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SCIENTIFIC INVESTIGATION OF GOLD CONTENT IN SOIL SAMPLES FROM LOCAL GOLD MINE IN TARLAY TOWNSHIP, EASTERN SHAN STATE

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Abstract

Myanmar has large mineral resources of gold, silver, copper, lead and nickel. Gold deposits are abundant throughout Myanmar from Kachin state, Shan state, central Myanmar, Mon state and Tanintharyi region in the south. Locally owned gold mines have delivered some benefits to surrounding communities. The aim of this paper is to investigate on mineralogical characteristics of gold from local mine with scientifically. The gold soil samples were collected from five different sites around gold mine from Mong Lin, Tarlay Township, East Shan State, in Myanmar. Soil samples from the lower position near to the surface about 300 ft which contains the greatest amount of inorganic matter were focused. The natural moisture content is essential in all studies of soil mechanics and pH of a soil influences nutrient availability, toxicity, microbial populations, and activity of certain pesticides. In this study, physicochemical properties of all samples such as moisture percent and pH were investigated. Elemental analysis of minerals in soil samples were carried out by EDXRF. According to observation, iron and silicon contents were higher than other minerals in all samples. Minor microelements of soil samples such as Al, K, Sb, As, Mn, Cu, Ca, Zr, Zn, Se S, Ti, Pb, Bi were also determined. Qualitative identification of gold in soil samples were conducted by Colorimetric method**.** Gold contents in soil samples in different sites of gold mine were determined by AAS.

Keywords: mineralogical characteristics, gold mine, elemental analysis

Introduction

Myanmar has large mineral resources of gold, silver, copper, tin, tungsten, lead, zinc and nickel. Precious stones such as jade, ruby and sapphire are some of the country's largest export items. Gold mines can be found across the country. The gold mining industry has evolved and diversified in the post-war. The government of Myanmar once owned all of the country's gold mines, after 2011, many of them were sold off to private

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owners. Establishment of more and more gold mines provides opportunity of improved infrastructure, tax revenues and skilled jobs in the mining area. The aim of this paper is to study scientifically on mineralogical characteristics of gold from local gold mine.

Soil

Soil is a natural body consisting of layers (soil horizons) of mineral constituents of variable thicknesses (Birkel and Peter, 1999). Soil is formed slowly as rock (the parent material) erodes into tiny pieces near the earth's surface. Organic matter decays and mixes with inorganic material (rock particles, minerals and water) to form soil.

Composition of Soil

A layer of natural materials on the earth's surface contains both organic and inorganic materials and capable of supporting plant life. The material covers the earth's surface in a thin layer.

It may be covered by water, or it may be exposed to the atmosphere. Soil contains four main components; inorganic material, organic matter, water, and air. Ideal soil should contain about 50 % solid material and 50 % pore space. The percentages of the four main soil components varies depending on the kind of vegetation, amount of mechanical compaction, and the amount of soil water present. The soil composition is shown in Figure 1 (Van *et al*., 2006).

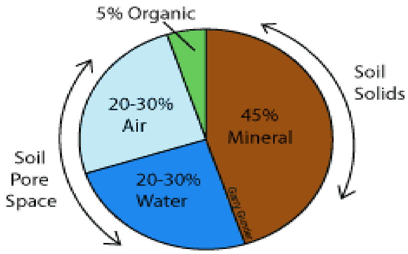

Figure 1: Soil Composition by Volume

Soil pH

Soil pH is an important consideration for farmers and gardeners. Many plants and soil life forms have a preference for either alkaline or acidic conditions, affecting the choice of crop or plant that can be grown without intervention to adjust the pH. Diseases affecting plants also tend to thrive in soil with a particular pH range. The pH can affect the availability of nutrients in the soil. Native soil pH is dependent upon soil minerals and amount of rainfall. The pH values of low rainfall areas soils are commonly in the neutral to alkaline range. Some soils have a pH of 7.8 to 8.3. Soils in the moderate to high rainfall areas tend to be acidic. In general, the availability of micronutrients is lower in alkaline soils. Additionally, soil pH affects the abundance of microorganisms. Bacteria are generally more prevalent in alkaline soils and fungi dominate in acidic soils.

Mineral Nutrients

The mineral nutrients are divided into two groups: macronutrients and micronutrients. Macronutrients can be broken into two more groups: primary and secondary nutrients. The primary nutrients are nitrogen (N), phosphorus (P), and potassium (K). These major nutrients usually are lacking from the soil first because plants use large amounts for their growth and survival. The secondary nutrients are calcium (Ca), magnesium (Mg), and sulfur (S). There are usually enough of these nutrients in the soil, so fertilization is not always needed. Micronutrients are those elements essential for plant growth which are needed in only very small (micro) quantities. The micronutrients are boron (B), copper (Cu), iron (Fe), chloride (Cl), manganese (Mn), molybdenum (Mo) and zinc (Zn).

Gold

Gold was discovered as shining yellow nuggets and is undoubtedly the first metal known to early civilizations. Gold is a chemical element with symbol Au (from Latin: *aurum*) and atomic number 79, making it one of the higher atomic number elements that occur naturally. In its purest form, it is a bright, slightly reddish yellow, dense, soft, malleable, and ductile metal. Chemically, gold is a transition metal and a group 11(IIIB) element. It is one of the least reactive chemical elements and is solid under standard conditions. Gold often occurs in free elemental (native) form, as nuggets or grains, in rocks, in veins, and in alluvial deposits. Gold ores are commonly classified by the metallurgist into two major categories: free milling and refractory ores. Based on the mineralogical characteristics and mineral processing techniques required, gold ores can be classified into 11 types as shown in Table1 (Zhou *et al*., 2004).

Table 1: Type of Gold Ore

No.	Ore type	Mode of occurrence of gold
1	Placers	Gold is easily liberated or has been liberated prior to processing, and normally ranges from 50-100 μm in size
2	Quartz vein-lode ores	Gold occurs mainly as native gold in quartz- veins, lodes or stockworks, some tellurides and occasionally aurostibite and maldonite. Commonly occurs as liberated gold particles but some disseminated gold may be present.
3	Oxidized ores	Gold usually occurs as either liberated or in the alteration products of sulfide minerals, and the degree of gold liberation is generally increased by oxidation
4	Silver-rich ores	Gold commonly occurs as electrum, although kustelite may be present in some ores. Native silver may be present.
5	Copper sulfide ores	Gold occurs as coarse liberated particles and fine particles locked in pyrite and copper sulfides.
6	Iron sulfide ores	Gold occurs as liberated particles, attachments to and inclusions in sulfide (commonly in pyrite, and less commonly in marcasite and pyrrhotite) and as submicroscopic gold in sulfide minerals.
7	Arsenic sulfide ores	Gold occurs as liberated particles and inclusions, and submicroscopic gold in arsenopyrite and oxidized products.
8	Antimony sulfide ores	Gold occurs mainly as native gold, with minor to moderate amount of aurostibite, either liberated or locked in sulfides
9	Bismuth sulfide ores	Gold occurs mainly as native gold, with minor to moderate amounts of maldonite. Submicroscopic gold can also be present in sulfides
10	Telluride ores	Gold occurs as native gold and gold tellurides, either liberated or locked in sulfides. Submicroscopic gold may be present
11	Carbonaceous – sulfidic ores	Gold occurs mainly as fine-grained gold particles and submicroscopic gold in sulfides, and surface gold absorbed onto the surface of carbonaceous matter and FeOx

Materials and Methods

Collection and Preparation of Soil Samples

The soil samples were randomly collected from five different sites around gold mine from Mong Lin, Tarlay Township, Eastern Shan State, in Myanmar on June, 2016. In this research work, soil from the lower position near to the surface about 300 ft, which contains the greatest amount of inorganic matter were investigated. The samples were broken up into small lumps and then air dried by spreading them on stout sheets of brown paper. After two weeks dried soils samples were ground and sifted. Gravel roots were discarded and the remaining part was taken for testing.

Determination of Physicochemical Properties of soil samples

Physicochemical properties of samples such as moisture percent and pH were determined by AOAC methods.

Elemental Analysis of Minerals in Different Soil Samples by EDXRF

Relative compositions of some elements in soil samples were measured by EDXRF method using EDX-700 instrument at Metallurgical' Research Centre ELA. The samples were weighed and then pre-ash operations were carried out on the sand-bath until all the combustible materials were burnt. The pre-ash samples were then placed inside the electric muffle furnace and heated gradually raising the temperature until 450 °C. The process of heating, cooling and weighing were repeated until constant weight of the ash samples were obtained. About 2.5 g of ash sample was fabricated into pellet for EDXRF.

Qualitative Identification of Gold in Soil Samples by Colorimetric Method

1 g of air-dried soil was placed in test tube and 2.5 mL of concentrated hydrochloric acid, 2.5 mL of distilled water and 30 % hydrogen peroxide were added. The mixture was stirred and heated in a water bath until bubbles were evolved. The heated sample was cooled in water. The 2 mL of 0.1 M EDTA solution as added into cooled solution and then it was vigorously shaken for about 5 minutes by hand. The resultant solution was washed with distilled water and separated by sponges. After that 2 mL 20 % of urea solution was sprayed by using syringe and then removed this added solution by syringe and

thoroughly removed by tissue. 2 mL of 0.5 M sodium ethanoate solution was sprayed on sponge by using syringe and then removed this added solution by syringe and thoroughly removed by tissue. Finally, 2 mL of 0.1M thiomichler' ketone was sprayed on sponge by using syringe.

Determination of Gold Contents in Gold Soil Samples by AAS

About 1 g of ash sample was accurately weighed and dissolved in 2 mL of concentrate hydrochloric acid. The resulting solution of ash sample was evaporated to dryness and dissolved in 6 mL of 25 % HCl solution (volume by volume) followed by centrifugation. The centrifuged solution was decanted and the clear solution was made up to 100 mL with deionized water. The resultant solution (10 mL) was pipetted accurately and made up to 100 mL with deionized water again. The sample solution prepared was now ready for analysis of mineral elements by AAS. Gold content of soil samples were measured at Metallurgical' Research Centre ELA.

Results and Discussion

Sample Collection

The gold soil samples were randomly collected from five different sites around gold mine from Mong Lin, Tarlay Township, Eastern Shan State, in Myanmar on June, 2016. Satellite images of study area showing the soil sampling sites of Mong Lin village in Tarlay Township was shown in Figures 2.

(a) (b)

Figure 2: Satellite images of study area showing the soil sampling sites of Mong Lin village in Tarlay Township

Physicochemical Properties of Soil Samples

In almost all soil tests, natural moisture content of the soil is to be determined. The knowledge of the natural moisture content is essential in all studies of soil mechanics. An adequate and balanced supply of moisture is essential for plant growth. Moisture is constantly being taken off by plants together with nutrients and is lost by transpiration (Rhoades and Loveday, 1990). The results are shown in Table 2 and Figure 3. Among the soil samples; sample 4 is higher in moisture percent than other samples. The natural moisture content will give an idea of the state of soil in the field. In addition, the amount of moisture in soil is related to the amount of rainfall, evapotranspiration. Therefore, the field of sample 4 area was high in moisture percent due to high amount of rainfall.

The pH of a soil influences nutrient availability, toxicity, microbial populations, and activity of certain pesticides. Soils with a pH less than 7 referred to as acidic and pH levels greater than 7 are considered basic or alkaline. Observed pH of the soil samples are shown in Table 3 and Figure 4.

The pH was found in the range from 6.5 to 7.1. This showed that most of the soil samples were slightly acidic condition. Soil acidification may also occur by addition of hydrogen, due to decomposition of organic matter, acid-forming fertilizers, exchange of basic cations with H^+ by the roots. Moreover, **a**cid soils are most often found in areas of high rainfall.

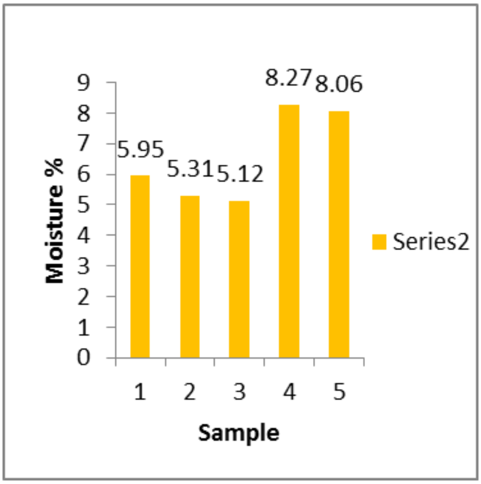

Figure 3: Moisture percent of soil samples

Table 2: Moisture Percent of Soil Samples

Soil Samples	Moisture (%)
1	5.95
2	5.31
3	5.12
4	8.27
5	8.06

Table 3: pH of Soil Samples

Sample	pH
1	6.5
2	6.8
3	6.5
4	7.1
5	6.7

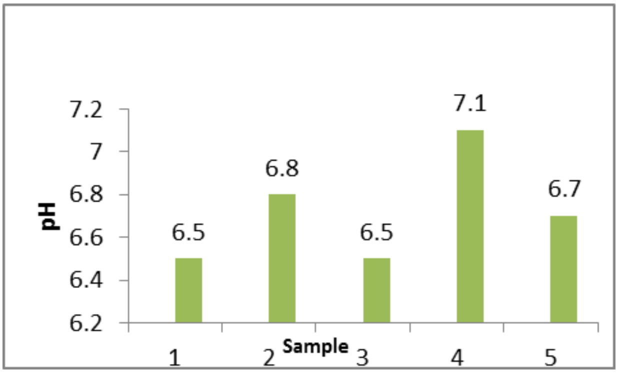

Figure 4: pH of soil samples

Elements Present in the Different Soil Samples by EDXRF

Relative abundance of element in different soil samples was determined by EDXRF. The results are shown in Figures 5(a) to 5 (e) and data are illustrated in Tables 4 (a) to 4(e).

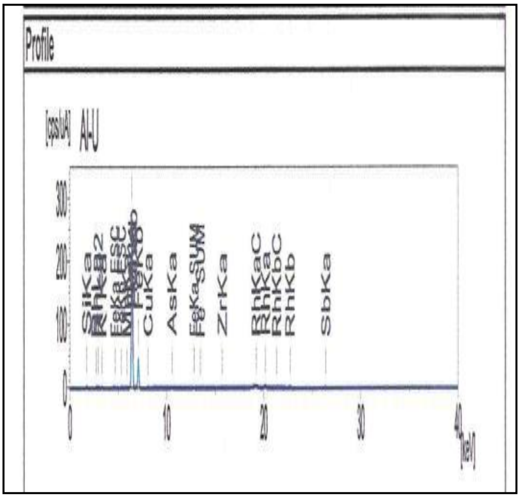

Figure 5:(a) EDXRF spectrum of the soil sample 1

Table 4: (a) Relative Abundance of Elements of Soil Sample 1

Elements	Relative abundance (%)
Fe	47.748
Si	47.116
Al	3.416
K	0.872
Sb	0.278
As	0.176
Mn	0.164
Cu	0.142
Ca	0.036
Zr	0.032
Zn	0.012
Se	0.012

Table 4: (b) Relative Abundance of Elements of Soil Sample 2

Elements	Relative abundance (%)
Si	66.528
Fe	31.698
S	0.543
K	0.416
Ca	0.256
Ti	0.243
Cu	0.138
As	0.092
Mn	0.081
Se	0.004

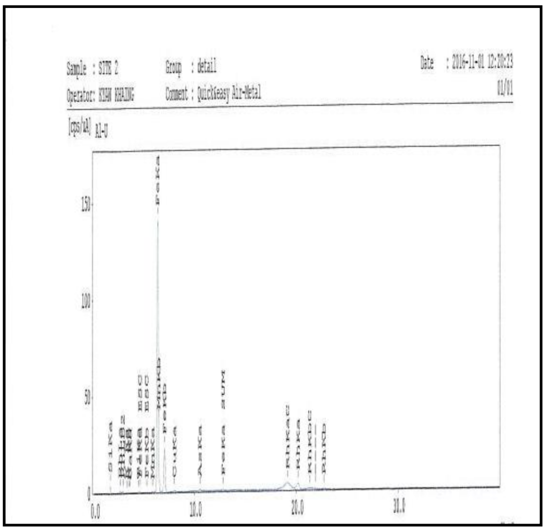

Figure 5: (b) EDXRF spectrum of the soil sample 2

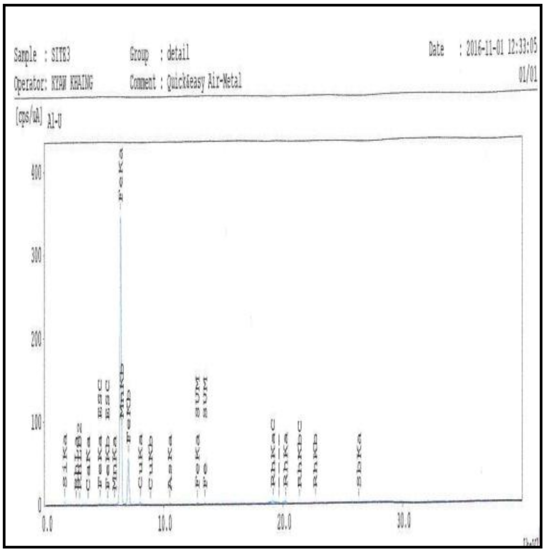

Figure 5: (c) EDXRF spectrum of the soil sample 34

Table 4: (c) Relative Abundance of Elements of Soil

Elements	Relative abundance (%)
Fe	51.576
Si	47.104
Cu	0.472
Sb	0.371
Ca	0.151
K	0.150
As	0.077
Mn	0.063
Se	0.027
Zn	0.009

Table 4: (d) Relative Abundance of Elements of Soil Sample 4

Elements	Relative abundance (%)
Si	70.516
Fe	26.262
Al	1.195
Ti	0.620
K	0.435
As	0.364
Ba	0.225
Ca	0.186
Cu	0.117
Mn	0.048
Pb	0.014
Bi	0.011
Se	0.008

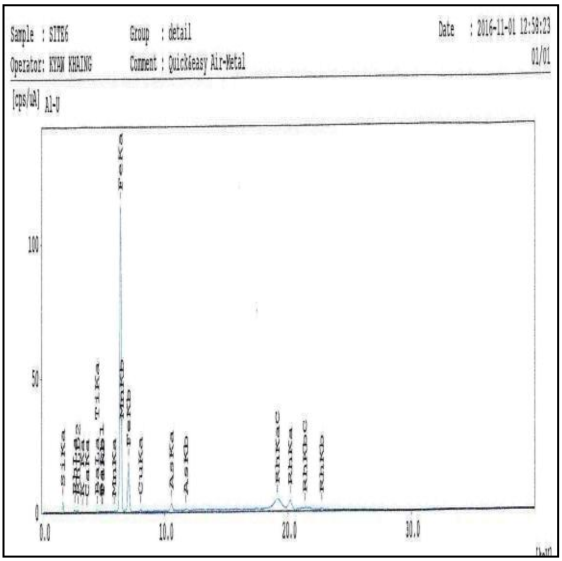

Figure 5: (d) EDXRF spectrum of soil the sample 4

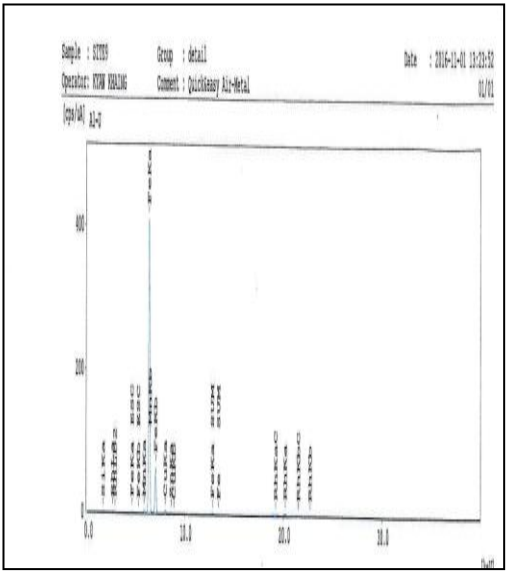

Figure 5: (e) EDXRF spectrum of the soil sample 5

Table 4: (e) Relative Abundance of Elements of Soil Sample 5

Elements	Relative abundance (%)
Fe	72.563
Si	23.890
Cu	1.440
Mn	0.932
S	0.649
Zn	0.319
Ca	0.117

According to EDXRF elemental analysis, iron content (47.748 %) and silicon content (47.116 %) were nearly same in sample 1. Iron content was found to be highest content in sample 5 (72.563 %). In sample 2 and 4, silicon content were 66.528 % and 70.516 % in the highest value. The microelements such as Al, K, Sb, As, Mn, Cu, Ca, Zr,Zn , Se in sample 1, S, K, Ca, Ti, Cu, As, Mn, Se in sample 2, Cu, Sb, Ca, K, As, Mn ,Se, Zn in sample 3, Al, Ti, K, As, Ba, Ca, Cu, Mn, Pb, Bi, Se in sample 4 and Cu, Mn, S, Zn, Ca in sample 5 were also observed. The comparison between iron and silicon contents of all soil samples is shown in Figure 6.

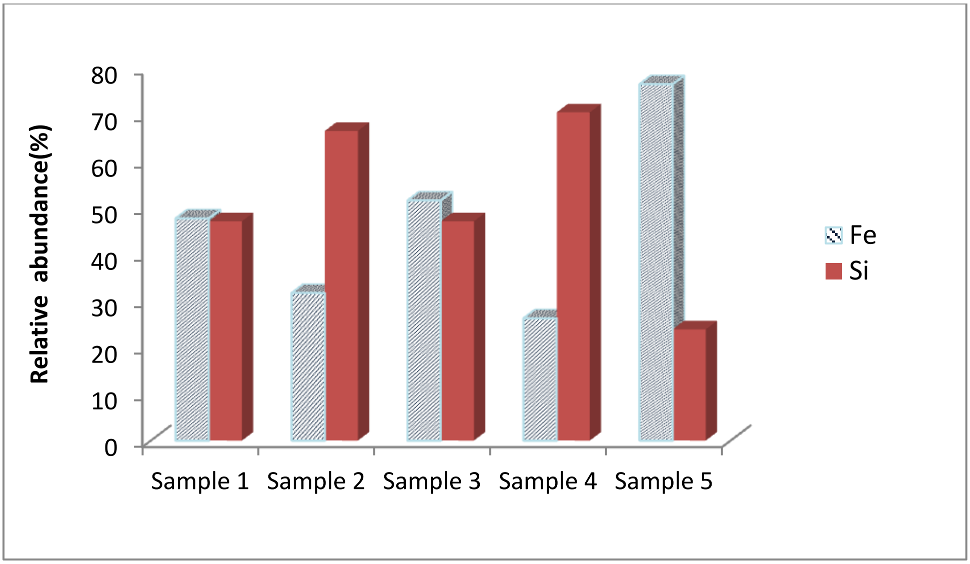

Figure 6: Comparison between iron and silicon content in samples

Qualitative Analysis of Gold by Colorimetric Method

Qualitative analysis of gold was performed by colorimetric method. Pink colour of sponges show that gold metal contained in soil samples while yellow colour indicated the absence of gold metal or very little gold content in the sample. The photograph of qualitative analysis of gold in soil samples are shown in Figure 7. It was found that samples 1,2,3,4 indicated pink colour but sample 5 was yellow colour. From this observation, all soil samples contained gold except sample 5 in which gold may be contained very little amount.

Pink Pink Pink Pink Yellow

Sample 1 Sample 2 Sample 3 Sample 4 Sample 5

Figure 7: Qualitative identification of gold content

Gold Contents in Gold Soil Samples by AAS

With a view to determine the gold content in soil samples was performed by AAS. The gold contents are shown in Table 5 and Figure 8. In this research, gold contents could be detected in all samples (range of 0.12 to 1.89 ppm). Among the samples, sample 4 was found to have highest content (ppm). However, sample 5 was found to have very low content of gold.

Table 5: Gold Contents of Gold Soil Samples by AAS

Sample	Gold Contents(ppm)
1	1.24
2	1.24
3	1.62
4	1.89
5	0.12

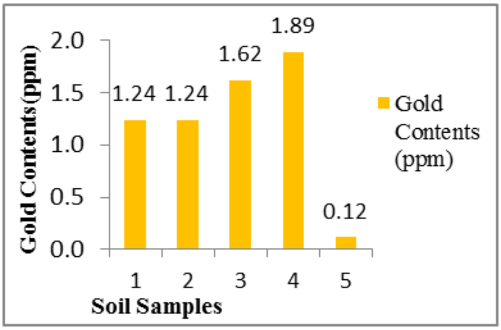

Figure 8: Gold content of gold soil

Conclusion

In this research work, gold soil samples of five different sites around gold mine from Mong Lin, Tarlay Township, Eastern Shan State, in Myanmar were investigated for physicochemical properties such as moisture content and pH. The minerals content of different soil samples were determined by EDXRF analysis. Qualitative identification of gold in soil samples was carried out by colorimetric method. In addition, gold contents of different soil samples were determined by AAS.

According to physicochemical properties investigation, the moisture percent of soil samples were found to be in the range of 5.12-8.27 %. The highest moisture percent 8.27 % in sample 4, due to highest rainfall among the different samples. pH of the soil samples was normally range from 6.5 to 7.1. The data showed that most of the soil samples were slightly acidic condition and neutral.

By using EDXRF, iron content (47.748 %) and silicon content (47.116 %) were nearly same in sample 1. Iron content was found to be highest in sample 3 (51.576 %) and sample 5 (72.563 %). However, silicon content of sample 2 and 4 were (66.528 %) and (70.516 %) with the highest value. The trace values of some metals (Ba, Al, As, Ti, Mn, Zr, Zn, K,Cr, Cu Sr, Sb, Se and Ni) of different soil samples were also investigated.

Qualitative analysis of gold were performed by colorimetric method. From the observation, four soil samples (Samples 1, 2, 3, 4) contained gold but sample 5 may contain very little gold content. The determination of gold by AAS method suggested that gold contents in samples 1, 2,3, 4, and 5 were 1.24 ppm, 1.24 ppm, 1.62 ppm, 1.89 ppm, and 0.12 ppm respectively.

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