

Heavy Metal Contamination of Soil by Quarry Dust at Asonomaso in the Ashanti Region of Ghana

B. M. Tiimub* P. A. Sarkodie I. Monney O. Maxwell

Faculty of Science and Environment Education, Departments of Science, Environmental Health and Sanitation Education, University of Education, Winneba, College of Agriculture Education, P.O. Box 40 Asante Mampong, Ghana, West Africa

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Abstract

Environmental pollution caused by quarry dust and heavy metals is a problem for many years in Asonomaso. The main aim of this paper was to determine the amount and types of heavy metal pollutants associated with the quarrying and also identify the probable adverse effects they have on human health and the environment. About 30 quarry dust samples were collected from two sampling sites between August and November, 2011 for analysis using AAS. Evaluation using SPSS 17.0 statistical programme revealed appreciable amounts of As, Hg, Mn, Cu Zn and Pb and Fe which differ from one site to another. AAS analysis revealed relatively higher concentrations of As, Ag, Cu and Zn in both primary and secondary quarry dust than dust away from the site. However, concentrations of Mn, Fe and Pb were higher in secondary quarry dust and dust away from the primary site. Heavy metal pollution of the Asonomaso environ attributable to the quarry is thus significant and its repercussions on the health of the residents must be seriously looked at.

Keywords: Quarry Dust, Heavy-metal, Impact, Asonomaso.

1.0 Introduction

Quarrying is necessary to provide much of the materials used in traditional hard flooring, such as granite, limestone, marble, sandstone, slate and even just clay to make ceramic tiles (Reddy and Reddy, 2007). However, like many other man-made activities, quarrying causes a significant impact on the environment (Raman *et al.*, 2005). In particular, it is often necessary to blast rocks with explosives in order to extract materials for processing but this method of extraction gives rise to some impacts including noise pollution, air pollution, and damage to biodiversity and habitat destruction. (<http://reference.Allrefer.com/encyclopedia/Q/quarryin.html>).

Crushed rock aggregate quarrying generates considerable volumes of quarry dust which significantly leads to production of considerable amounts of wastes harboring a number of heavy metals (Hameed and Sakar, 2009). There are 35 metals that concern us because of occupational or residential exposure; 23 of these are the heavy elements or "heavy metals": antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc (Glanze, 1996). Interestingly, small amounts of these elements are common in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chronic toxicity (poisoning).

1.1 Heavy metal occurrences in earth minerals, rocks and soils

1.1.1 Arsenic

Arsenic is a naturally occurring element in the earth's crust. Arsenic is found in the deep bedrock materials as well as the shallow glacial materials in the study areas. They are also found alongside the gold ores such as arsenopyrites (FeAsS) (Coakley *et al.*, 2001). Arsenic is usually present in the environment in inorganic form. The inorganic arsenic easily dissolves and enters underground and surface waters. The presence of arsenic in the environment may be attributed to one of the following sources: residual arsenic from former pesticide use, smelter emission from fines of quarry such as arsenopyrites. Acute gastrointestinal symptoms, central and peripheral neuropathy, bone marrow suppression, hepatic toxicity and mild mucous membrane and cutaneous changes were observed. According to (IARC, 1980), inorganic form of arsenic leads to increased incidence of skin cancer which had been observed in populations consuming drinking water with high inorganic arsenic concentration.

1.1.2. Mercury

Elemental mercury is a silvery metallic liquid that is volatile at room temperature. Mercury is found in soil and rocks typically as an ore known as cinnabar, consisting of insoluble mercuric sulphide. In Ghana, the presence of mercury in the environment may be attributed to the use of mercury in gold recovery processes where the inorganic form of the metal either is washed into rivers or is vaporized readily into the atmosphere (Obiri *et al.*, 2006; Essumang *et al.*, 2007). The nature of mercury toxicity depends on its chemical form. For example, methylmercury (MeHg) is very toxic as compared to inorganic mercury. The methylmercury is of special

concern because of its enhanced lipophilicity, bioaccumulation and volatility as compared with the inorganic mercury. For this reason, it is able to cross biological membranes more easily and enters the brain, spinal cord, the peripheral nerves and the placenta. The foetus in the uterus may show symptoms of cerebral palsy through mercury intoxication, even though the mother may not show symptoms of mercury poisoning (Harte *et al.*, 2008; WHO, 1990).

1.1.3. Zinc

Zinc is an element of moderate abundance in the earth crust. It occurs in rocks as chalcophile and sphalarite, ZnS (referred to as zinc in Europe). The natural zinc content of soils is estimated to be 300mg/kg. The presence of zinc in the environment is associated with mining and smelting which pollutes the air, water and soil with fine particles, which ultimately undergo oxidation to release Zn^{2+} . Zinc is used in a wide variety of industrial, agricultural, and consumer products. It is found in all human tissues and all body fluids and is essential for growth, development and reproduction. Zinc is usually present in tap water at concentrations less than 0.2 mg/L, although drinking water in galvanized pipes can contain up to 2 to 5 mg/L. Typically, concentrations are much less than 5 mg/L, which is based on the threshold for metallic taste in water. However, low blood levels of zinc are also associated with hypogeusia, in which there is loss of sense of taste. Gastrointestinal distress is a common symptom following acute oral exposure to zinc compounds (USEPA 2009).

1.1.4. Iron

Iron in the study area is associated with the rock system. The rock systems contain high amount of iron and other toxic chemicals such as manganese. The high concentration of iron in the study area is from the weathering of the rock system. Other sources of iron in the study area is the occasional discharge of mining waste, acid mine drainage which may increase iron levels in the surface water. Iron is one of the major constituent in the lithosphere (i.e. soil or rock) soil as oxides or hydroxides. Manganese is also used in the alloying of iron to produce stainless steel and other products of iron (Essumang *et al.*, 2007).

1.1.5. Sources and toxicity of Manganese

Manganese is one of the most abundant metals in soils, where it occurs as oxides and hydroxides, and it cycles through its various oxidation states. Manganese occurs principally as pyrolusite (MnO_2), and to a lesser extent as rhodochrosite ($MnCO_3$). More than 25 million tonnes are mined every year, representing 5 million tons of the metal, and reserves are estimated to exceed 3 billion tonnes of the metal (USEPA, 2009). In Ghana, manganese in mining communities is due to leaching of manganese from waste rocks. The toxicity of iron is governed by absorption. That is, the more you take in the more you are at risk. The iron is absorbed in the ferrous state by cells of the intestinal mucous (Essumang *et al.*, 2007). There are many health problems associated with ingestion of high amounts of iron in drinking water, these include: anorexia, oliguria, diarrhoea, hypothermia, metabolic acidosis to some extent death. The toxicity of manganese is also governed by absorption. That is the more you take in the more you are at risk. Manganese is a neurotoxin. High levels of manganese are associated with the following symptoms; tremors, weakness in the legs, staggering gait, behavioral disorders, etc. Children exposed to high levels of manganese exhibit low Intelligent Quotients (IQs) (WHO, 1990).

1.1.6. Sources and toxicities of lead and copper

The presence of lead and copper in the study, area is due to weathering and leaching of these two metals from waste rocks dumps (Obiri *et al.*, 2006). Other sources of lead and copper are the weathering of the rocks, which contains high levels of lead and copper. Similarly, improper disposal of lead (IV) acid batteries and copper wire also accounts for high levels of lead and copper in the study area. Copper can be released into the environment by both natural sources such as wind-blown dust, decaying vegetation, forest fires and sea spray and human activities such as mining, metal production, wood production and phosphate fertilizer production. Because copper is released both naturally and through human activity, it is very widespread in the environment. Copper is often found near mines, industrial settings, landfills and waste disposals. Most copper compounds will settle and be bound to either water sediment or soil particles. Soluble copper compounds form the largest threat to human health.

Usually water-soluble copper compounds occur in the environment after release through application in agriculture. Lead is a neurotoxin metal. It affects the central nervous system. Children exposed to high levels of lead contaminated water have low IQs. Other symptoms associated with exposure to lead are behavioral disorders, tremors, etc. Copper can be found in many kinds of food, in drinking water and in air. Because of that, we absorb eminent quantities of copper each day by eating, drinking and breathing. The absorption of copper is necessary, because copper is a trace element that is essential for human health. Although humans can handle proportionally large concentrations of copper, too much copper can still cause eminent health problems (WHO, 1990).

Heavy metal toxicity can result in damaged or reduced mental and central nervous functions, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposures may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis. Allergies are not

uncommon and repeated long-term contact with some metals or their compounds may even cause cancer (CDC, 2007; Bollinger, 2010). For some heavy metals, toxic levels can be just above the background concentrations naturally found in nature. Therefore, it is important for us to inform ourselves about the heavy metals and to take protective measures against excessive exposure.

The association of symptoms indicative of acute traced metal toxicity is not difficult to recognize because the symptoms are usually severe, rapid in onset, and associated with a known exposure or ingestion (Duruibe *et al.*, 2007): Cramping, nausea, and vomiting; pain; sweating; headaches; difficulty in breathing; impaired cognitive, motor, and language skills; mania; and convulsions. Duruibe *et al.*, (2007), further identified that, the symptoms of toxicity resulting from chronic exposure (impaired cognitive, motor, and language skills; learning difficulties; nervousness and emotional instability; and insomnia, nausea, lethargy, and feeling ill) are also easily recognized; though, they are much more difficult to associate with their cause.

Symptoms of chronic exposure are very similar to symptoms of other health conditions and often develop slowly over months or even years. Sometimes the symptoms of chronic exposure actually abate from time to time, leading the person to postpone seeking treatment, thinking the symptoms are related to something else (Bollinger, 2010).

Biritwum in 2009, from University of Cape Coast observed that “minerals endowed in the soils of third world countries had become a curse rather than a blessing, as the processes used in their extraction left the land in very bad shapes and its inhabitants poor and diseased.” He said it was unfortunate that agencies that were tasked with the watch-dog role did not live up to the expectation of such mining communities and appealed to government to consider the cry of the people living in forest areas in the recent advocacy for forest mining.

Those metals are described as "heavy metals" which, in their standard state, have a specific gravity (density) of more than about 5 g/cm³. Under the new guidance quarry dust is a fraction passing 0.063 mm (63 microns) (BSI, 2003).

Well-known environmentalist Yellappa Reddy, on 24th June, in Mahusudhan, 2010 expressed that the quarry dust contains toxic particles such as silicon, fluoride, iron and other heavy metals. He pointed that if the fine dust got into the lung, it might cause diseases such as lung cancer, allergic bronchitis and other breathing problems. Additionally, the toxic dust could also reduce oxygen content in the blood and could impact negatively on children's health."If the quarry dust gets into the atmosphere due to wind, it could negatively impact on water precipitation and cloud formation, causing less rainfall. As the quarry dust does not easily disintegrate, it blocks the pores in the earth reducing the water seepage. Therefore, it also has an impact on the groundwater. The fluoride in the quarry dust also pollutes the water bodies," Reddy added.

1.2 Problem Statement

Environmental pollution caused by quarry dust and heavy metals is a problem for many years in Asonomaso. Interactive diagnostic survey analysis of disease prevalence patterns in Asonomaso with some residents who were interviewed at random estimated that cancer, acute respiratory infections, mental retardation, skin diseases, acute eye infections, among others, constituted the top six causes of OPD attendance in the Asonomaso area as at the time this study was conducted. In addition, toxicity symptoms of plants have also been observed by experienced farmers in the area who further predicted that serious deleterious effects of quarry dust on animals, humans, and general impact on the environment may even worsen the plight of the inhabitants in the near future. It is against this background that this study was carried out to determine whether the amounts of the heavy metals identified from the soil samples are potentially hazardous to human health and the environment.

1.3 Objectives

The main objective of the project was to determine the levels of heavy metals in quarry dust and assess its impact on the environment.

1.3.1 Specific Objectives

Specifically, the project sought to;

1. Determine the levels of seven heavy metals in primary and secondary quarry dust at A. Kannin Quarry Products and Concrete Limited at Asonomaso.
2. Determine the levels of heavy metals in soil sample away from the quarry site.
3. Identify the possible impacts of the seven heavy metals on the environment and inhabitants of Asonomaso.

1.4 Hypothesis

It was hypothesized that soil samples in the surroundings of quarry site contain high levels of heavy metals than those away from quarry site.

1.5 Significance of the Study

The rate at which quarry operations are polluting the environment in Ghana is a source of serious concern and worry. Surprisingly however, most of food crops such as cassava, plantain, and cocoyam serve as a major foodstuff while water bodies such as lake, streams, rivers, springs etc. serve as major source of drinking water and for other domestic activities. In view of this, the results of this project would serve to: provide evidence as to whether quarry operations have negative effect on the environment and inhabitants in the study area.

Air borne diseases are linked with inhaling polluted air. Residents of the quarry sites claim that in some cases they do not know the source of certain diseases and infections that invade them. The leaching and seepage of heavy metals, spillage of cyanide solutions and other toxic chemicals from quarry dust, is suspected to have contaminated most food crops and water bodies in such areas.

In view of this, a study of this nature is important to determine the extent of pollution by heavy metals in quarry dust in the study area and compare it with the WHO and GEPA permissible guidelines and standards in order to ascertain whether indeed the communities perception of pollution of their environment is justifiable.

2.1 Methodology

2.2 Profile of the Study Area

Northern Mines & Quarries Limited is located on the Kona, Kumasi-Mampong Road (500m North of Asonomaso Nkwanta Junction) is a Granite Stone Quarry which deals in production of Quality Grade Chippings, Aggregates, Boulders, Quarry Dust and other Quarry Products. Its main activity involves the crushing of granite rocks into aggregate quarry products for various construction purposes. The crushing of rocks again discharges airborne particles in the form of quarry dust which invariably pollute the environment.

Asonomaso which comprised the specific study area with a population of about 2,500 people is, located 200km away from Accra, and is in the Kwabre East District with a total population of 115,556 in Ashanti Region of Ghana in West Africa. The study area lies on latitude $0^{\circ}57'0''N$ and longitude $7^{\circ}2'0''W$ (Kwabre East District Profile 2010; Ghana Statistical Service, 2010). It can easily be located between Adanwomase and Safo. The main source of employment for the people of Asonomaso is farming with a few engaged in “Kente” weaving. The most efficient method of farming in Asonomaso is shifting cultivation which has led to the destruction of virgin forests. Asonomaso has primary and Junior High School but no Senior High School or tertiary institution. The inhabitants have electricity supply as their source of light and rivers and boreholes as their main source of water for domestic purposes. Fortunately, they have a modernized hospital, so their health history could be easily traced from that hospital

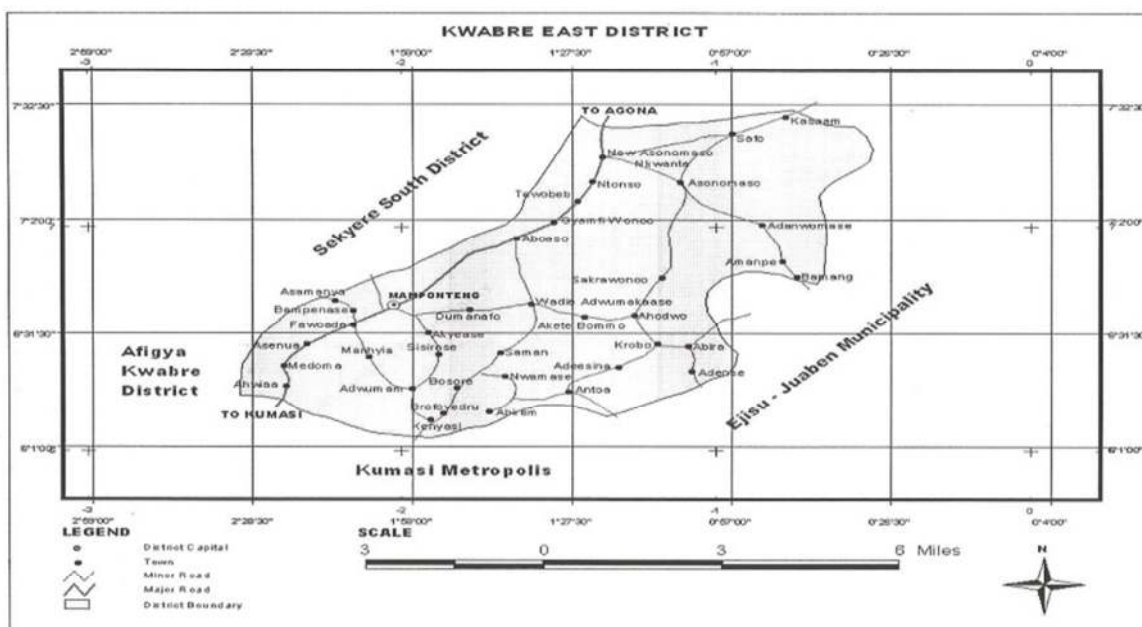


Figure 1 Map of Kwabre East District.

2.3 Vegetation

Asonomaso has a large heavily dense green forest. The outskirts of the forest is surrounded by shrubs and other green plants. There are a variety of timber species densely distributed in the forest. The commonest ones include *Milicia excelsa* and *Turaeanthus africanus*. The forest is characterized by tall trees that rise above the rest of the

canopies. Although the trees that form canopy are are closed together, they do not interlock (Kwabre East District Profile, 2010).

2.4 Sampling Procedure and Data Collection.

The whole Asonomaso catchment area has two sites that generate considerable amounts of primary and secondary quarry dust. Soil samples containing the primary and secondary quarry dust were taken separately for analysis of heavy metals. A third soil sample which served as control was collected from a site located about 1 km from the quarry plant. This site was infact, free from quarry dust deposits. Sampling took place between August and November 2011 and AAS analysis of As, Mn, Fe, Pb, Hg, Cu and Zn commenced immediately.

2.5 Digestion of the samples for analysis of Mn, Zn, Cu, Fe, Pb, As, and Hg.

The Diethylenetriaminepentaacetic acid (DTPA) extractant reagents included: - 0.005M DTPA, 0.01M CaCl₂, 0.1M Triethanolamine (TEA) (mass = 149.19g) at an adjusted pH of 7.30 with HCl (1N HCl = 85.90 ml / IL)

2.5.1 Preparation of Solution for digestion of Soil Samples

A known volume of DTPA (3.934g) was added to 2.94g CaCl₂. Then, 2H₂O + 29.34 ml TEA were dissolved in 2 litre of distilled water. The pH was adjusted to 7.3 ± 0.05 with 1.0M HCl while stirring to obtain the solution which is stable for several months.

2.5.2 Procedure for Digestion of Soil Samples

About 10g of air-dried soil was weighed into plastic bottles and 100 ml DTPA extractant was added. The solution was shaken for 2 hrs and filtered with Whitman 42 filter paper. The resulting exact amount (filtrate) was used to analyze the concentrations of As, Hg, Mn, Cu, Zn, Pb and Fe on an AAS (Atomic Absorption Spectrometer) using appropriate standards.

Calculation

Mn, Zn, Cu, Fe (mg/kg) = mg/L on AAS × 5 × df

Where df = dilution factor

Ranges

Zn: 0.18-3.91 mg/kg; Cu: 0.16-3.96 mg/kg; Fe: 1.83-30.6 mg/kg and Mn: 0.96-12.96 mg/kg

2.6 Arsenic Determination Procedure

About 25-50 ml of extracted solution was measured into a 100 ml volumetric flask and 1g ammonium chloride and 5 ml ammonium solution was added immediately. Again, 25 ml of 0.1 M magnesium sulphate was added and vigorously shaken and the solution was made up to the mark with distilled water. It was then allowed to stand for at least 5 minutes with repeated shaking. The solution was filtered when settled and the 1st 10-20 ml filtrate was discarded. About 50ml of the remaining filtrate was titrated after adding one drop of EBT indicator with 0.1 M Titriplex III solution until the colour changed to green.

Calculation

1 ml of 0.1M Titriplex III solution ≡ 1 ml of 0.1M Magnesium Sulphate = 7.491mg of As = C

$$\text{As (mg/L)} = \frac{C \times 50 \times 100}{1000000} = \frac{C \times 5}{1000} = \frac{C}{200}$$

2.7 Lead Determination Procedure

About 50 ml of solution containing about 50 mg of Pb was measured into a conical flask and 2.0g of Potassium Sodium tartrate was added. One drop of EBT indicator and 2 ml of ammonia solution were added. The solution was heated to about 40 °C and titrated quickly with 0.1 M Titriplex solution until colour changes from red to green (microburet).

Calculation

1 ml of 0.1M Titriplex = 20.721 mg of Pb.

2.8 Mercury (Hg) Determination Procedure

About 25.50ml of extracted solution containing Hg (approximately 30mg/100ml) was measured and 5ml of 0.10 M Titriplex III solutions was added. It was allowed to stand for about 5 minutes and 1 drop of EBT indicator and 1 ml of ammonium solution were added. Excess Titriplex solution was titrated back with 0.10M Zinc Sulphate solution until the sample colour changed to pink-red.

Calculation

1ml of 0.10M Titriplex III solution ≡ 20.061 mg of Hg.

2.9 Copper (Cu) Determination Procedure

About 25.50ml of solution containing about 20mg/100ml of Cu was measured and sufficient diluted ammonia solution was added (to resolve the OH⁻ formed) at a pH of 8 or lower. Ammonium chloride was added to

maintain pH at 8 whilst 1-2 drops of Murexide indicator solution was added to the solution which was titrated with 0.01M titriplex III solution until the colour changed from orange-yellow to bright violet.

Calculation

1ml of 0.01M Titriplex III solution \equiv 0.635mg of Cu.

2.10 Manganese (Mn) Determination Procedure

About 100ml of solution containing about 30mg/100ml Mn was measured into a conical flask (250ml) and 25ml of 5% potassium sodium tartrate solution, 2ml of ammonia solution and 0.1g of ascorbic acid were added. The mixture was heated to 70 – 80 °C and EBT spatula was added. A pH (10 – 11) was checked and the mixture was titrated with Titriplex III solution until the colour changed red to green (permanent).

Calculation

1ml of 0.10M Titriplex III solution \equiv 5.494mg of Mn.

2.11 Zinc (Zn) Determination Procedure

About 25 ml of solution containing Zn salt solution was measured into a 100ml volumetric flask and diluted to 100ml with distilled water. The content was transferred into a 250ml conical flask and coarsely neutralized with 10% NaOH. One spatula full of EBT and 1ml of ammonia solution were added. The resulting solution was titrated with 0.10 M Titriplex III solutions until the colour changed to green.

Calculation

1ml of 0.10M Titriplex III solution \equiv 6.538mg/ml of Zn

2.12 Iron (Fe) Determination Procedure

About 25-50ml solution containing about 20mg Fe was measured into a 100ml volumetric flask. It was made up to 100ml with distilled water and the pH was adjusted to about 2.5. The solution was heated with HNO₃ and 1ml of EBT indicator was added. The solution was titrated with 0.10M Titriplex III solution until the red colour disappeared.

Calculation

1ml of 0.10M Titriplex solution \equiv 5.585mg of Fe

3.0 Results and discussion

3.1 Levels of Heavy metals in Quarry Dust.

Table 3.1: Mean Heavy Metal Concentrations in Quarry Dust and Dust Away from Site

Treatment	As	Hg	Mn	Cu	Fe	Pb	Zn
Primary quarry dust	0.1050 ^a	0.0900 ^a	0.325 ^a	1.250 ^a	1.275 ^a	0.040 ^a	0.2000 ^a
Secondary quarry dust	0.0950 ^a	0.0950 ^a	0.975 ^b	0.975 ^a	2.625 ^b	0.195 ^b	0.2000 ^a
Dust away from site (Control)	0.0700 ^b	0.0800 ^b	0.225 ^a	0.140 ^b	1.135 ^a	0.030 ^a	0.1450 ^b
L.S.D	0.01757	0.01757	0.3042	0.5237	0.2744	0.5445	0.01757
C.V	4.5	4.6	13.9	15.4	3.8	143.3	2.2

*Treatment means with different letters (a and b) within the columns are significantly different at 0.05 probability level.

From table 3.1, the highest concentration of Arsenic (0.1050 mg/L) was recorded from the primary quarry dust whilst the lowest value (0.0700 mg/L) was recorded in the dust away from the site. The secondary quarry dust recorded a mean value of 0.0950 mg/L over the study period. However, the mean differences between the three sites were statistically not significant (P< 0.017) at 0.05 probability level for Arsenic.

In addition, the mean concentration of mercury from the three sites was generally similar, ranging from 0.08000 – 0.0950 mg/L. The lowest value was recorded in the dust away from the site whilst the highest value was recorded in the secondary quarry dust. The mean mercury value of 0.0900 mg/L was recorded at the primary quarry dust. Similarly, the mean differences in the concentration of mercury from all the sites were statistically not significant (P<0.017) at 0.05 probability level (Table 3.1).

On the contrary, the mean concentration of manganese from the three sites was significantly different. The lowest value (0.225 mg/L) was recorded in the dust away from the quarry site whilst the highest value (0.975 mg/L) was recorded in the secondary quarry dust. The mean manganese value of 0.325 mg/L was recorded at the primary quarry dust. The mean difference in the concentration of Manganese from all the sites was statistically significant (P<0.304) at 0.05 probability level (Table 3.1).

On the other hand, the highest concentration of Copper (1.250 mg/L) was recorded from the primary quarry dust whilst the lowest value (0.140 mg/L) was recorded in the dust away from the site. The secondary quarry dust recorded a mean value of 0.975 mg/L over the study period. The mean differences between the three

sites were statistically significant ($P < 0.523$) at 0.05 probability level for Copper (Table 3.1).

Again, the highest concentration of Iron (2.625 mg/L) was recorded from the secondary quarry dust whilst the lowest value (1.135 mg/L) was recorded in the dust away from the site. The primary quarry dust recorded a mean value of 1.275 mg/L over the study period. The mean differences between the three sites were statistically significant ($P < 0.274$) at 0.05 probability level for Iron (Table 3.1).

Moreover, the mean concentration of Lead from the three sites was significantly different, ranging from 0.030 – 0.195 mg/L. The lowest value was recorded in the dust away from the site whilst the highest value was recorded in the secondary quarry dust. The mean Lead value of 0.040 was recorded at the primary quarry dust. The mean differences in the concentration of Lead from all the sites were statistically significant ($P < 0.274$) at 0.05 probability level (Table 3.1).

In addition, the mean concentration of Zinc from the three sites was generally similar, ranging from 0.2000 – 0.1450 mg/L. The lowest value was in the dust away from the site whilst the highest value was the same in both the primary and the secondary quarry dust. The mean differences in the concentration of Zinc from all the sites were statistically not significant ($P < 0.017$) at 0.05 probability level (Table 3.1).

4.0 Discussion

4.1 Heavy Metals Concentration in Quarry Dust and Dust Away from the Site

The levels of Arsenic concentration for primary and secondary quarry dust were not significantly different. According to Coakley, 1996, Arsenic is found in the deep bedrock materials. The presence of arsenic in the site may be attributed to crusher emission from fines of quarry such as arsenopyrites. However, the levels of arsenic concentration in primary and secondary quarry dust were significantly different from the dust away from the quarry site. Although arsenic is a naturally occurring element in the earth's crust, it is usually present in the environment in inorganic form. The inorganic arsenic easily dissolves and enters underground and surface waters. This might have accounted for the difference in levels of arsenic concentration in the dust away from the site compared to the primary and secondary quarry dust.

Similarly, the levels were the same for mercury concentration. Elemental mercury is a silvery metallic liquid that is volatile at room temperature. Mercury is found in soil and rocks typically as an ore known as cinnabar, consisting of insoluble mercuric sulphide. The presence of mercury in the site may be attributed to the crushing of rocks into quarry fines (Obiri *et al.*, 2006; Essumang *et al.*, 2007). Daily crushing of rocks in the sites generates considerable amount of quarry dust harboring higher levels of mercury concentration compared to dust away from the site.

For Manganese concentration, the levels for primary quarry dust and dust away from site were not significantly different. Manganese is one of the most abundant metals in soils, where it occurs as oxides and hydroxides, and it cycles through its various oxidation states. Manganese occurs principally as pyrolusite (MnO_2), and to a lesser extent as rhodochrosite ($MnCO_3$) (Essumang *et al.*, 2007). Manganese is an essential element for all species. Manganese in the quarry dust and dust away from the site was probably due to leaching effect of its sediments from waste rocks.

It was also observed that the levels of copper concentration in the quarry dust were significantly different from the dust away from the site. The presence of copper in the study area may be due to weathering and leaching of the metal from waste rocks dumps (AGCL, 2001). Similarly, improper disposal of lead copper wire may further account for high levels of copper in the study area. Copper can be released into the environment by both natural sources and human activities. Examples of natural sources are wind-blown dust, decaying vegetation and forest fires.

The levels of iron concentration in secondary quarry dust were significantly different from dust away from the site. Iron in the quarry dust may be associated with the rock system and the high concentration of iron in the study area may directly emanate from weathering of the rock system. Other sources of iron in the study area may be the occasional discharge of mining waste which increases its concentration in the quarry dust. Iron is one of the major constituents in the lithosphere (i.e. soil or rock) occurring as oxides or hydroxides (AGCL, 2001).

Concentration levels were the same for lead. The presence of lead in the study area is probably due to weathering and leaching of the metal from waste rocks dumps (AGCL, 2001). Other source of lead is the weathering of the rocks, which contains high levels of lead. Similarly, improper disposal of lead (IV) acid batteries also accounts for high levels of lead in the study area.

Finally, the zinc concentration recorded in the quarry dust was significantly different from the dust away from the site. Zinc is an element of moderate abundance in the earth crust. It occurs in rocks as chalcophile and sphalarite, ZnS (referred to as zinc in Europe). The presence of zinc in the environment is associated with mining and smelting which pollutes the air and soil with fine particles, which ultimately undergo oxidation to release Zn^{2+} . Hence, the results obtained, was correlative to what pertains to literature from other researchers (USEPA, WHO and GEPA).

4.2 Conclusions and Recommendations for resource management consideration

Generally, the levels of concentration of Arsenic, Mercury, Copper and Zinc were relatively higher in the primary and secondary quarry dust than dust away from the site. Levels of Manganese, Iron and Lead concentration were higher in Secondary quarry dust than Primary quarry dust and dust away from the site. Thus, the quarry activity in the study area has inflicted serious heavy metal pollution of the soil in the environment of Asonomaso, thereby, necessitating to the following additional research and resource management considerations:

- Further research should consider analyses of drinking water, and bio-assessment of urine and blood samples in the mining site for the concentrations of trace metals compare it with the levels found in dust samples.
- There is the need to conduct further studies on the toxicity symptoms of plants in the study area (particularly food crops, medicinal plants and pasture/forage plants).
- Further research should analyze other metals such as cadmium, chromium, selenium and cobalt concentrations in water and dust samples from the quarry site.
- The Chiefs and Assembly Men, Town Committee members at Asonomaso should link up and upstage relevant discussion with A. Kannin Quarry Products and Concrete Limited at Asonomaso to upgrade the Basic schools and health facilities at the Hospital and initiate opportunities for the community members to benefit from routine medical screening.
- Scholarship awards schemes should be instituted for pupils from the area as part of the company's corporate social responsibilities to improve the standards of living.
- Generally, there is the need to construct several monitoring water wells and dust collection screens around the peripheries of the quarry site to serve as impact assessment sampling points by the EPA and other standards regulatory agencies.

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