ESTIMATION OF COPPER IN COPPER ORES COLLECTED FROM JANGKOT ROLPA, NEPAL

A MINI RESEARCH REPORT SUBMITTED TO THE

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INSTITUTE OF SCIENCE AND TECHNOLOGY

TRIBHUVAN UNIVERSITY

SUBMITTED BY

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Baishakh , 2081

CERTIFICATE OF APPROVAL

This mini research report entitled "**ESTIMATION OF COPPER IN COPPER ORES COLLECTED FROM JANGKOT ROLPA, NEPAL"** by Anil Rajaure, Department of Science, Mahendra Multiple campus, Tribhuvan University (T.U.) completed under the mentorship of Asst. Prof. Dr. Deval Prasad Bhattarai, Department of Chemistry, Amrit Campus, Tribhuvan University, is hereby submitted to have been accepted by the Institute of Science and Technology (IoST) research committee.

30 /01/ 2081

LETTER OF CONSENT

This mini research report **entitled "ESTIMATION OF COPPER IN COPPER ORES COLLECTED FROM JANGKOT ROLPA, NEPAL"** by Anil Rajaure, Department of Science, Mahendra Multiple Campus, Institute of Science and Technology (IoST),Tribhuvan University (T.U.), is hereby completed under my mentorship. This is novel work and has been performed genuinely and conducted under good ethics of research. This research is useful in the estimation of minerals in Nepal and expected to work in policy design. This work is performed under the support of Mini Research Grant -2080 provided by Dean's Office, Institute of Science and Technology (IoST), Tribhuvan University (T.U.).

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DECLARATION

It is hereby declared that this mini research report entitled "**ESTIMATION OF COPPER IN COPPER ORES COLLECTED FROM JANGKOT ROLPA, NEPAL"** being submitted to the office of the Dean, Institute of Science and Technology (IoST), Tribhuvan University (T.U.), Nepal is carried out by me under the mentorship of Dr. Deval Prasad Bhattarai and all the proposed goals in the proposal have been achieved and have been included in this report.

The reported work is original and has not been submitted earlier in part or full in this or any other form to any university or institute.

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Anil Rajaure

2081/01/30

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Anil Rajaure

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ABSTRACT

Nepal is a country rich in natural resources. There is evidence of the presence of mines of different types of elements, but scientific research in this field is found to be less. Zinc, iron, copper, etc. are the major sources of mines here which have been extracted since time immemorial. But these days, significant research and extraction of such minerals have not been found to occur. In this context, it seems desirable to study and research the mines available in Nepal. In this study, five samples of copper ores were collected from Jangkot Rolpa and examined using Titrimetric analysis, atomic absorption spectroscopy and x-ray diffraction (XRD) methods. The results show that sample C1RJ has the highest copper concentration (2.20% by titration and 1.64% by AAS) among the test samples, indicating that the collected samples contain extractable amounts of copper in that location. The XRD results confirms the ores are auzurite, malachite, cuprite and chalcocite. However, further research is required to carry out the quality of the copper deposit.

Keywords: Jangkot, Copper ore, Titration, AAS, *XRD*

शोधसार

नेपाल प्राकृति सम्पदाले भरीपूर्ण देश हो। यहा विभिन्न प्रकारका तत्वहरुको खानीहरु रहेको प्रमाणहरु छन् तर यस सम्बन्धमा बैज्ञानिक खोज अनुसन्धान कम भएको पाइन्छ। जस्ता, फलाम, तावा, इत्यादी यहाका खानीका श्रोतहरु हुन् जुन परापुर्बक कालदेखि नै उत्खनन गरिदै आए पनि हालका दिनहरुमा यसका बारेमा अनुसन्धान तथा प्रभावकारी उत्खनन गरिएको खासै पाइदैन। एस सन्दर्भमा, नेपालमा उपलब्ध खानीहरूको अध्ययन तथा अनुसन्धान गर्न बान्छनीय देखिन्छ। एस अनुसन्धान कार्यमा, रोल्पा जिल्लाको जंकोटमा रहेको तामा खानीको रासायनिक पक्षको अनुसन्धान गरिएको छ।

जंकोट रोल्पाबाट ५ वटा नमुनाहरु संकलन गरि टाइट्रेसन बिधीबाट तथा तत्वहरुको अवशोषण क्षमता अध्ययन विधिबाट परीक्षण गरियो। अध्ययन अनुसार संकलित धाउहरुमा नमुना १ (C1RJ) बाट अधिकतम २.२० प्रतिशत (टाइट्रेसन बिधीबाट) १.६४ प्रतिशत (तत्वहरुको अवशोषण क्षमता अध्ययन, ए ए एस), तामाको मात्रा रहेको पाइयो जुन तामाको निकासी योग्य मात्रा हो। संकलित धाउहरुमा अजुराइट, मालाकाइट, क्युप्राइट र चाल्कोसाइट देखिन्छ। यद्यपि, खानीको वर्गिकरण गर्न अझै गहिराइ सम्मको अध्ययन जरुरी छ।

Keywords: Jangkot, Copper Ore, Titration, AAS

LIST OF ACRONYMS AND ABBREVIATIONS

AAS:	Atomic Absorption Spectroscopy
DMG:	Dimethylglyoxime
EDTA:	Ethylenediamine Tetraacetic Acid
EG:	Ethylene Glycol
EPA:	Environmental Protection Agency
EW:	Electrowinning
FIA:	Fluorescence Immunoassay
ICP-OES:	Inductively Coupled Plasma Optical Emission Spectroscopy
LIBS:	Laser-Induced Breakdown Spectroscopy
MT:	Metric ton
UV:	Ultraviolet
WHO:	World Health Organization
XRD:	X-Ray Diffraction
XRF:	X-ray Fluorescence Spectroscopy

LIST OF SYMBOLS

%:	percentage
g:	gram
kg:	kilogram
M:	molarity
mg:	milligram
mL:	milliliter
N:	normality
nm:	nanometer
V:	voltage

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CHAPTER 1

1. INTRODUCTION

1.1. Background

Ores are naturally occurring minerals that contain an extractable amount of metals (Guilbert & Park Jr, 2007). Different metals have their respective ores from which metal can be extracted. The most common ores of copper are chalcopyrite ($CuFeS_2$), malachite $CuCO_3(OH)_2$, cuprite (Cu_2O), chalcocite (Cu_2S), azurite $Cu_3(CO_3)_2OH$, covellite (CuS) and bornite (Cu_5FeS_4) (Kaphle, 2020; Samans, 1949). The amount of copper in any ores varies from 0.2% - 40% and is classified as rich grade (5-40) %, high grade (1-5) % and low grade (0.2-1) %. However, copper can be extracted economically and profitably if its ore contains at least 2 % copper (Sverdrup et al., 2021). Copper is the focus because it has a wide variety of applications. Household utensils made up of copper have been used since the earliest time. The reason behind this is that copper is less corrosive (Hu et al., 2014), has good antimicrobial properties (Arendsen et al., 2019), and alloy can be formed with other metals (Hu et al., 2014). Copper can be alloyed with other metals to increase its strength and resistance to temperature (Hu et al., 2014). In recent years, the use of copper in electrical industries for the production of electrical and electronic equipment, wires, coins, crafts, etc. due to its high ability to conduct current electricity (Richardson, 1997). Recently, copper has been used in electrical industries for the production of electronic equipment like wires, and coins, etc. due to its high ability to conduct electricity (Richardson, 1997). It also has great applications in biological fields (Wang et al., 2021). It also has great biological applications. It possesses protecting the cardiovascular system, and bone fracture healing and exerts antibacterial effects (Wang, Casner, et al., 2021). A huge amount of copper is being consumed these days for household and industrial applications, for which the extraction of copper is essential. Copper can be extracted in pure form from its different ores. Copper is an essential micronutrient element for living organisms, including humans for metabolic processes (Elguindi, 2011).

1.2. Occurrence of Copper Ores in Nepal

Copper is regarded as an essential metal because it has a wide variety of applications from ancient times. Copper was mined traditionally in different places in Nepal but not nowadays. The ores such as chalcopyrite ($CuFeS_2$), Malachite $CuCO_3(OH)_2$, Azurite $Cu_3(CO_3)_2OH$, Covellite (CuS), Cuprite (Cu_2O), Bronite (Cu_5FeS_4) and Chalcocite are found in Nepal. Some small-scale copper mines were reported in Gyazi (Gorkha), Okharbot (Myagdi), and Wapsa (Solukhumbu) till 1995. Other copper mines like Dhusa (Dhading), Kalitar (Makwanpur), Wapsa (Solukhumbu), Dadeldhura, Bhut Khola (Tanahu), Khandeshori Danfechuli Marma (Darchula), Pandav Khani (Baglung), Baise Khani (Myagdi), Mul Khani (Gulmi), Dolakha, Kurele (Udayapur), Chirling Khola (Bhojpur), Jantar Khani (Okhaldhunga), Siddi Khani (Ilam) are major areas. Many scattered old workings mines are also known from different parts of Darchula, Bajhang, Bajura, Baglung, Myagdi, Gulmi, Tanahun, Gorkha, Makwanpur, Ramechhap, Okhaldhunga, Dhankuta, and Taplejung districts, 1 mining license and 7 Prospecting licenses for copper have been issued by the department of mines and geology, Kathmandu, Nepal (DMG, Annual report. 2019). The average concentration of copper ores is about 0.6 % and most of the ores are in the form of sulfide such as chalcopyrite ($CuFeS_2$), Bornite, Covellite, Chalcocite, conversely, the average concentration of copper in polymetallic nodule is estimated at 1.3% and mostly the copper extracted by the process of sulphuric leaching, smelting and an application of the cuprion process (Su, Kun; Ma, et. al., 2020). There is still a high possibility of copper deposits. However, searching for deposits and identification of the extractable ores of copper is lacking. Copper is useful for various purposes in day-to-day life however it is a non-renewable resource. So, searching for a new deposit is very necessary (Kaphle, 2020).

1.3. Identification of Copper Ores by XRD Pattern

Occasionally copper is found in its native form but more frequently it is found mixed with other minerals. There are many minerals and ores of copper among them the most common ores of copper are chalcopyrite, malachite cuprite, chalcocite, azurite, covellite, and bornite (Kaphle, 2020) (Samans, 1949). The amount of copper in each ore is different. It depends on the nature and composition of the ore as well as the impurities. The crystallographic orientation of each ore is listed below.

1.3.1. Chalcopyrite ($CuFeS_2$)

The most frequent and widely distributed copper ore mineral is chalcopyrite ($CuFeS_2$). Most of the world's copper production comes from an important copper source chalcopyrite. It can be identified from XRD peaks as it is found in pure crystalline form. The crystal structure on irradiation with x-ray, the diffraction peaks located at 29.34, 48.68, 49.04, and 57.84 degrees, respectively belong to the crystal (112), (220), (204), and (312) surfaces confirming the chalcopyrite ore (Wen, S., Liu, J., & Deng, 2021).

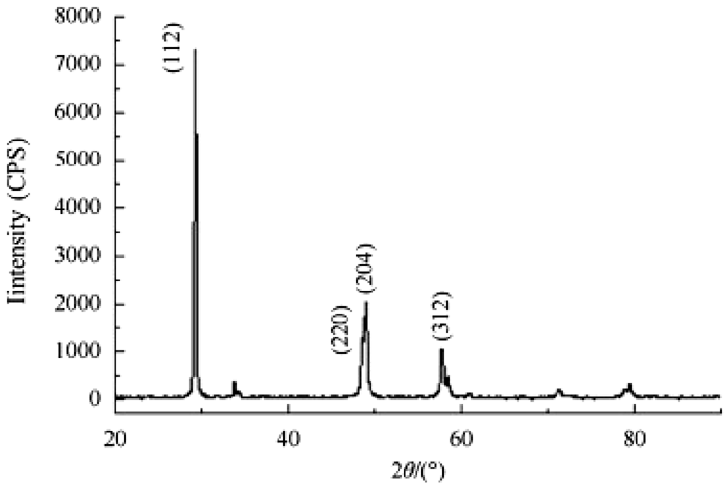


Figure 5: XRD diffraction pattern of chalcopyrite mineral (Wen, S., Liu, J., & Deng, 2021)

1.3.2. Malachite ($CuCO_3(OH)_2$)

The most widely distributed copper ore minerals are known as malachite $CuCO_3(OH)_2$. It typically takes the form of green-colored crystals or grains. It is one of the most important sources of copper. Most of the world's copper production comes from an important copper source, malachite. It can be identified from XRD peaks as found in pure crystalline form (Sekiguchi, Shimadzu, 1995).

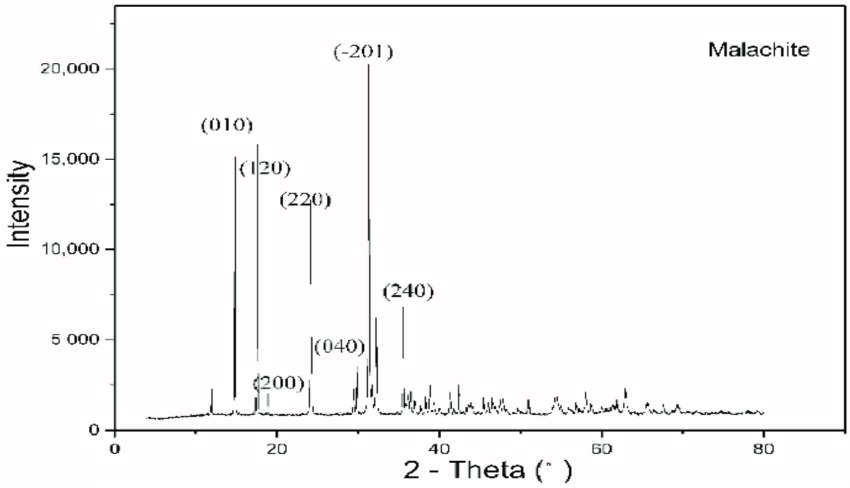


Figure 6: XRD diffraction pattern of malachite mineral (H.sekiguchi, shimadzu., 1995)

1.3.3. Chalcocite (Cu_2S)

The most frequent and widely distributed copper ore mineral is chalcocite (Cu_2S). It is frequently discovered in porphyry copper deposits and typically takes the form of dark-colored crystals or grains. It can be identified from XRD peaks as it is found in pure crystalline form (Wen, S., Liu, J., & Deng, 2021).

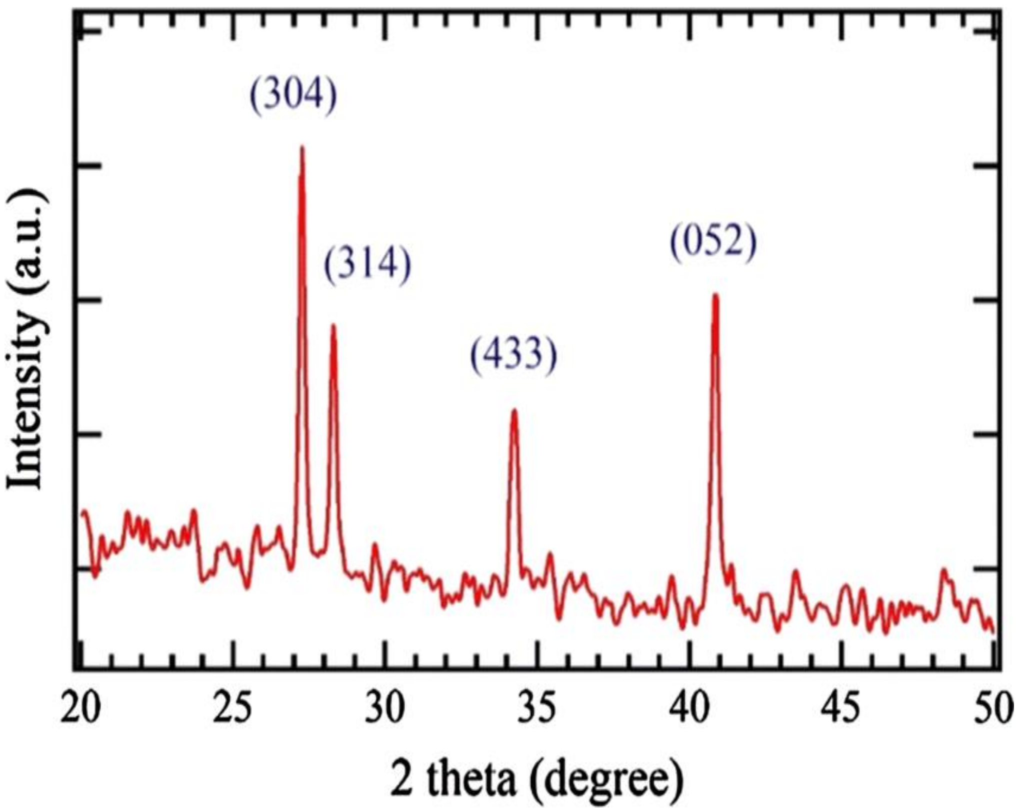


Figure 3: XRD diffraction pattern of chalcocite mineral (Wen, S., Liu, J., & Deng, 2021)

1.3.4. Azurite ($Cu_3(CO_3)_2OH$)

The most frequent and widely distributed copper ore mineral is azurite ($Cu_3(CO_3)_2OH$). It is a blue-colored carbonate mineral, which is found in oxidized copper deposits. It is used as a gemstone and as jewelry. It can be identified from XRD peaks as it is found in pure crystalline form (K. Tomita, Kyoritsu Shuppan, 1966).

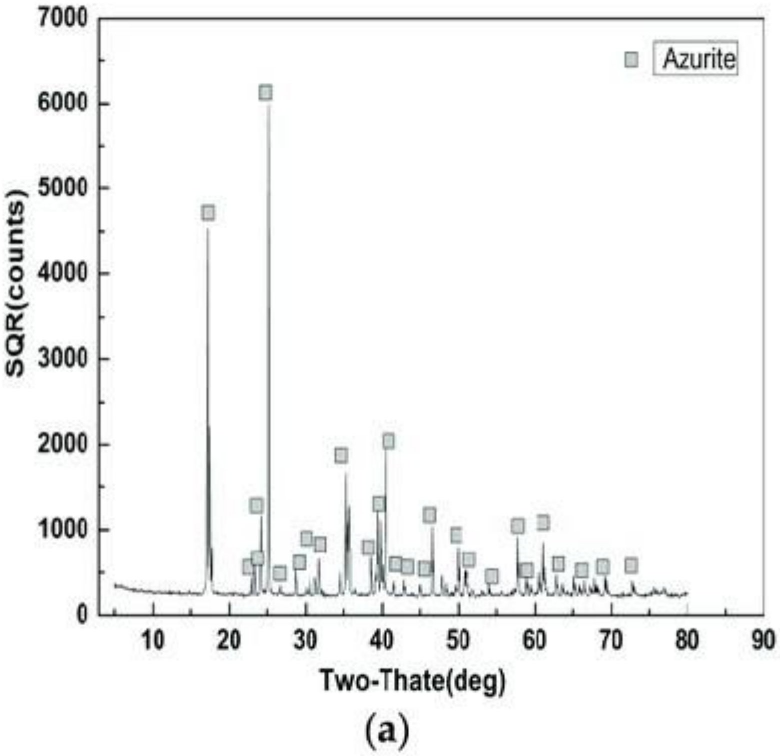


Figure 4: XRD diffraction pattern of azurite mineral (K. Tomita, Kyoritsu shuppan., 1966)

1.3.4. Covellite (CuS)

Covellite (CuS) is a widely distributed copper ore. It is found in oxidized zones of copper deposits and takes the form of an indigo-blue color. It can be identified from XRD peaks as it is found in pure crystalline form (K. Tomita, Kyoritsu Shuppan, 1966).

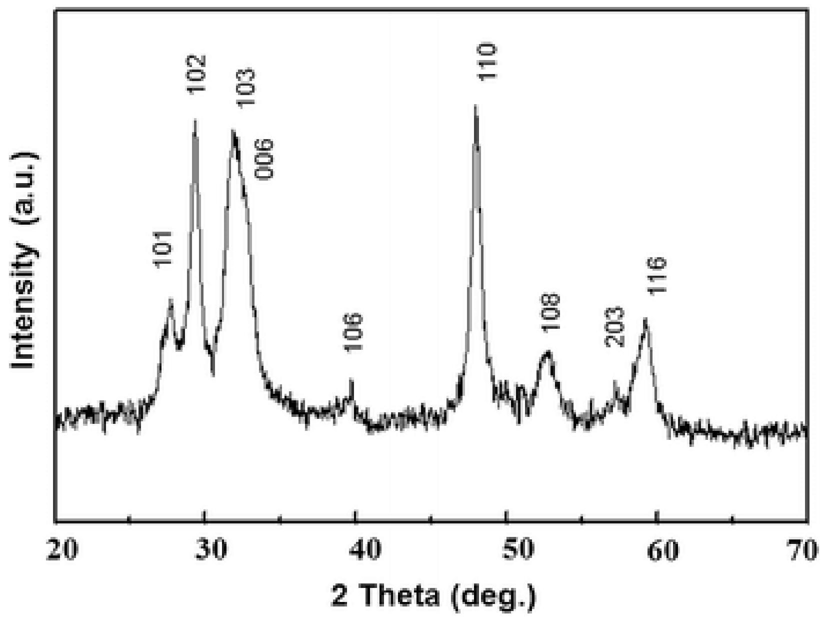


Figure 5: XRD diffraction pattern of covellite mineral (K. Tomita, Kyoritsu shuppan., 1966)

1.3.5. Bornite (Cu_5FeS_4)

The most frequent and widely distributed copper ore mineral is Bornite (Cu_5FeS_4). It is frequently discovered in hydrothermal and sedimentary copper deposits and typically takes the form of iridescent purple to brown-colored crystals or grains. Bornite is also known as peacock ore. It can be identified from the XRD peak as it is found in pure crystalline form (Wen, S., Liu, J., & Deng, 2021).

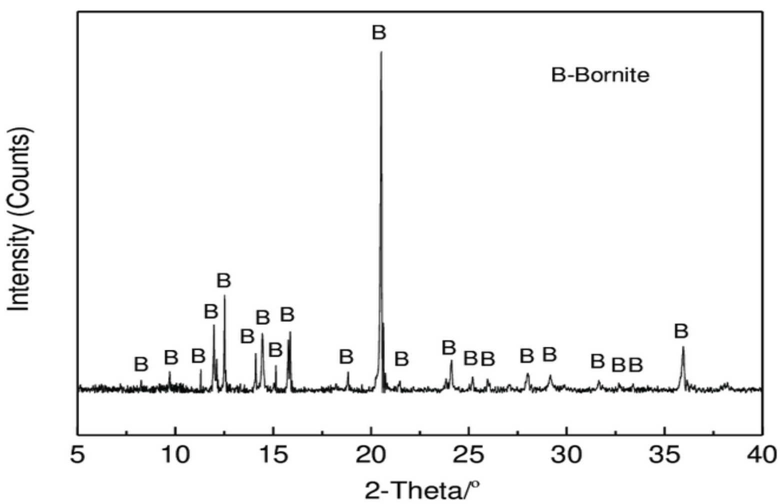


Figure 6 XRD diffraction pattern of Bornite mineral (Wen, S., Liu, J., & Deng, 2021)

1.4. Estimation of Copper in Copper ores

Estimation of copper from copeer ore can be done by using different Analytical methods as X-ray Fluorescence (XRF),Uv spectroscopy ,Titration ,Atomic Absorption Spectroscopy (AAS).

XRF is simple and quick technique for elemental analysis.The powder sample is ingested to XRF instrument ,which works by bombarding the sample with high energy X -rays .The energies and intensities of emitted X-rays are measured and determine the composition of sample.similarly,In titration method The powder copper ore is digested with conc.hydrochloric and conc nitric acid and heated with Conc sulphuric acid .Then 50 mL of distilled water ,5 mL of bromine water , 1:1 ammonia solution was added to faint alkaline and then 7 mL of glacial acetic acid was added followed by boiling and cooling. The prepared analyte is then titrated with sodium thiosuphate for end point.

Other, the reliable method for the estimation of copper from copper ore is AAS. In the method the dissolved sample solution is atomized and exposed to light source. copper atoms absorb light at resonance wavelength, which is proportional to the concentration of copper atoms in the sample.

1.5. Objectives

1.5.1. General Objectives

The general objective is to identify the ore site and estimate the amount of copper in those collected ore samples.

1.5.2. Specific Objectives

1) Finding the ore site and collecting the copper ore samples.
2) Identification of copper ore samples by XRD method
3) Determination of the amount of copper on those samples by titration method
4) Determination of the amount of copper on those ores by the AAS method

CHAPTER 2

2. LITERATURE REVIEW

2.1. World History of Copper Extraction

Although the exact beginnings of human use of metals are unknown, but archaeologists estimate that copper, silver, and gold were used as early as 7000 years ago (7000BP),2 in both the Middle East and America (Radetzki, M. 2009).

Copper was smelted in different places independently. In China, copper was smelted before 2800 BS and around 600 AD in Central America, in the 9th or 10th century AD in West Africa (Cowen, R et al., 2009). Lung (1986) reported the cementation or contact precipitation used in nine centuries to deposit cement copper from a solution with metallic iron as a reductant. Haj-Hussein (1996) reported, among the different methods, the flow injection analysis method for the ultraviolet spectrophotometric determination of copper in copper ores. The ore sample was dissolved in concentrated perchloric acid, and neutralized with ammonia, and the resulting solution was used for the determination of copper. This Analysis system is based on the reaction of copper (II) ions with pyrophosphate and subsequent measurement of the absorbance of the di-pyro-phosphato-cuprate (II) complex at 240 nm.

Balasubramaniam et al., (2002) used optical and scanning electron microscopy, as well as microhardness measurements, to describe the material used in the creation of an ancient Indian ochre-colored pottery (OCP) human figure from the 2650–800 BC period. X-ray diffraction revealed that the green surface of the patina is mostly made up of cuprite, with tiny quantities of malachite and brochantite. The metal was almost pure Cu, with very small C and Sb impurities present.

Ghaedi et al. (2006) reported a simple method for the simultaneous pre-concentration of nutritionally important minerals. The method was based on the formation of metal complexes by 4, 6- dihydroxy-2-mercaptopyrimidine (DHMP) loaded on activated carbon. Then the metal complexes were eluted using 5 mL of 2 M HNO_3 in acetone which were detected by atomic absorption spectroscopy (AAS) at resonance line. This method has high reliability, reproducibility, sensitivity, and high tolerance limit of common ions and a low detection limit is a powerful tool for rapid and sensitive determination of ions.

Rifai et al., (2020) used Laser Induced Breakdown Spectroscopy to quantify several elements in pressed pellets of copper-nickel ore powder. The study included 32 samples. The materials were examined with a commercial LIBS instrument. The blank samples were utilized to assess the accuracy and robustness of the calibration model. The research illustrates how the Laser Induced Breakdown Spectroscopy approach may correctly detect the concentration of many elements of interest in copper-nickel ore samples quickly and with little sample preparation.

2.2. Nepal History of Copper Extraction

About 100 years ago, in the Myagdi district, there were lots of copper mines that were underused. There are about 17 big copper mines in Dhawalagiri, Malika, Bishal copper mines, Raghuganga rural Municipality, and Beni Municipality in Myagdi district. But these mines have not been mined due to a lack of modern equipment. Rumle Hill in Raghuganga, Malika Bank Hill in Dhaulagiri-5, Thadakhani village Malkabang, Okharbot in Malika rural Municipality, etc. also have been reported to as mines of copper ores. Local people of that area extracted copper from the mines and manufactured different utensils for their uses. But there are still lots of tunnels that were used to excavate mines in the upper hills above the villages. Across the deep terrain, there are several copper mines. Due to lack of use, the mines are already buried in the soil. Local said lack of equipment and the legal hassles were the main challenges in resuming the copper mines. They said if the government facilitated legal provisions and provided equipment needed for excavation, it would not be difficult to resume the mines.

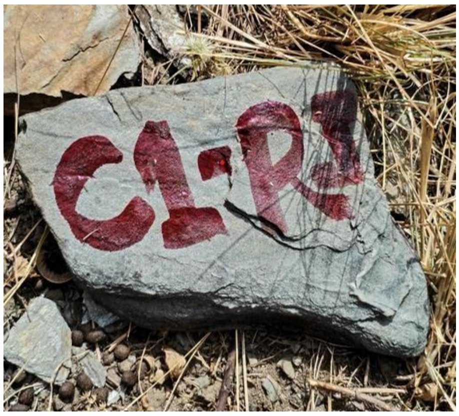
CHAPTER 3

3. MATERIALS AND METHODS

3.1. Sample Collection

Sample ores were collected in air-tight polybags from Jangkot, Rolpa District, Nepal (longitude 82.5456°E, Latitude 28.4050°N and Altitude 3665 m) Channel sampling, as well as grabbing methods, were applied to collect the ores samples. Some samples were collected from previously mined areas where channels were already prepared by local people. The ores samples collected from those channels were from a 20-50 m tunnel in the mountain. As far as possible we entered inside the channels to collect samples. However, some samples were collected from the surface i.e. grabbed samples. Those grabbed samples were collected based on the possibility of sources shown by local peoples and the nature of ores. In some cases, new channels were constructed, and collected the samples. The sites from where samples were collected were labeled well. For example, C1-RJ refers to channel one of Rolpa Jangkot. The Google map of the sample collection site is shown in Figure 1 and some glimpses taken during sample collection are as shown in Figure 8 a-f.

Figure 7: Google map of the sample collection site



a) Entering inside old tunnel

b) Channel labeling (C1 -RJ)

c) Collecting samples inside the tunnel

(d) Representative ore sample

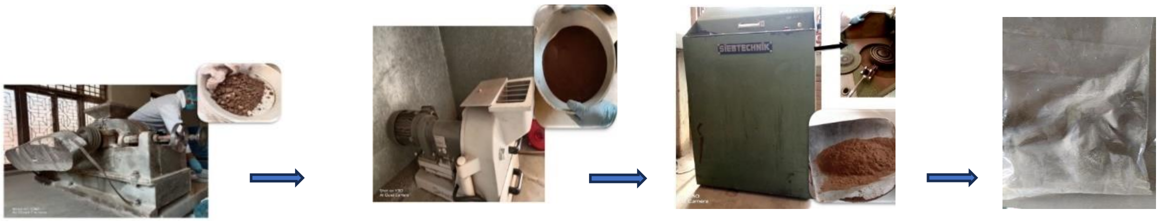
(e) Group photo around sampling

(f) Night stay at Bhawang

Figure 8 :a-f) Photographs taken during sampling

3.2. Powdering of Sample

Collected ores were ground into a fine powder using a crushing and pulverization machine. For this crushing and grounding of the samples, collaboration with Nepal Environmental and Scientific Services (P.) Limited was done. Following are some glimpses of the sample preparation process.



Grinding pulverizing Ball milling Sample ore

Figure 9: a-d) Ore sample , after crushing, grinding, pulverization,

3.3. Preparation of solution

3.3.1. Preparation of 0.005 N $Na_2S_2O_3$ Solution

0.62 g of sodium thiosulphate was weighed out and dissolved in distilled water in a 500 mL volumetric flask and made volume up to the mark. Shaken well to mix the solution.

3.3.2. Ammonia solution

50 mL of ammonia solution was mixed with 50 ml of distilled water to make a faint alkaline.

3.3.3. Starch solution

1 g of starch was weighed out and dissolved in 100 mL of hot distilled water.

3.3.4. KI solution

10 g of KI was weighed out dissolved in 100 mL of distilled water and shaken well to mix the solution.

3.4. Analyte Preparation

All chemicals used were of analytical reagent grade. All solutions were prepared with distilled water. The powder of the sample was digested through the wet digestion method. In a 250 mL beaker containing 0.5 g of powdered sample, 10 mL of conc. HCl and 15 mL of conc. HNO_3 was added and heated gently to decompose the ore. Then, 4 mL of conc. H_2SO_4 was added and boiled almost to dryness and cooled. 50 mL of distilled water and 5 mL of bromine water were added followed by boiling to expel bromine. And then 1:1 ammonia solution was added to faint alkaline and then 7 mL of glacial acetic acid was added followed by boiling and cooling. The mixture was filtered off and stored (Jeffery et al., 1942).

3.5. Estimation of Copper by Titration

The analyte solution prepared was taken and 2 mL of 10 % KI solution was added. The solution was kept in the dark for about 10 minutes. Then 1 mL of starch solution was added, color changed to blue color. Then titration was done with 0.005 N sodium thiosulphate with constant stirring until the colorless was obtained. The titration was repeated until concurrent reading. After complete titration, the amount of copper was estimated using the following formula

1 mL of 0.1 N sodium thiosulphate = 0.006354 g of Cu

1 mL of 0.005 N sodium thiosulphate = 0.0003177 g of Cu

$$cu\ in\ ore\ (\%) = \frac{0.0003177 \times volume\ of\ thiosulphate\ consumed}{Amount\ of\ ore\ taken} \times 100$$

3.6. Estimation of Copper by AAS

Estimation of copper in copper ores can also be done by the AAS method. The method utilizes the fact that when unexcited atoms of an element are exposed to a continuous light source, they absorb light of the same frequency that they emit in the excited state. Thus, the measurement of the light absorbed at the wavelength of the resonance line by unexcited atoms of an element can be used for its determination.

For the estimation, a calibration curve at maximum absorbance wavelength was made. Copper was analyzed at the wavelength of 324.8 nm with a slit width of 0.5 nm (Ghaedi et al., 2006) (Qureslu et al., 1974). An atomic absorption spectrometer (SIMADZU, AA7000) was used to determine the quantity of copper in the ores. For the quantification, a calibration curve of Cu(II) was prepared by taking standard solutions of suitable concentration.

3.7. XRD Measurement of Copper Ore

X-ray diffraction (XRD) is a common technique used to analyze the crystal structure and composition of materials, including copper ore. Copper ore typically contains various minerals including Copper sulfides such as Chalcopyrite and Bornite. Copper oxides such as cuprite and malachite. XRD technique was used to analyze the phase composition of ore samples by using a Rigaku-D/max 2500 PC diffractometer. Monochromatic x-ray of wavelength 1.54 Å obtained from the CuKα target was used to scan the samples at the scanning rate of 10°/min in the scanning range is 10° ~ 70° at 50 kV and 300 mA. The obtained XRD patterns were analyzed by using Jade 6.5 software and matched with JCPDS files.

CHAPTER 4

4. RESULTS AND DISCUSSION

4.1. Estimation by Titration

The amount of copper in the collected ore samples was determined in the laboratory by a very simple and relevant method, titration method. The standard method of analyte preparation was used before titration. After the preparation of the analyte, the standard iodometric titration method was applied. The volume of reagent consumed was noted when the sharp change in the color of the analyte from blue to colorless. The amount of copper in the analyte solution was then calculated using the principle of equivalency (equation 1). The titration method is the most reliable and simple method to determine the analyte concentration when the concentration of the analyte is more than 0.01%. For lower concentrations of analyte, this method is not valid and must find a new spectroscopic method. The amount of copper present in the analyte solution is tabulated in Table 1.

Table 1: Amount of copper in ore samples presented in percentage determined by titration method.

S.N.	Sample of ores	Volume of thiosulphate consumed (mL)	% of copper in the sample	Standard deviation
1	C1RJ	34.7	2.20	0.022
2	C2RJ	0.5	0.03	0.005
3	C3RJ	0.2	0.01	0.003
4	C4RJ	4.8	0.20	0.020
5	C5RJ	2.4	0.14	0.008

From the titration table, it is obvious that the amount of copper is highest in ore collected from the C1RJ channel. This amount is highest among the collected samples. The amount of copper contained in the lowest amount is in C3RJ. Based on the classification of ore, the C1RJ sample lies in the range of high-grade ore whereas the rest of all samples lie in the low-grade ores. Based on the literature and real practice, ore containing more than 2% copper is recommended as high-grade ore and the copper can be extracted profitably from them. This implies the C1RJ ore can be recommended for the extraction of copper. The detailed findings are shown in Figure 10..

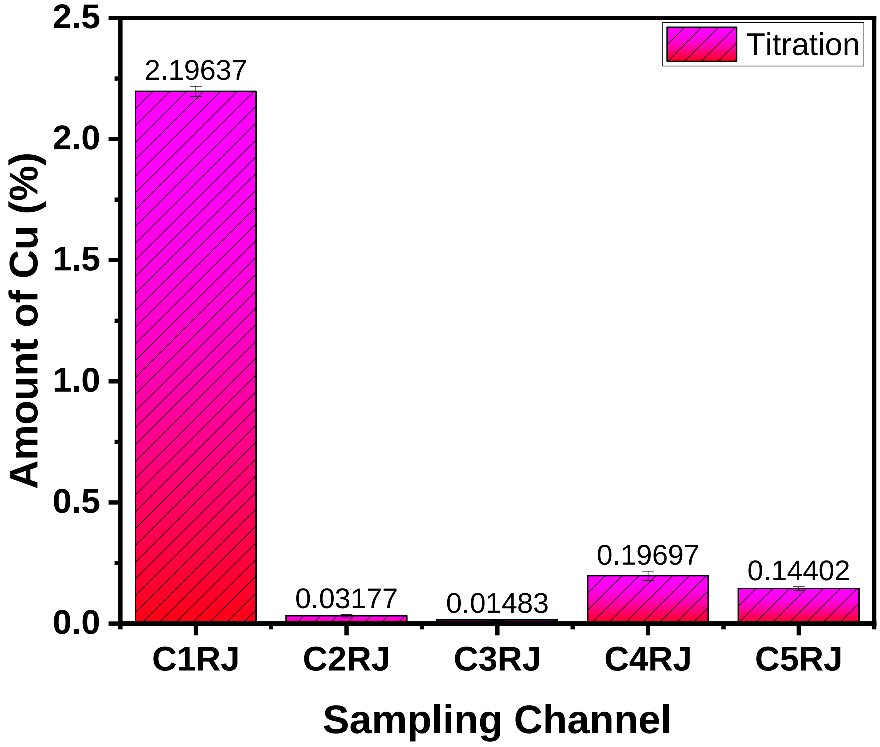


Figure 10: Amount of copper in percentage in the collected ore samples determined by titration method. The relative error bars in the bar diagram show a standard deviation value (n=3)

Interestingly, the amount of copper in collected samples is drastically different for all. Dramatic differences in the occurrence of copper in the core samples indicate that there may be possibilities of some titration errors. The main possibilities could be, i) loss of iodine by evaporation from the solution, ii) oxidation of iodine in an acidic medium, iii) starch solution. To avoid such errors precise measurement with caution was made. Not limited to this, triplicate measurements were performed to validate the finding, and the standard deviations were calculated. It is found that for all measurements, the titrant value is similar and there is the lowest value of standard deviation. The coefficient of variance at a 95% confidence interval is also acceptable.

Except C1RJ sample, all the samples contain a very low amount of copper. To ensure the amount of copper titration value a new spectroscopic method for their quantification is needed. Hence, the AAS method was used to measure copper in all the analyte samples

4.2. Findings from AAS method

4.2.1. Calibration Curve

The amount of copper in the copper ores was determined by the AAS method. For which a calibration curve was prepared. Mostly volumetric and AAS methods are used for the chemical analysis and estimation of copper content in its ore. The volumetric method favored the rich and high-grade sample with higher copper content in its ore, but the AAS method favored the low-grade ore or sample. The crossmatch of the volumetric method with the AAS method favored all grades of ore. Hence for all the samples, we used the AAS method. The calibration curve obtained from the standard copper (II) solution is given in Figure 11.

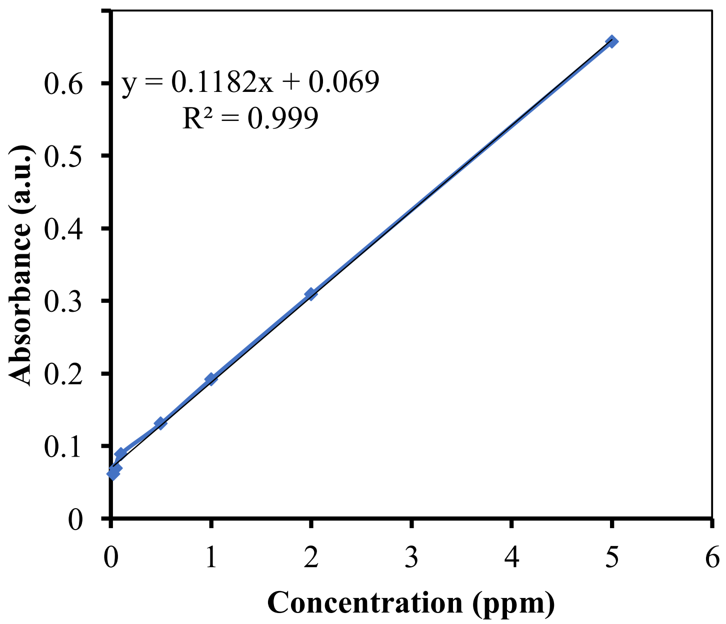


Figure 11: Calibration curve of copper in μg/g by AAS Method

4.2.2. Linearity range

The linearity range is also known as the working range in the calibration curve as shown in Figure 12. For exact quantification of the copper in the ores, it is necessary to find the linearity or working range. For the measurement of the Cu in the respective ores, the linearity range was determined by measuring the absorbance of standard samples of concentrations ranging from 0.025 to 20 ppm. The linearity range was found to be 0.05 to 5 ppm. Before 0.05ppm, the instrument can detect the presence of a Cu atom but cannot exactly quantify its amount. So, the detection limit of the instrument is 0.025 ppm whereas the limit of quantification is 0.05 ppm for Cu atom. Similarly, beyond 5 ppm the absorbance data breaks the linearity range. This indicates that the instrument can only exactly quantify the sample concentration below 5 ppm.

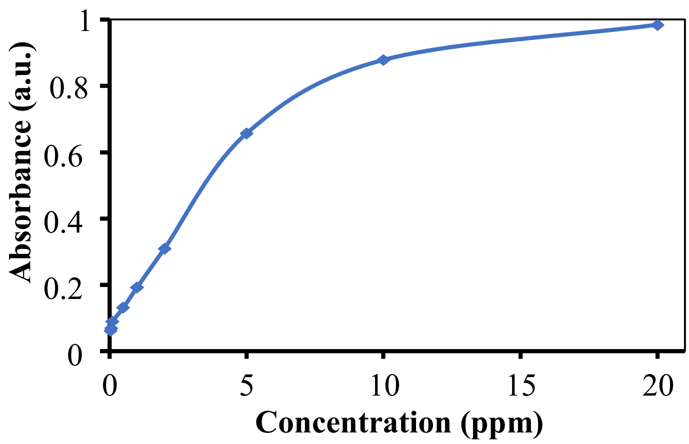


Figure 12: Linearity range for Cu measurement by AAS

4.2.3. AAS Results

The amount of copper in the analyte sample prepared like the titration method was determined using the AAS method. This method was used because the amount of copper in the analyte solution determined by the titration method was obtained very small value. To ensure the reliability of the titration method for a very dilute solution AAS method was employed. From the AAS measurement method, the results obtained are comparable with the value obtained from titration. For instance, the amount of copper in C1RJ is 1.64 % which is the highest value. This value is comparable with the value obtained from the titration method. Higher the amount of copper in this sample by titration method may be due to titration error only. However, there is lowest value for C5RJ measured by the AAS method which is drastically different from the titration method. In this regard, the value obtained from the AAS method is taken as the correct value for two reasons: i) AAS is an instrumental method and there is the lowest possibility of handling error, and ii) the spectroscopic method is reliable for dilute solution. The amount of copper obtained in different samples by the AAS method is shown in Figure 13.

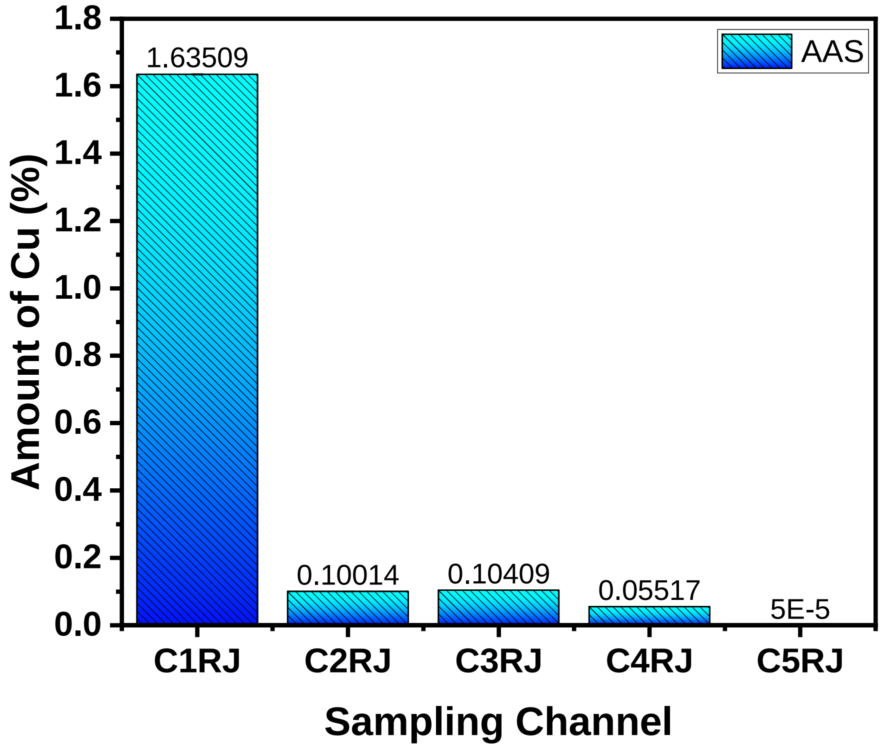


Figure 13: Amount of copper in its ore collected from Jangkot, Rolpa measured by AAS method

The amount of copper in its ore determined by titration and AAS methods are compared as in Figure 14. The measured values are comparable and not drastically different except for sample C5RJ. The amount of copper in this sample is negligible i.e. nearly equal to 0.0005% measured by AAS. There is a significantly different amount of copper in the samples even though all the samples were collected from the same area. This difference in the amount of copper may be due to two reasons: i) variation in the channel length from where sampling was done and ii) unequal distribution of ores in the deposit area. However, the findings suggest that further study is needed to explore the possibility of copper deposits.

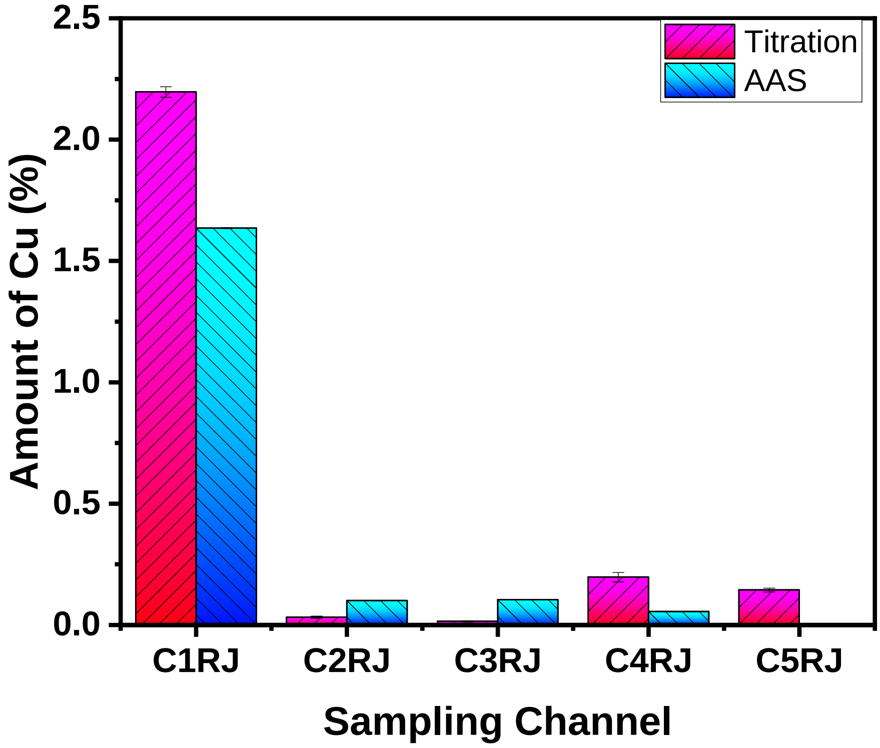


Figure 14: Amount of copper determined by titration and AAS method

4.3 XRD Results

X-ray diffraction (XRD) is one of the primary techniques used by mineralogists and solid-state chemists to examine the physio-chemical makeup of unknown materials. The experimentally determined XRD diffraction pattern of the samples is given below in Figure 15

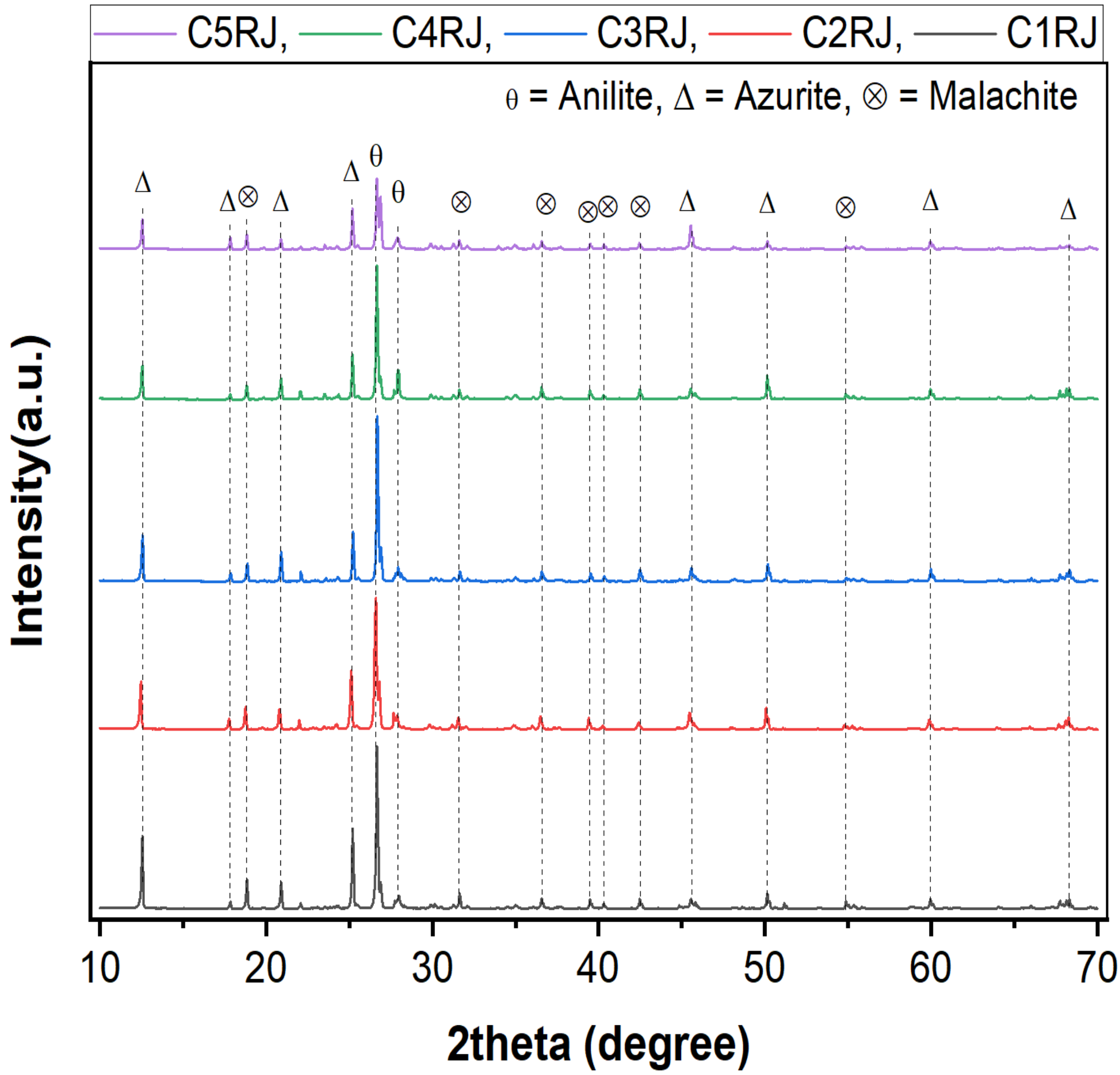


Figure 15 : XRD diffraction pattern of sample C1RJ -C5RJ

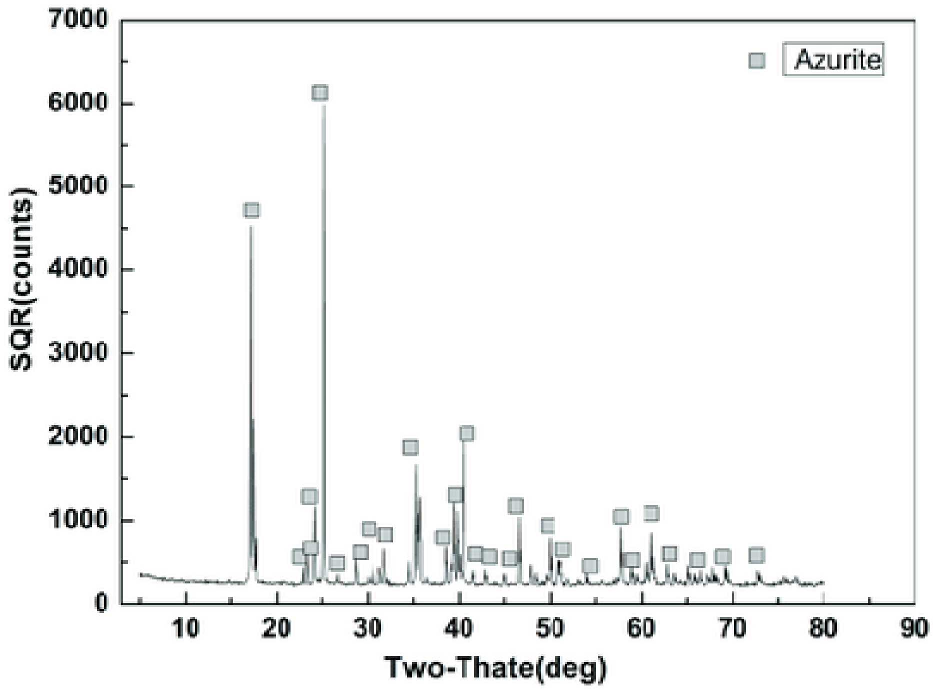


Figure 16: XRD diffraction pattern of azurite mineral

The experimentally determined XRD diffraction pattern of the sample is similar to the XRD diffraction pattern of AzuriteAll the samples collected from the jangkot Rolpa from XRD appears the dominance of azurite and contains other ores malachite ,chalcocite and cuprite. In addition to this, the experimentally determined XRD diffraction pattern presented in Figure 15 has been compared with the XRD diffraction pattern of Azurite for verification.

The obtained different peak at 2θ values and crystalline planes of Azurite present in the samples (C1RJ,C2RJ , C3RJ ,C3RJ,C4RJ and C5RJ) are as:

Table 2: Peak at 2θ values with crystalline plane

2θ value	Crystalline plane
25.31	(102)
44.94	(123)
49.96	(-124)
50.94	(115)
51.09	(124)
55.01	(300)
61.45	(215)
67.25	(-117)
67.76	(322)
68.16	(304)

This Finding is matched with JCPDS file 11-0682

Chalcocite is also present in the obtained ore samples C4RJ and C5RJ. With their crystalline planes (110) and (114), the peaks at 2θ values are 31.62 and 45.44. This result is consistent with JCPDS file 29-0578. Additionally included in the C5RJ sample ore are malachite and cuprite.36.41, 42.29, 61.34 are the peaks at 2θ values, and their crystalline planes are (111), (200), and (220). This finding corresponds to JCPDS file number 05-0667. Malachite's crystalline planes are (200), (220), (040), (201), (021), (21-1), (330), and (221), and its peak at 2θ values are 18.88,24.09,29.90,31.23,31.63,32.16,36.48, and 39.32. This result corresponds to JCPDS file 41-1390.

CHAPTER 5

5. CONCLUSIONS AND RECOMMENDATION

5.1. Conclusion

The total copper content is measured by titration method and AAS method. The titration results revealed that C1RJ contains 2.20% copper, which is an extractable level. Similarly, other samples include low-grade copper from 0.01 to 0.30 %. To ensure the reliability of the titration method for a very dilute solution AAS method was also employed. From the AAS measurement method, the results obtained are comparable with the value obtained from titration. For instance, the amount of copper in C1RJ is 1.64% which is the highest value and there is the lowest value for C5RJ measured by the AAS method. The value obtained from the titration method is somehow different from the AAS method may be due to titration error.

However, it can be concluded that the obtained percentage value of copper by both methods in sample C1RJ ore is at an extractable level.

The result of the XRD diffraction pattern of copper ore confirms that the collected sample ore dominance Azurite also including some ores malachite, cuprite and chalcocite.

5.2. Recommendations

When analyzing copper ore, the volumetric measurement method and AAS method were employed for quantitative determination. Based on the findings and conclusion presented, the following recommendations are suggested.

a. Preliminary test of ores by X-ray Fluorescence (XRF) to find the amount of copper in the ore samples.
b. For more reliability and low percentage ores determination, Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), is better to use.

CHAPTER 6

6. SUMMARY

This study presents a detailed chemical analysis of a Copper ore sample to determine its elemental composition, impurities, and potential environmental impact. The chemical analysis was conducted using various chemical and instrumental methods.

The collected samples of copper ores were analyzed in the lab by a titrimetric method using a standard protocol. The amount of copper in the selected ore is variable. The ore is analyzed by titration method which results in sample C1RJ having a high amount of copper i.e. 2.20% and other samples having a low amount. To test the reliability of the titration method, the amount of copper in the copper ores was evaluated using the AAS method.

The result of AAS showed that among the collected copper ore samples C1RJ has maximum copper content, which is 1.64%, and minimum for the C5RJ. The AAS method helps with the quantitative estimation of copper ore.

The qualitative estimation XRD diffraction pattern of copper ore is used. The result of the XRD diffraction pattern of copper ore confirms that the collected sample ore dominance Azurite also including some ores malachite, cuprite and chalcocite.

The amount of copper in each ore is different. It depends on the nature and composition of the ore as well as impurities. The detailed chemical analysis of the copper ore sample provides valuable data for decision-making in the mining industry. The result can guide the selection of appropriate extraction and purification methods based on ores composition and impurity level.

REFERENCE

Arendsen, L. P., Thakar, R., & Sultan, A. H. (2019).The use of copper as an antimicrobial agent in health care, including obstetrics and gynecology.*Clinical Microbiology Reviews*, *32*(4), e00125-18

Balasubramaniam, R., Mungole, M. N., Prabhakar, V. N., Sharma, D. V, & Banerjee, D. (2002). Studies on ancient Indian OCP period copper. *Indian Journal of History of Science*, *37*(1),

Biurrun, Amaya; Caballero, Luis; Pelaz, Carmen; León, Elena; Gago, Alberto (1999). "Treatment of a Legionella pneumophila-Colonized Water Distribution System Using Copper-Silver Ionization and Continuous Chlorination" (PDF). *Infection Control and Hospital Epidemiology*. 20 (6): 426-428.
doi:10.1086/501645. JSTOR 30141645. PMID 10395146. S2CID 32388649.

DMG, Annual report. 2019.

Elguindi, J. (2011). Advantages and challenges of increased antimicrobial copper use and copper mining. *Applied Microbiology and Biotechnology*, *91*(2011), 237–
249. https://sci-hub.se/10.1007/s00253-011-3383-3

Emsley, John (2003). Nature's building blocks: an A–Z guide to the elements. Oxford University Press. pp. 121–125. ISBN 978-0-19-850340-8. Retrieved 2 May 2011.

Energy-efficiency policy opportunities for electric motor-driven systems, International Energy Agency, (2011) Working Paper on the Energy Efficiency
Series, by Paul Waide and Conrad U. Brunner, OECD/IEA 2011

Ghaedi, M., Asadpour, E., & Vafaie, A. (2006). Simultaneous Preconcentration and Determination of Copper, Nickel, Cobalt, Lead, and Iron Content Using a Surfactant-Coated Alumina. *Http://Dx.Doi.Org/10.1246/Bcsj.79.432*,*79*(3), 432–436. https://doi.org/10.1246/BCSJ.79.432 1–16.

Guilbert, J. M., & Park Jr, C. F. (2007). The geology of ore deposits. Waveland Press.

Habashi, F. (2005). *A short history of hydrometallurgy.Hydrometallurgy*, *79*(1–2), 15–22.

Haj-Hussein, A. T. (1996). Ultraviolet spectrophotometric determination of copper in copper ores by flow-injection analysis. *Talanta*, *43*(11), 1909–1914. https://doi.org/10.1016/0039-9140(96)01968-6

Hu, C. Y., Kou, S. W., &Guo, J. J. (2014).The application research of ship metal corrosion in marine environment.936, 1091–1096.

IE3 energy-saving motors, Engineer Live, http://www.engineerlive.com/Design-Engineer/Motors_and_Drives/IE3_energy-saving_motors/22687/

Jeffery, G. H., Bassett, J., Mendham, J., & Denney, R. C. (1942). Textbook of Quantitative Chemical Analysis Vogels's. *Longman Scientific & Technical*, *25*(4), 523–531.

Joseph, Günter, 1999, Copper: Its Trade, Manufacture, Use, and Environmental Status, edited by Kundig, Konrad J.A., ASM International, pp. 141–192 and pp. 331–375.

K Rifai, L Özcan, F Doucet, F. V. (2020). *Sci-Hub* | Quantification of copper, nickel, and other elements in copper-nickel ore samples using laser-induced breakdown spectroscopy. Spectrochimica Acta Part B: Atomic Spectroscopy,
105766 | 10.1016/j.sab.2020.105766. Spectrochimica Acta Part B: Atomic Spectroscopy. https://sci-hub.se/10.1016/j.sab.2020.105766

Kaphle, K. P. (2020). Mineral Resources of Nepal and their present status. Kathmandu, Nepal: Published by Nepal Geological Society, 1–15.

Li, X., Wang, Y., Yin, C., & Yin, Z. (2020). Copper nanowires in recent electronic applications: progress and perspectives. *Journal of Materials Chemistry C*, *8*(3), 849–872. https://doi.org/10.1039/C9TC04744A

Lung, T. (1986). *Sci-Hub* | *The history of copper cementation on iron — The world's first hydrometallurgical process from medieval China. Hydrometallurgy, 17(*1*),* 113–129 | 10.1016/0304-386x(86)90025-3. Hydrometallurgy. https://sci-hub.se/10.1016/0304-386x(86)90025-3

Montero, David A.; Arellano, Carolina; Pardo, Mirka; Vera, Rosa; Gálvez, Ricardo; Cifuentes, Marcela; Berasain, María A.; Gómez, Marisol; Ramírez, Claudio; Vidal, Roberto M. (5 January 2019). "Antimicrobial properties of a novel copper-based composite coating with potential for use in healthcare facilities". *Antimicrobial Resistance and Infection Control.* *8* (1):3. doi:10.1186/s13756-018-0456-4. ISSN 20472994 PMC 6321648. PMID 30627427).

O'Gorman, J., & Humphreys, H. (2012). Application of copper to prevent and control infection. Where are we now? *Journal of Hospital Infection*, *81*(4), 217–223. https://doi.org/10.1016/J.JHIN.2012.05.009

Qureslu, H, Clwema, M. N., Qureshi, / H, & Cheema, M. N. (1974). Determination of Copper in Saindak Valley, Baluchistan, Copper Find PINSTECH CHEM-2 Determination of Copper in Saindak Valley, Baluchistan, Copper Find.

Richardson, H. W. (1997). Handbook of copper compounds and applications. CRC Press

Su, K., Ma, X., Parianos, J., & Zhao, B. (2020). Thermodynamic and experimental study on efficient extraction of valuable metals from polymetallic nodules. *Minerals*, *10*(4), 360.

Sverdrup, H. U., Olafsdottir, A. H., & Ragnarsdottir, K. V. (2021). Development of a Biophysical Economics Module for the Global Integrated Assessment Model WORLD7. 247–283. https://doi.org/10.1007/978-3-030-67190-7_10

Wang, P., Yuan, Y., Xu, K., Zhong, H., Yang, Y., Jin, S., Yang, K., & Qi, X. (2021). Biological applications of copper-containing materials.Bioactive Materials, *6*(4), 916–927

Wen, S., Liu, J., & Deng, J. (2021). *Sci-Hub* | Component release of fluid inclusions in sulfide mineral. Fluid Inclusion Effect in Flotation of Sulfide Minerals, 97– 150 | 10.1016/B978-0-12-819845-2.00005-3. Component Release of Fluid Inclusions in Sulfide Mineral. Fluid Inclusion Effect in Flotation of Sulfide Minerals. https://scihub.se/https://www.sciencedirect.com/science/article/abs/pii/B97801281984 52000053

Radetzki, M. (2009). Seven thousand years in the service of humanity—the history of copper, the red metal. *Resources Policy*, *34*(4), 176-184

APPENDIX

Appendix 1: Pictures captured during sample digestion

Appendix 2: Picture captured during titration

Expenditure details

S. N.	Expenditure Title	Total cost (NRs)
1	Mentor	5,000
2.	Sample collection	22,460
3.	Chemicals and Reagents	10,000
4.	AAS Characterization	7,990
5.	Instruments	17,000
6.	Stationery, Printing, Binding	6,500
7.	Transportation	5,500
8.	Miscellaneous	550
	Total	**75,000**

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