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Charnley AK (1992). Mechanisms of fungal pathogenesis in insects with particular reference to locusts. In: Lomer CJ, Prior C (eds) Biological Controls of Locusts and Grasshoppers: Proceedings of an international workshop held at Cotonou, Benin. Oxford: CAB International, pp 181-190.

Mundree SG, Farrant JM (2000). Some physiological and molecular insights into the mechanisms of desiccation tolerance in the resurrection plant Xerophyta viscasa Baker. In Cherry et al. (eds) Plant tolerance to abiotic stresses in Agriculture: Role of Genetic Engineering, Kluwer Academic Publishers, Netherlands, pp 201-222.

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Review

An appraisal of the water related contaminants as they affect the environment around the Enugu coal mines of Enugu state, southeastern Nigeria

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Enugu metropolis is within the Anambra basin, which comprises mainly sedimentary rocks of sandstone, siltstone, mudstone and shales in the Lower Benue trough and as the capital of Enugu state in Nigeria and also as one of the major municipal and industrial centers in southeastern Nigeria experiences much groundwater contamination due to coal mining activity. The Area is richly endowed with sub-bituminous three-coal seams within the Mamu Formation. It also lacks prolific and potable groundwater due to the thinning-out of the Ajali sandstone aquifer through Udi town and Ninth-mile into Enugu metropolis. Generally, the specific discharge of Ajali sandstone (17.5 m^2/day) is higher than that of Mamu Formation (14.5 m^2/day). This appraisal becomes necessary to acquaint the Enugu city developers on the need for the prediction and understanding of the Environmental Impact Assessment (EIA) on the future development, management and maintenance of the mine water. The study also aims at identifying various contaminants, sources, level of concentrations, effects and control measures. Many springs, streams and seepages exist on the foot of most of the hills and ridges. The springs form the headwaters of the major streams and rivers like Ekulu, Iva and Nyaba at the base of the escarpment. Out of the streams and rivers in Enugu coal city, Ekulu River is the largest and thus very important for industrial and agricultural purposes. However, the coal mines discharge their effluents and waste waters directly into the Ekulu River with toxic heavy metals like As, Cd, Cr, Fe, Mn, Ni and Pb that contaminate the water and sediments. At the mines, most of the seepages, springs and streams rise directly from the perennial flood water from the mines. The water from the coal mines with special treatment for pH and iron contents can be employed in augmenting the present inadequate water supply that comes from the Ninth Mile borehole network and Ekulu River reservoir. The pH can be treated with hydrated lime, while iron (Fe^{2+}) can be treated with aeration and filtration.

Key words: Groundwater, coal mine, Ajali sandstone, sub-bituminous, coal, rivers, seepage.

INTRODUCTION

It is very important to note that coal is sediment, organoclastic in nature, composed of lithified plant remains, which has the important distinction of being a combustible material (Thomas, 1992). Using the inductively coupled plasma-optical emission spectrometry (ICP-OES) in laboratory analyses, two distinct relationships exist among the major and trace elements in the Maastritchian Coal Measures of Southeastern Nigeria. The first represents rocks from a detrital suite dominated by quartz and clay minerals while the second

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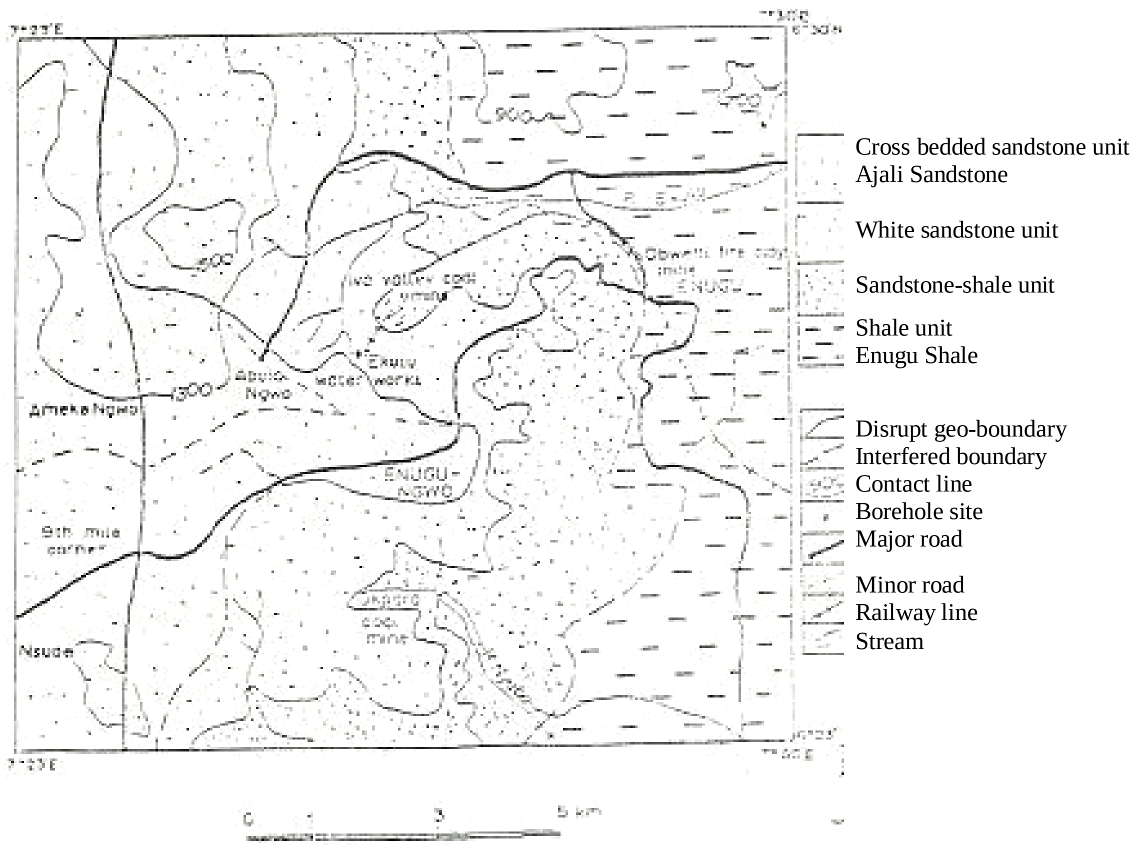

Figure 1. Physiographic and geological map of the area (Ezeigbo and Ezeanyim, 1993).

suite comprises the coal samples deposited in the peat swamp (Ogala et al., 2009). These suites are unrelated because there is no transition from one to the other.

The Ajali sandstone, which overlies Mamu formation (Figure 1) consists of thick friable poorly to moderately sorted highly cross-bedded sandstone that is generally whitish in colour, but sometimes stained red, yellow or brown due to the presence of iron oxide. Ajali sandstone is the main aquiferous unit supplying water to Enugu and environs. Water always drips downward from Ajali sandstone into underlying Mamu formation through the interconnected fracturing of the rock materials.

Major streams and rivers in Enugu metropolis include Ekulu, Asata, Ogbette and Nyaba (Figure 2). Ephemeral streams rise from about 300 m a.m.s.l. (above mean sea level) as springs and flow through deep V-Shaped valleys incised in the soil materials and the Ajali sandstone, but more perennial streams rise from the middle levels of the escarpment near the base of the Ajali sandstone. The area is well drained. The streams or rivers, some of which appear fracture-controlled in their flow paths give rise to dendritic drainage pattern (Ezeigbo and Ezeanyim, 1993). The flow pattern is provided by numerous fractures connecting the two aquiferous systems and the coal mines.

Vertical flows into the underlying Mamu aquifers also occur through the numerous fractures and stratigraphic discontinuities. The fractures act as vertical drains through which groundwater enters into the coal mines. Groundwater flows in the fractures from the overlying unconfined aquifer downward into the mines and laterally into the confined aquifers. This is because; the hydraulic head in the unconfined aquifer is always greater than in the confined aquifer.

DISCUSSION

There are two types of aquifer in Enugu metropolis, namely unconfined aquifer where there exist Ajali sandstone and an upper white sandstone member of Mamu formation, and a confined aquifer where there are lower and upper confined units within the Mamu formation (Figure 3). It must be noted that chromium contamination is common in soils in both ground and surface waters in industrial areas (Katz and Salem, 1994). Hence, metals are efficiently bound and accumulated by sediments, but are also subject to partial release into the overlying water (Jackson, 1998).

However, there is a pronounced shortage of potable

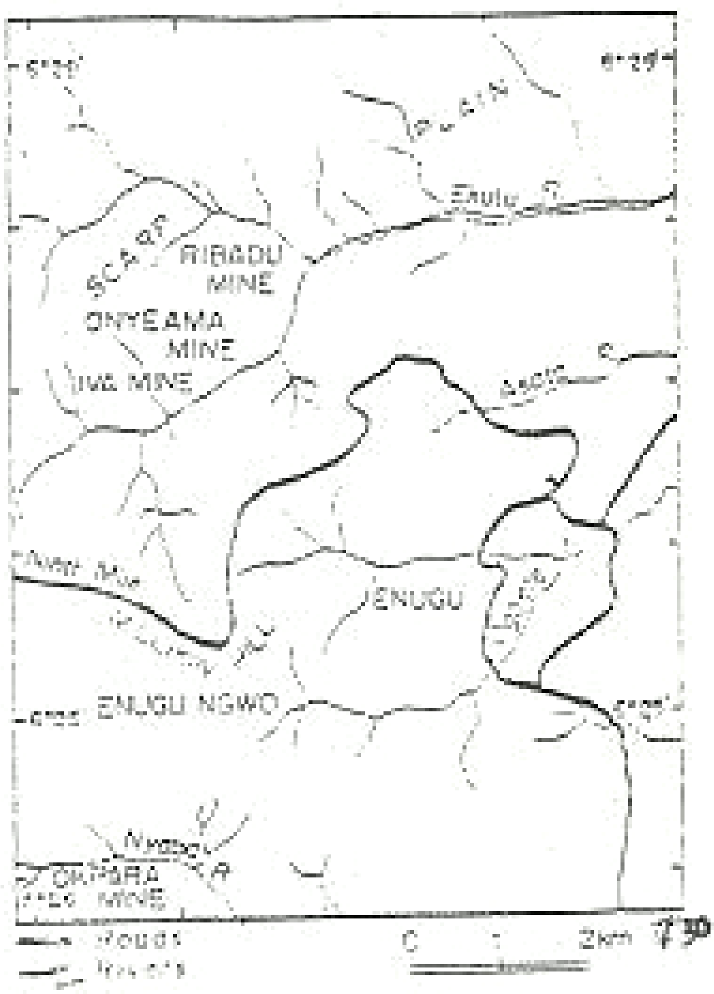

Figure 2. Drainage of the area (Ezeigbo and Ezeanyim, 1993).

drinking water within most parts of Enugu metropolis due to thinning out of Ajali sandstone (aquifer) and increase in Mamu formation (aquiclude), but in Ninth mile and Udi thickness of the Ajali Sandstone is greater than its thickness in other parts of Enugu metropolis.

The hydrodynamics and hydrology of the area indicate that the mines are overlain by unconfined and confined aquiferous systems. The mine water is derived principally from the unconfined aquifer (Uma, 1992). The flow-path is provided by numerous fractures that connect the two aquiferous units to the Onyeama and Okpara mines.

Acid mine drainage contamination is increased by the indiscriminate dumping of mine spoils whose leachates contaminate both surface water (springs, streams, rivers) and groundwater. Water seeping out through the fractures collect in sumps at the floor of the long walls (that is, active mine tunnels) and are subsequently pumped out of the mines through the main adit channel. The acid mine drainage water from the mines was pumped into the nearby streams and rivers, thereby contaminating the surface water that augment water supply to Enugu municipality.

It was observed during the fieldwork that some fractures were filled with compact clayey materials (mudrock). This was also peculiar in the minor joints of the coal seams (cleating). Therefore, seepage is confined to the major fractures that extended into the Ajali sandstone and upper part of Mamu formation. The major sources of the contaminants are the shales of Mamu formation which contain pyrite (FeS_2) flakes and show sulphur stains. When the pyrite flakes are exposed to air (oxygen), the water therein forms soluble hydrous iron sulphates. The soluble hydrous iron sulphates appear as white, red and yellow salt crusts on the surfaces of weathered rocks. As the natural water flows inside and outside the coal mines through these weathered rock surfaces, it readily dissolves the compounds, which hydrolyze the water to form acidic, high iron and high sulphate drainages. The shales of the Mamu formation contain pyrite flakes and sulphur stains. Pyrite is

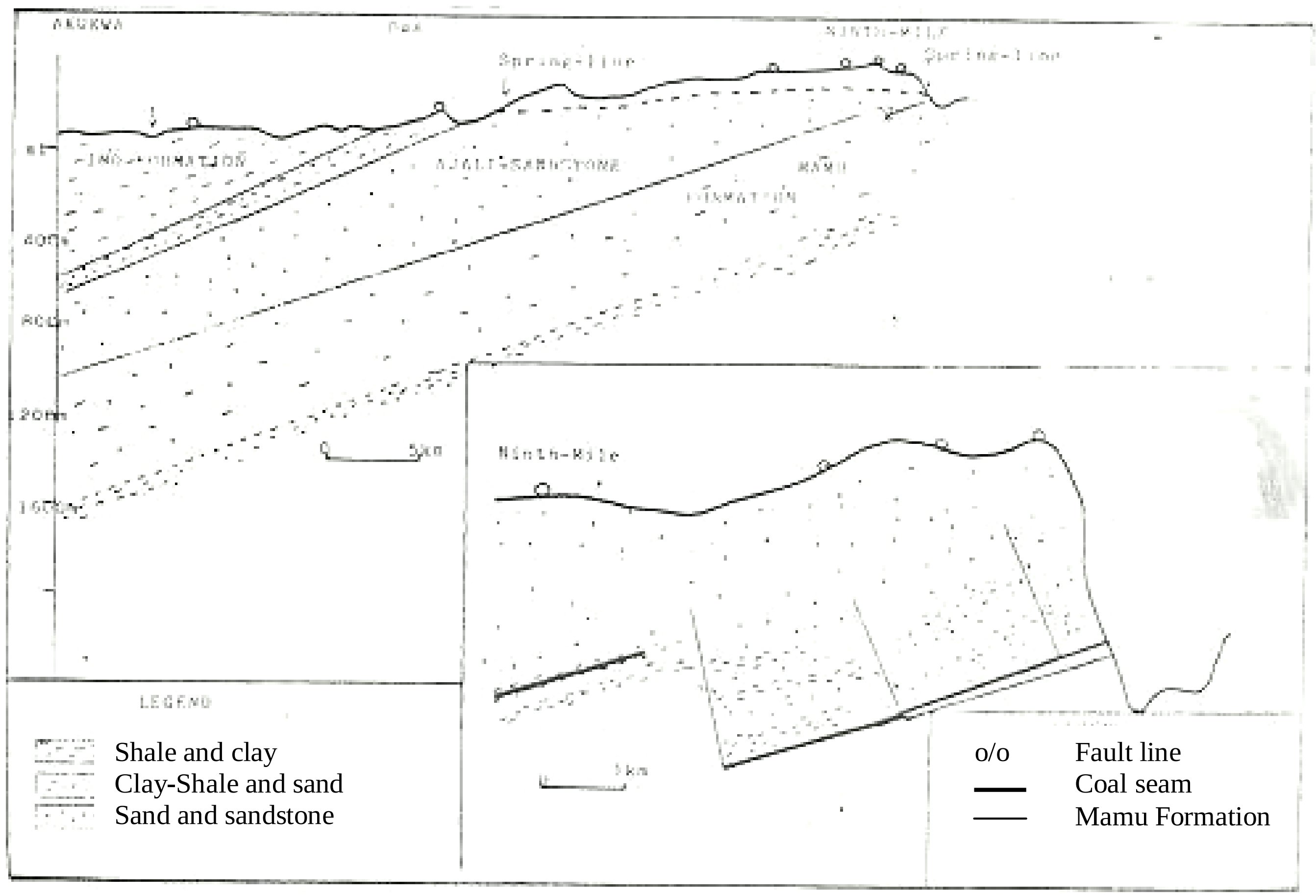

Figure 3. Generalized geologic sections across the area: figure shows regional features and inset the specific features in the mining environment (Uma, 1992).

associated with toxic heavy metals like Arsenic (As), Chromium (Cr), Cadmium (Cd), Nickel (Ni), Lead (Pb), Copper (Cu), Zinc (Zn), Aluminum (Al) and Manganese (Mn). The amount of iron, sulphates, Cu, Zn, Al and Mn discharged into the mine water and environment depends on the characteristics, amount and type of pyrite (FeS_2) in the overburden rock, time of exposure and amount of available water. The less time pyritic material is exposed to air, the less acid is formed. Therefore, it is advisable to cover pyritic material with earth to act as an oxygen barrier. Low pH values of the mine water indicate moderate hard water. The under-mining of the aquifers cause huge volumes of the polluted mine water to flood the mines which are subsequently channeled into some of the nearby streams and rivers like Ekulu, Nyaba and Ogbette.

The mine waters contain high contents of magnesium 12.16-158.08 mg/l and high iron 1.70-25.76 mg/l as major cations. Generally, other cations; calcium, sodium and potassium are less than 14.50 mg/l (Table 1). The major anion is sulphate 58.00-420.00 mg/l. Thus, the water is mainly of magnesium-sulphate type. Bicarbonate ranged from 9.60-80.50 mg/L, but the water that is not directly influenced by coal mining activity has bicarbonate as major anion. The mine waters have low pH 2.30-6.30, and thus, the water is moderately hard and corrosive with high leaching action, and an elevated total dissolved solid (65.00-785.00 mg/L). Aerial transport of precursors of acid rain cause leaching of heavy metals to sediments and suspension in the water column. Except for Mn, there is a steady decrease in the concentration of all metals from November to March corresponding to the decreasing run-off. Metal concentrations are generally higher in the coal samples than in the sediments, but seasonal fluctuations are higher in sediments than in the coal samples (Adaikpoh et al., 2005).

The coal mine spoils are most often dumped into the streams and on the river banks. Besides polluting these surface waters, the spoils increase total acidity, iron, sulphates and hardness. The spoils have been a major source of siltation, increased suspended matter (high turbidity) and total dissolved solids (TDS). The sediments destroy spawing grounds, shield sunlight and consume oxygen needed for aquatic life sustainability. These ions

Table 1. Hydrogeochemical data of Enugu Coal mine groundwater (Ezeigbo and Ezeanyim, 1993).

Geochemical parameter	Onyeama mine	Okpara mine	Iva valley mine	Ogbette Coal Preparatory mine
pH	2.80	2.30	6.10	6.30
Colour (platinum cobalt true colour)	5.00	10.00	20.00	25.00
Electrical conductivity (homs) u/cms	700.00	1550.00	110.00	800.00
Total hardness (mg/l)	100.00	100.00	80.00	-
Silica as SiO_2 (mg/l)	30.00	30.00	7.50	12.50
Nitrate (mg/l)	1.20	1.11	0.13	1.02
Total iron (mg/l)	8.40	25.76	1.70	6.40
Sulphide(mg/l)	1.40	-	1.80	-
Sulphate (mg/l)	310.00	420.00	58.00	174.00
Magnesium(mg/l)	158.08	85.12	12.16	111.87
Sodium (mg/l)	6.95	10.33	4.40	-
Potassium (mg/l))	9.46	2.19	2.35	-
Calcium(mg/l)	4.00	6.41	4.01	3.21
Chloride (mg/l)	10.42	1.99	-	8.93
Phenolp Acidity	124.00	320.00	10.00	10.00
Total alkalinity	20.00	16.00	80.00	90.00
Total dissolved solids	330.00	785.00	65.00	515 .00
Free carbondioxide	230.00	38.00	8.00	68.00
Bicarbonate	16.00	9.60	65.00	80.50

are highly toxic to man, plants and aquatic life, and thus render the water unfit for human drinking and agriculture; and unusable for other domestic and industrial purposes. The acidity of the streams and rivers does not support plants and animal life living within the water environment and thus, the re-establishment of this life will require several months.

The level of concentration of some heavy metals like Mn, Cr, As, Ni and Pb as analyzed in coal and sediments samples from River Ekulu in Enugu coal city using Atomic Absorption Spectrophotometer (AAS) model Spectra AA-10 Variant indicated mean concentrations of Mn 0.256-0.389 mg/kg and Cr 0.214-0.267 mg/kg which are high relative to concentrations of Cd 0.036-0.043 mg/kg, As 0.016-0.018 mg/kg, Ni 0.064-0.067 mg/kg and Pb 0.013-0.017 mg/kg (Adaikpoh et al., 2005).

The surface water needs protection from coal mine waste water by constructing sumps and treatment tanks where mine waste water will be discharged into. The sumps treatment involves removal of suspended solids in raw mine waste water by flocculation and settling processes using hydrated aluminum sulphate crystals (alum), while treatment tanks receive or contain the acid mine water free of suspended matter. Therefore, in order to control the acid mine water contamination of the streams and rivers, the acid mine water should be properly treated before being pumped into the surface water body. This is possible by aeration to remove dissolved iron and addition of lime to improve low pH concentration levels.

Calcination helps to control pollution in coal mines through its chambers that trap and retain gases. Calcination of coal waste spoils at high temperatures increases the pH of leachates from 2.3 to 8.5 and reduces the total dissolved solids (TDS) from 60 mg/l to nil. Calcinations can reduce heavy metals like iron in the coal wastes from 25.76 mg/l to less than 0.2 mg/l. However, calcination generates toxic gases.

The drainage of mine waste water is very important to avoid oxidation of metallic sulphides, improve slope stability and reduce corrosion of mining plants and equipment. Quality of the drainage water depends on geological, hydrogeological and mining factors, and this quality of mine waste water varies from one mine to another.

The quantity of mine waste water inflow from surface sources or rapid infiltration of rain water to underground workings will depend on transmissivity of the geological formations, dimensions of the fractures, hydraulic head, thickness of the projection layers, etc. The largest water inflows correspond with the area of higher rainfall (Raphael and David, 1993). In mine water management, opinions are divided into two groups due to the source of mine water. One opinion has it that the mine water comes from the overlying and highly prolific Ajali Sandstone, while the other opinion has it that the mine water comes from the aquiferous horizons of the Mamu Formation that are interlayered with coal seams. The total annual abstraction from the Ajali unconfined aquifer is about 1,750 m^3/yr, while Mamu aquifer is about 750 m^3/yr

(Ezeigbo and Ezeanyim, 1993). However, because the thickness of the Ajali sandstone (aquifer) thinned-out as it enters Enugu metropolis, the total discharge Qt m^3/yr will be less than that of the Mamu formation (aquiclude), but the Mamu formation contains the three coal seams and mine water. Therefore, the mine waters no matter the volume; it is generated mainly from the overlying Ajali Sandstone, and then it flows into and retained by the Mamu formation (aquiclude) where the coal seams occur.

CONCLUSION

Nigeria overdependence on petroleum and its derivatives for domestic and industrial purposes has led to the instability in the prices of oil, gas and other sources of energy (Onuegbu et al., 2010). The advantages of coal mining in Enugu municipality are enormous, with its unavoidable environmental problems. Besides the rapid remarkable growth of population, industrialization, agricultural activity and employment opportunity in the Enugu municipality, the environmental problems include water contamination, air pollution, faults reactivation and devegetation. The water contamination damages public and industrial water supply and endangers aquatic life.

Toxic heavy metals like As, Cd, Cr, Mn, Ni and Pb through sewage sludge and effluents application, mine waste, industrial waste disposal and application of fertilizers and pesticides. Generally, coal deposits contain great amounts of trace for example, Pb, As, Cd, Cr and minor elements in their overall composition. Water contamination can be controlled by treating the mine waste water before pumping it into the streams and by proper disposal of mine wastes and tailings so as to shed them from air and water environments. The enormous volume of mine waste water pumped out reactivates the faults of the Mamu formation in the mine environment. It was noted that the annual abstraction from the unconfined Ajali sandstone (aquifer) is about 1,750 m^3 /yr, while that of the Mamu formation (aquiclude) is about 750 m^3/yr.

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Full Length Research Paper

Heavy metal concentration in soil of some mechanic workshops of Zaria-Nigeria

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This research paper investigated the elemental composition of soil samples from four selected mechanic workshops in Zaria. A total of eight samples were analyzed at Centre for Energy Research and Training (CERT) Ahmadu Bello University Zaria using standardless X-Ray Fluorescence spectroscopy (XRF). From the result, it was found that Silicon (Si) has the highest mean concentration ranging from 0.0013-0.0024 ppm and Ba, Ni, Cr, Mn, Cu, V, Mo and Zn having very low concentration witha mean of (0.000035 0.000053) ppm, (0.000009 0.000012) ppm, (0.0000054 0.000012) ppm, (0.0000049 0.000012) ppm, (0.0000052 0.000017) ppm, (0.0000052 0.000029) ppm, (0.0000068 0.00007) ppm and (0.00001 0.000055) ppm respectively. Lead was found in only one sampling point (Samaru Dogon Icce) with an abundance of 0.00018 ppm which is less than the maximum permissible limits (MPL) recommended by W.H.O. Hence, the result shows that there were no much toxic elements in some of the mechanic workshops in Zaria. It is advisable that substances containing heavy metals should not be disposed in farm lands or any dumpsites close to residential areas.

Key words: Heavy metals, soil, contamination, mechanic workshop.

INTRODUCTION

Man's activity in the environment has led to the pollution of soil mainly by chemical contaminants. Presently in developing countries like Nigeria where estimates have been made that; there is large number of illiteracy in the country, lack of knowledge on how to eradicate the problem of soil pollution. The presence of heavy metals in soil can affect the quality of food, groundwater, micro-organisms activity, plant growth etc. (Antoaneta et al., 2009). When contaminated soils are later abandoned and then used for agricultural purposes such as farming, animal breeding, herding etc. plants take in these metals in the process. For the fact that they are not bio-degradable (cannot be broken down into smaller parts by bacteria), can have adverse effect on plants. Also these heavy metals have toxic effect on living organisms in the soil when permissible concentration levels are exceeded.

In Zaria (Kaduna state), because of the large number of roadsides mechanical workshops where motor oil, body parts, grease, battery electrodes and electrolytes which contained heavy metals are commonly found and used and because most of the activities in the mechanical workshops are carried out on the ground (soil), the soil is mostly contaminated. Generally, the most common of these heavy metals found in the soil include Lead (Pb), Copper (Cu), Zinc (Zn), Cadmium (Cd) etc. Lead and copper are the commonly heavy metals found in the soil. Lead at certain exposure level, is a poisonous substance to animals as well as human beings.

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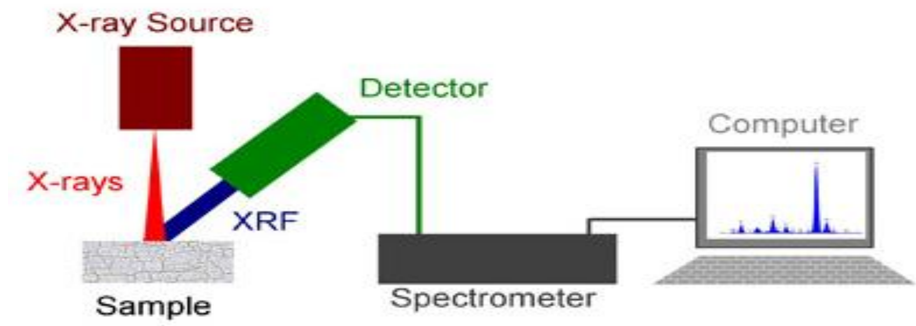

Figure 1. Schematic arrangement of Energy Dispersive XRF spectrometer Source: http://www.horiba.com/scientific/products/x-ray-fluorescence-analysis/tutorial/xrf-spectroscopy.

According to USDA (2000), acute (immediate) poisoning from heavy metals is rare through ingestion or dermal contact, but it is possible. Chronic problems associated with long-term heavy metal exposures are mental lapse (lead); toxicological effects on kidney, liver and gastrointestinal tract (cadmium); skin poisoning and harmful effects on kidneys and the central nervous system (Adelekan and Abegunde, 2011). According to an estimate made by the National Institutes of Occupational Safety and Health (NIOSH), more than 3 million workers are potentially exposed to lead in the work place (Binns and Ricks, 2004). In most part of the United States, heavy metal toxicity is an uncommon condition; however, it is a clinically significant condition when it does occur. If unrecognised or inappropriately treated, toxicity can result in significant illness and reduced quality of life (Ferner, 2001). Therefore, it is important for research to be conducted to evaluate and limit exposure of dangerous levels of these heavy metals in the environment.

EXPERIMENTAL

Sample collection

A total of eight samples were collected from four locations (Samaru, Kofar-Doka, Sabon Gari and Tudun Wada). At each sampling point, samples were collected randomly using polythene bags and hand gloves and then transported to the laboratory for analysis.

Sample preparation

The samples were homogenised and crushed with an agate mortar grain size less than 125 nm. Three drops of toluene acid (binder) was then added to 0.5 g of the powdered sample and crushing continued until the mixture was returned to fine powder again. The 0.5 g weighed of the crushed sample was placed under a hydraulic press machine and a 10-tone pressure was applied which compressed and converted to fine powder and then into pellet form. The pellets were carefully labelled, covered with Mila and stored in partitioned sample storage plastic containers for analysis.

Sample analysis

The analysis was done using Mini pal which is a compact energy dispersive X-ray spectrometer designed for the elemental analysis of a wide range of samples (Figure 1). The system is controlled by a PC running the dedicated Mini pal analytical software. The Mini pal 4 version in use is PW 4030 X-ray spectrometer, which is an energy dispersive microprocessor controlled analytical instrument designed for the detection and measurement of elements in a sample (solids, powders and liquids), from sodium to uranium. The source (X-ray tube in this case) irradiates the sample and the detector measures the irradiation coming from the samples. The detector that is able to measure the different energies of the characteristic radiation coming from the sample directly.

RESULTS AND DISCUSSION

Two categories of soil samples were collected and analysed for heavy metals from each sampling point. A total of eight samples were obtained, four of which are at the surface and the remaining four are at about 0.5 m beneath the surface of the ground, the results of the analysis are presented in Figures 2 to 5.

The results obtained from Samaru Dogon Icce (Figure 2) workshop shows the presence of lead, this is because Samaru Dogon Icce workshop is one of the busiest workshop in Zaria and its environs, and it is located along several higher institutions and the busiest Zaria - Sokoto express way. This leads to more number of vehicles in the area which constitutes the accumulation of lead. Lead (Pb) is only present in point 1 in Samaru Dogon Icce workshop, because point 1 was collected from the surface of the soil where lead accumulated more while point 2 was collected 0.5 m beneath the soil surface which has lesser content of lead compared to that of point 1.

Lead was only found in Samaru Dogon Icce workshop because all the samples which were analysed was collected during the rainy season which lead to the washing away of top soil accompanied by washing away of some of these metals. Also, the presence of Pb in

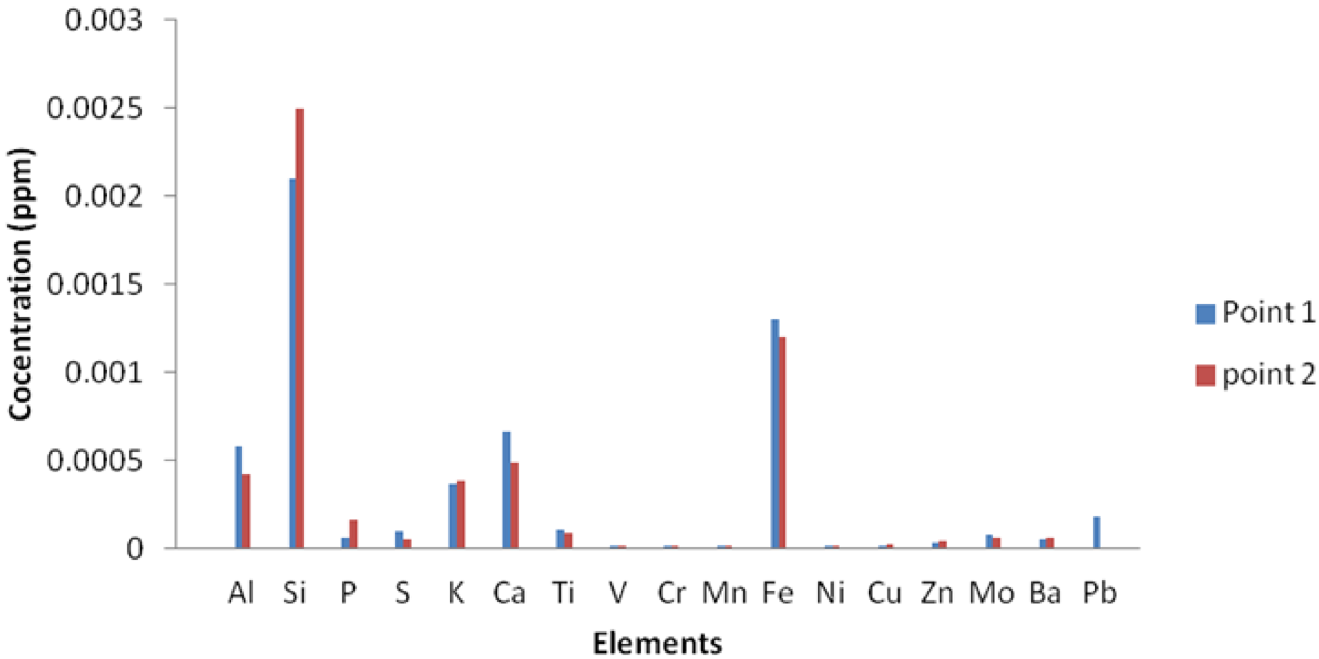

Figure 2. Variation of concentration of Elements from Samaru Dogon Icce mechanic workshop.

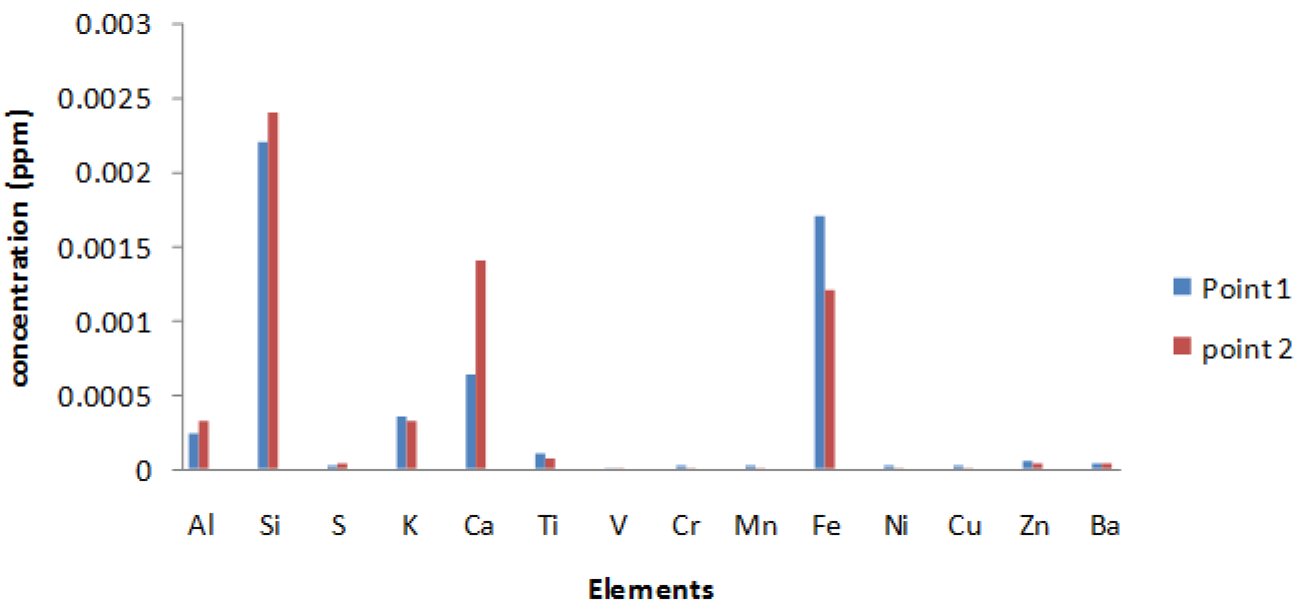

Figure 3. Variation of concentration of elements from Sabon Gari mechanic workshop.

auto-repair workshop in Samaru Dogon Icce soils may be due to fall-out of lead from batteries or lead accumulators, which are commonly used and abandoned in the workshops. The presence of iron (Fe) in large concentration from Sabon Gari (Figure 3) and Kofar Doka (Figure 4) mechanic workshops deserves evaluation because of the fact that different types of trees are present in the site, the dropping and decomposition of their leaves accumulate in the soil.

In all samples from the four mechanic workshops, it can be observed that silicon has the highest concentration with a mean ranging between 0.0013 to 0.0024 ppm. This is due to the fact that silicon is the key component of sand. Some of the soil obtained from these mechanic

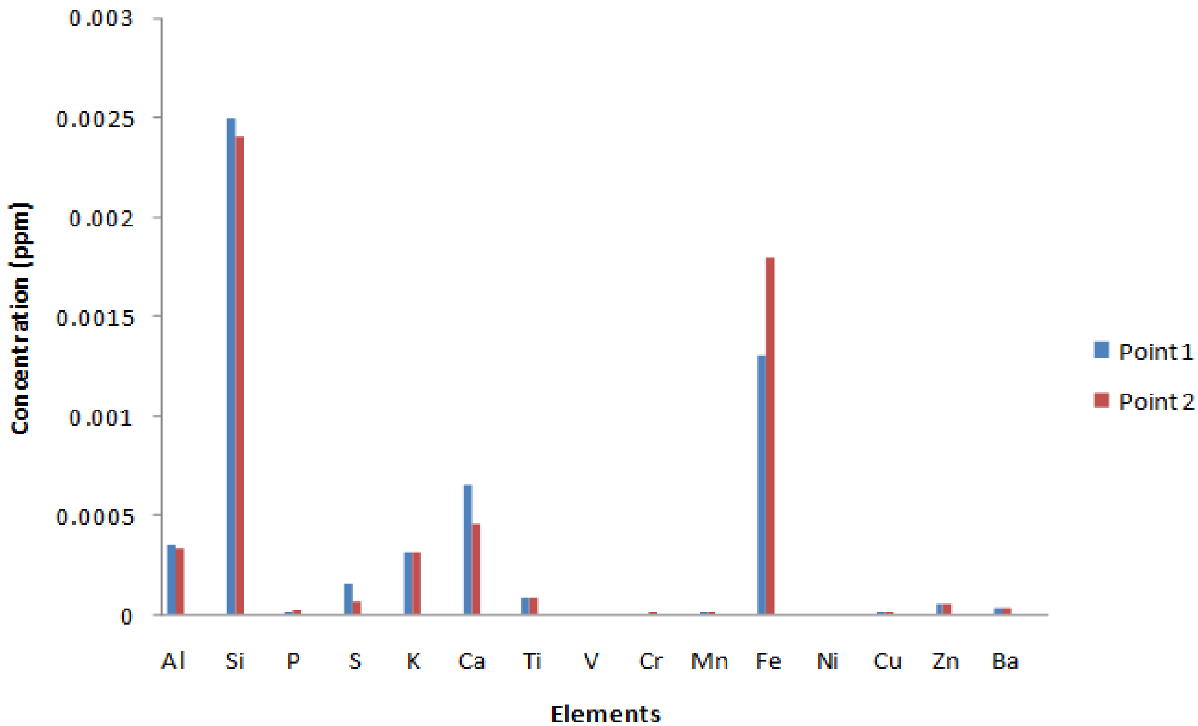

Figure 4. Variation of concentration of Elements from Kofar Doka mechanic workshop.

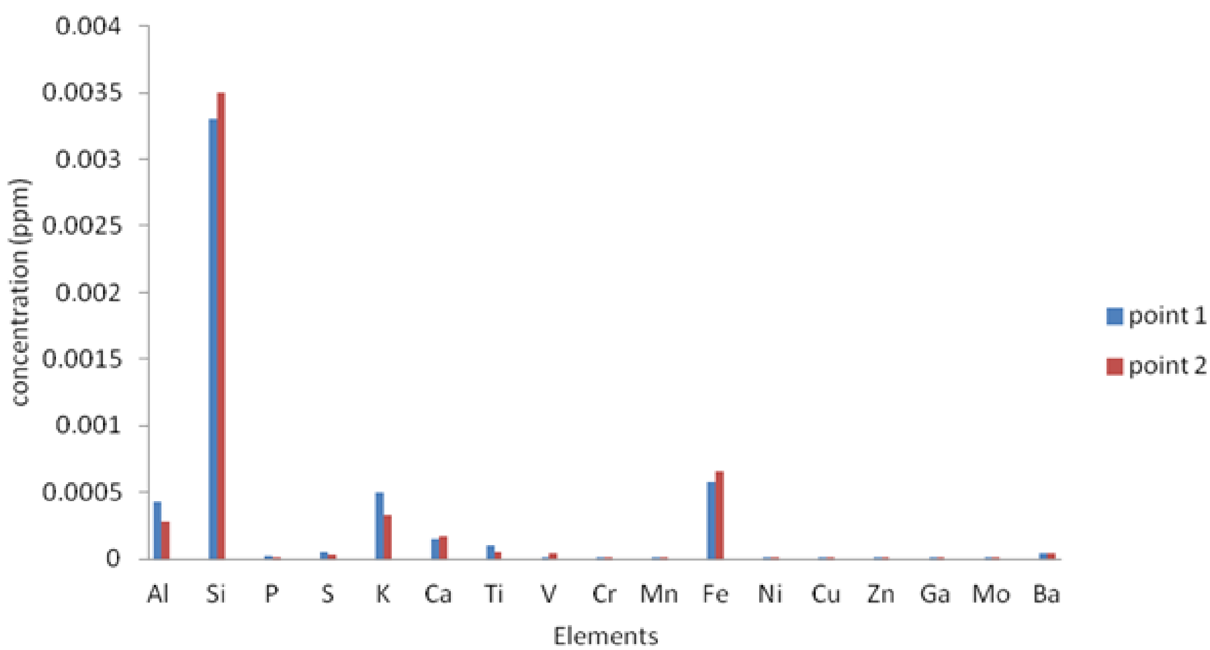

Figure 5. Variation of concentration of elements from Samaru Dogon Icce mechanic workshop.

workshops with excess silicon can be used as manure by local farmers to enhance and standardize rice production for the public consumption and industrial purposes. Also any crop that is cultivated using such soil as manure is expected to have high concentration of silicon and when taken by animals it helps in building strong bones and formation of connective tissues, it also assists in healthy growth of hair, skin and finger nails (Buhari, 2011).

By mere observation on the frequency distribution charts, one can see that there is no much difference in the concentrations of both points 1 and 2. Only for the concentration of Point 1 and Point 2 from Kofar Doka and Sabon Gari mechanic workshop; the concentration of Fe of Point 2 is large compared to that of Pont 1. This is because Point 2 was taken from the area very close to trees and iron (Fe) is much more present in the leaves that frequently drop and decomposed. From Figures 2 to 5, concentration of potassium for both points 1 and 2 are low and in very close ranges compared to the remaining elements. This is because in soils, plants absorb potassium in greater amount than any other nutrient. The total K content of soils frequently exceeds 20,000 ppm (parts per million). Nearly all of this is in the structural component of soil minerals and is not available for plant growth. Because of large differences in soil parent materials and the effect of weathering of these materials in the United States, the amount of K supplied by soils varies (George et el; 2002). For children, ingestion contaminated soil is most significant in pathway for land (Chaney et al., 1989; EPA, 1997). Also, the maximum permissible limits (MPL) for lead is 15 ppm (15 part per million) while the abundance recorded in this work is only 0.00018 ppm. This is the indication that the mechanic workshop does not cause much toxicity to the plants and animals in the area even though lead is poisonous no matter the amount of concentration, its toxicity can result in significant illness and reduced quality of life (Ferner, 2001).

It can also be observed from Figures 1 to 4 that Ba, Ni, Cr, Mn, Cu, V, Mo and Zn have very low concentration with a mean of (0.000035-0.000053)ppm, (0.000009-0.000012)ppm, (0.0000054 0.000012)ppm, (0.0000049 0.000012)ppm, (0.0000052 0.000017)ppm, (0.0000052 0.000029)ppm, (0.0000068 0.00007)ppm and (0.00001-0.000055)ppm respectively. This is because soil samples were collected from a depth of 0 to 15 cm and also were collected during the rainy season which may have caused the washing away of top soil leading to washing away of most of these metals from the soil surface and also because heavy metals in auto-repair workshop soils are not significantly derived from the natural geology or the processes of weathering and deposition (Ayodele and Modupe, 2007). From Figures 1 to 5, the order of abundance is Si>Fe>Al>Ca>K>Pb>Ti>P>S>Zn>Ba>Mn>Cu>V>Cr, with an exemption of Pb that is only present in trace amount in the samples collected from Samaru Dogon Icce mechanic workshop. Pb is considered the primary contaminant of most auto-mobile workshops no matter the amount of concentration.

Conclusion

The heavy metal concentrations in soil samples from some selected mechanic workshops of Zaria and environs were collected and analysed using XRF at Centre for Energy and Training (CERT), Ahmadu Bello University, Zaria. The result obtained from this work shows that the pollution levels within the study area as a result of fall-out of lead from batteries or lead accumulator has not risen to a dangerous level at the moment. But there is also the danger of build-up of small doses either through inhalation or absorption through skin or bio-accumulation. Data obtained from this research work shows that Si has the highest concentration in all the samples analysed with a mean concentration of 0.0013 to 0.0024 ppm. Silicon is also the only element that does not damage plant when accumulated in excess. Therefore some of the soil obtained from these mechanic workshops with excess silicon can be used as manure by local farmers to enhance and standardize rice production for the public consumption and industrial purposes. Also V, Mn, S and Cr have the lowest concentration level in all of the samples collected and analysed from the mechanic workshops. Hence, all these soil samples collected for analysis when used up by humans are less prone to Human Carcinogen (Ayodele et al., 2007) and less exposed to diseases such as brain damage, skin and throat irritation.

Lead derived mostly from exhausts of vehicles is in Nigeria still used as minor additives to gasoline and various auto-lubricants. It is estimated that about 2800 metric tons of vehicular gaseous lead emission is deposited to urban areas in Nigeria annually (Ayodele and Modupe, 2007). Concern for lead concentration in automobile workshop soils may therefore arise principally due to the fact that mechanic workshop could be identified as playground or near residential areas where children play about freely.

However, Pb concentration was only obtained from a sample collected from Samaru Dogon Icce mechanic workshop with a concentration of 0.00018 ppm which is less than the maximum permissible limits (MPL) of Pb recommended by WHO which is 15 ppm (15 part per million). Since lead is a very poisonous element, it is advisable not to use the soil from Samaru Dogon Icce mechanic workshop for crop cultivation since its toxicity can result in significant illness and reduced quality of life (Ferner, 2001).

RECOMMENDATION

Based on the observations and experience from this work, the following were recommended:

(i) This research work should be carried out from time to time so as to monitor the amount of heavy metals released into the soil to avoid accumulation.
(ii) Also, the research should also be carried out in the dry season or preferably in both dry and rainy season so as to get more accurate results.

(iii) There is need to investigate any water body close to the mechanic workshops so as to assess and monitor the concentration level of heavy metals likely present in the water due to the activities in the mechanic workshops.

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Full Length Research Paper

Evaluation of noise reduction in a cigarette factory, China

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Millions of workers are exposed to occupational noise that increases their risk of hearing impairment and evidence on the effectiveness of precaution is lacking. This study was undertaken to assess the effect of noise control strategy in a cigarette factory in China. We chose the representative points in the unit, monitored the noise level and analyzed frequency spectrum at the same workplace before and after sound absorbing panels installation on the ceiling and walls. Results showed that the sound pressure levels were dropped from 81.3 dB(A) to 74.8 dB(A) and reduced by 6.5 dB(A) on average. Installation of the panels had a dramatic effect. From the frequency spectrum analysis, the noise was broadband and evenly disturbed. The frequency (1000, 2000Hz) noise was sharply attenuated, which was in consistent with materials' characteristics. We eagerly recommend it as a successful example in other cigarette factories.

Key words: Sound absorbing panel, noise control, evaluation, cigarette factory.

INTRODUCTION

Cigarette smoking is one of the most common habits in the world, especially in China. It has 320 million smokers which constitute one third of the world's total smokers (Liyuan et al., 2013). As one of the largest tobacco-producing countries, tobacco industry plays an irreplaceable role in its national economy. However, with the prosperity of modern industry, noise becomes the most serious hazardous factor at workplace. Worldwide, the industrial noise levels are higher in the developing regions than those in the developed regions (Nelson et al., 2005). It is the third major contemporary world pollution, which ranks after the atmospheric pollution and water pollution (Li, 2012).

Generally speaking, noise is defined as annoying and unwanted sound. It is stemmed by machinery and equipment used in factory, the filter tip shaping machines account for large amounts of noise and it is a necessary by-product of the desired action. Prolonged exposure to noise may present significant damage for workers and those in the surroundings. In the work environment, the disturbing sounds not only affect the hearing of employees but also have physiological and psychological implications (Passchier-Vermeer and Passchier, 2000; Sliwinska-Kowalska and Davis, 2012). Noise-induced hearing loss is one of the most common of all industrial diseases (Tak and Calvert, 2008). Chronic exposure to excessive noise can cause decreased hearing and auditory fatigue. What's worse, it leads to a change from temporary threshold shift to permanent threshold shift with the result of hearing impairment. Severe cases can cause noise-induced deafness. Although hearing loss is permanent and irreversible, it is preventable. Occupational hearing loss depends not only on intensity, exposure time, frequency, but also on type of noise and individual susceptibility (Doko-Jelinić et al., 2009). Shield the noise source, cut off the route of transmission, protect the susceptible population, can all reduce noise level.

In addition to auditory system specificity damage,

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exposure to noise also contributes to cardiovascular disease, psychiatric disorder, endocrine disorder, social behavior and performance non-auditory effects (Stansfeld and Matheson, 2003). Therefore, noise has systemic effects. Studies indicate noise-induced hearing loss may be associated with the chance for development of hypertension (Chang et al., 2011; Nawaz and Hasnain, 2010). Van Kempen et al. (2002) present a very nice meta-analysis of literature on noise exposure and blood pressure and ischemic heart disease, which is consistent with a slight increase of cardiovascular disease risk in populations exposed to environmental noise. Continuous exposure to occupational noise is strongly related with the prevalence of coronary heart disease (Gan et al., 2011). Some epidemiological studies have also suggested that chronic noise exposure may result in neurasthenic syndrome, such as headache, dizziness, insomnia, and memory loss.

Most of the researches focus on administrative controls, that is, on changing the behavior of workers rather than changing the noise in a permanent way. Yet little is known about the effective of this intervention (Verbeek et al., 2012). Few cigarette factory noise control studies are reported in the literature. However whether installation of absorbing materials is an effective way of reducing occupational noise remains unclear. In this study, we try to install sound absorbing materials on the ceiling and walls in a cigarette filter tip shaping room for the first time. Meanwhile we monitor the noise level and frequency spectrum in the workplace before and after noise control strategy.

MATERIALS AND METHODS

Noise control strategy

The filter tip shaping workshop mainly produces cigarette filters. It is from north to south, with a volume of 114×30×4.2 m^3. The north is sealed glass windows, and the remaining three sides are covered with concrete walls. Walls, floors and ceilings in the unit are general for factory. They are hard surface designed for durability and there is no obvious sound absorbing effect. The unit is located 14 sets of filter tip shaping machine aligned in parallel with 6 m space. Each machine with a length of 17 m is operated by 1 or 2 staff in turn who work 8 h shifts.

Taking into account, mechanical noise could not be controlled very well; we believed that the best approach to control the noise was to install sound absorbing materials. As a pilot study, we chose the Ecophon acoustic panels both on ceiling and walls. The Ecophon acoustic panels had two important features. On one hand it had good high frequency sound absorbing effect, on the other hand the surface covered with Akutex FT coating had stain-resistant and dustproof function. In this study, noise reduction project was in two parts, that is, the ceiling and walls. Figure 1 shows the effect of sound absorbing panels installed on the ceiling and walls. Master Solo S was hanged horizontally on the ceiling (1714 m^2). However, given the ventilation and lighting system, it was impossible to install horizontal panels. We chose the Master Baffle, that is, the vertical ceiling (318 m^2). In order to withstand the strong impact, the walls were embedded with Super G (903 m^2) except when met with doors or signaling devices.

Measurements

We chose the evenly distributed seven production lines and each production line testing three points (21 points in total). The three points (east, west and central) were along with the production line. In order to prevent any kind of reflection of sound, the east and west points were in pedestrian corridor centerline 2.0 m away from walls. And the central point was in the operating position 1.0 m away from the machine.

AWA6270+A noise meter (calibrated by Hunan institute of metrology and test) was used for objective measurement of the existing sound pressure level and frequency spectrum analysis. When all the machines were running normally, the noise level was horizontally tested at 1.5 m above floor and 1.0 m away from the conductor. Each point measured three times, and finally took the average. Then we opted the strongest point for frequency spectrum analysis. After sounding absorbing panel installation, we once again measured the noise intensity and frequency spectrum at the same workplace.

Statistical methods

Noise level statistical analyses were performed with Statistical Package for Social Science (SPSS) 13.0. And paired t test was applied to evaluate differences between the measurements before and after the workshop was treated with sound absorbing panels. The level of $P < 0.05$ was considered statistically significant.

RESULTS

Noise levels before and after panel addition

Workplace noise intensity was measured at 7 filter tip shaping machines 21 points. Table 1 showed the result of test before and after sound absorbing materials installation on the ceiling and walls. The sound pressure levels were attenuated after installation of sound absorbing panels. It could drop 6.5 dB(A) on average and 10.0 dB(A) at most. So it could reduce the intensity of sound by 8.0%. Significant differences were found before and after treatment ($t=14.606$, $P=0.000<0.05$). Therefore, the sound absorbing panels could dramatically reduce noise levels and provide sound reduction.

Frequency spectrum analysis of CX5 central before and after panel addition

Based on the analysis of frequency spectrum (Table 2 and Figure 2), acoustic noise was broadband and evenly distributed, peaking at frequency 500 Hz. After installation of sound absorbing materials, the sound pressure level of each frequency was lowered and the noise was reduced at most 9.3 dB(A). The high frequency noise (1000, 2000Hz) was decreased more sharply than low frequency noise. By comparison of these two groups of data, significant differences were found ($t=7.878$, $P=0.000<0.05$). Therefore, the sound absorbing panels prove to be true and could provide sound absorption as expected.

Figure 1. Ecophon acoustic panels installed on the ceiling and walls.

Table 1. Noise reduction before and after treatment (dB(A)).

Test location	Before treatment	After treatment	Reduction
CX1 east	77.8	70.2	7.6
CX1 central	81.5	78.8	2.7
CX1 west	80.5	76.8	3.7
CX2 east	77.7	69.3	8.4
CX2 central	83.5	79.7	3.8
CX2 west	80.6	75.6	5.0
CX3 east	76.9	69.7	7.2
CX3 central	81.7	78.6	3.1
CX3 west	79.5	73.3	6.2
CX4 east	81.8	71.8	10.0
CX4 central	84.5	77.5	7.0
CX4 west	83.4	73.8	9.6
CX5 east	82.0	73.5	8.5
CX5 central	86.2	79.7	6.5
CX5 west	83.7	76.1	7.6
CX6 east	81.0	74.3	6.7
CX6 central	80.7	74.7	6.0
CX6 west	81.9	76.8	5.1
CX7 east	79.6	71.4	8.2
CX7 central	80.5	74.8	5.7
CX7 west	81.7	74.6	7.1
Average	81.3	74.8	6.5

DISCUSSION

Due to the machinery used, noise in cigarette factories is obviously a prominent problem. Even though there are several methods to reduce or control the noise transmitted to the workers and the most effective of these is the engineering controls; that is, remove the noise at the source. However, applying this technique is relatively expensive and may not always be feasible or practical or may be insufficient to reduce noise to an acceptable level

Table 2. Spectrum analysis before and after treatment (dB(A)).

Center frequency (Hz)	Before treatment	After treatment	Reduction
125	80.5	77.5	3.0
250	86.9	81.5	5.4
500	88.7	82.2	6.5
1000	85.6	76.3	9.3
2000	83.4	74.4	9.0
4000	81.2	73.7	7.5
8000	78.1	72.6	5.5

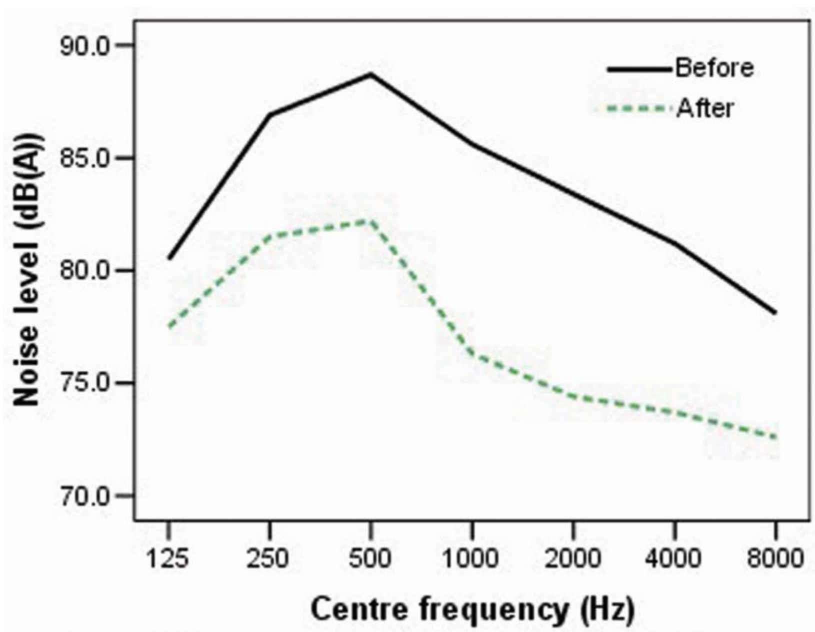

Figure 2. Frequency spectrum analysis of CX5 central.

(Lusk et al., 2003; Sahin, 2003). Hearing protection devices are known to be very effective, but they have two major problems: the inability to communicate and discomfort (Davis, 2008; Reddy et al., 2012). Therefore, most of the workers do not properly use these protective measures. In every effort to reduce the workshop noise, this study proposes an approach that add sound absorbing panels on ceiling and walls to attenuate noise transmission.

Prior to the noise treatment implementation, the maximum noise point (CX5 central) was 86.3 dB(A) which exceeded the International Labor Organization (ILO) recommended level in workplace. After treatment, the noise level dropped from 81.3 dB(A) to 74.8 dB(A) on average. And this was similar with the study (MacLeod et al., 2007) carried out in hospital. The different cavity depth, different arrangement type and its application may account for the difference. Thus one may be possible to gain even greater noise reduction than achieved in this study (6.5 dB(A)). As a qualitative and exploratory study, when the engineering and administrative controls are not feasible we strongly recommend it as an example for others to copy in noise reduction in cigarette factories.

Although the sound absorbing panels are proved to reduce noise to a relatively safe level, we should always pay attention to the chronic low level noise exposure on workers and protect their health. The effective method is occupational health examination once a year. With annual health examination, it is possible to detect a slight change before significant clinical symptoms appear.

Conclusion

Our findings indicate that the sound absorbing panels had a dramatic effect. Through the frequency spectrum analysis, the noise in the cigarette factory was broadband and evenly disturbed. And the frequency (1000, 2000Hz) noise was sharply attenuated, which was in consistent with materials' characteristics.

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International Journal of Physical Sciences

Full Length Research Paper

Discrete singular convolution for Lennard-Jones potential using Shannon kernel

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In this paper, the idea of discrete singular convolution (DSC) as a viable computation method for analyzing physical systems has been underlined. Discrete singular convolution has been used for solving the Schrödinger equation for water molecules, subject to the Lennard Jones potential, and the DSC differentiator has been used for obtaining the energy eigen-states of water, for a given grid size for discretization, along with the Shannon kernel for approximation of the singular delta-type kernel in the problem.

Key words: Discrete singular convolution, computational methodology, Schrödinger equation, Lennard Jones potential.

INTRODUCTION

In the world of computational methodology, one has global and local methods for analysis. Global methods are more accurate and localized than local methods. However, local methods are more useful for handling particular kinds of problems, especially those involving certain boundary conditions.

Discrete singular convolution (DSC) is a potential numerical approach for solving computational problems. Wei worked on the application of this method for problems such as the use of discrete singular convolution for solving the Fokker-Planck equation (Wei, 1999) analyzing the nonlinear dynamic response of laminated plates (Civalek, 2013) and free vibration analysis of multiple-stepped beams (Duan and Xinwei, 2013). The purpose of this paper is to use the DSC algorithm for the numerical solution of the Schrodinger equation for solving for the energy eigen values of the Schrodinger equation for the Lennard Jones potential in water using the Shannon kernel. This is along the lines drawn by *Wei* in his seminal paper on the topic (Wei, 2000).

The Lennard Jones potential has been a subject of interest among physicists with the associated computational methods used to analyze it. Huacuja et al. (2007) have analyzed the molecular configurations which minimize the Lennard Jones potential. Barr et al. (1995) and McGeoch (1996) have established the plinth of computational analysis in terms of statistical and experimental aspects of algorithms. As per one of the main criteria for computational methods, one needs to optimize the resources available in one's disposal for the evaluation or analysis of a problem. For studying problems involving either sample size approaching to infinity or a discontinuity in any variable, one needs to devise a way to circumvent this problem using the tools available. Barr et al. (1995), McGeoch (1996), Pattengale et al. (2009) and Terán-Villanueva et al. (2013) have proposed a set of principles that allow us to extract scientific knowledge from these methods. This includes relevant computational experiments, as per the literature related to the given subject, which must be reproducible and should relate with other studies carried out in the relevant field.

Solving the Schrödinger equation is a non-deterministic polynomial (NP) type of problem. This means that if the

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problem's solution can be guessed in some polynomial time, but no rule is followed on how to make the guess for the solution Arkady (2013). None of the instances of the equation's guessed solutions have yielded an algorithm for exactly solving this equation in a polynomial or reasonable number of steps for any quantum system. It is in this context that the idea of discretizing the Schrödinger equation for solutions becomes worth noting. For this one could use the idea of convolution, as in the case of discrete singular convolution (DSC), explained in the following section. More importantly, going by McGeoch's formulation, one needs to test the relevance of Wei's DSC algorithm for solving for the Schrodinger equation for more complex systems than the Morse potential for iodine.

DISCRETE SINGULAR CONVOLUTION

Discrete singular convolution is a general approach for numerically solving problems involving singular convolution such as in Hilbert transforms and Abel Transforms. Using the appropriate kernel, one can use the formalism to solve a number of physical problems. The discrete singular convolution approach is based on the theory of distributions. Let W be a distribution and $f(x)$ be an element of the space of test functions for the kernel. If W is a singular kernel, we can define what is known as the singular convolution:

$$F(x) = W * f(x) = \int_{-\infty}^{\infty} W(x-y)f(y)dy$$

One such kernel is the singular kernel of the delta type (δ). One must remember that the Dirac Delta function is a generalized function itself and not strictly a function, as per the conditions satisfied by functions. Since these are singular kernels, one cannot use them in computation methods. To overcome this problem, one defines a sequence of functions that are approximations of the distribution:

$$\lim_{\alpha \to \alpha_0} W_\alpha(x) \to W(x)$$

Here α_0 is the generalized limit. For a singular kernel of the delta type, one has a delta sequence.

Delta sequence

Any sequence of functions $f_n(x)$ which converges to the Delta function for $n \to \infty$. One can define the approximation to the convolution as:

$$F_\alpha(x) = \sum_j W_\alpha(x - x_j) \times f(x_j)$$

Here, $\{x_j\}$ represents the set of points for which the algorithm is defined. One must note that this algorithm is valid only for smooth approximations of the Kernel. One kernel of the Delta type is the Shannon kernel, which is defined as:

$$\frac{\sin\,(\alpha(x-x_0))}{(x-x_0)}$$

One often defines an algorithm sampling element or the *Nyquist* frequency for discrete singular convolution. It can be defined as:

$$\alpha = \frac{\pi}{\Delta}$$

One can then define the Shannon kernel as:

$$\frac{\sin\,(\frac{\pi}{\Delta}(x-x_0))}{\frac{\pi}{\Delta}(x-x_0)}$$

DSC approach for Schrodinger equation

We have a grid representation for the coordinate so that the potential part of the Hamiltonian is made diagonal. One can represent the Hamiltonian in the matrix form:

$$H(x_i, x_j) = -\frac{\bar{h}^2}{2m}\delta_\alpha{}''(x_i - x_j) + V(x_i)\delta_{ij}$$

where

$$\delta_\alpha{}''(x_i - x_j) = \frac{d^2}{dx^2}[\delta_\alpha(x - x_j)]|_{x=x_i}$$

and

$$\delta_\alpha(x - x_j) = \frac{\sin\,(\frac{\pi}{\Delta}(x-x_j))}{\frac{\pi}{\Delta}(x-x_j)}$$

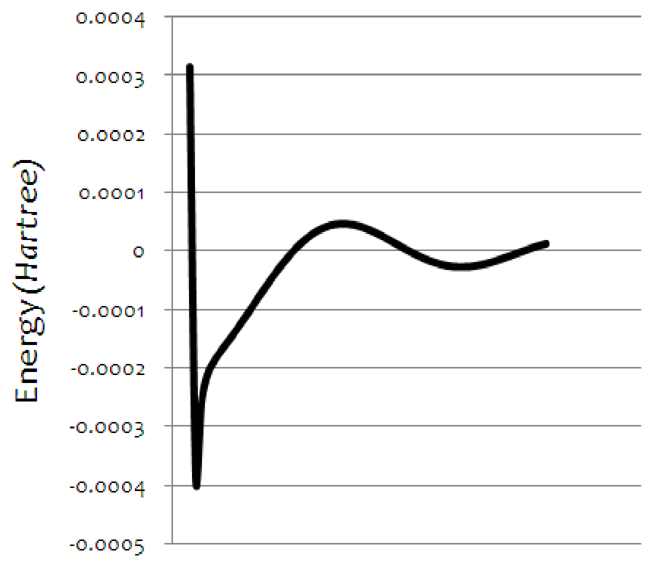
in this case.

Lennard Jones potential

Lennard-Jones potential describes the interaction between uncharged molecules. It is mildly attractive as two molecules approach each another from a distance,

Table 1. Energy Eigenvalues *(in Hartree)*

1.005E+03	8.074E-06	-2.730E-05	2.890E-06
2.294E-01	2.477E-06	-2.730E-05	1.282E-05
3.142E-04	-2.913E-06	-2.661E-05	2.156E-05
-3.876E-04	-7.982E-06	-2.523E-05	2.890E-05
-2.592E-04	-1.259E-05	-2.340E-05	3.509E-05
-2.122E-04	-1.668E-05	-2.106E-05	3.991E-05
-1.906E-04	-2.018E-05	-1.821E-05	4.335E-05
-1.755E-04	-2.294E-05	-1.505E-05	4.542E-05
-1.619E-04	-2.523E-05	-1.161E-05	4.633E-05
-1.484E-04	-2.661E-05	-7.982E-06	4.587E-05
-1.344E-04	2.913E-06	-4.312E-06	4.450E-05
-1.202E-04	6.285E-06	-6.400E-07	4.220E-05
-1.055E-04	9.381E-06	-6.124E-05	3.876E-05
-9.060E-05	1.216E-05	-4.679E-05	3.486E-05
-7.569E-05	-3.326E-05	-2.025E-05	3.005E-05
1.379E-05	1.945E-05	-8.166E-06	2.500E-05



Graph 1. Plot of eigenvalues obtained.

but is strongly repulsive when they are close to each other. The 12:6 Lennard Jones potential form is given as:

$$V = 4\varepsilon\left((\frac{\sigma}{r})^{12} - (\frac{\sigma}{r})^{6}\right)$$

METHODOLOGY

In this work, discrete singular convolution methodology was used to analyze the system of water molecules, subject to the conditions:

$$\sigma = 0.3166 \times 10^{-9} m$$
$$\varepsilon = 1.08 \times 10^{-21} J/mol$$

To begin with, the Hamiltonian matrix was obtained for the system, using the DSC-Hamiltonian matrix formulation (A), using the Shannon kernel, for the parameters,

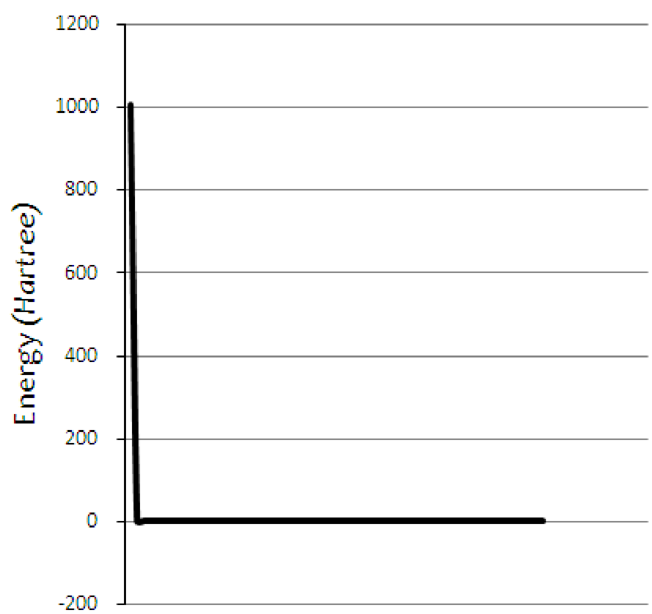
$$\Delta = 1 \times 10^{-12} m$$
r = 0.942×10^{-10} m.

the mean bond length of water.

Thereafter, the diagonalization of the matrix was carried out to obtain the eigen vectors of the given system, subject to the Lennard Jones potential.

RESULTS

For 64 grid-points for the DSC evaluation, the following eigen values were found in Table 1. Magnifying Graph 1, one finds these interesting characteristics. The representation for the entire range of eigenvalues gives us a graph similar to that for the Wigner Distribution (Graph 2). Wigner distribution is the probability



Graph 2. Wigner Distribution.

distribution on the interval [−*R*, *R*] whose probability density function is a semicircle of radius *R* centered at (0, 0), and given by:

$$f(x) = \begin{cases} \frac{2}{\pi R^2}\sqrt{R^2 - x^2}, -R \leq x \leq R \\ 0, R < |x| \end{cases}$$

This distribution arises as the limiting distribution of eigen values of symmetric matrices whose size approaches infinity. The given data complies with this distribution, and increasingly so as the number of grid points are increased from 16 to 64.

Conclusion

The discrete singular convolution method was studied and used for finding the eigen values of water molecules under the influence of the Lennard Jones potential.

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