produces successful results.

Anomalous element enrichment from underlying mineralization may occur due to secondary dispersion in overlying soil, weathered product, and groundwater during weathering and leaching processes. The dispersion of the elements can be large, forming an exploration target larger than the actual size of the deposit.

Lithogeochemistry

Rock sampling is useful during regional work to recognize favorable geochemical provinces and favorable host rocks to host mineral deposits. Most of the epigenetic and syngenetic mineral deposits show primary dispersion around the mineralization, due to the presence of abnormally high values of the trace elements.

Lithogeochemistry aims to identify primary dispersion, diagnosis of other geochemical characteristics, and association of trace elements, which are different in sterile rocks.

Rock outcrop can be sampled directly by breaking up a small hand sample using a geological hammer or hammer and chisel. Generally, 1–3 kg is a suitable sample size (mass). Sampling is based on the analysis of fresh rocks or individual minerals. Sampling is conducted on a uniform grid across a geologic terrain that includes various rock types from fresh outcrops, wall rocks, and core samples.

Sampling of fluvial sediments

River sediment sampling is the most widely used in all reconnaissance and detailed study of watersheds. Many minerals, particularly sulfide minerals, are unstable in the weathering environment, breaking down as a result of oxidation and other chemical reactions. The process will produce secondary dispersion of both minerals and trace elements. Elements will move in solid form and in solution greater relative distances within the basin drainage.

The mobility of different elements will vary significantly, between fine-grained particles and, eventually, in detrital rock fragments, clay minerals, organic and inorganic colloids enriched in ore minerals, and in pathfinders, which are deposited downstream.

The optimum size fraction varies in different environments, and generally 80 mesh size is recommended. Samples are generally collected in natural sediment traps along streams.

Hydrogeochemical sampling

There are two types of water sources, i.e., groundwater and surface water; they have very different chemical and physical properties. Groundwater is produced in springs and wells. It has a better potential in geochemical prospecting especially if it is acidic (low pH) by dissolving and transporting metallic elements such as Cu, Pb, Zn, Mo, Sn, S, U, Ni, and Co more than in surface waters, due to chemical weathering and oxidation followed by leaching.

Surface water from streams, rivers, and oceans has less dissolving power, and fine-grained sediments absorb much of the metals carried by the water. River water samples and sediment samples are collected simultaneously for analysis.

Water samples are easy to obtain. About a liter of water is collected and stored in a special container. Metal solubility decreases with increasing pH 4–7. Therefore, the pH is recorded at the time of sampling and other physicochemical parameters (Eh, temperature, salinity, total dissolved solids, among others). Suspended solids are filtered before analysis.

Geochemistry of radiogenic isotopes.

The spontaneous deposition of short-lived radon decay products onto solid surfaces (“collectors”) provides the basis for a simple and efficient way of prospecting for uranium. The alpha activity of two of the decay products, 218Po and 214Po, can be measured by conventional counting techniques following the exposure of a collector to a radon source. Laboratory studies have shown: (a) radon decay products can be collected on a wide variety of materials; (b) the number of radon decay products increases with the collector surface area; (c) a negative charge applied to the collectors enhances the number of decay products collected; (d) the shape of the collectors is relatively unimportant; and (e) reproducibility is about ± 5% of the measured value.

Geochemical sampling of glacial sediments.

In mountainous regions containing extensive glacier systems there is a lack of suitable material for conventional geochemical sampling. As a result, in most geochemical sampling programs a few stream-sediment samples collected at, or near, the terminus of valley glaciers is used to evaluate the mineral potential of the glaciated area. Developed and tested a technique which utilizes the medial moraines of valley glaciers for systematic geochemical exploration of the glacial catchment area. Moraine sampling provides geochemical information that is site-specific in that geochemical anomalies can be traced directly up-ice to bedrock sources.

Vegetation sampling

The principles underlying chemical or botanical studies of vegetation as a method of locating buried ore deposits are basically simple. The root systems of trees can be portrayed as powerful sampling mechanisms, bringing representative solutions up from a large volume of ground below the surface. Then, as the water is removed by evaporation, the mineral content of these solutions is left behind and concentrated in the leaves.

CONCLUSION

A mineral deposit formed when a primary mineral deposit is subjected to alterations through chemical and/or mechanical weathering. Secondary deposits are divided into three groups: sedimentary rocks, secondarily enriched mineral deposits, and residual or detrital mineral deposits. When rock minerals undergo a transformation process due to the change of temperature and pressure (such as metamorphism and weathering), the newly created stable minerals are known as the secondary minerals.

Different methods are applicable and used for the identification of different mineral deposit Soil sampling is used to locate and identify the concentration from the leaching of the surface mineral and Lithogeochemistry aims to identify primary dispersion, diagnosis of other geochemical characteristics, and association of trace elements, which are different in sterile rocks. Hydrogeochemical sampling is used to identify the mineral deposited by the water / fluvial action. Similarly, the use of vegetation can be helpful to identify the mineral present below the vegetation as it is shown by the color of the leaves.

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GLACIER LAKE OUTBURST FLOODS (GLOFS) IN NEPAL: ITS CAUSES AND CONSEQUENCES

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ABSTRACT

A glacier is a large body of ice that is moving from a higher to a lower elevation due to action of gravity. Nepal Himalaya consists of higher mountains at high elevation and snow falls regularly to form glacier and glacier lakes. Many of them are at potentially risk level. The retreat of Glacier Lake and the melting in snow cause many disastrous effect like glacial lake outburst floods in Himalayan region. Rapid changes in the climate and increasing temperature causes the melting of the snow and results in the GLOFs. This article provides brief information about GLOF events that have occurred in Nepal history and its causes and consequences. Regular monitoring of the glacial lakes should be done to identify and reduce the risk of GLOFs.

***Key Words**: Glacier, Mountain, Avalanche, Risk*

INTRODUCTION

Glacier means the large sheet of ice which moves towards lower elevation due to the action of gravity. Glacier Lake is formed when the movement of block of ice melted is blocked by ice or due to the terminal moraines or may be due to the geomorphology of the movement path. Glacial lakes are found on the mountain region. In that region there are so many glacial lakes. The Dig Tsho, Imja, TshoRolpa are some example of glacial lake of Nepal. The water of such lake get dammed by snow or rocks weakened by snow. In winter the lake changed into snow, so the lake looks like plains of snow. In the summer snow melts and water is visible and looks like a lake.

The GLOF is the type of outburst flood that occurs when the dam containing a glacial lake fails. The water of glacial lakes outburst due to different reason, it cause floods in the area around it, this is known as glacial lake outburst flood. Many big glaciers melted rapidly forming a large number of glacial lakes. Due to an increase in the rate and snow melt, the accumulation of water in these lakes has been increasing rapidly. Sudden discharge of large volumes of water with debris from these lakes causes glacial lake outburst floods (GLOFs). There are two distinctly different forms of glacial lake outburst: (1) Those that result from the collapse or overtopping of ice deposit or ice dams formed by the glacier and (2) those that happens when draining of water from lake is very rapid. TshoRolpa glacier, located in Rolwaling valley which lies on to the North east direction of Kathmandu at an altitude of 4850m. The lake is dammed by 490ft high unconsolidated terminal moraine which is considered as most dangerous glacier lake in Nepal (ICIMOD, 2011).

Figure 1: Glacier lake outburst flood

OBJECTIVES

Glacial Lake Outburst Floods being one of the disasters that causes destruction of life and infrastructures. So, the study of the GLOF is important. The study objectives are

To know how the GLOF works.
To know about the history of the GLOFs of the Nepal and other region.
To know about the cause, effect and consequences of GLOFs.
To know about preventive measurement of GOLFs.
To assist the Government of Nepal in developing an overall strategy to address possible risks from GLOFs in the future.

METHODOLOGY

Available secondary sources such as books, documentary, article etc and published secondary data of different researches were used for the analysis within the topic. The data were also collected through various website. Primary data collection was not possible for the present study, which is the limitation of the present study. Only desk study was done for the preparation of this article without field investigation. All the data are collected according to the format.

RESULT AND DISCUSSION

GLOFs in Nepal

Since 1977, Nepal has experienced 26 GLOF events of which 14 originated in the country (Richardson and Reynolds,2000). Water level has already reduced in the four lakes to reduce the risk of GLOFs; TshoRolpa and ImjaTsho in Nepal and 2 in TAR China.Table 1 present major GOLF event recorded in Nepal (ICIMOD 2011).

Not only this many other GLOF events had occurred in Nepal. Lastly, in May 05, 2012, GLOF event had occurred from the Annapurna and the Macchapuchre range which had killed many people.

According to the data of 26 GLOF events in the Himalayas analysed by Richardson and Reynolds (2000), majority of moraine dam failure are caused by:

a. 50% GLOFs occurred by overtopping due to ice avalanche into the lake from hanging or claving glaciers.

b. 12% GLOFs occurred by seepage.

c. 8% GLOFs occurred by overtopping due to rock avalanche.

d. 4% GLOFs by melting of dead ice core.

e. 23% by unknown phenomenon.

Table: Major GLOF event of Nepal (ICIMOD 2011)

S. N.	Date	River basin	Name of lake	Causes of GLOFs	Remarks and damages
1.	450 years ago	Setikhola	Machhapuchhare	Ice-cored moraine collapsed	Pokhara covered by 5060m thick debris
2.	Aug 1935	Sun koshi	Taraco	Moraine Collapse due to seepage	66700m^3 of wheat field livestock etc.
3.	Sept 21 1964	Arun	Gelhaipco	Moraine collapse due to glacier sliding into the lake	Dam breach 40m deep and 23 million m^3 of water draining out. Bulk density of 2.45 t/m^3. Highway and 12 trucks etc.
4.	1964	Sun koshi	Zhangzangbo	Moraine collapse dueto glacier sliding	No remarkable damages.
5.	1964	Trishuli	Longda		
6.	1968	Arun	Ayaco	The lake brusting three times in 1968,1969 &1970	Road concrete bridge etc.
7.	1969	Arun	Ayaco		
8.	1970	Arun	Ayaco		
9.	September 3 1977	Dudh koshi	Nare	Ice-covered moraine collapse	Mini-hydroplant, roads,bridges,farmland
10.	1980	Tamur	Punchaa		One village destroyed villager migrated after GLOF.
11.	11 July 1982	Sunkoshi	Zhangrangbo	Moraine collapse due to glacier falling into the lake	Dam breech 50m deep and 40-60m in width maximum drainage being 16000m3 :19 million m3 of water drained out. Araniko highway, friendship bridge, Sunkoshi hydropower station, farm land etc.
12.	Aug 27 1982	Arun	Jinco	Moraine dam collapse due to glacier sliding into the lake	1600 heads of livestock, 187000m^3 of farm land and houses of 8 villages washed away.
13.	August 4 1985	Dushkoshi	Dig Tsho	Moraine collapse due to glacier ice avalanche	Namche hydropower station, 14 bridges trails, cultivated land etc.
14.	July12 1991	Tamakoshi	Chubung	Moraine dam collapse of Ripinoshae glacier	Houses, Farmland etc were washed away.
15.	May 1995	Kali gandaki	Tsarang chu upstream in mustang		

Recent study on the GLOFs of Nepal

According to recent study of International Centre for Integrated Mountain Development (ICIMOD), out of 3624 glacial lakes mapped 1410 lakes are considered large enough to cause serious damage, 47 lakes were considered potentially dangerous. The PDGLs were ranked to determine the priority for potential GLOF risk reduction.

TABLE 5.5 SUMMARY OF POTENTIALLY DANGEROUS GLACIAL LAKES IN THE KOSHI, GANDAKI, AND KARNALI BASINS OF NEPAL, THE TAR OF CHINA, AND INDIA

Basin	Sub-basin	Nepal	TAR, China	India	Total
Koshi	Tamor	4	–	–	42
	Arun	4	13	–	
	Dudh Koshi	9	–	–	
	Tama Koshi	1	7	–	
	Sun Koshi	–	4	–	
Gandaki	Trishuli	1	1	–	3
	Marsyangdi	1	–	–	
Karnali	Kali	–	–	1	2
	Humla	1	–	–	
Total		21	25	1	47

Based on recent study of ICIMOD 2020

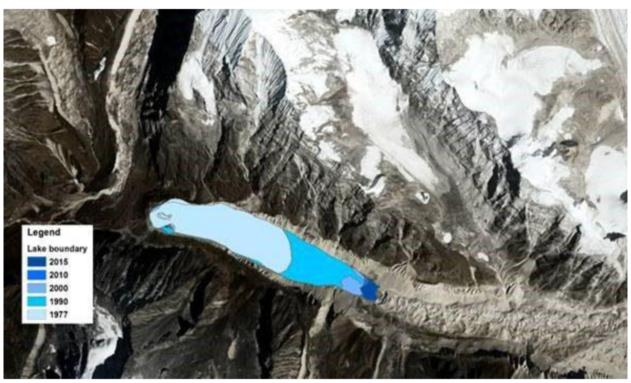

Figure 2: Reassessing Tsho Rolpa glacial lake-ICIMOD

Figure 3: Imja Glacial Lake (Satellite Image Google Earth, 2010)

Causes, effects and preventive measures of GLOFs

Causes

Rapidly melting of ice caps and snow incorporated in dam/forming dam.
Erosion of the rocks that damming glacial lakes.
Pressure of large amount of water on glacial lake.
Earthquake, Volcanic activities under ice.
Avalanche of rocks or heavy snow mass in glacial lake.
Blocking of the subsurface outflow tunnels.
Rapid slope movement into the lake.

Impacts

Devastating to any infrastructure and human being.
Modification of river courses and induced landsliding.
Temporary landslide damming and the LDOFs.
Longterm effect on the suspended load of river.

Preventive Measures

Reducing the volume of water from the lake by establishing outways.
Maintaining a moraine dam and landslide at valley walls.
Establishing a monitoring system and early alarming system.
Developing awareness to local people residing at the potential paths of GLOFs.
Preparedness and buildup of rescue systems are sought.
Learn from the past events and prepared for the future events.
A clear vision of strategy for management of GLOFs in Nepal is necessary.
Nepal should collaborate with international disaster relief agencies and international redcross.

CONCLUSION

Nepal being a Himalayan country, at the higher elevation snow flows regularly and many glacial lakes are formed. Out of which some lakes are at potentially dangerous level. The risk of the GLOFs is in highly amount in our Himalayas. The human influence on the climate is the one of reason for outburst. The rapidly change in climate of the earth can cause rapidly melting of snow. Due to extreme increase in temperature since the mid-1970s, with highest temperature release millions of cubic meters of water and debris leading to the loss of lives, properties and livelihoods among remote and impoverished mountain communities. The outburst changes the entire ecosystem. So, for the safety and to be preventive from GLOF events, its type, possible causes of collapse should be known so that the mitigation measures can be applied. Regular monitoring should be done to identify dangerous glacial lakes. Artificial drainage system must be continued.

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REVIEW OF MAJOR SEISMIC EVENTS ON THE HIMALAYA

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ABSTRACT

The Himalayas, the collision zone of the Indian and the Eurasian plates, have been affected by numerous earthquakes. Here, the study tries to understand the location, magnitude, and destruction caused by major earthquake events in the Himalayas ranging between 1255-2015 A.D. For the purpose of study, previous research on earthquakes is studied. A total of 11 large earthquakes have been recorded in the recent history of which 5 are of magnitude greater than 8.0. The records of earlier earthquakes are few compared to recent ones. Nepal has been affected by most of these events causing the death of many people and heavy loss of properties.

Key Words: *Himalaya, Seismicity, Earthquake*

INTRODUCTION

The Himalaya is the result of the northward movement of the Indian plate at the rate of 5cm/year and its interaction with the Eurasian plate, the overthrusting of Indian plate beneath the Eurasian plate results in the Himalayan arc and causes earthquakes in the Himalayan seismic belt (Figure 1) and the convergence of the Indian, and the Eurasian plates, earthquake occurrence and accommodated slip on the detachment (MHT) (Seeber and Armbruster, 1981). MHT is the surface underthrusting the Indian shield over the Himalayan rocks and forming the major thrust like MFT, MBT, MCT, and STDS. The record of the earthquakes dates back to 1255 during the reign of King Abhya Malla but the exact magnitude of the 1255 earthquake is unknown. The magnitude of major earthquakes 1897 Shillong (8.0-8.1) and Mw (8.7), 1905 (8.6), 1934 Kangra (8.3), 1950 great Assam (8.5) and 2015 Gorkha (Mw 7.8, M_L 7.6) assigned by the different researcher (Ambraseys & Bilham, 2003) and (Richter, 1958), Gutenberg and Richter (1954), (Tandon, 1954) and (Bhattarai et al., 2015) respectively and that of other earthquakes 1408, 1505 was not assigned properly but the magnitude of the 1833 earthquake was 7.6 assigned by F94 method (Bilham, 1995). In this article, rupture zone of the earthquakes from 1255 to the 2015 Gorkha earthquake in the Himalayan arc and its effect on the major thrust and its slip surface is discussed, and thus the socioeconomic loss due to the shaking of the ground and associated hazard with it is described.

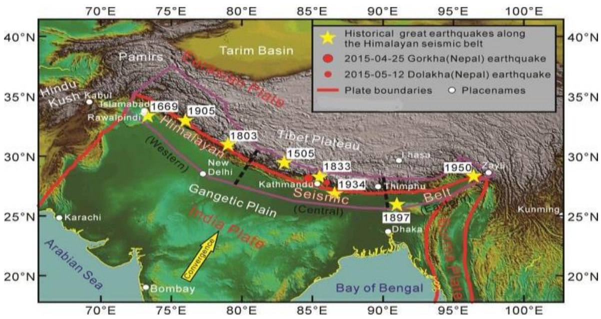

Figure 1: Seismotectonic map around the Himalayan seismic belt [Source:(Xue, Qin, & Yang, 2017)]

1255 Earthquake

The chronicle of one of the largest events, on June 7, 1255, specifies that temples and houses collapsed, killing one-third of the inhabitants, including King Abhaya Malladeva (Pant, 2002). The aftershocks were felt for 4 months, strengthening the inference that this event was a great earthquake. Although the 1255 and 1344 earthquakes were very destructive, they are documented only in the Kathmandu Valley (Bollinger, Tapponnier, Sapkota, & Klinger, 2016). The earthquake is interpreted to have produced a minimum observed fault slip of ~5 m in the trench exposure. The 1255 earthquake might have ruptured the Himalayan front over a length of ~800 km from ~85.87° to 93.76°E longitudes (Mishra et al., 2016). A reexamination of the observations and analysis recently reported to conclude that an 800 km section of the Himalayan Frontal Thrust ruptured in 1255 A.D. shows that the conclusion is flawed and without merit because of misinterpretations of trench logs and incorrect interpretation of radiocarbon statistics (Pierce & Wesnousky, 2016). Severe damages in prevalent masonry, adobe houses along with monumental constructions (Gautam & Chaulagain, 2016).

1408 Earthquake

The epicentre of the earthquake lay near Nepal-Tibet Border, Bagmati zone, the magnitude was 8.2 and killed around 2500 people ("Historical Earthquakes in Nepal", Disaster Preparedness Network Nepal). The 1408 AD earthquake may have ruptured the MFT up to the surface in central Nepal between Kathmandu and Pokhara, east of the surface trace of the great 1505 AD earthquake which affected western Nepal (Bollinger et al., 2016).

1505 Earthquake

The magnitudes of these events and of seismic events that necessarily happened between the late sixteenth and the eighteenth centuries are likely smaller than 7.5 because they occurred during the chronicle-rich Mughal period in northern India and would have been reported if felt over significantly large areas. An absence of large earthquakes has characterized the Central Himalaya since the great Himalayan earthquake of 1505. This Mw 8.4 (or greater) earthquake is known to have damaged several cities in India as well as monasteries scattered along a 600-km swath of the southern edge of the Tibetan plateau and the Mustang province of Nepal. Preliminary work at a trench site in far-western Nepal has likely discovered the first direct evidence for surface rupture of the Main Frontal Thrust (MFT) during the 1505 earthquake (Yule, Dawson, Lave, Sapkota, & Tiwari, 2006).

1681 Earthquake

Not much research has been carried out in relation to the 1681 earthquake, however, (Gautam & Chaulagain, 2016) mentions that there were many casualties due to the earthquake, and damages were concentrated in the residential houses.

1810 Earthquake

In the earthquake of 1810A.D., some casualties were reported in Bhaktapur, and significant damage occurred in residential houses and monumental constructions (Gautam & Chaulagain, 2016).

1833 Earthquake

At 23:35 Calcutta time on 26 August 1833 a 1 million square km land from India, Nepal, and Tibet was shaken by a strong earthquake and hence which triggered landslides and rockfalls, destroyed more than 4600 dwellings and many temples, but apparently resulted in fewer than 500 fatalities (Bilham, 1995). Loss of life was due to the large foreshocks five hours and 15 minutes before the mainshock and not had been severed by the main one. Some villages in northern Nepal and 30% or more houses were destroyed in Tibet and a few damages in India were a few fatalities and a few buildings totally destroyed (Bilham, 1995). Mainshock was felt from Delhi to Chittagong, intensity was high in the mountainous region north of Kathmandu and southern Tibet. The moment magnitude determined by the F94 model is M=7.5+-0.3 (Bilham, 1995), close to M=7.6 adopted by (Khattri & Tyagi, 1983). A Possible location of the epicentre of the main shock was 50km north or northeast of Kathmandu (Bilham, 1995). The relatively small rupture area of the 1833 earthquake indicates that it contributed insignificantly to reducing potential slip in the Central Himalayan Seismic Gap between the Kangra 1905 and Bihar 1934 rupture zones. The slip associated with the event may have been 1-2 m, an amount consistent with a renewal time of 100 years (Bilham, 1995). Due to this earthquake, 414 casualties were reported in and around Kathmandu valley. In total, 18,000 houses were damaged and around 4000 damages were concentrated in Kathmandu valley and immediate vicinities like Banepa (Gautam & Chaulagain, 2016).

The Assam Earthquake-1897

The Assam earthquake of 12 June 1897 is the largest known Indian interplate earthquake with a magnitude of 8-8.1 (Ambraseys & Bilham, 2003). Previously, the magnitude was obtained to be Ms 8.7 (Richter, 1958). Many aftershocks were felt at different places over a wide area through the end of 1898 (Oldham, 1900). The earthquake raised the northern edge of the Shillong Plateau by more than 10 m and caused widespread liquefaction, subsidence and uplift, landslides, and flooding in the Brahmaputra and Sylhet floodplains (Ambraseys & Bilham, 2003). The author also mentions that the earthquake ruptured a 110 km-long fault beneath the Shillong Plateau. The earthquake resulted in the Shillong Plateau being thrust violently upwards by about 11 metres. The fault slip was about 18 m (accuracy more or less by 7 m). At the epicentre, vertical acceleration is thought to have been greater than 1g and the surface velocity is estimated at 3 m/s (Bilham & England, 2001). About 1542 people were killed and hundreds more injured. Damage from the earthquake extended into Kolkata where dozens of buildings were badly damaged or partially collapsed. Shaking from the event was felt across India, as far as Ahmedabad and Peshawar. Seiches were also observed in Myanmar. (Documentation on past disasters, their impact, measures taken, vulnerable areas in Assam, 2015)

1905 earthquake

The 1905 earthquake shook a large part of northwest Himalaya and the adjoining Gangetic plain on April 4, 1905. This is one of the four major earthquakes since 1897 and its magnitude was assigned as 8.6 by (Richter, 1958). According to (Middlemiss, 1910), with an intervening region of lower intensity there were two separate higher intensity zones, which are the Himalayan foothill towns of Kangra and Dehra dun in the northwest and southwest and both zone overlapped parts of outer and lesser Himalaya and thus stand on either side of MBT and the Kangra zone had higher intensity than the Dehra dun. Chander (1988) explained that during the Kangra earthquake, slip occurred only on the MBT and involved slip along MBT and a deep-seated fault jointly and hence substantial subsidence occurred.

The elevation changes can be explained with the small rupture in the Dehra dun and slip on rupture is not more than 40cm, which supports a larger rupture in Shahpur-Mandi sector and hence influences the elevation changes around the Dehra dun which would be negligible on comparison with distance (Chander, 1988). Rupture extending over a distance of 280 km from northwest to southwest high-intensity zone parallel to the general strike of the Himalaya, but the southeastern edge of rupture would lie 10-15 km northwest of the leveling line near Dehra Dun, depth of the rupture due to this earthquake concealed with 10-15 km (Chander, 1988) which is not consistent with the extent of rupture about 80km suggested by (Molnar, 1987).

1934 earthquake

In the last 150 years, Himalayan belt has been affected by five major earthquakes (those 1897,1905,1934,1950 and Gorkha 2015), and 1934 Nepal Bihar was one of them. Gutenberg and Richter (1954) assigned a magnitude of 8.3 for this earthquake. (Richter, 1958; Singh & Gupta, 1980) estimated the epicentre in the Gangetic plains, south of the Main Frontal Thrust (MFT). (Seeber & Armbruster, 1981) concluded that the slip occurred on a plane lying beneath the Indo-Gangetic plains and dipping gently northward and said that the epicentre for the earthquake also lay beneath the plains and not the Himalaya.

The extensive destruction in the eastern Lesser Himalaya, Nepal supports the inference that the rupture, and epicentre, lay beneath the Himalaya, and not south of the range. The relocation of epicentre of the quake calculated by (Chen & Molnar, 1977) lies within the area of Nepal where damage was most and that the extent of faulting associated with it probably are typical of great earthquake in the Himalaya (Pandey & Molnar, 1988) and also explained that the impression that we gain from both the distribution and the various causes of damage is that if faults ruptured bedrock in northern India , then the location of such faults are not revealed clearly by the distribution of intensity.

According to (Seeber, Armbruster, & Quittmeyer, 1981) and (Seeber & Armbruster, 1981) the 1934 rupture occurred in detachment whose northern limit was north of the MBT in the belt of intermediate earthquakes (Ni & Barazangi, 1984; Seeber & Armbruster, 1981; Seeber et al., 1981) and southern limit was 100km south of MBT towards Main Frontal Thrust. (Pandey & Molnar, 1988) inferred that the length of the rupture zone was 200±100 km and slip of about 6.2 m.

The destruction and damage are not only due to the shaking of the ground but also slumping and landsliding. The difference in building structures in Nepal and India results make it difficult to compare the intensities in Nepal and India (Rana, 1935). In the earthquake, in total, 8519 casualties were in the Nepalese side of which 4296 casualties were reported within the Kathmandu valley. More than 200,000 houses, monuments and historical constructions, about 81,000 structures were damaged. 55,000 buildings were damaged in the Kathmandu valley among them 12,397 completely collapsed. This earthquake induced slumping and landslide in the eastern hills of Nepal due to which damages were triggered (Gautam & Chaulagain, 2016).

The Assam-Tibet Earthquake-1950

The Assam-Tibet Earthquake or the Assam-Tibet earthquake of 15 Aug 1950 was of magnitude 8.5 (Tandon, 1954). The earthquake took place at the northeastern border of the State of Assam, India, and was followed by a very large number of aftershocks with epicentres scattered over a large area around the epicentre of the main shock. There were more than 50 aftershocks of magnitude greater than 6.0, magnitude (Tandon, 1954). The author also states that the focal region of the earthquake was confined to the earth's outer crust. The exact estimation of the depth as possible for only 14 shocks showed most of the aftershocks originated between 10-20 km depth. The earthquake killed 1526 people in Assam (NGDC, 2022) and another 3300 in Tibet. Dykes blocked the tributaries of the Brahmaputra River. Some broke without causing damage while that at the Subansiri River opened after 8 days and the wave, 7 meters high, submerged several villages and killed 532 persons. Seiches were observed in many lakes and fjords of Norway and at least 3 reservoirs in England. (USGS, 1994)

015 Gorkha Earthquake

Central Nepal was struck on 25 April 2015 by the Mw 7.8 (M_L 7.6) Gorkha earthquake, which initiated about 80 km northwest of Kathmandu (Figure 2) and ruptured toward the east along a 140 km long west-northwest–east-southeast fault segment (Bhattarai et al., 2015). The earthquake originated northwest of Kathmandu within a cluster of background seismicity that fringes the bottom of the locked portion of the Main Himalayan Thrust fault (MHT) and the rupture propagated eastwards for about 140 km, unzipping the lower edge of the locked portion of the fault (Avouac, Meng, Wei, Wang, & Ampuero, 2015). A Mw 7.3 aftershock with a very similar focal mechanism occurred on 12 May, 75 km east of Kathmandu. The main shock and the aftershocks have partially released the accumulated interseismic strain along the Main Himalayan Thrust (Sreejith et al., 2018).

Gorkha seismic sequence is the most devastating event in Nepal after the 1934 Bihar-Nepal earthquake. As many as 755,549 building in central, eastern and western Nepal were either completely collapsed or partially damaged; structural damage in affected areas is attributed to structural and material deficiencies as well as effect of local amplification, topographical and ridge effects (Gautam & Chaulagain, 2016). The seismic event caused 8778 fatalities and 22,303 injuries, and more than 790,000 buildings were fully or partially damaged in Nepal (Government of Nepal, 2015, http://drrportal.gov.np). It triggered numerous landslides, avalanches, and rockslides above and near the rupture zone (Bhattarai et al., 2015).

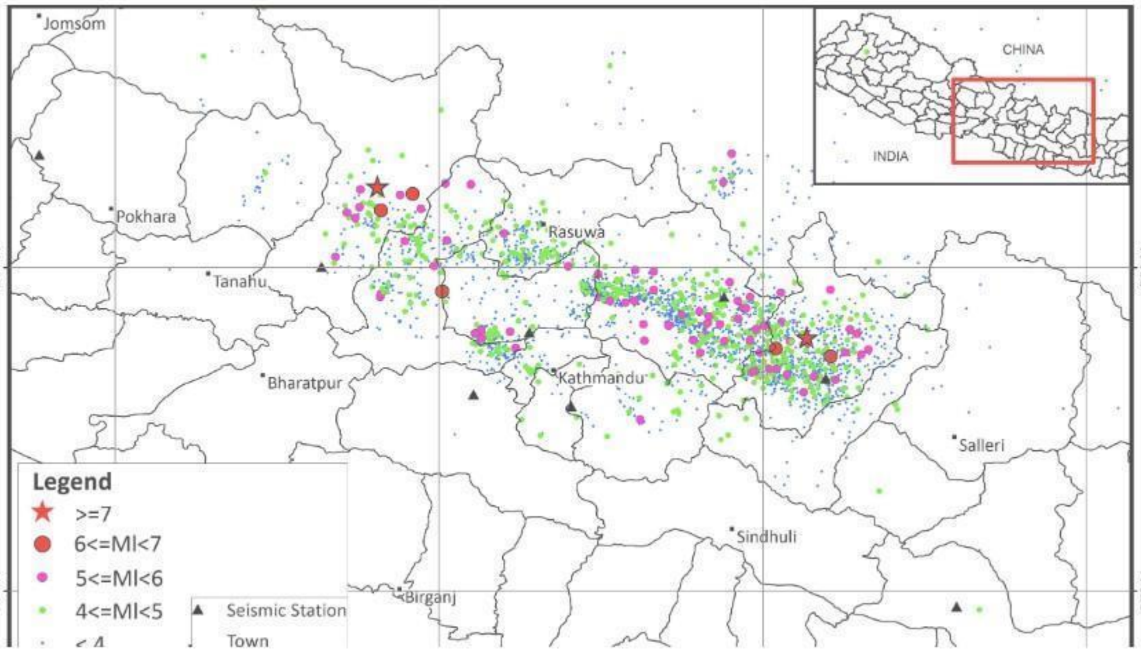

Figure 2: Location of epicentres of the 2015 Gorkha Earthquake (Source: Nepal Seismological Centre)

CONCLUSIONS

The Himalaya is a region of high seismic activity. There have been several large seismic events leading to the loss of huge lives and wealth. These seismic events have affected the entire region of the Himalaya. These large earthquakes are followed by many aftershocks. Paleo seismic studies of past earthquakes are a bit scant. The region with high seismic activities due to the collision, experienced many large earthquakes in the last 9 centuries. Most of those are associated with the MFT, the MBT and the MCT because MHT locked the huge amount of stress due to collision strained through these thrust. The 1897 earthquake was associated with Shillong plateau, the 1905 earthquake had rupture along MBT, the 1934 also had rupture and slip along MBT while the 1950 Assam earthquake released the stress locked in the Main Himalayan Thrust. The 2015 Gorkha earthquake, propagated eastwards for about 140 km, unzipping the lower edge of the locked portion of the fault (MHT) and caused 8778 fatalities, 22,303 injuries and more than 790,000 buildings were fully or partially damaged due to shaking and triggering of landslide, avalanches, and rockfall above the rupture zone.

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SPATIAL DISTRIBUTIONS OF AQUIFER HYDRAULIC PROPERTIES FROM PUMPING TEST DATA IN NAWALPARASI EAST OF BARDAGHAT SUSTA, SOUTHEASTERN SECTION

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ABSTRACT

Spatial distribution of aquifer hydraulic properties was carried out from direct pumping test data in Nawalaparasi East of Bardaghat Susta at southeastern section. The study area lies within the longitudes 84°3'6"E to 84°14'26"E and latitudes 27°33'57"N to 27°41'42" N, underlain by alluvial deposits of the Narayani River and local streams. Pump testing was carried out in over thirteen locations in the study area. The single-well test approach was used, employing the constant discharge and recovery methods. The Copper-Jacob's straight-line method was used to analyze the pump test results. This enables the computing of the aquifer hydraulic properties. Static water level ranges from 0 to 65.1 meters. Aquifer transmissivity value ranges from 0.014151 m^2/day to 2.379 m2/day, including variable transmissivity potentials, while hydraulic conductivity values range from 0.00007667 m/day to 0.04575 m/day. Various 2D maps of aquifer transmissivity, hydraulic conductivity, static water level and drawdown were constructed to show their spatial distribution in the study area. For groundwater investigation and development, numerous regional 2D maps will be helpful.

Key Words: *Aquifer Hydraulic properties, Pumping test, Copper-Jacob.*

INTRODUCTION

One of the major issues when thinking about a groundwater development project is frequently the absence of information on which to base an evaluation of the aquifer's variability (Hamil & Bell, 1986**).** The lack of information on the range in the value of aquifer hydraulic characteristics is a common issue (Ezeh et al.). With the goal of assessing the spatial distribution of hydraulic properties, numerous investigational techniques are frequently used. Under ideal circumstances, these techniques have not taken the place of the pumping test (Sattar et al., 2016), because pumping test data are available in this work, extrapolations using regional distribution are made simple and practicable.

Location

The study area is located in the Southeastern section of the Nawalparasi East of Bardaghat Susta (Figure 6). The area lies between geographical co-ordinate longitudes 84°3'6"E to 84°14'26"E and latitudes 27°33'57"N to 27°41'42" N. Boreholes are generally observed in the southeastern part of the district mainly on local government named as Madhyabindu, Kawasoti, Devchuli and Gaindacoat municipality.

Geology and Hydrogeology

The study area lies in the Dune valley of the Nepal Himalaya. This area is formed by accumulation of the collective out wash of the local river and streams ~~and~~ sediments are carried out through Bhabar zone and

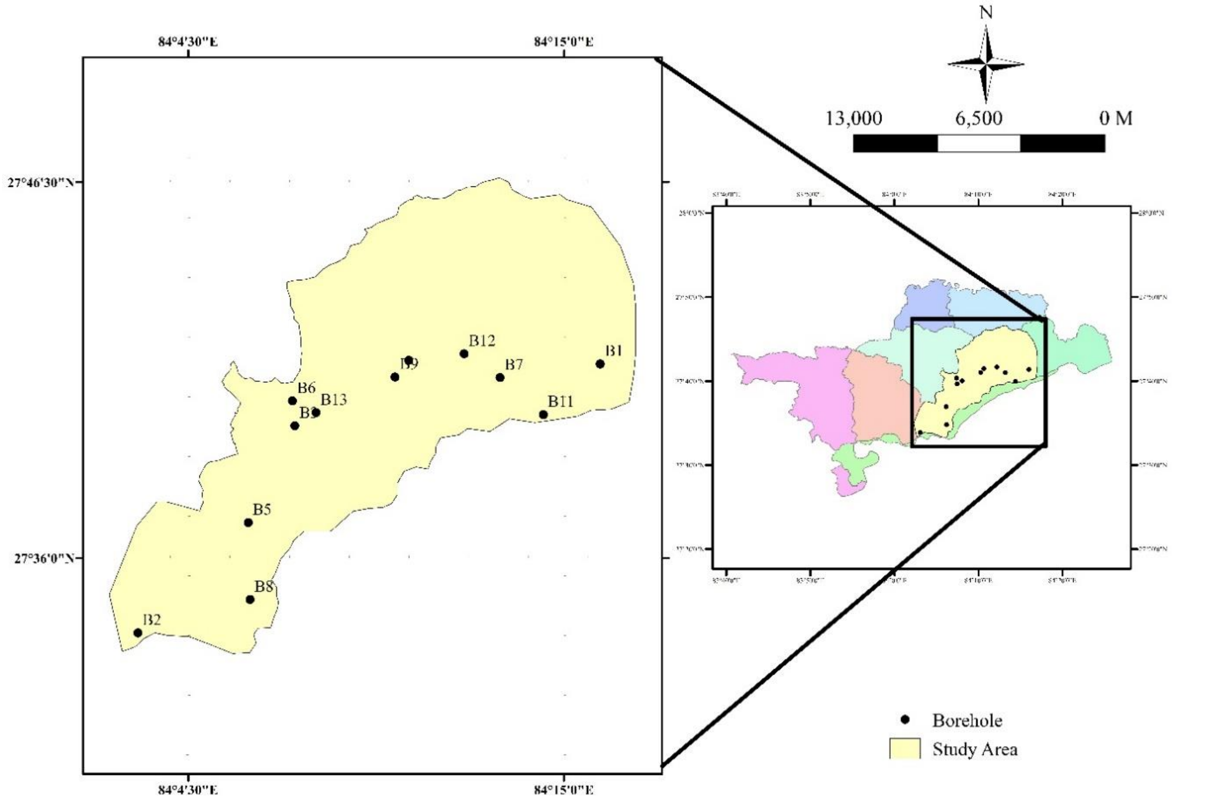

Figure 6: Location of the study area

lesser Himalaya regions contain highly porous, permeable, and unconsolidated to poorly consolidated alluvial or fan deposits originated form Upper Siwalik and lesser Himalayan region. The deposited sediments are mainly gravel, Pebble, cobbles, sand.

Theory and Methods

Pumping test is a variable scientific means of asserting the immediate and perennial yield of a drilled hole. The test in essence, involves abstracting water from the well at a known rate and then observing the decline water level in the aquifer in the vicinity of the well. The objective of this test among others includes the following:

To ascertain the immediate and perennial yield of the well.
To determine and propose a future operational set-up for the hole.
To determine the aquifer loss, well loss and efficiency of the well.
To deduct aquifer parameters such as Transmissivity (T) and Hydraulic Conductivity (K).

The test was carried out in thirteen (13) locations, employing the constant discharge and recovery methods. Well depth, screen length, pump capacity and depth of installation were well data inventories obtained during the exercise. Static water level (SWL) was measured and recorded before pumping. The pumping began varied at all locations. The drawdown due to water abstraction was taken in the interval of 1 minutes for 10 minutes. After this, it was 2 minutes for 20 minutes, at 5 minutes' interval for 40 minutes. After this, it was 10 minutes for another 60 minutes. At the end of this, drawdown was measured for every 60 minutes, for the remaining duration of pumping. 20 liters container was used to collect the pump water with respect to time in order to compute discharge (Q). The water discharge is measured at 10 minutes,

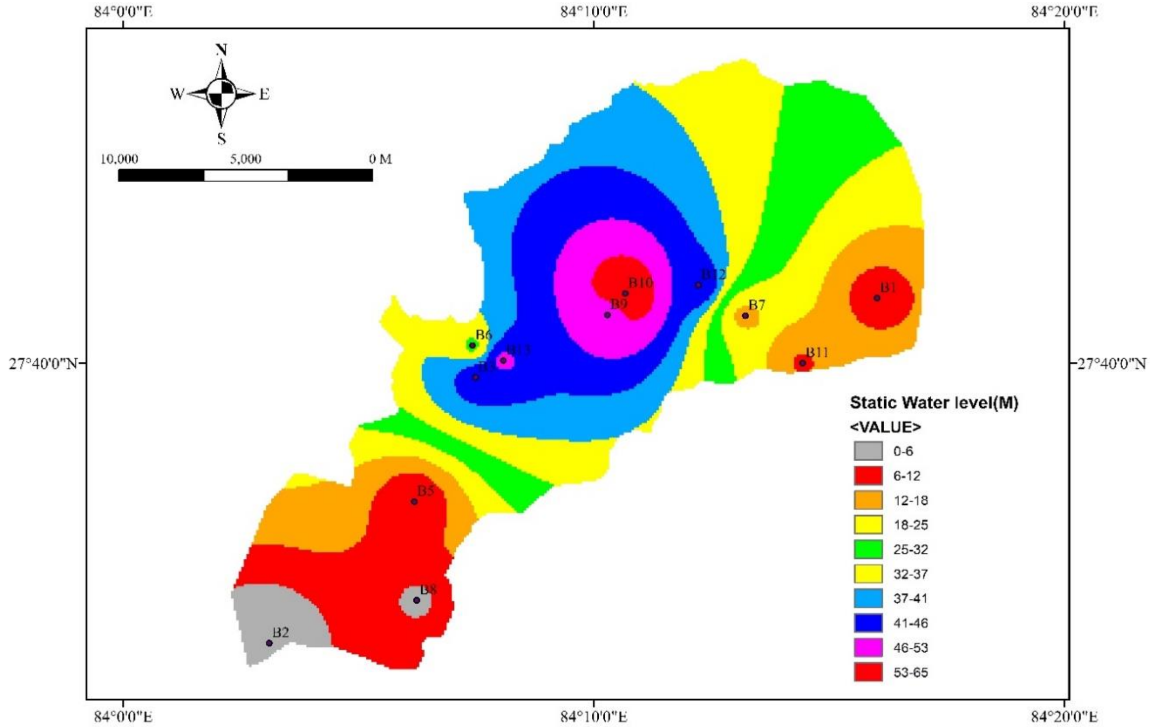

Figure 2: 2D Spatial distribution map of static water level in the study area.

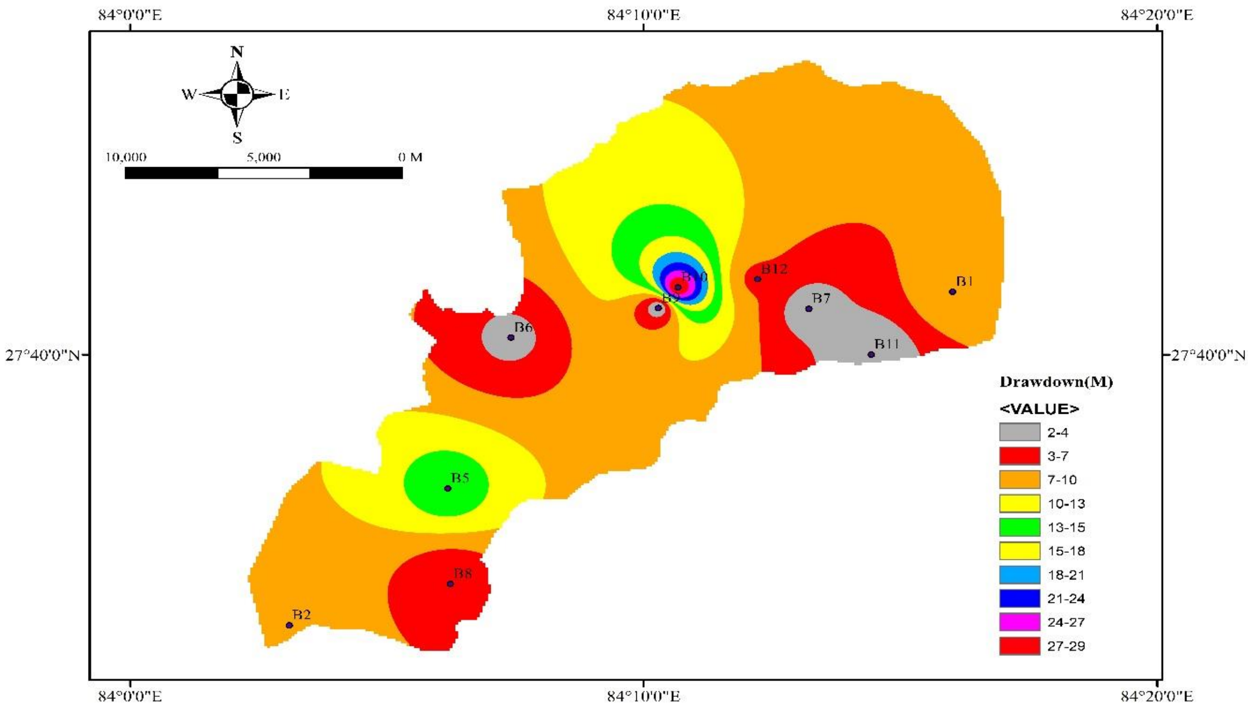

Figure 3: 2D spatial distribution map of Drawdown in the study area.

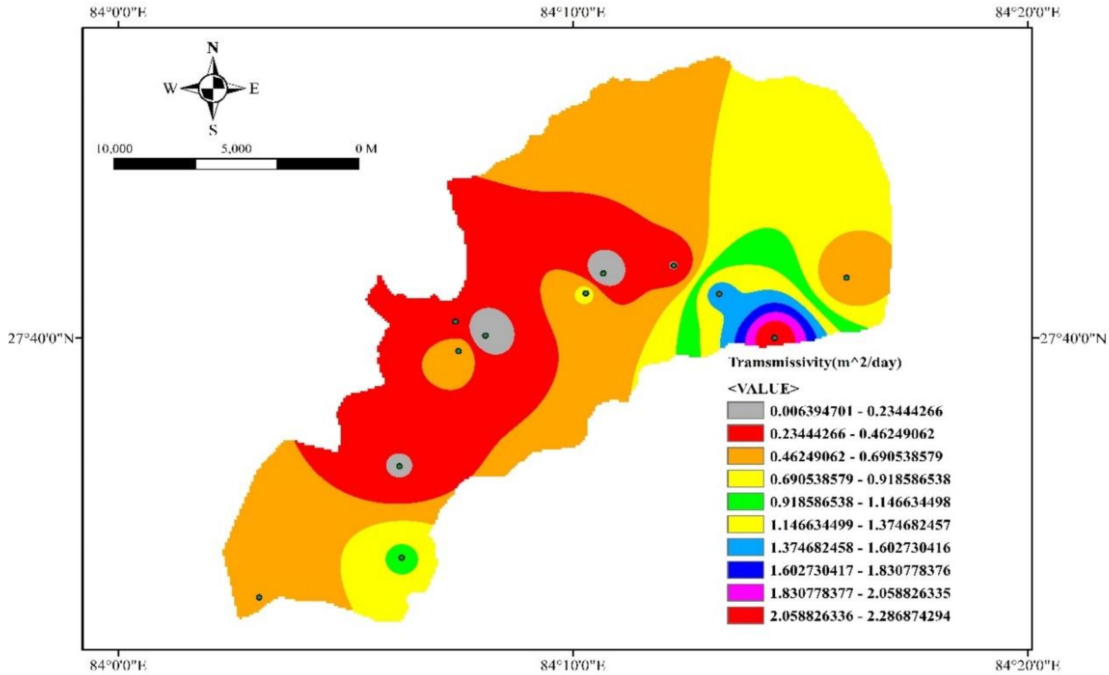

Figure 4: 2D spatial distribution map of Transmissivity in the study area.

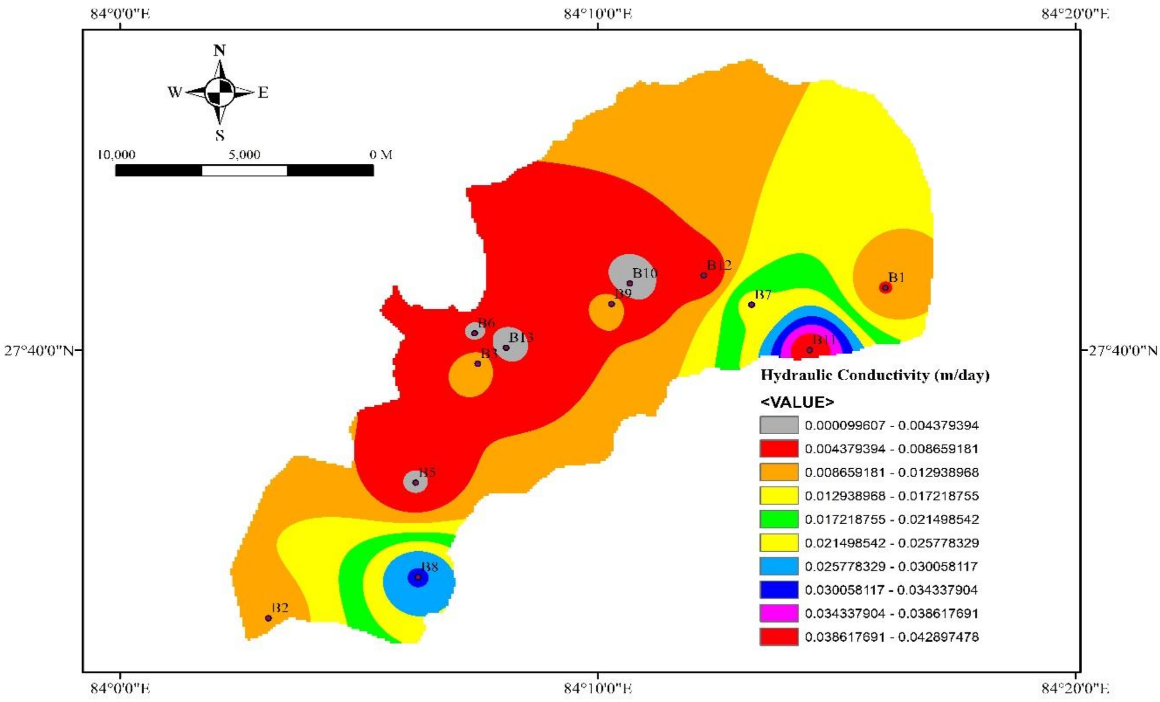

Figure 5: 2D Spatial distribution map of Hydraulic conductivity of the study area.

minutes and 60 minutes respectively. The Copper-Jacob's method (Cooper Jr & Jacob, 1946) was used to analyse the pump test result of drawdown with respect to time using semi logarithmic graph. Transmissivity (T) was estimated by fitting a straight line to drawdown on an arthmetric axis versus time on a logarithmic axis (Udom, 2014). Quantitatively T was obtained using Equation 1.

$$T = \frac{2.3Q}{4\pi\Delta s} \quad (1)$$

Where, Q is discharge and Δs is the drawdown per cycle. Knowing T, it was possible to compute Hydraulic Conductivity (K) using

$$T = Kb \quad (2)$$

Where, b is the aquifer thickness.

RESULTS AND DISCUSSION

Spatial distribution 2D maps of static water level (SWL), Drawdown, Transmissivity ~~(T),~~ Hydraulic conductivity ~~(K)~~ were constructed. SWL (Figure) is much deeper around the part of the central area ranging from 46 to 65 meters and shallow to southern area. Drawdown is variable in the study area. High drawdown is observed at the northern part ranging from 27 to 29 meters (Figure). Moderated transmissivity ~~(T)~~ values occur around the northern and southern part ranging from the 0.46249 m^2/day to 1.83077 m^2/day. The transmissivity value is highly variable in the study area (Figure). The hydraulic conductivity (K) is also variable in the study area. The hydraulic conductivity value ranges form 0.000099 m/day to 0.049289 m/day in overall area (Figure). The high hydraulic conductivity is present in the central part of the study area.

CONCLUSION

The research area's spatial distribution of aquifer hydraulic characteristics has reinforced the integrity of the data analysis. In areas where there is uncertainty on the aquifer production rate, the spatial distributions have made it possible to quantitatively estimate aquifer parameters. According to the spatial distribution of the aquifer hydraulic properties, the central region of the study area has considerable excellent values for the aquifer features that are being addressed. Presently, the available pumping test data used for the quantitative exploration has proved plausible in the study area. It may be necessary to conduct in-depth geosounding in the research area's, adjacent areas with intermediate and low aquifer hydraulic characteristics to identify better horizons. For groundwater investigation and development, the numerous regional 2D maps will be a helpful guide.

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STATUS OF POTENTIAL MINERAL RESOURCES AND POSSIBLE MINERAL RESOURCES IN LUMBINI PROVINCE

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ABSTRACT

This report explores the present status of the mineral resources in Nepal mainly from Lumbini Province, primarily to make an estimate based on geology of range of minerals that may exist and to convert mineral resources into reserves. Mineral resources are playing vital role in the development of economy, industry and gross domestic products (GDP). However, the mineral resources are unevenly distributed across the geographical regions. In addition, some minerals are deposited in a particular place on a small scale. As a result, Nepal has not been able to mobilize mineral resources due to lack of detailed study. It requires rigorous study to identify the amount and quantity of mineral depositsin a particular area that can be dug out for commercial purpose. The data were mainly generated from a review of various materials and concludes that the government should give high priority to explore, excavate the mineral resources. It requires clear policy efforts and provisions from Government regarding roles and responsibilities towards the proper mobilization of mineral resources.

Key words: *mineral resources, gross domestic product, excavate, mobilization*

INTRODUCTION

Nepal is located in the middle of the 2500 km long Himalayan chain. Mountainous terrain makes for over 83% of Nepal's area. Nepal is well endowed with a variety of agricultural products, minerals, water, forests, and medicinal herbs. Exploiting and using these precious resources, particularly mineral resources, is crucial for the nation's economic prosperity. The hilly area's geological environment is conducive to the mineral resources of metals, nonmetals, and energy/fuel, as well as a significant amount of dimension and ornamental stones.

Minerals are a nation's untapped natural resource and hidden riches. People have been mining them and using them in a variety of ways since prehistoric times.

The efficient use of these resources is essential for industrial growth, job creation, reducing reliance on imports of goods and services, saving foreign exchange, reducing the trade deficit, bolstering the national economy, and raising GDP.

Mining History

Since the foundation of the Nepal Bureau of Mines in 1961 (2018BS) and the Nepal Geological Survey in 1967 (2024BS), systematic geological mapping, mineral exploration, and detail mineral investigation have been underway. The Department of Mines and Geology (DMG) was created in 1977 after the Government of Nepal (GON) combined the two departments. When DMG and UNDP supported initiatives (1969–

1972), Mineral Exploration Development saw its peak between 1969 and 1984.

Fig 1: Mineral Resources Location Map of Nepal (Source, DMG)

Mines and mineral sector

Department of Mines and Geology is engaged in the exploration, excavation and evaluation of mineral resources in Nepal. Department of Mines and Geology (DMG) has divided the industry into six sub-sectors as follows:

Table 1: Different category of Mineral Deposit

Metallic Minerals	Non-Metallic Minerals	Fuels Minerals	Gemstones	Decorative and Dimension stones	Construction Minerals
• Iron • Copper • Zinc and Lead • Cobalt • Nickel • Gold • Silver • Tin	• Limestone • Phosphorite • Magnesite	• Coal • Petroleum • Natural Gas • Methane Gas • Hot Springs	• Tourmaline • Beryl/ Aquamarine • Garnets • Kyanites • Rock crystals	• Marbles • Granites • Quartzite's • Slate	• Rocks • Basalt • Colored sandstone • Phyllite, Slates, Flaggy quartzite and schist

Metallic minerals, including iron, copper, zinc, lead, gold, platinum, silver and tin, are generally extracted from ore minerals. A numbers of metallic ore minerals are known to be found in various regions of Nepal.

Non-metallic minerals such as magnesite, phosphorite, talc, limestone, dolomite, quartz, mica, clay, silica sand, gemstones, decorative and dimension stones, construction materials etc. are found throughout the country.

Fuel minerals are naturally occurring carbon or hydrocarbon fuels such as petroleum, peat and natural gas formed by decomposition of organisms. Overview Gemstones are pieces of minerals (or other rock or organic material) that can be converted to jewellery or other accessories. Certain gemstones such as tourmaline, Beryl/Aquamarine, Garnets, Kyanites and Rock crystals are available in Nepal. Decorative and dimensions stones are a variety of indigenous, metamorphic, and sedimentary rocks including Marbles, Granites and Quartzite that are available in Nepal.

Construction minerals refers to Rocks, basalt, colored sandstone, phyllite, slates, flaggy quartzite and schist are used for roofing, paving and flooring.

Mineral Resources in Nepal Himalya

Underlying Siwalik and Pre-Siwalik rocks beneath the Quaternary sediments at depth contain stratigraphic and structural traps suitable for petroleum and natural gas reserves, and the southernmost Terai Plain (northern fringe of Indo Gangetic plain) area has potential for gravel, sand, ground water, and these resources. The Sub-Himalayan region, which includes the Dune Valley and the Siwalik Foothills and Churia Range, has the potential to hold building materials, radioactive minerals, a small amount of low-grade coal seams, and structural traps and reservoir rocks for petroleum and natural gas.

Similar to the Greater Himalaya, the Lesser Himalaya (Mahabharat Range includes Midland/Valleys) holds great promise for metallic minerals, including iron, copper, lead, zinc, cobalt, nickel, tin, tungsten, and molybdenum. For valuable and semiprecious stones, marble, and metallic minerals including lead, zinc, uranium, gold, and silver, among others, some places in the Higher Himalaya are highly promising.

There is potential for limestone, dolomite, gypsum, salt (brine water), radioactive materials, and natural gas in the Tibetan Tethys Zone (Inner Himalaya) in the extreme north. Exploration and exploitation of these mineral deposits remain difficult due to hard mountainous terrain, complex geology, a lack of infrastructure, and financial constraints.

Lumbini Province

The holy pilgrimage site of Lumbini in the Rupandehi District, which is also the birthplace of Gautam Buddha, the founder of Buddhism, is whence the province of Lumbini gets its name. On October 6, 2020, the Provincial Assembly changed the initial designation of Province No. 5 to Lumbini Province, making Deukhuri the official capital of the province. Geographically, the Province is bounded by the provinces of Gandaki to the east and north, Karnali to the north and west, Sudurpaschim to the west, and India to the south. Mountains, Hills, and Terai are the three ecological areas, and they each take up 3.1%, 69.3%, and 27.6% of the province, respectively.

Mineral Resources in Lumbini Province

There are many mineral deposits reported from this province. Some of them are in use and some are in the process of exploration whereas others are only known in occurrences. Some of the mineral are:

Fig: 2 Mineral distribution map of Lumbini Province

Phosphorite (Phosphate rock)

One of the primary raw materials used to create chemical fertilisers like triple super phosphate (TSP) and fused magnesium phosphate (FMP) is phosphorite, often known as phosphate rock. About 300,000 mt of chemical fertiliser are currently needed annually in Nepal, and this demand is rising. Other than three fertiliser manufacturing facilities, the nation has no other phosphorite + magnesium-based fertiliser industries. Pre-Cambrian to Lower Paleozoic massive cherty and stromatolitic dolomite are the only sources of phosphorite (0.7-4.7m thick bed). Dark grey to brownish detrital phosphorite particles less than 1 mm to 1 cm in size were discovered during preliminary phosphorite prospecting in the dang Area. Eocene argillaceous limestone lenses andbeds in the Sewar khola section in the Pyuthan District. The P205 content in this bed is normally below 5% and rarely upto 10%. Source bed or area of this detrital phosphorite fragments has not yet been identified. However, it could be a very good source of phosphorite

Coal

There are four stratigraphic sites in Nepal where low to medium grade coal seam occurrences/deposits are known: (a)

Quaternary peat/lignite; (b) Siwalik coal; (c) Eocene coal; and (d) Gondwana coal. In the Kathmandu Valley, peat/lignite is mined and mostly utilised in brick burning, along with firewood. Because of their sporadic minor occurrences, Siwalik's little coal seams are not particularly lucrative economically. A few locations in the Sallyan, Rolpa, Pyuthan, and Palpa districts as well as Tosh, Siuja, Azimara, and Abidhara in Dang contain erratic seams of eocene coal that are restricted to orthoquartzite. In these districts, 11 small-scale coal mines are in operation. In addition, DMG also grants 4 prospecting licences.

Eocene Coal, Tosh(Dang)

The tosh Coal deposit is located at an altitude of 4000m and lies approximately 18km north from the Ghorai bazar along the under construction Dang-Rukum motor road.

Coal bearing carbonaceous shale in form of lenses with laterally pinching seams in three separate stratigraphic horizons within northerly dipping ortho quartzites of tosh series of Eocene age. The lower coal horizon is represented by at least eight coaly lenticles of varying sizes over 1.5km distance. The middle and upper coal horizons are however, represented by 2-3 lenticles each and occur roughly 300m and 400m strtigraphically above the lower coal horizon. Lithostratigraphically, the rock of the tosh series are equivalent to Nagthats of Kumaon, Garhwal and Subathu of Simla Himalayas (C.K Sharma).

Gold

A number of small and isolated gold placers are known to occur in the Lesser Himalaya, the source and potential of which are yet to be determined and explored. Most of known places occur in lagre catchment basin posing difficultyin establishing the potential target areas.

Primary Gold (Lungri khola Prospects)

The Lungri Khola possibilities are in Nepal's Lumbini province's Rolpa district. A Dang-Libang road links the Sulichaur settlement, where the upstream alluvial gold prospect starts, with the East-West route. About 20 km upstream in the drainage basin is where the primary gold mineralization is located. The Joshi (1986) mineralization is found in the Jaljala Nappe (Lesser Himalayan Crystalline Thrust Sheet) sequence. Precambrian rocks from the Jelbang Formation and the Telkhola Formation, primarily chlorite schist and quartzites, make up the majority of the area around the prospect.

In the green schist facies rock of the Jelbang Formation and the micaceous marble of the Telkhola Formation, a 30 km long discontinuous mineralization zone has been identified. With the UNDP's technical help, evaluation of probable placer gold via test mining is also ongoing in the Lungri Khola region. The size of the gold particles ranges from tiny to over 1.5mm. During departmental operations, the largest nugget was measured at 6mm*3mm. It is anticipated that this placer is closely related to the primary gold mineralization that has been detected in the catchment region

Cobalt

Cobaltite is the main cobalt ore. Other ore minerals like erythrine and absolite are also recorded in different prospects. Few old workings for cobalt are known from Netadarling and Tamghas (Gulmi) and Samarbhamar (Arghakhanchi). They are also recorded from Lamadanda (Dhading) Nangra

(Kavre), Bhorle (Ramechhap), Bauli Gad (Bajhang), etc. All these old workings/ prospects need proper review and evaluation before further exploration. Cobalt is mainly used in making high resistant steel and alloys and also in glass factories to produce blue colored glass.

Tamghas Area

Cobalt-copper mineralization at Tamghas located along the contact zone of white dark grey dolomite and calcareous phyllite in the form of mm to cm thick seams (laminated).

Samarbhamar Area

The cobalt mineralization occurs along the bedding planes as mm to cm thick as laminae as well as in fissure together with chalcopyrite. The rock chip sample from Bhulke Khani showed upto 0.4% Co, 0.11% Cu, 32ppm Ag, 14ppm Mo.

Cement Grade Limestone

It is a crucial raw ingredient in the production of cement. The demand for cement is rising as a result of the rapid expansion of development activities such as the building of roads, bridges, dams, irrigation cannels, housing complexes, multistory buildings, etc. The districts of Khotang, Udayapur, Syangja, Palpa, Arghakhanchi, Dang, Pyuthan, Sallyan, Rolpa, Bajhang Baitadi, and Darchula have some lime-stone deposits that have been identified. More than 2.5 billion tonnes of cement-grade limestone may be found, and 196 prospecting licences for limestone have been granted to the private sector by DMG (GoN, 2011). However, because of the murky minerals policy, there is friction between the locals and the firm in some parts of the Palpa district.

Argha-khanchi Limestone Deposit, shows probable reservedeposited in lower Pre Cambrian- Paleozoic age with 47.32% CaO and 2.58% MgO having reserve of 8.6 million tonnes and Gandari Limestone Deposit, Dang shows probable reserve deposited in Eocene age with 47%CaO and 1.5%MgO having 10 million tonnes estimated reserve.

Dolomite

It is utilised in building materials, mostly for paving roads, building homes, and other civil construction projects. In the steel business, some dolomite could be utilised as flux, and in the glass sector, as filler. It occurs mainly in Dhankuta, Khotang, Udayapur, Sindhuli, Dolakha, Kavre, Kathmandu, Makawanpur, Dhading, Syangja, Palpa, Baglung, Gulmi, Arghakhanchi, Dang Pyuthan, Sallyan, Rolpa, Rukum, Jajarkot, Surkhet, Dailekh, Jumla, Achham, Doti, Bajhang, Bajura, Baitadi, and Darchula districts in the Lesser Himalayan and in some parts of Higher Himalayan region. Most of them have not yet been thoroughly investigated, and it is uncertain what grade and quality of raw materials they can be used as in industries.

Construction Material

Stones in the form of river boulders, gravel, roofing slate, paving stones, and building block stone, marble and sand are the largest visible resources which can be found throughout the country. Construction minerals occur in two forms

River boulders and Gravel

The rivers of the Siwalik and Terai Belts contain these crucial resources for Nepal. The initial assessment of these materials is finished. Boulders are exportable and can be mined in numerous rivers.

Natural bedrock deposits

Natural bedrock deposits in the form of limestone, dolomite, granite, augen gneiss, slate, quartzite, etc. occur quite extensively in various rock groups of Lesser Himalaya. There are several quarries operating in the Kathmandu valley and Pokhara in which these deposits are the primary source of building materials for houses and other constructions.

CONCLUSION

Mineral resources include metallic, non-metallic, fuel minerals, industrial minerals, and building materials are abundant in the Lumbini Province. Some mineral resources, such as energy resources and metallic or non-metallic minerals, are underutilised, whilst others, such as boulder, sand, gravel, slate, granite, and limestone, do not require as much money to search and exploit.

The results of prospecting could be helpful in developing the best exploration models to turn these resources into reserves. Dolomite from Pyuthan and the Gandari Limestone Deposit, as well as cobalt deposits, can both be valuable in the mineral sector. The mineral phosphorite can be used to create fertiliser, which may be crucial to the mineral sector. The number and variety of mineral resources in a certain location that may be mined for commercial purposes must be determined through thorough research. The successful mobilisation of natural resources necessitates defined policy efforts and regulations about roles and duties. Working with municipal and provincial political levels, the government should create a reasonable mineral policy.

In order to find the potential metallic resource economic reserves in the province as well as in Nepal, more extensive research in already-known locations, an evaluation of specific deposits, and research in new geologically prospective places may be helpful.

ACKNOWLEDGEMENT

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STUDY OF SPRINGS OF DHARAPANI, LUKUNSUWARA AND THULSUWARA VILLAGE OF KASKI DISTRICT, NEPAL

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ABSTRACT

In hilly region spring water is the main source of drinking water and for household use. Different factors like geology, geomorphology, soil type, rock type and geological structures plays important role in the formation of springs. Every spring is different from one other in terms of catchment area, recharge and discharge. To understand the status of spring fieldwork was conducted. During fieldwork measurement of discharge of spring, Physico-chemical parameters of spring water was measured. Dharapani, Lukunsuwara and Thulsuwara village, Kaski District, Nepal geologically lies in Lesser Himalaya. In the study area more springs are concentrated in the altitude range of 800-1300m from mean sea level and most of them are of contact and fracture type. Similarly, physio-chemical parameters like DO, pH, cd and temperature and discharge of every spring had been measured. Values of these physicochemical parameters are acceptable according to Nepal standard for drinking and for irrigation. This study gives the general information of springs of study area in terms of discharge, distribution and physiochemical parameters of spring water.

INTRODUCTION

Water that is present below the water table, typically in the zone of saturation, is referred to as groundwater. It plays a crucial role in regulating river and stream flow since groundwater and surface water are in a cycle that makes it a significant supply of drinking water for a sizable portion of the world's population. A spring is where surface water and groundwater meet. Springs are the locations on the ground's surface where, as a result of gravity, groundwater rises to the surface. The primary supply of drinking water comes from natural springs, where we obtain groundwater naturally without drilling any wells or pumping. In many places, springs are only a source of drinking water. Particularly in the hilly terrain, springs serve as a supply of water for a variety of uses, including drinking, irrigation, and water for cattle. They also serve as a source of water for the local streams. But at present time due to the different factors like increase in population, decrease in open land, urbanization many springs has disappeared (Tambe et al., 2011). These springs are also affected directly and indirectly by the climate change. Development of springs in any area is controlled by geology, geomorphology, soil type, rock type, geological structures and other different factors (Mahamuni & Upasani, 2011). In hilly region, springs are only the reliable and the sustainable source of fresh water. Though the Himalayan range is a source of many perennial rivers but still maximum population living below this range use spring water for drinking and domestic purpose (Bisht & Srivastava, 1995). But every spring is different from others in terms of type of catchment area, recharge and discharge (Rai et al., 1998). This is also governed by natural slope, geology and geological structures.

(Bryan, 1919; Kresic, 2010) have classified springs into following type:

1. Depression spring: It is formed when water table reaches the surface due to topographic undulations.
2. Contact spring: It is placed at the locations where relatively permeable rocks overlie rocks of low permeability.
3. Fracture spring: It occurred due to existence of jointed or permeable fracture zones in low permeability rocks.
4. Karst spring: This type of spring is developed with the large quantities of water move through the cavities, channels, conduits and other openings developed in limestones.
5. Fault spring: This is also a type of fracture springs and termed as fault springs when faulting may also give rise to conditions favorable for spring formation as groundwater (at depth) under hydrostatic pressure (such as in confined aquifers) can move up along such faults. Similarly, Meinzer has classified springs with respect to discharge.

Magnitude	Discharge
First	>10m3/sec
Second	1-10 m3/sec
Third	0.1-1 m3/sec
Fourth	10-100lps
Fifth	1-10lps
Sixth	0.1-1lps
Seventh	10-100mlps
Eight	<10mlps

The state of springs can be understood by measuring the discharge at various times and the in-situ physiochemical characteristics. And several concepts related to hydrology and hydrogeology can be grasped by comparing them. Similar to that, it can provide information about the accessibility and availability of water.

Location

The study area is located in the Dharapani, Lukunsuwara and Thulsuwara village, Kaski District, Nepal (Figure). The area lies geographically between co-ordinate longitudes 83°54'10"E to 83°55'50"E and latitudes

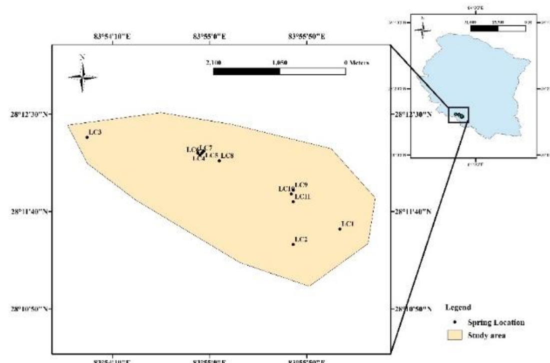

Figure 1: Location map of the study area.

28°10'50"N to 28°12’30” N.

Geological Setting

Geologically the study area lies within the lesser Himalaya. Study area dominantly contains the phyllite and quartzite beds. The phyllite are thinly to mediumly foliated. These beds have NE dipping. Dip amount ranges from 27˚ to 54˚. Rocks present in this area is highly fractured.

Spring Inventory

A community can benefit from the abundance of springs that are accessible in the research area. For drinking water and other residential and agricultural uses, spring water is frequently regarded as a dependable and high-quality supply. There are no man-made water sources, such as drilled or dug wells. Therefore, the main sources of water in this region are springs and streams. There are 11 springs that have been identified during fieldwork that are used for domestic and drinking water. All the total 11 springs are perennial in origin. Springs are located in altitudes ranging from 800m to 1300 m above mean sea level as shown in Figure 7. Springs in any area are of different types. Types of springs are classified on a different basis. On the basis of the origin of the spring, springs are classified into depression, fracture, and Fracture +Depression types. In the study area only two types of springs, contact and fracture are observed. This classification of springs is affected by the local geology, orientation of bedding and joints, and also the nature of fracture (Valdiya and Bartarya, 1989). Direct field observation is done to classify the different types of springs. On the basis of field observation obtained result is shown in Table 3.

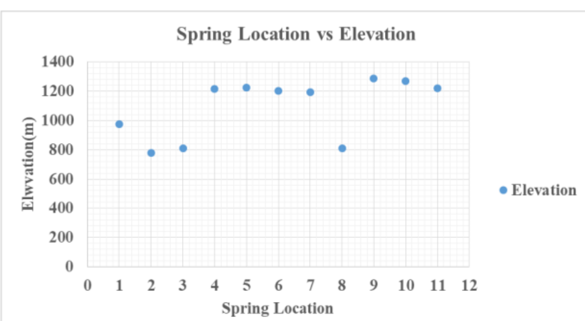

Figure 7: Altitude Variation of Spring in the study area.

Similarly, the discharge of 11 springs was calculated. Then this discharge was used for the classification of springs on the basis of discharge based on (Meinzer, 1923) classification system. The result obtained shows that among the springs, all springs are fifth magnitude springs. All these results is shown in Table 3.

Physio-Chemical Parametres

Water is a universal solvent. Most materials it comes into contact with are dissolved by it. Easily transferable energies include gases and heat energy. The quality of the water changes as a result of all these dissolving components. Precipitated water typically picks up dissolved components from aquifers, gases, minerals, and salts when it permeates the ground to generate groundwater. These things all affect the aquifer's water quality. So, groundwater geochemistry provides information about geochemical reactions that occurred between groundwater and aquifer materials, groundwater flow path, and groundwater age and flow rate (Driscoll, 1986). Physicochemical parameters of each spring's water were measured during fieldwork. The physiochemical parameters that have been measured are as follows: Color, Test, Odour, Turbidity, Temperature, pH, Dissolved oxygen (Do) and Cadmium (Cd), in the field, the temperature and pH of water samples were measured. The pH of most natural waters ranges between 5.0 and 8.5.The pH of acidic, freshly fallen rainwater may range between 5.5 and 6.0, according to Valdiya and Bartarya (1991). The hydrogen ion concentration decreases when it reacts with soils and minerals that contain weak alkaline materials. The water's pH may rise to 8.0-8.5. The pH value is influenced by several factors, including water source,

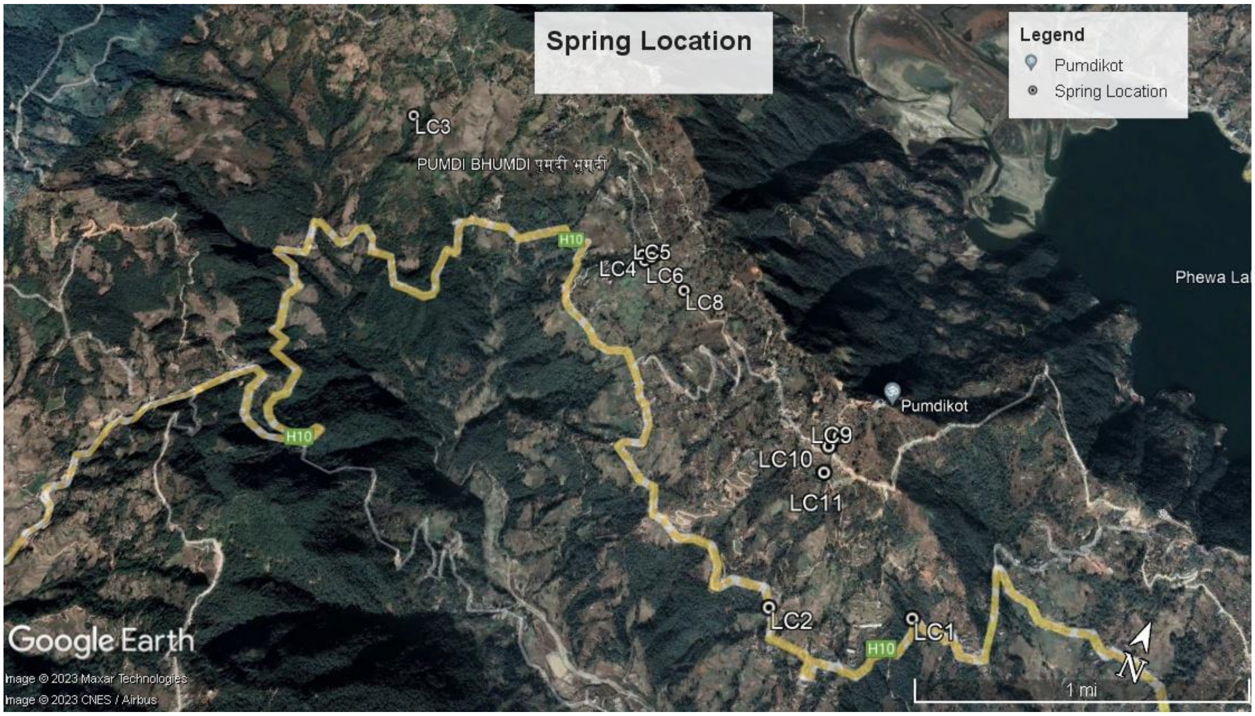

Figure 8: Google earth map showing location of spring.

Table 3: The type of spring with discharge and magnitude.

S.N	Location	Spring Type	Discharge(l/sec)	Magnitude
1	LC1	Contact	3.8	Fifth
2	LC2	Fracture	3.6	Fifth
3	LC3	Contact	3.7	Fifth
4	LC4	Contact	4.7	Fifth
5	LC5	Contact	5.2	Fifth
6	LC6	Contact	1.5	Fifth
7	LC7	Contact	4.2	Fifth
8	LC8	Contact	3.7	Fifth
9	LC9	Contact	6.3	Fifth
10	LC10	Contact	5.9	Fifth
11	LC11	Contact	4.3	Fifth

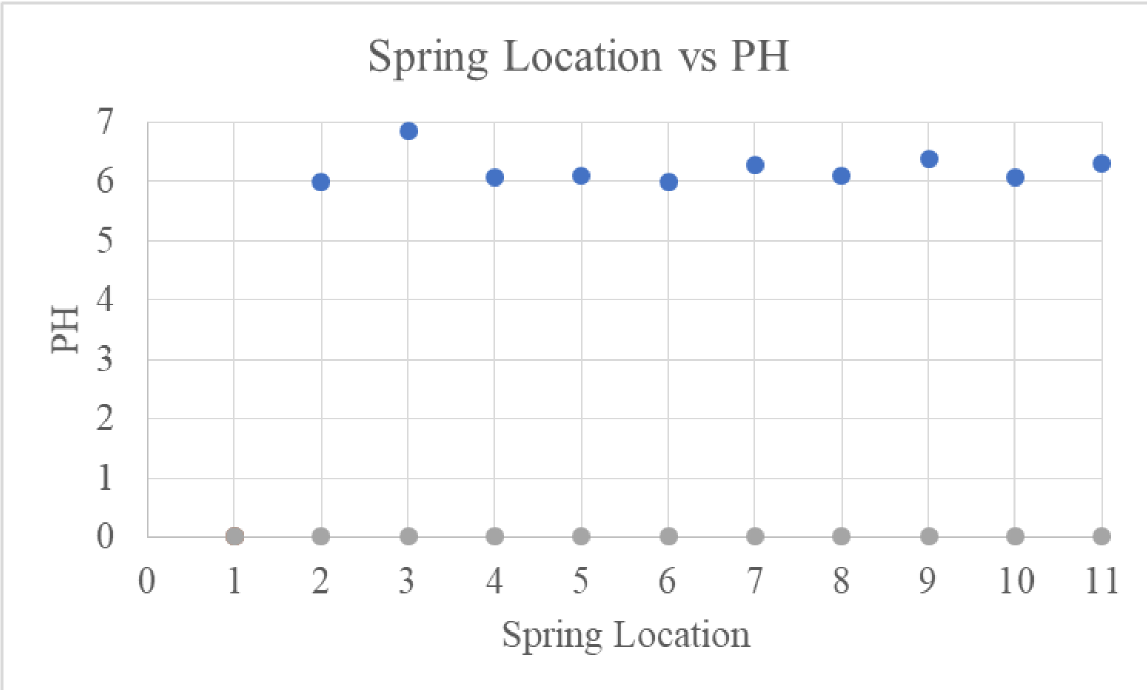

Figure 4: Spring location vs. pH distribution graph.

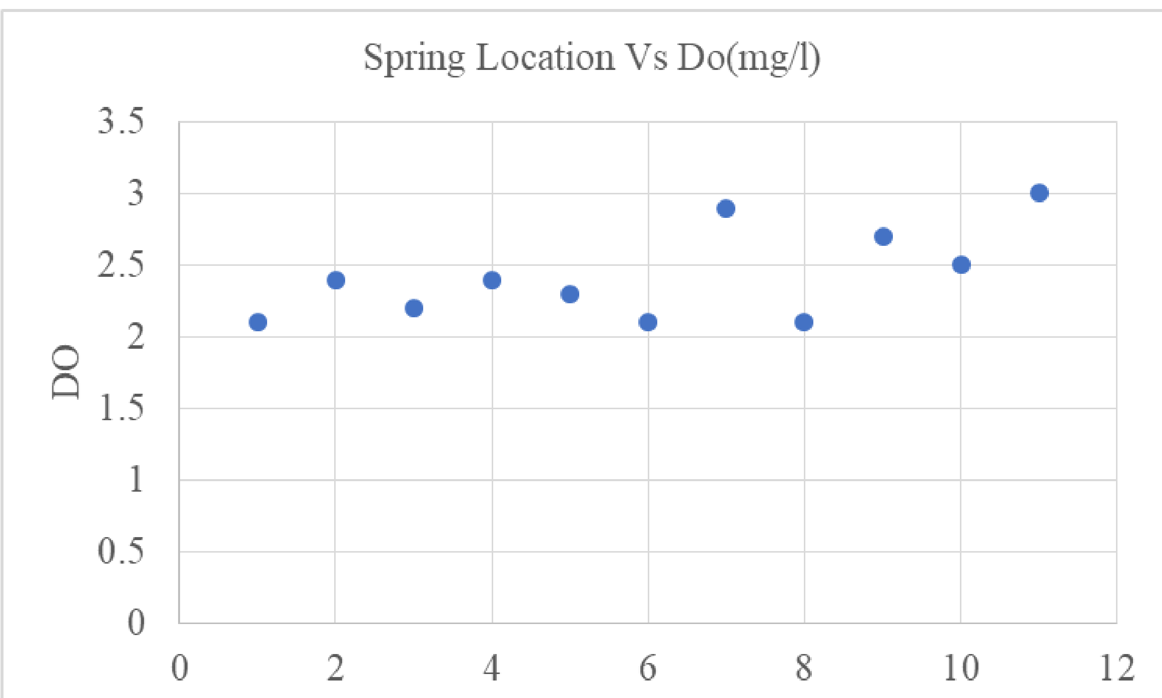

Figure 5: Table 4 Spring location vs. Do distribution graph

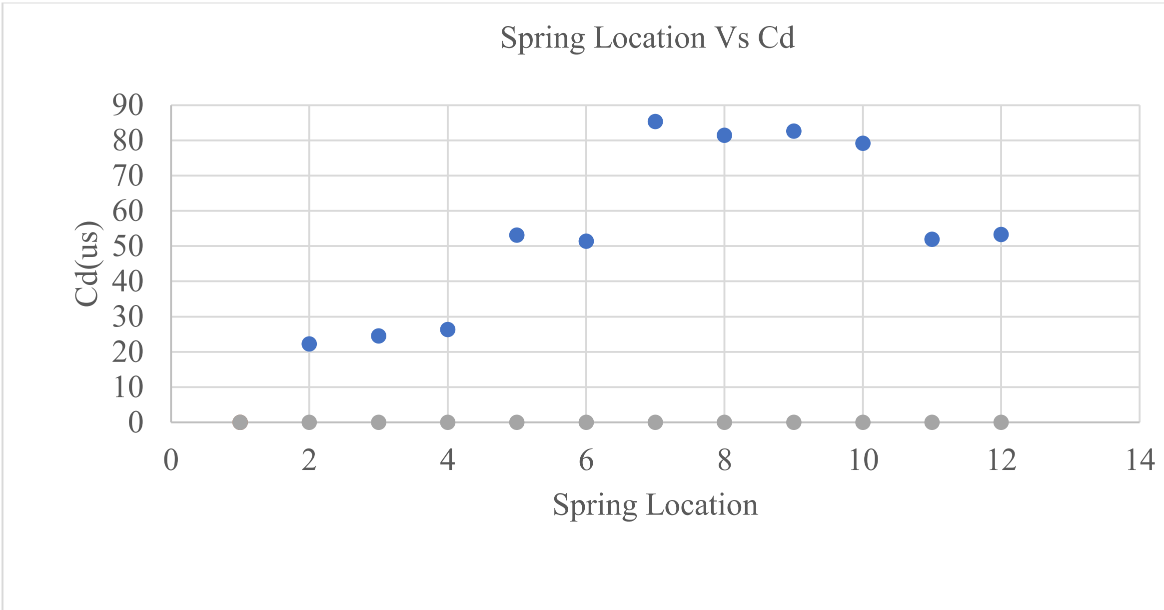

Figure 9: Spring Location vs. Cd distribution graph.

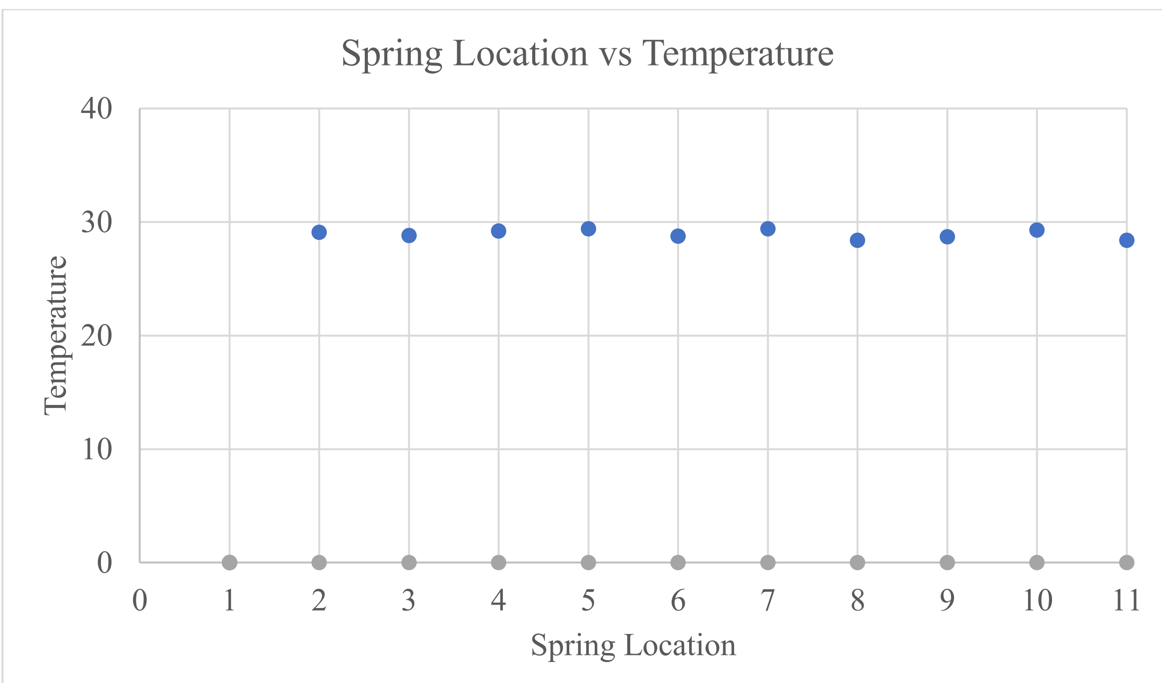

Figure 10: Spring Location vs. Temperature distribution graph.

rainfall, water temperature, geology, soil, and discharge. The amount of dissolved oxygen in water is very important in determining the level of pollution in groundwater. Polluted water typically has less dissolved oxygen. Water with more than 4mg/l DO is considered to be good drinking purpose Figure . From the Figure it is seen that pH of spring water is less than 7. So spring water of the study area is basic in nature. From Figure 10 it is clear that the variation of water temperature of different springs of the study area. This indicates that the depth of aquifer feeding these springs is less than because aquifer having lesser depth gets affected by atmospheric temperature. The Cd vs. spring location value is shown in Figure 9. From Table 3 it is seen that the variation of discharge of spring. This table shows that the springs of the study area are highly sensitive to the precipitation and their discharge.

CONCLUSION

Geologically the study area lies within the lesser Himalaya. Rocks in this area is highly fractured. Study area dominantly contains phyllite. There are 11 springs along which all are perennial. These spring are fracture and contact springs types. Springs present in the study area are fifth magnitude springs. Values of Physio-chemical parameters are acceptable according to Nepal standard for drinking and for irrigation. Discharge of every spring is dependent on the precipitation.

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STUDY OF VOLUMETRIC RESERVE ESTIMATION AND EVALUATION OF CONSTRUCTION MATERIAL AT MARTAL KHOLA SECTION, EASTERN CHITWAN

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ABSTRACT

Sand, pebble, cobble, boulder, gravel, clay, granules are most common construction material deposited in Siwalik range of Nepal Himalaya. They are generally used as raw material in concrete, road construction, mixing with asphalt and filling material, among other uses construction material are non-renewable natural resources and hidden treasure of country. The technique employs geological observation to estimate construction materials with respect to depositional environment. Graphically volumetric estimation is carried out to evaluate the construction material. The grain size of construction material was studied at the Martal Khola section of eastern Chitwan covering an area of 1886.76m^2. The thickness of overburden, volume in cubic meter and reserve in tons was calculated. The main advantage of this approach is that it requires no complicated mathematical modelling and makes no assumption about the spatial distribution of material. Result from the study could be used for sustainable development of such resources and plays vital role to industrial development, employment generation, maximize foreign good service, save foreign currency, control trade deficit, strength economy of country and contribute substantially to national GDP.

***Key Words**: Reserve estimation, Construction material, Overburden, Sand, Gravel*

INTRODUCTION

The Sub Himalaya (Churia/Siwalik foothill) is a potential area of construction material. Construction materials are non-renewable natural resources and hidden treasure of country that are mined and used in different forms for various construction purposes. They were formed from the sedimentary rock weathering, erosion, transportation and deposition from lesser and higher Himalaya. These material are naturally found building construction material that is generally used in construction of various structure. Mechanical and physical characteristics of rock generally depend on their composition and texture, because they reflect their sedimentary environment. For the extraction of construction material, reserve estimation is one of the essential task. Reserve are estimated volume of material anticipated to be commercially recoverable from known accumulation of given data forward, under existing economic condition, by established operating practice under current geological and engineering data available. Vast quantities of river boulders, cobbles, pebbles and sands are mined as construction materials/aggregates. DMG (Sharma et al 1988) has evaluated such materials (boulders = 347,006,000 m^3, cobbles = 214,261,000 m^3 and pebble = 229,205,000 m^3) in the major rivers in Terai region.

GPS coordinate: 27º36'15" N

84º40'12" E

Elevation: 248 m

The specific objective of present investigation is:

- To prepare a geological map and cross section.
- To study the geological control of mineralization in the area.
- To prepare the columnar section and route map of the study area.

METHODOLOGY

For the analysis, a desk study was carried out where relevant literatures, maps were reviewed. The desk study was followed by the geological field investigation, where the GPS coordinate was taken, and the location was traced in the topographical map. The various construction material was traced in the study area and the sampling site was chosen. Here in the field study, we have done Volumetric reserve estimation.

Graphical method was carried out to estimate the volume of construction materials. Area of the construction materials was delineated using compass measurements and plotted in graph. The thickness of construction materials (overburden) was measured at different locations. Eleven grids of 2×2 m were taken in order to analyze grain size distribution of the materials and then averaged.

Steps used in reserve estimation

1. Boundary delineation with compass bearing and plotting on the graph at suitable scale.
2. Calculation of total area inside the boundary with graphical method and scale conversion.
3. 2×2 m^2 grid taken and located on the map.
4. Estimation of percentage of clay, sand, granule, pebble, cobble and boulders at each grid.
5. Calculation of percentage of each material from average in individual grid.
6. Measurement of thickness of the sediment at various point to obtain average thickness.
7. Calculation of volume of each construction material was by taking product of the thickness and the average percentage of material and total area.
8. Calculation of total volumetric reserve by adding volume of each material.
9. Conversion of reserve in tons by multiplying with specific gravity.

GEOLOGICAL SETTING

Regional Geology

The Sub-Himalaya or the Siwalik of Nepal is delineated by the Himalayan Frontal Thrust (HFT) and the Main Boundary Thrust (MBT) in south and north respectively. The Siwalik consists of very thick (4000 to 6000m) molasses like fluvial sedimentary deposit (Gansser, 1964). This is the 10 to 25km wide belt of the Neogene Siwalik Group rocks that forms the topographic front of the Himalaya. It rises from the fluvial plains of the active foreland basin, and this front generally mapped as the trace of the Main Frontal Thrust (MFT). Among the different classification of the Siwalik Group, the present study is carried out following the three- fold classification (Auden, 1934; Hagen, 1969).

Tectonically, the study area lies in the northern belt, lower member of middle Siwalik. The Middle Siwalik consist of thick bedded lower member of middle Siwalik composed of salt and pepper'' appearance sandstone and siltstone with minor conglomerate and red shale. Whereas the lower member of middle Siwalik composed of fine to medium grained sandstone interbedded with siltstone and mudstone

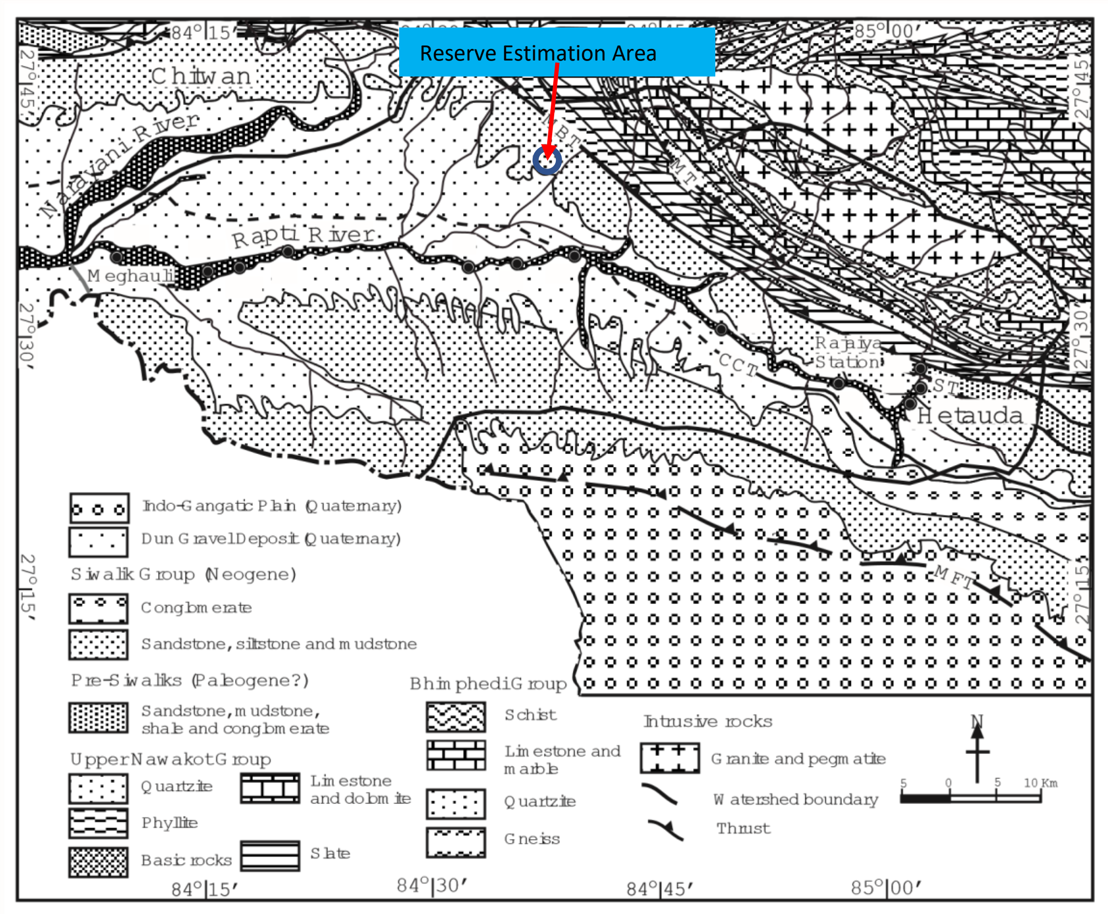

Figure 1: Geological Map of Chitwan Dun Valley (Tamrakar, Maharjan, & Shrestha, 2008).

RESULT

Table 1: Estimation of value of construction materials at the bank of the Martal Khola.

Materials	Grid (in %)											Average (%)
	1	2	3	4	5	6	7	8	9	10	11	
Sand	7	10	22	27	7	47	40	55	50	45	40	32.27
Pebble	12	20	21	20	12	16	20	6	20	15	15	16.09
Cobble	12	30	28	15	26	15	21	7	12	20	25	19.18
Boulder	8	5	4	3	4	2	2	5	3	5	3	4
Clay	8	3	2	2	6	1	3	3	3	2	2	3.18
Granules	50	22	20	25	40	25	13	20	7	11	10	21.09
Others	3	10	3	8	3	3	2	4	5	2	5	4.36

Now,
From calculation of area from graph we get total area = 1886.76 m^2
The thickness of bed = 1.05 m
The total volume = 1981.098 m^3

Calculation

Table 2: Calculation of reserve of different materials at the bank of Martal Khola.

Materials	Volume (m^3)	Reserve in tons
Sand	$\frac{32.27}{100}\times 1981.098 =$ 639.3	2.5×639.3= 1598.25
Pebble	$\frac{16.09}{100}\times 1981.098 =$ 318.75	2.5×318.75 = 796.89
Cobble	$\frac{19.18}{100}\times 1981.098 =$ 379.97	2.5×379.97 = 949.94
Boulder	$\frac{4}{100}\times 1981.098 =$ 79.24	2.5×79.24 = 198.1
Clay	$\frac{3.18}{100}\times 1981.098 =$ 62.99	2.5×79.24 = 157.49
Granules	$\frac{21.09}{100}\times 1981.098 =$ 417.81	2.5×417.81 = 1044.53
Others	$\frac{4.36}{100}\times 1981.098 =$ 86.37	2.5×86.38 = 215.94

Hence, the reserve volume estimation of sand, cobble, pebble, boulder, clay, and granules were estimate in tons.

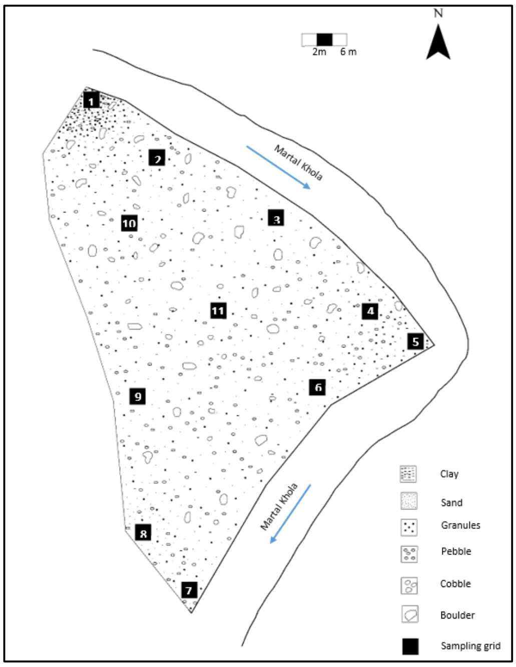

Figure 11: Reserve estimation map prepared at the Martal Khola.

DISCUSSION AND CONCLUSION

The Construction material distribution seems to have stratigraphic control in local scale. The study of the geological history, depositional environment, different geological structures, mineral and fossil content was done. Different geological measurements, preparation of columnar section, route maps, geological map, cross section of the studied area was carried out to meet the objectives of our study.

Significantly in mining aspect of geology, the volumetric reserve estimation of construction material at the right bank of the Martal Khola was carried out. In the estimation the area 1886.76 m^2 was included in respective eleven grid of 2×2 m^2. The percentage of sand (32.27%), granules (21.09%), cobble (19.18%), pebble (16.09%), boulder (4%), clay (3.18%) and others (4.36%) are shown in the pie chart below:

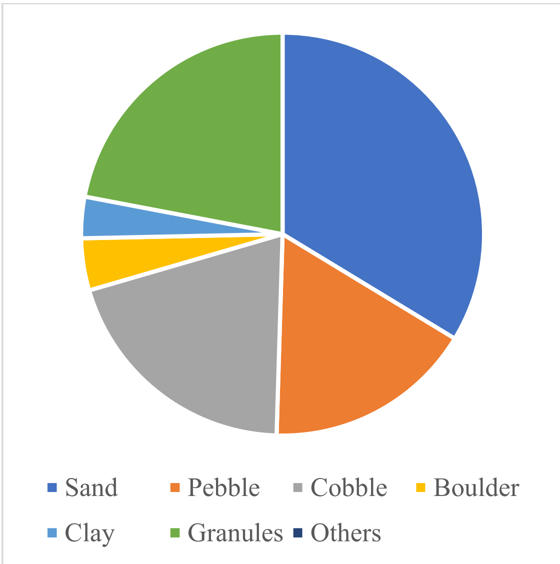

Figure 3: Pie chart showing proportion of various construction materials.

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SPRING WATER QUALITY ANALYSIS AND DISTRIBUTION MAPPING IN THE BIDUR - LIKHU - SURYAGANDHI AREA, NUWAKOT DISTRICT, CENTRAL NEPAL

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ABSTRACT

The study aimed to analyse water quality, conduct a questionnaire survey, and map springs in the study area. The study area included an analysis of various aspects related to spring water sources, such as elevation, slope, aspect, land use, drainage density, discharge, and geology. The researchers utilized instruments to inspect water quality parameters like temperature, pH, Electrical Conductivity, and Total Dissolved Solids (TDS) in each spring. Additionally, water samples were taken and analysed afterward to determine the levels of hardness, phosphate, ammonia, iron, chloride, and nitrate in the water.

Most of these springs are located at elevations ranging from 500m to 1050m. As for the deposits surrounding the spring sources, 41% are in residual soil, 36% in rock, 14% in rock colluvium, and 9% in alluvium. Regarding discharge, most springs in the study area have an average flow rate of 0.2–0.5 litters per second. The study aimed to analyse water quality, conduct a questionnaire survey, and map springs in the study area to understand hydrogeology and assess drinking water suitability.

Key Words: *Physio-chemical parameters, springs, discharge,*

INTRODUCTION

Water is an indispensable part of every biotic creature, which plays a significant role in its existence. On Earth, water can be found in surface water and groundwater. Surface water includes rivers, streams, lakes, reservoirs, etc.; groundwater is in the form of different wells and springs. Kansakar (2002) stated that the steep topography and low permeability of crystalline basement rock limit the groundwater resource in the mid-hill, estimating an annual groundwater recharge of 1723 million cubic meters in Nepal's mid-hills. Groundwater can be extracted by the various forms of wells by artificial construction, and groundwater that naturally outflows are springs. Springs are the most critical water supply source in Nepal's hills and mountains, generally used for domestic and irrigation purposes. However, spring water's quantity and quality depend on many factors, such as geology, topography, climate variability, land use, urbanization, etc. Natural stressors (especially climate change) and improper watershed management have decreased discharge in many Himalayan springs (Agarwal et al. 2012). ICIMOD (2015) reported that the drying up of springs in Nepal's mid-hill region was caused by a combination of biophysical (e.g., climate variability, changes in land use) and socioeconomic (e.g., spring maintenance) factors. Almost 80 percent of the 13 million hill and mountain people in Nepal rely on the springs as their primary source of water (CBS 2012). The well-protection and management of the spring are essential for sustainable use. The change in precipitation pattern, i.e., high-intensity low, duration rainfall, has impacted spring recharge.

Springs are areas on the Earth's surface where underground water emerges, often forming a stream, pond, or marsh (Glazier 2009). Springs occur in many forms and have been classified according to their cause, rock structure, discharge, temperature, and variability (Todd and Mays, 2012). Mahamuni and Kulkarni (2012) collected information from 15 Himalayan springs, including location, elevation, discharge, pH, salinity, temperature, TDS, and electrical conductivity. They discovered that reduced rainfall, uneven rainfall, and decreased infiltration can all lead to a decrease in spring discharge and that spring discharge is highly dependent on aquifer properties. As a result, they concluded that understanding “mountain aquifers” is critical to effectively managing Himalayan springs. The protection and maintenance of spring sources are pre-requisite for the water supply in the mid-hills of Nepal. Spatial variation in topography and geology, as well as temporal variation in hydrology and climate, all affect spring discharge (Chinnasamy and Prathapar 2016). Springs are typically owned and managed by the community. This approach has made People more involved in protecting and conserving spring sources. Spring water is collected in a tank and supplied to the rural communities according to the routine to avoid overuse and keep the supply in the dry season. Almost all people of the hills depend on the spring sources for drinking water and other water requirements. Springs play a crucial role in improving the livelihood of the people of the mountain. The optimal utilization and management of spring sources by local communities have solved the problem of walking long distances to fetch water in most of the area's communities.

Nuwakot is one of the highly affected districts by earthquakes causing many casualties (Chaulagain et al. 2018). It has also been involved in the discharge of springs; some sources were shifted, and some sources were dried up. The current research aims to identify, survey, and document the spring sources of Nuwakot, Nepal.

REGIONAL GEOLOGY

According to (Stöcklin & Bhattarai, 1977), the individual study area lies within the Kuncha Formation, considered the oldest unit of the Lesser Himalaya. This formation comprises metasandstone, pelitic to psammitic phyllite, meta-conglomerate, gritty phyllite, and a lesser proportion of quartzite. Phyllite swells when it encounters water, resulting in the hill slope's weak stability. Colluvium-derived River terraces are often observed lying on either side of the river valley from neighboring hills.

METHODOLOGY

During the research stage, all geological and hydrogeological studies related to the site and previously published topographical maps and aerial photos of the region, hydrogeology, hydrology, and other related papers were used to evaluate geomorphological characteristics. In-situ tests were performed, including pH, TDS, temperature, and conductivity. Google Earth and ArcGIS were used for processing and analyzing the field and laboratory data.

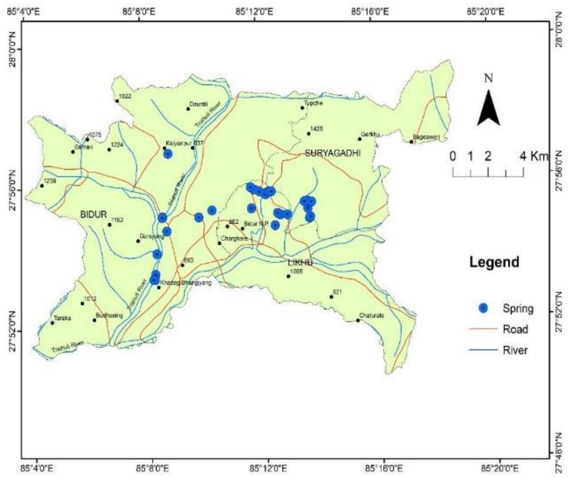

Figure 12 Distribution map of springs of the study area

RESULT AND DISCUSSION

Mapping with GIS

GIS is a tool for efficiently handling and presenting both spatial and non-spatial data. It provides fast and accessible information on factors influencing groundwater levels, such as geology, lithostratigraphy, geomorphology, and land use. Possible groundwater zones are estimated through visual examination or digital methods based on geological and geomorphological details. Remote sensing and GIS are used to evaluate groundwater potential zones in a study area by assigning weights to thematic maps and integrating them for groundwater possible zone development. This study is crucial for sustainable groundwater resource use and management and increasing groundwater recharge. Most springs in the study area are found on moderate slopes (20-45°). Slope affects runoff and is a factor in determining groundwater potential and flow direction. Gentle slopes allow for more percolation, while steep slopes result in increased runoff and decreased percolation. The hill is classified into five categories, as shown in Figure 2. An aspect map shows the slope direction for terrain, with southern regions having more potential for groundwater recharge due to slower runoff. The map is classified into ten categories based on equal intervals, and the direction of the slope is represented by colours, with more springs observed in the southwest order and some also in the east and southeast exposure.

Most springs are found in areas with moderate drainage density, facilitating overland flow and infiltration, leading to groundwater sources. Areas with higher drainage density reduce percolation, while low density provides better filtration conditions. In the study area, springs are found at elevations ranging from 580m to 890m. The height is an essential factor in determining the favorable locations for water infiltration. Low hills have low surface runoff and high percolation rates, while high elevations Favor runoff and fast water evacuation by drainage.

Types of Spring:

The study area exhibited a diverse distribution of springs, comprising three distinct types: depression springs, accounting for 70%; fracture springs constituting 24%; and karst springs, representing 6% of the total observed springs. These springs were spatially dispersed across different land cover categories, with the majority (52%) found within forested regions, followed by 39% in agricultural areas, 5% in shrublands, and 4% in grasslands. The assessment reveals diverse spring occurrences relating to geological formations and land cover, offering valuable hydrological insights.

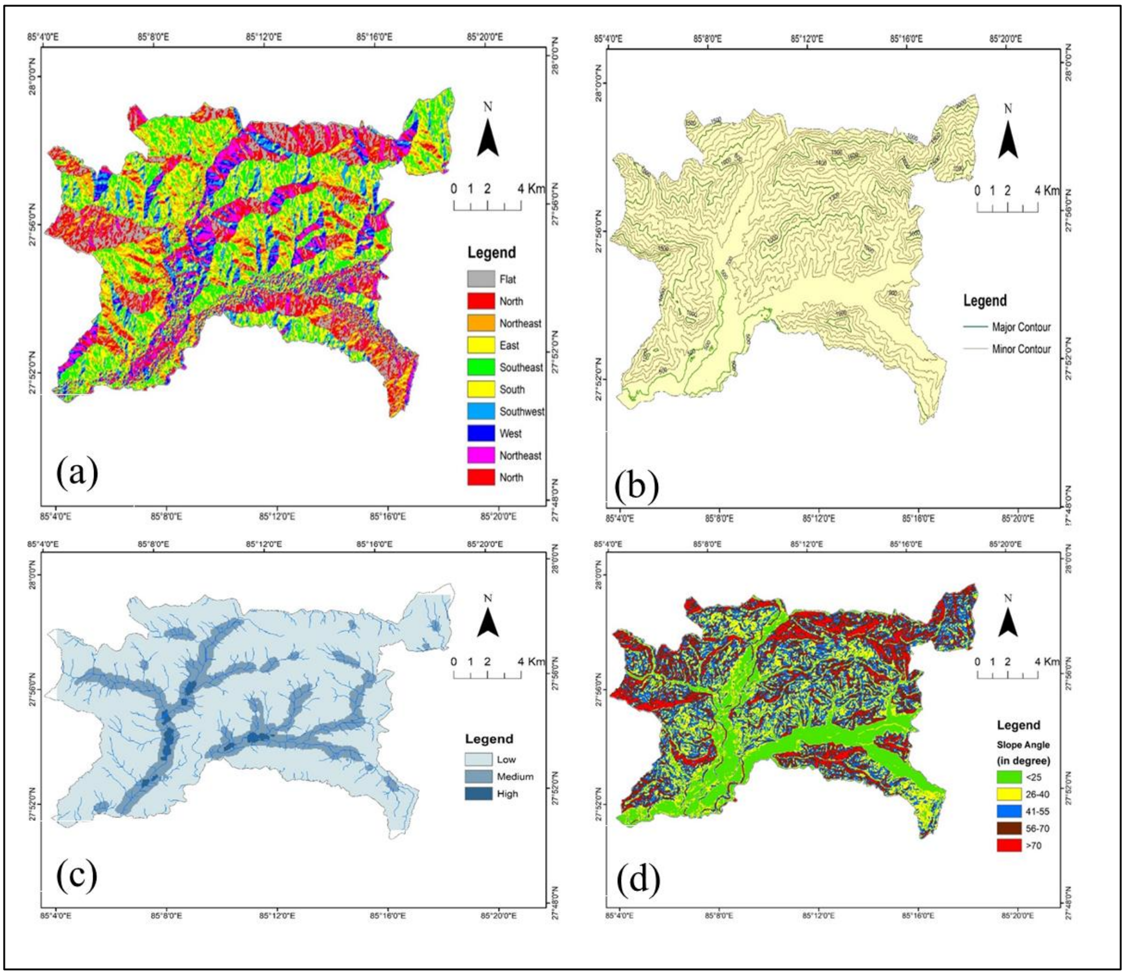

Figure 13 Factor map of Study area (a) Aspect map (b) Elevation map (c) Drainage density (d) Slope map

Physico-Chemical Analysis:

Behold the comprehensive compilation of spring water quality test results thoughtfully placed alongside Nepal's revered National Drinking Water Quality 2062. The table below lays bare the intricate details of various essential parameters, each meticulously analyzed to assess the purity and suitability of this life-sustaining resource. From temperature and pH to electrical conductivity, total dissolved solids, coliform, iron, FRC (Free Residual Chlorine), nitrate, ammonia, phosphate, chloride, and hardness, every critical aspect is rigorously examined to ensure compliance with the stringent standards set forth by the national authorities. This assortment of data serves as a testament to the commitment to ensuring the safety and reliability of the water that nurtures the well-being of the nation's populace, underscoring the crucial significance of safeguarding this precious natural asset.

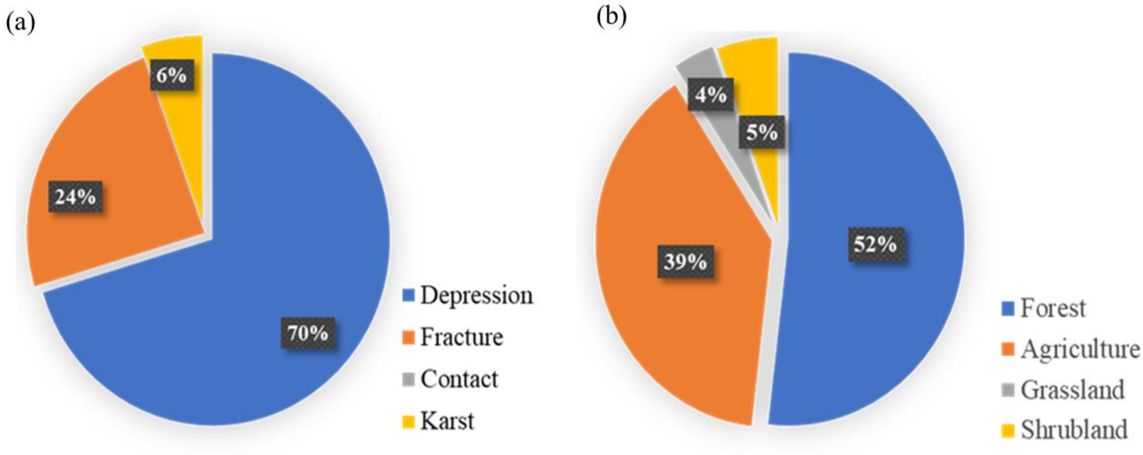

Figure 15 Different types of springs and their location (a) Type of Springs (b) Location land use

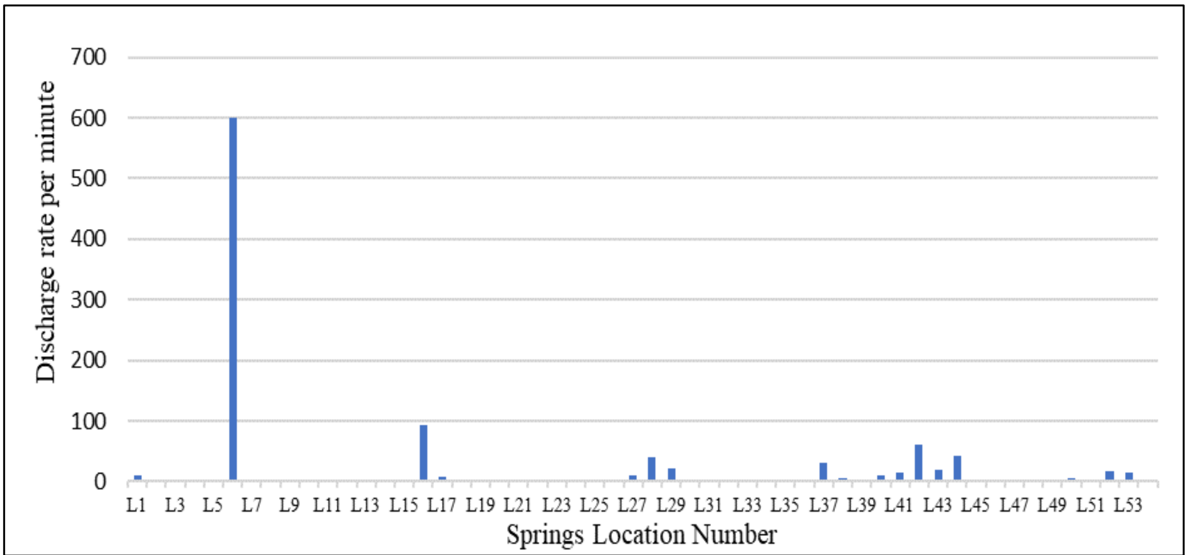

Figure 16 Discharge rate of spring

Table 6 Detail Information on selected springs.

Spring Number	Discharge (l/sec)	Uses	Temperature (°c)	pH	Electrical Conductivity (uS/cm)	Total Dissolved Solids, TDS (mg/L)	Coliform (CFU/100 ml)	Iron (mg/L)	FRC (mg/L)	Nitrate (mg/L)	Ammonia (mg/L)	Phosphate (mg/L)	Chloride (mg/L)	Hardness (mg/L)	Types of Spring
SP_1	0.3	Drinking	25.6	6.79	38.4	19.3	Absent	0	Absent	0	0.2	0.05	31.36	16	Depression Spring
SP_2	0.45	Drinking	28	6.81	350	172	Absent	0	Absent	0	0	0	19.6	120	Fracture Spring
SP_3	0.08	Drinking	23.2	6.81	440	220	Absent	0	Absent	0	0	0	11.76	152	Depression Spring
SP_4	0.05	Drinking	19.6	6.76	340	165	Absent	0	Absent	0	0	0	66.64	24	Contact Spring
SP_5	0.23	Irrigation	20.7	6.79	330	170	Absent	0	Absent	25	0	0	23.52	136	Depression Spring
SP_6	0.26	Drinking & Irrigatio	23.2	6.81	130	60	Absent	0	Absent	25	0	0	27.44	40	Fracture Spring
SP_7	0.07	Irrigation	22.5	6.79	24.6	12.6	Absent	0	Absent	0	0	0	31.36	56	Depression Spring
SP_8	0.32	Irrigation	23.7	6.82	26.3	13.1	Absent	0	Absent	0	0	0	43.12	24	Fracture Spring
SP_9	0.24	Drinking & Irrigatio	24.1	6.77	64.2	32.3	Absent	0	Absent	0	0	0	50.96	16	Fracture Spring
SP_{10}	0.03	Drinking	24.2	6.82	17.5	8.7	Absent	0	Absent	0	0.2	0	35.28	24	Fracture Spring
SP_{11}	0.13	Drinking & Irrigatio	22.6	6.79	34.5	17.2	Absent	0	Absent	0	0.5	0	74.48	16	Contact Spring
SP_{12}	0.17	Drinking	18.9	6.8	44.8	22.3	Absent	0	Absent	0	0	0	27.44	16	Fracture Spring
SP_{13}	0.11	Drinking	25.7	6.79	92.7	46.3	Absent	0	Absent	0	0.5	0	39.2	24	Fracture Spring
SP_{14}	0.19	Drinking & Irrigatio	22.6	6.77	38.3	19.1	Absent	0	Absent	0	0	0	47.04	16	Fracture Spring
SP_{15}	0.06	Drinking	24.1	6.81	45.7	22.4	Absent	0	Absent	0	0	0	62.72	24	Depression Spring
SP_{16}	0.25	Drinking & Irrigatio	23.2	6.83	51.6	25.9	Absent	0	Absent	25	0.2	0	47.04	48	Fracture Spring
SP_{17}	0.13	Drinking & Irrigatio	22.5	6.82	70.5	35.2	Absent	0	Absent	0	0	0	74.48	24	Fracture Spring
SP_{18}	2.35	Drinking	22.2	6.68	35.3	17.6	Absent	0	Absent	10	0.2	0	74.48	24	Fracture Spring
SP_{19}	0.07	Drinking	21.3	6.72	32.6	48.2	Absent	0	Absent	0	0	0	54.88	16	Contact Spring
SP_{20}	0.14	Drinking	24.7	6.77	29.6	59.4	Absent	0	Absent	0	0	0	82.32	16	Depression Spring
SP_{21}	0.11	Drinking	17.5	6.71	42.5	21.3	Absent	0	Absent	25	0	0	43.12	24	Fracture Spring

Table 5 Comparison of Water Quality Parameters of Selected Springs with National Drinking Water Quality Standards, 2062.

Spring No.	Chloride (mg/L)	Nitrate (mg/L)	pH	Ammonia (mg/L)	TDS (mg/L)	Electrical Conductivity (uS/cm)	FRC (mg/L)	Hardness (mg/L)
NDWQS, 2062	**250**	**50**	**6.5 - 8.5**	**1.5**	**1000**	**1500**	**0.1 - 0.2**	**500**
SP_1	31.36	0	6.79	0.2	19.3	38.4	Absent	16
SP_2	19.6	0	6.81	0	172	350	Absent	120
SP_3	11.76	0	6.81	0	220	440	Absent	152
SP_4	66.64	0	6.76	0	165	340	Absent	24
SP_5	23.52	25	6.79	0	170	330	Absent	136
SP_6	27.44	25	6.81	0	60	130	Absent	40
SP_7	31.36	0	6.79	0	12.6	24.6	Absent	56
SP_8	43.12	0	6.82	0	13.1	26.3	Absent	24
SP_9	50.96	0	6.77	0	32.3	64.2	Absent	16
SP_{10}	35.28	0	6.82	0.2	8.7	17.5	Absent	24
SP_{11}	74.48	0	6.79	0.5	17.2	34.5	Absent	16
SP_{12}	27.44	0	6.8	0	22.3	44.8	Absent	16
SP_{13}	39.2	0	6.79	0.5	46.3	92.7	Absent	24
SP_{14}	47.04	0	6.77	0	19.1	38.3	Absent	16
SP_{15}	62.72	0	6.81	0	22.4	45.7	Absent	24
SP_{16}	47.04	25	6.83	0.2	25.9	51.6	Absent	48
SP_{17}	74.48	0	6.82	0	35.2	70.5	Absent	24
SP_{18}	74.48	10	6.68	0.2	17.6	35.3	Absent	24
SP_{19}	54.88	0	6.72	0	48.2	32.6	Absent	16
SP_{20}	82.32	0	6.77	0	59.4	29.6	Absent	16
SP_{21}	43.12	25	6.71	0	21.3	42.5	Absent	24

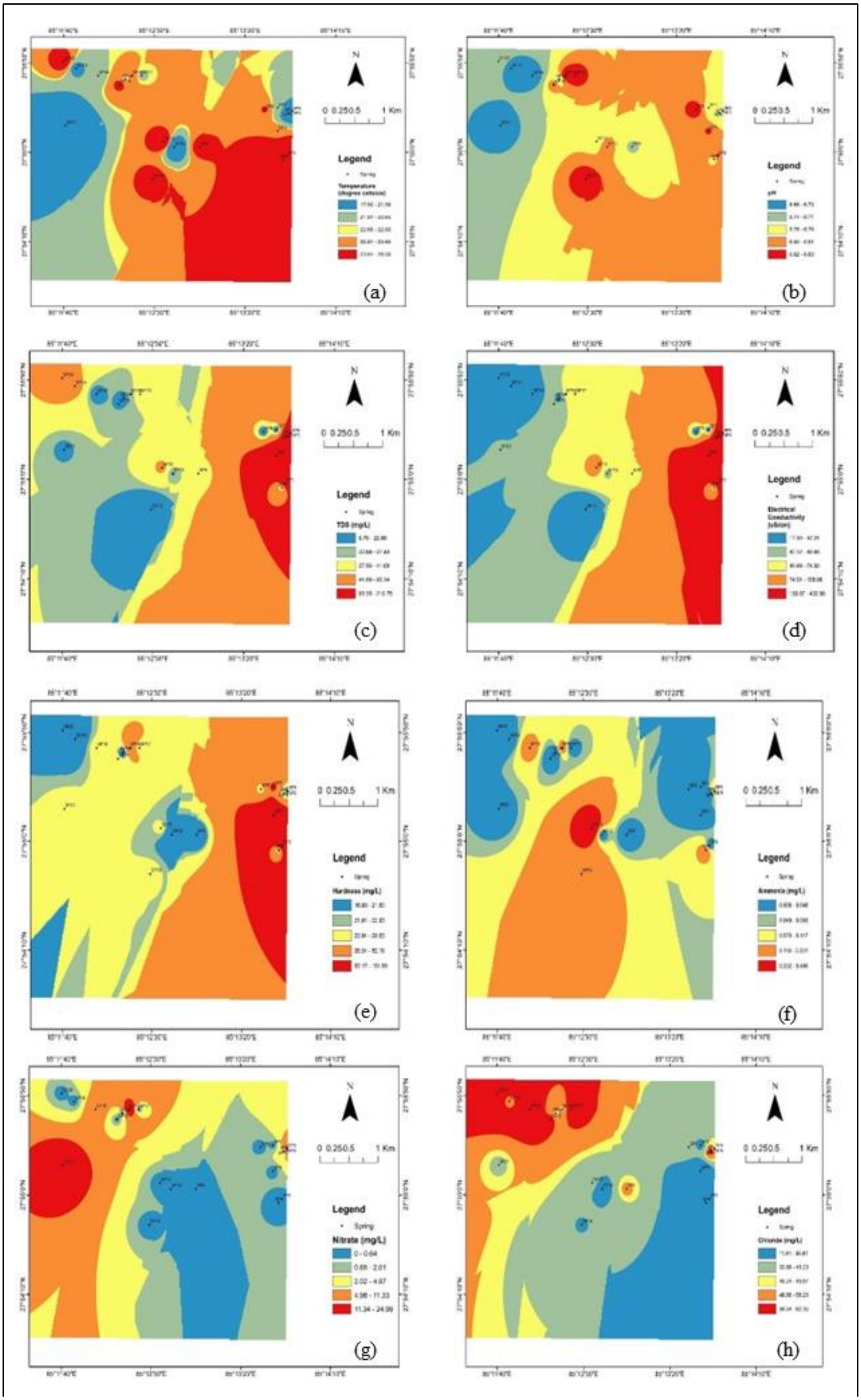

Figure 17 Maps showing spatial distribution of physico-chemical parameters of Spring Water. (a) Temperature (b) pH (c) TDS (d) Electric Conductivity (e) Hardness (f) Ammonia (g) Nitrate (h) Chloride

CONCLUSION

The elevation, geology, slope, aspect, land use, and drainage density influence spring occurrence. All the 21 springs studied are perennial in nature. Seasonal fluctuation indicates a significant role of rainfall for the recharge of spring sources that is marked by the decrease in discharge in the dry season to that of the post-monsoon season. Most springs are observed in the spare forest and cultivation at 580m to 890m and in slopes varying from 20 to 45 degrees. Most of the springs' locations are moderate stream density and have emerged from the colluvium soil and rock. In total, 57.14% of springs are fracture springs, 28.57 % of springs are depression springs, and 14.29 % of springs are contact springs in the study area.

Finally, it was concluded that high lineament density, flat areas, dense vegetation, near water bodies, and least drainage density have higher chances of spring occurrence than others. High lineament density provides enough cracks and fractures for subsurface water to come above, and flat areas or at least slope degrees offer much time for infiltration of the rainfall to be collected beneath the ground. Similarly, dense vegetation plays a role in allowing water to infiltrate the earth compared to barren land. Least drainage density increases infiltration and helps in water to consume, which may come out as spring water.

Regarding the discharge magnitude, only a few of the springs were affected by the Gorkha Earthquake in 2015. The immediate impact was the drying up of springs, while later, most of the springs in the study area remained unaffected. Spring water use wholly depends on the people of different places as per their comfort. The easily accessible sources have been utilized, whereas those that are inaccessible and farther from the settlement area have remained unused.

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COMPARISON OF UCS OF LESSER HIMALAYAN ROCK USING PLT AND SHT IN RASUWA DISTRICT, CENTRAL NEPAL

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ABSTRACT

The Point Load Test (PLT) and Schmidth Hammer Test (SHT) are the index tests that are easy and convenient insitu test to know the Uniaxial Compressive Strength (UCS) of any rock specimen or exposure. These test conducted on mountainous study area having proper metasandstone with phyllitic schist exposure have resulted approximately 17% and 29% differences in UCS from SHT and PLT performed on both parallel and perpendicular to anisotropy respectively. The UCS of the Schmidth Hammer rebound values more than 55 are obtained from the linear equation of UCS vs. rebound values generated by plotting respective UCS for rebound values less than 55. Some of the factors that may have affected the results could be the weathering condition and the consistency of the Schmidt Hammer. This study focuses on the reliability of the UCS of a rock from PLI and SHT.

***Key Words**: Point load, Schmidth Hammer, index test, uncorrected point load,*

INTRODUCTION

The mechanical strength of rock is an essential property for designing and constructing rock engineering; its precision directly influences the safety and stability of both construction and operation, in addition to the financial rationality of construction. (Wang et al., 2014). It is assumed that accurate estimation of the strength characteristics of rocks aids the achievement of estimated cost, construction time and safety. The standard procedure for testing of rock is outlined in International Society of Rock Mechanics (ISRM) 1985 Part 2 and American Society for Testing Materials (ASTM) D-573-16. Previous studies indicated that the rebound, in combination with dry unit weight, gives a good prediction of uniaxial compressive strength of the rock (Hucka 1965; Deere and Miller 1966; and Dearman 1974).

The Uniaxial Compressive Strength (UCS) of a rock specimen is vital for the engineering design. Some of the index test can be performed at the site to know the UCS. So in this study, we have compares the results from two significant index tests i.e. Point Load Test (PLT) and Schmidt Hammer Test (SHT).

GEOLOGY

The Study area is Nuwakot district of Central region that belongs to Bagmati Province, Nepal having the elevation of 500-600m above the mean sea level. The geology of the study area belongs to the Lesser Himalayan Zone of Central Nepal (Stöcklin & Bhattarai, 1977). The predominant rock type is phyllitic schist with metasandstone, but in some areas phyllite quartzite can also be found interbedded with Ulleri gneiss rock.

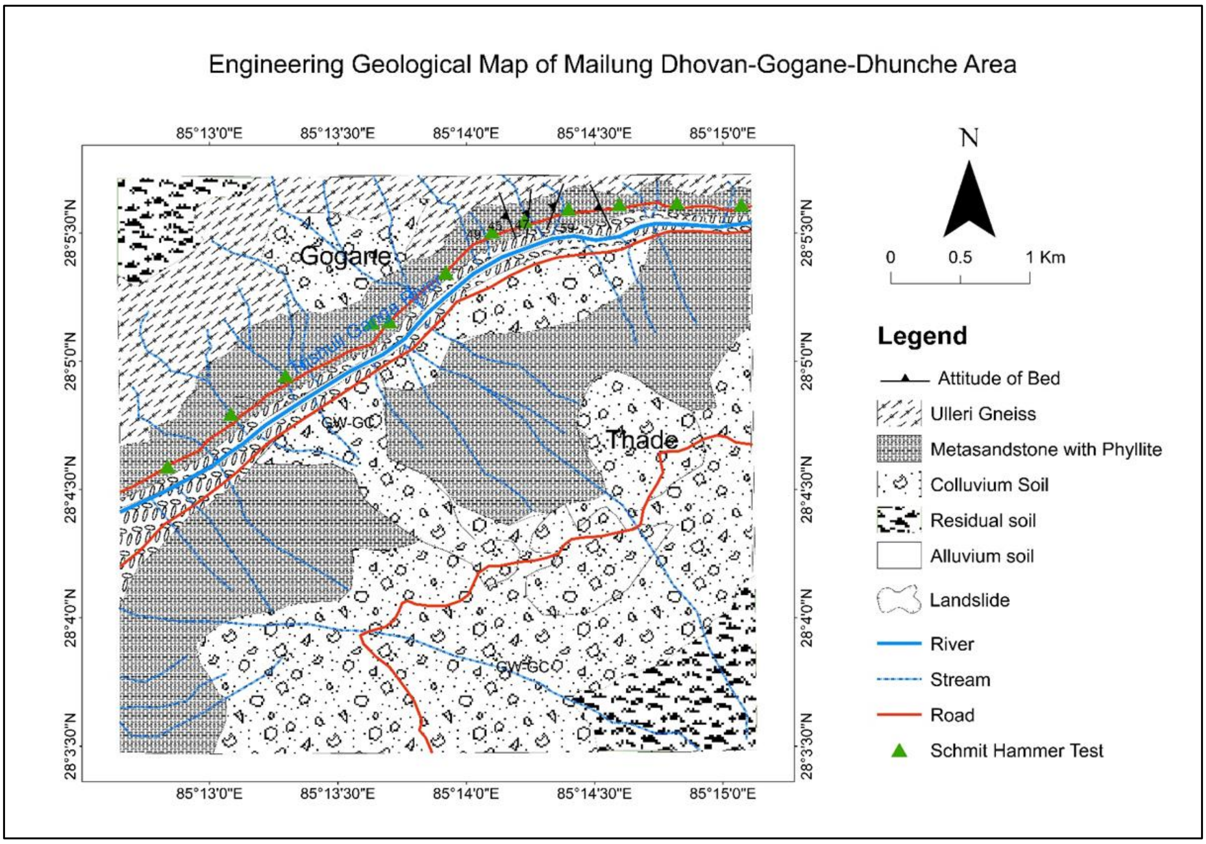

Figure 18 Engineering geological map of Mailung Dobhan-Gogane, Rasuwa

METHODOLOGY

For the purpose of determining the rock strength with in the study area, Schmidt Hammer Rebound Test and Point Load Test were conducted. The SHT was conducted in 19 stations and PLT was performed on the 8 irregular lump sample that were collected along the same section.

Schmidt Hammer Rebound Test (SHRT):

Schmidt Hammer a quick and inexpensive measure of surface hardness that is widely used for estimating the mechanical properties of rock material (Aydin & Basu, 2005). The process of operation is concise: a spring-loaded hammer strikes the rock surface indirectly via a plunger, and the hammer's rebound distance is read directly from a numerical scale or electronic display ranging from 10 to 100. (Torabi et al., 2010). The schematic view of Schmidt hammer is given in Figure 19 below.

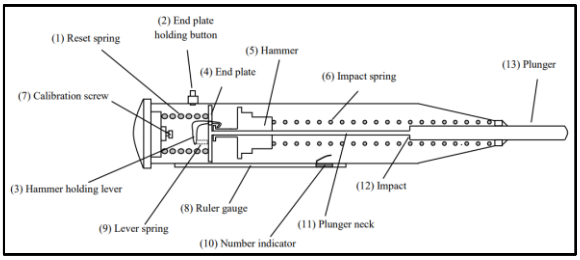

Figure 19 Details of an L type Schmidt hammer (Torabi et al., 2010)

Point Load Test (PLT):

The Point Load Test (PLT) is an index test, which means it can be performed quickly and without the use of advanced tools to provide important information about the mechanical characteristics of rocks. PL tests can also be executed in irregular blocks with the geometry of a rectangular prism. According to the ASTM standard, a specific block's cross-section is regarded as a trapezoid with parallel top and bottom bases (W1 and W2) and constant height (D). The loading technique is similar to the Block Lump Test, with an average width calculated (W=(W1+W2)/2).

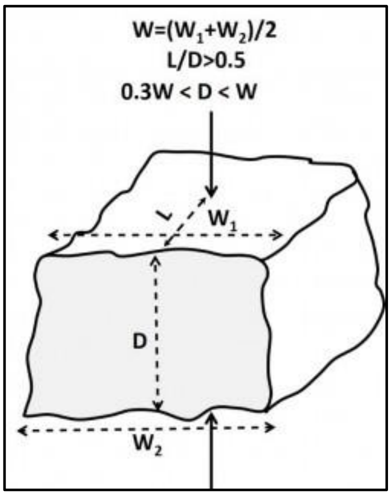

Figure 20 Sample's Dimension Requirements for the Irregular Lump PL Test and loading forces applied by the apparatus platens (source: geoengineer.org)

<u>*Uncorrected Point Load Strength Index*</u>:

The uncorrected point load strength I_s is calculated as:

$$I_s = \frac{P}{D_e^2} \text{ Mpa}$$

where, P = failure load, N,

$De^2 = 4A/\pi$ for axial, block, and lump tests, mm^2; [where: A = WD = minimum cross-sectional area of a plane through the platen contact points.

It is widely recognized that the size of a tested specimen influences its mechanical properties. This is strongly related to the non-homogeneous nature of rock materials. In larger samples, there is a greater chance that a weaker plane or a fracture would impact the material's behavior. As a result, the I_S value is corrected based on the sample size to a reference dimension (50mm) as follows:

$$I_{s50} = \frac{P}{(W \times D)^{0.75}\sqrt{50}}$$

<u>*Estimation of Uniaxial Compressive Strength (UCS) based on I_{S50}*</u>

The PL tests are used to classify rocks, but they can also be used to calculate the UCS of the tested rock. Many studies on the association between I_{S50} and UCS have been conducted, and research has revealed that there is no legitimate relationship that can predict the real UCS of a material with high accuracy based on I_{S50}. An estimated value, however, can be determined. The following formula can be used to calculate the UCS:

$$UCS = c \times I_{s50}$$

Here, assumed generalized value of c for lump sample is 15.

Based on their Uniaxial Compressive Strength, rocks can be characterized from very weak to very strong as following:

Table 7 Rock strength characterization based on UCS

Strength classification	Strength range (MPa)	Typical rock types
Very weak	10-20	weathered and weakly-compacted sedimentary rocks
Weak	20-40	weakly-cemented sedimentary rocks, schists
Medium	40-80	competent sedimentary rocks; some low-density coarse-grained igneous rocks
Strong	80-160	competent igneous rocks; some metamorphic rocks and fine-grained sandstones

Table 8 PLI Calculation Table

Sample		W	D	D_e^2	D_e	L	L/D	Breaking point, P (kN)	Uncorrected, I_s (Mpa)	Corrected, I_{s50}	UCS (mpa)
S1	parallel to foilation	140	80	14254.55	119.39	160	2.00	10.00	0.70	1.30	19.48
	perpendicular to foliation	108	60	8247.27	90.81	130	2.17	15.00	1.82	2.94	44.06
S2	parallel to foliation	100	90	11454.55	107.03	120	1.33	25.00	2.18	3.83	57.39
	perpendicular to foliation	120	93	14203.64	119.18	130	1.40	25.00	1.76	3.26	48.84
S3	parallel to foliation	110	97	13580.00	116.53	170	1.75	40.00	2.95	5.39	80.82
	perpendicular to foliation	120	95	14509.09	120.45	170	1.79	57.00	3.93	7.31	109.60
S4	parallel to foliation	90	65	7445.45	86.29	180	2.77	25.00	3.36	5.29	79.28
	perpendicular to foliation	110	80	11200.00	105.83	170	2.13	48.00	4.29	7.47	112.07
S5	parallel to foliation	125	85	13522.73	116.29	205	2.41	51.00	3.77	6.89	103.38
	perpendicular to foliation	125	95	15113.64	122.94	130	1.37	58.00	3.84	7.21	108.16
S6	parallel to foliation	130	80	13236.36	115.05	150	1.88	38.00	2.87	5.22	78.27
	perpendicular to foliation	115	88	12880.00	113.49	176	2.00	51.00	3.96	7.15	107.23
S7	parallel to foliation	100	70	8909.09	94.39	105	1.50	27.00	3.03	4.99	74.84
	perpendicular to foliation	105	85	11359.09	106.58	130	1.53	47.00	4.14	7.24	108.58
S8	parallel to foliation	130	65	10754.55	103.70	150	2.31	30.00	2.79	4.81	72.21
	perpendicular to foliation	107	75	10213.64	101.06	120	1.60	40.00	3.92	6.67	100.08
									Average	**5.43**	**81.52**

The Calculation Table 8 suggested that the average Uniaxial Compressive Strength (UCS) of the metasandstone rock of the study area is approximately 81 MPa which means the strength of the rock is medium to strong.

LAB TEST

The samples collected from the study area were tested in the Lab, here in Kathmandu. The breaking point under PL machine of 8 pair of samples varies from 10 kN to 60 kN in room temperature. The samples were tested both parallel and perpendicular to anisotropy (foliation).

A point load tester (see Photograph 1) consists of a loading system typically comprised of a loading frame, platens, a measuring system for indicating load, P, (required to break the specimen), and a means for measuring the distance, D, between the two platen contact points. The equipment was resistant to shock and vibration so that the accuracy of readings is not adversely affected by repeated testing.

Procedure for PLI:

Two sets of samples were taken whose W: D was more than 0.5 from eight locations in the study area. The samples were placed in the Point Load Test machine and breaking point in kN was recorded for both parallel and perpendicular direction of the anisotropy (foliation) respectively as shown in Photograph 2 and Photograph 3. The distance D was recorded within ±5% accuracy. The load was steadily increased so that the specimen failed within 10 to 60 seconds.

Photograph 1 (a) Close view of Point Load Machine, and (b) Full View of Point Load Machine.

Photograph 2 Sample after PLT perpendicular to anisotropy

Photograph 3 Sample after PLT parallel to anisotropy

RESULTS

Test results of UCS and PLT (I_{S50}) conducted on 8 irregular lump samples were compared taking UCS as the dependent variable and PL index from SHT as the independent variable. Below mentioned equation gives the linear equation fitting relationship between Schmidt rebound number, N, and UCS's scatter as shown in Figure 21.

$$UCS = 1.3316N - 17.961$$

The value of the coefficient of determination is 97% for this correlation which is decent.

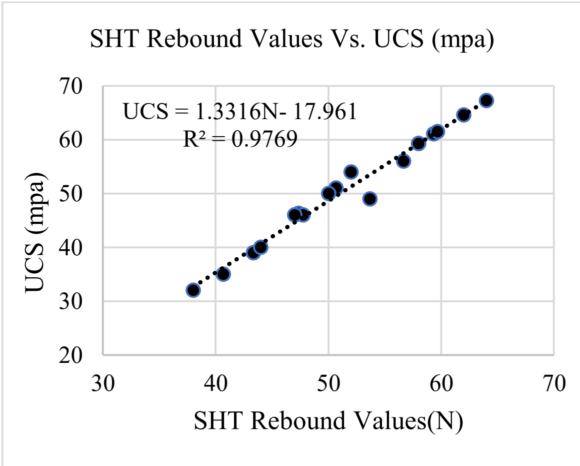

Figure 21 Correlation between UCS and Schmidt Rebound Number (N)

<u>Comparison between the UCS from PLT and SHT:</u>

The UCS from PLT in 8 pair of samples ranges from 19.48 mpa to 103.38 mpa for parallel to anisotropy which is weak plane of the sample, averaging of 70.7 mpa but it ranges from 44.06 mpa to 112.07 mpa for perpendicular to anisotropy, averaging of 92.3 mpa. The results from SHT ranges from 38 mpa to 68.59 mpa and average of 54.7 mpa for the same location from where the samples were extracted. This resulted approximately 17% and 29% differences in UCS from SHT and PLT performed on both parallel and perpendicular to anisotropy respectively.

The variation in the UCS may be due to the rough surface and weathering where the SHT was done. The comparison is shown below in Table 9.

Table 9 Schmidt Hammer Rebound values with their respective strength and PLT

SHT		PLT		Samples
Rebound Value, N	UCS (MPa)	Parallel to Anisotropy	Perpendicular to Anisotropy	
58	59.27	19.48	44.06	S1
52	54	57.39	48.84	S2
58	59.27	80.82	109.60	S3
46	44	79.28	112.07	S4
50	50	103.38	108.16	S5
62	64.60	78.27	107.23	S6
42	38	74.84	108.58	S7
65	68.59	72.21	100.08	S8

DISCUSSIONS

The results obtained from the Schmidt Hammer Rebound and Point Load Test indicates that the overall strength of the rock is approximately 51mpa which is competent and favourable to any structures to be build considering the factors like landslide or rock fall zone, gully erosion, weathering condition, amount of rainfall, presence of secondary structures etc.

The previous works suggested the following equation correlating the UCS to Schmidt hammer rebound number:

Table 10 Equations correlating UCS to Schmidt hammer rebound

Reference		Equation	R²
Singh et al. (1983)		UCS=2SCH	0.72
Haramy and DeMarco (1985)		UCS=0.994SCH_0.383	0.7
Katz et al. (2000)		UCS=0.792+0.067SCH±0.231	0.96
Yilmaz and Sendir (2002)		UCS=exp (0.818+0.059)	0.96
Yasar and Erdogan (2004a, b)		UCS=4E-0.06SCH4.2917	0.8
Aydin & Basu, (2005)		UCS=1.4459e0.0706SCH(L)	0.84
		UCS=0.9165e0.0669x(N)	0.86
Shalabi et al. (2007)		UCS=3.201SCH-46.59	0.76
Yagiz (2009)		$UCS=0.0028SCH^{2.584}$	0.92
Gupta (2009)	Granite	UCS=0.474SCH+31.3	0.03
	Quartzite	UCS=0.64SCH+37.5	0.96
	Marble	UCS=14.1SCH-642	0.79

Where, UCS uniaxial compressive strength (megapascals), SCH Schmidt hammer rebound number, N/L hammer type.

Based upon this study, it is safe to conclude that a strong correlation with significant reliability (R^2 =97%) occurs between SHT and Unconfined Compressive Strength (UCS). The study also suggested that the data from PLT is more reliable as compared to SHT even though the samples were block samples and sampled by using geological hammer which have affected the overall strength of the sample. Additionally, the samples were all surficial which obviously have gone through some extend of weathering process.

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