Heavy Metals Concentration in Ground Water caused by Automobile Workshop Activities and its Health Implication on the Inhabitants of Makurdi Metropolis, Nigeria

Usman, A. A.
[1]*Department of Chemical Sciences (Chemistry), Salem University, Lokoja, Nigeria*
E-mail: adaji.andrew@yahoo.com

Odoma, A. N.
Department of Earth Sciences (Geology), Kogi State University, Anyigba, Nigeria

Ozulu, G. U.
Department of Earth Sciences (Geology), Salem University, Lokoja, Nigeria

ABSTRACT

This experimentation is conducted to assess the ground water in Makurdi metropolis, North Central Nigeria for possible contamination by automobile mechanic workshops. Water samples were collected systematically from some hand dug wells around the two oldest and largest mechanic workshops (Apir and Northbank mechanic villages respectively) within Makurdi metropolis. At each sample location, the water samples were collected from five different wells each 10m apart in the direction outward from the mechanic village. Reference samples were also collected about 150m away from the last well sampled in each of the sites to serve as control. Generally, heavy metal concentrations were found to be within the WHO acceptable limits for drinking water with the exception of Zinc (Zn) and Cadmium (Cd) concentrations which exceeded the WHO limits of 1.5mg/l and 0.001mg/l respectively in some of the samples. The results indicate that the activities taking place at the mechanic workshops affect the level of heavy metal concentrations in water in the areas. The elevated levels of heavy metals constitute a serious threat to both surface and groundwater, which have direct health implication on its users.

Keywords: *Heavy metals, mechanic workshops, ground water and WHO*

INTRODUCTION

Nigeria is the most populous country in Africa and one of the consequences of this is the vast number of vehicles that are used for commercial and private purposes. A common practice in Nigerian cities and towns is to allocate large portions of land, sometimes reaching 5 ha or more, to groups of small scale auto-mechanic businesses and designate these as ‘mechanic villages’ where they locate their workshops and repair yards to offer their services to the public. The larger the city, the larger is the number of such mechanic villages contained in it. It is presumed that there are environmental threats associated with this practice. Although few studies conducted on these auto mechanic villages have been reported for some small and medium size cities in the country namely: Iwo (Ipeaiyeda and Dawodu, 2008), Port Harcourt (Iwegbue, 2007), Akure (Ilemobayo and Kolade, 2008), and locations in the Imo river basin (Nwachukwu, Feng and Achilike, 2010), there is a need to conduct studies in other Nigerian cities so that ground water in contrast to surface water is naturally protected from chemical and biological contaminations and hence the preference for it by man (Adeyeye and Abulude, 2004). This protection can however, be limited to a number of activities. One of such activities is anthropogenic activity. Another is the disposal of hazardous industrial wastes on land and this has the potential for severe large-scale contamination. Sequel to the latter contamination source, toxic metals as well as organic substances have found their way into water resources. Heavy metals such as cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn) are principal pollutants of aquatic ecosystems because of their environmental persistence, toxicity and great potential of accumulation in the food chains. The consequences of these metal contaminants in water are widespread and are detrimental to the overall health status of the users. Sometimes water which collects on the top of the impervious layers may only be reached by digging deep down the water table. Such openings are known as wells.

The term heavy metal refers to any metallic chemical element that has a relatively high density (or specific gravity) greater than 5.0 and can be relatively toxic in small concentrations (Martin, Duncan and Coughtrey, 1982). The occurrence of the heavy metals is mostly in very small quantity in most environments. When they are found in more than the required quantity, then heavy metal pollution is said to have occurred. In natural water bodies, there are several sources of input of heavy metals and other chemicals which in very small quantities are required for growth in plants and animals; these when in high concentrations cause pollution to aquatic life and through the food chain to terrestrial animals and man. The toxicity of metals is dependent on their solubility and this in turn depends on the pH and on the presence of different types of anions and cations (Nduka and Orisakwe, 2007).

Makurdi is the capital city of Benue State in North Central Nigeria located in the middle belt zone of Nigeria. It is one of Nigeria's largest cities in this zone and it has an estimated motor vehicle population of over 100,000. These require regular maintenance provided for in more than five mechanic villages scattered around the city. Sizes of these villages vary but the typical medium sized village occupies about 5ha of land area, contains about 40 to 50 auto-mechanic workshops and serves about 400 to 500 vehicles daily. Activities conducted in these shops are typical of auto-mechanic repair shops and invariably involve working with and spilling of oils, greases, petrol, diesel, battery electrolyte, paints and other materials which contain heavy metals unto bare soil. A major source of well pollution to reckon with is the proximity of wells to drainages of sewage and laundry water as well as proximity to refuse dumps. Also the proximity of wells to mechanic village sites and small scale industries are a major source of well pollution. Drinking water plays an important role in the bodily intake of the elements by humans. Even though some metals are essential to man, at elevated levels, essential and non-essential elements can cause morphological abnormalities; reduce growth and increase mortality and mutagenic effects (Abulude, Obidaran and Orungbemi, 2007). The areas of study are the two largest and oldest mechanic village sites located within Makurdi metropolis. These are the mechanic villages at Apir and Northbank. These areas are characterized by a moderate population of humans with its chains of motor sprayers, vulcanizers and other various forms of business activities involving daily use of water. A major source of water supply in these areas is well water which is used for a number of purposes, for example, washing and mixing of chemicals as well as for drinking by residents around the villages. Improper waste disposal practices contaminate the soils and gradually the entire ground water in the area, impairing ground water quality for many applications including drinking.

The study of underground contamination will be of immense help to researchers and environmental regulators working in the area to understand and evolve by initiating remedial measures. Adelekan and Abegunde (2011) have studied heavy metals contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria and found that when compared to the limits set by WHO for drinking water, heavy metals with the exception of Cu were higher than the limits. Sachitananda and Prakash (2006) have studied ground water pollution at Mettupalyamtaluk, India and found that continuous disposal of industrial effluent on land which has limited capacity assimilating to the pollution load has led to ground water pollution. The aim of this research is therefore to assess the extent of pollution caused to well water in the area due to activities taken place at the mechanic villages and to compare the results with existing standards for water quality evaluation.

MATERIALS AND METHOD

Water samples were collected from the two major mechanic villages in Makurdi metropolis. At the Northbank mechanic village, water samples were collected from five different wells which were set at a distance of 10m apart as one moves out of the mechanic village (i.e. each well is separated from the next by 10m). Also at Apir mechanic village, water samples were collected from five different wells each 10m apart in the direction outward from the mechanic village. Reference samples were also collected about 150m away from the last well sampled in each of the sites to serve as control. Collection of samples was done using a clean plastic container which was dipped inside a well each time to draw water. The samples were then labeled and taken to the laboratory for analysis. Labelled plastic containers (thoroughly washed with distilled water and then with aqueous solution of 1:1 HNO_3) were used for collection and storage of the water samples. The water samples were preserved by adding to conc. HNO_3 gradually until the pH of the sample decreased to <2. This was to prevent the constituents under investigation from precipitation or from loss by adsorption or ion exchange within the walls of the container (APHA, 1985). Finally, the samples were stored in the plastic bottles and refrigerated below 4°C. The pH and temperature of the samples were determined immediately after sampling. The pH was measured with a pH meter (Hanna instruments, model 8621) using standard procedures (APHA 1985).

The methods used for determination of the metals are all detailed in APHA (1985). A 100cm^3 aliquot of the sample was digested with nitric acid in a beaker at 120°C until a clear solution was obtained. The samples were analyzed for zinc (Zn), copper (Cu), lead (Pb), iron (Fe), manganese (Mn), cadmium (Cd), chromium (Cr), arsenic (As), mercury (Hg) and silver (Ag) using Atomic Absorption Spectrophotometer (AAS) model 210 VGP, in the Soil science department, University of Agriculture, Makurdi. All assays were done in triplicates.

RESULTS AND DISCUSSION

The mean pH of the water samples were found to be alkaline ranging from 6.8 to 7.4 as shown in Table 1. They were all within the WHO recommended standard 6.5 – 8.5 (WHO, 2004). The results of the mean concentration of heavy metals in well water samples including the reference samples determined at the various locations are presented in fig 1 and 2 respectively. The concentrations of Fe, Pb and Cu in the wells at the two sites were generally found to decrease steadily with increasing distance away from the mechanic villages. Fe enters underground water sources from deterioration of metal scraps and other iron materials (GEMS, 1992). Possible sources of Pb in water include motor batteries and lead materials used by mechanics. Copper is used in electroplating of metals to prevent corrosion and may enter water when it deteriorates. Fe, Pb and Cu were all found to be within the WHO limits of 1.0 mg/l, 0.1 mg/l and 1.5 mg/l respectively (WHO, 1985).

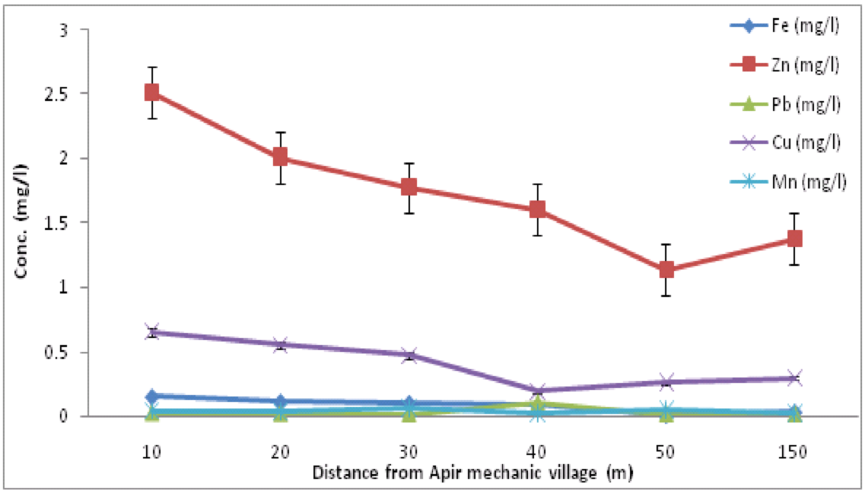
The highest concentration of 2.510 mg/l was obtained for Zn at Apir mechanic village. Zinc (Zn) concentrations were found to gradually decrease with increasing distance away from the sites. The results obtained for Northbank mechanic village showed that the Zn concentration were within the WHO limits of 1.5 mg/l (WHO, 1985), whereas the concentration at Apir mechanic village showed an increase in Zn concentration above the maximum allowable limits. This may be attributable to the age of the mechanic village and also the fact that it has an increased activity over the Northbank mechanic village owing to its size. The higher Zn concentrations here can be largely attributed to the fact that zinc is used in galvanizing most iron materials and these materials are among the major materials that are found in the mechanic villages. When these materials disintegrate, it is the outer layer made up of Zn that corrodes first into water thereby polluting it. According to APHA (1985) and GEMS (1992), Zn may enter underground water from deterioration of galvanized iron. Manganese (Mn) at both sites was also found to be within the acceptable limits of 0.5mg/l set by WHO although there was an irregular pattern of concentration versus distance as shown in the charts. One can deduce that Mn concentrations in water could be mainly from sources other than from mechanic activities. The concentration of cadmium (Cd) was observed to be above the WHO allowable limits of 0.001 mg/l. It also decreases at distances away from the sites. The chemistry and occurrence of Cd is similar to that of Zn. It is found in nature largely as an impurity of Zn-Pb ores. Cd may be present in wastes from electroplating plants, pigment works, textiles, metallurgical operations among others (GEMS, 1992). Groundwater Cd concentrations as great as 3.2 mg/l have been reported to result from the seepage of Cd from electroplating plants (GEMS, 1992).

Both mercury (Hg) and silver (Ag) concentrations in the sites investigated generally decrease with increasing distances away from the mechanics villages and are within the allowable limits of 0.001 mg/l and 0.05 mg/l respectively set by the WHO in 1985. Even though the concentration of chromium (Cr) falls within WHO standards which are 0.05 mg/l, it shows an irregular pattern at the Apir mechanic village. Steels are at times coated with Cr which helps to prevent the steel from rusting. When this deteriorates, it finds itself in underground waters through seeping. The higher concentrations of Fe, Zn, Cu and Mn obtained for the reference samples at Apir mechanic village over the concentration at 50m away from the site might be due to the proximity of the mechanic village to the surrounding settlements where their activities may influence metal concentrations. The higher concentration of these heavy metals poses serious health hazard to users of the sampled water. This buttresses the observation of Abulude, Obidaran and Orungbemi (2007) that though some metals are essential to man, yet, at elevated levels essential and non essential elements can cause morphological abnormalities, reduced growth and increase mortality and mutagenic effects.

Table 1: Mean pH and Temperature of water samples

Distance from Mechanic village (in metres)	Apir Mechanic Village		North bank Mechanic Village	
	pH	Temp (°C)	pH	Temp (°C)
10	6.7	28	7.0	29
20	6.6	29	6.8	27
30	7.4	28	6.9	28
40	6.8	29	7.2	28
50	7.1	29	7.0	28
150	7.3	28	6.8	28

Source: Experimentation, 2013



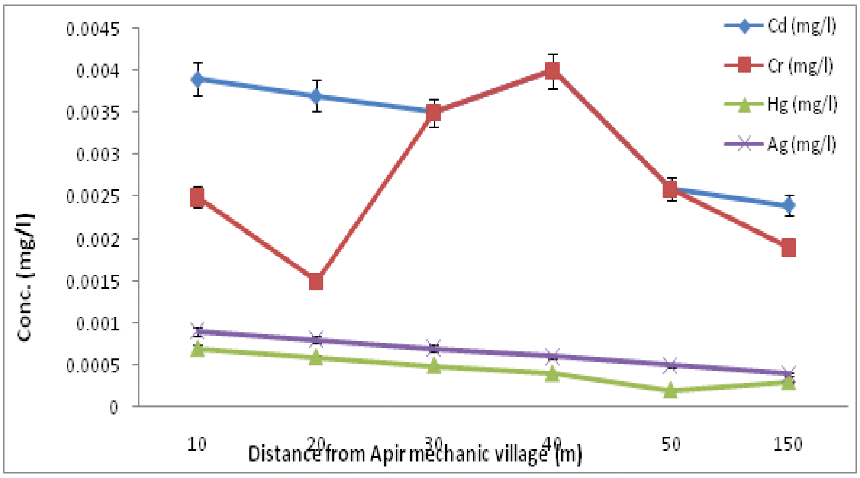
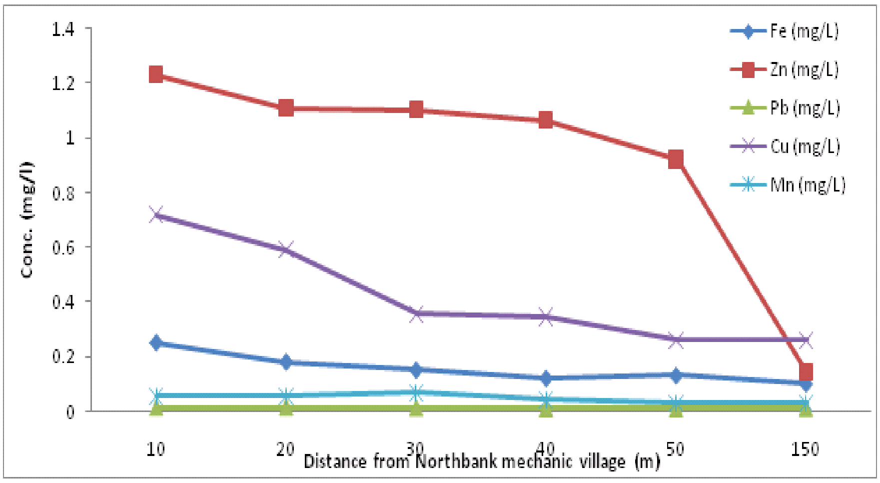


Fig 1: Mean Heavy metal concentrations in wells at Apir mechanic village



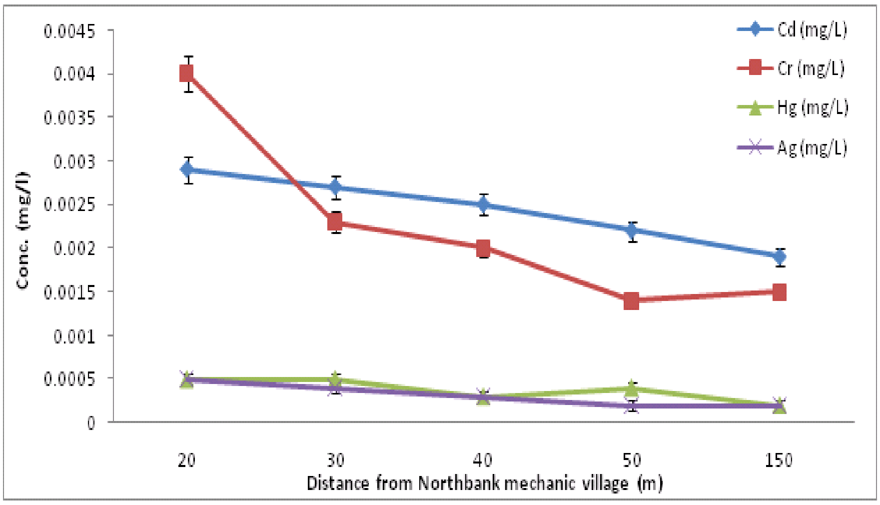


Fig 2: Mean Heavy metal concentrations in wells at Northbank mechanic village

CONCLUSION

It has been generally observed that the concentrations of heavy metals studied at Apir mechanic village were higher than those at Northbank. This may be attributed to the larger scale mechanic activities taking place there. The concentration of Zinc at Apir mechanic village is well over the allowable limits set by the WHO and thus have a serious negative health impact on the users of the sampled waters. Also both sites show an increase in Cd concentration over the maximum allowable limits set by WHO for drinking water. Apart from these, all the metals investigated have their concentrations within the acceptable limits of the WHO. The behaviour of Mn and Cr concentrations showed that their presence in water might not be primarily due to the mechanic village activities but from other sources. The results obtained from the reference samples indicated that to a large extent, the activities taking place at the mechanic villages really affect the level of heavy metals. It is recommended that,

i. to avoid high level concentrations of these metals in water, wells which are used for drinking should not be dug near mechanic villages;

ii. Adequate measures should be taken immediately to ensure a regular and adequate supply of treated water to the area. This will reduce the use of well water to activities other than for drinking purposes; and

iii. Mechanic materials which are considered as scraps should be dumped far away from settlements to avoid the seeping of these metals to underground waters due to disintegration. Also, such materials may be recycled (instead of indiscriminate dumping) and new items of significant use made out from them.

REFERENCES

Abulude F. O., Obidaran G. O. and **Orungbemi S.** (2007). Determination of physio-chemical parameter and Trace metal conducts of drinking water samples in Akure, Nigeria. *American Public Health Association Electronic Journal of Environmental Agricultural and Food Chemistry,* 6(8), pp 2297-2303.

Adelekan, B. A. and **Abegunde K. D.** (2011). Heavy metals contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria. *International Journal of the Physical Sciences,* 6(5), 1045-1058.

Adeyeye E. I. and **Abulude E. O.** (2004). Analytical assessments of some surface and ground water resources in Ile-Ife, Nigeria. *Journal of Chemical Society of Nigeria,* 2004, 98-103.

American Public Health Association (APHA) (1985). Standard Methods for the Examination of Water and Waste. 16thEdn., Washington, D. C.

GEMS/Water Operational Guide (1992). *UNEP/WHO/UNESCO/WMO* Project on Global Water Quality Monitoring 3rd Edition.

Ilemobayo, O. and **Kolade I.** (2008). Profile of Heavy Metals from Automobile Workshops in Akure, Nigeria. *Journal of Environmental Science and Technology,* 1, 19-26.

Ipeaiyeda, A. R. and **Dawodu, M.** (2008). Heavy Metals Contamination of Topsoil and Dispersion in the Vicinities of Reclaimed Auto-repair Workshops in Iwo Nigeria. *Bulletin of Chemical Society of Ethiopia,* 22(3), 339-348.

Iwegbue, C. M. (2007). Metal Fractionation in Soil Profiles at Automobile Mechanic Waste Dumps around Port Harcourt. *Waste Management Research,* 25(6), 585-593.

Martin, M. H., Duncan, E. M. and **Coughtrey, P. J.** (1982). The distribution of heavy metals in a contaminated woodland ecosystem. *Environmental Pollution (B)* (3), 147–57.

Nduka, J. K. C. and **Orisakwe, O. E.** (2007). Heavy metal levels and physic-chemical quality of potable water supply in Warri, Nigeria. Annali di Chimica, 97, 867-874.

Nwachukwu, M. A., Feng, H. and **Achilike, K.** (2010). Integrated Study for Automobile Wastes Management and Environmentally Friendly Mechanic Villages in the Imo River Basin, Nigeria. *African Journal of Environment, Science and Technology,* 4(4), 234-249, Available online at *www.academicjournals.org/AJEST.*

Sachitananda, M. and **Prakash, N.** (2006). Ground water pollution and emerging environmental challenges of industrial effluent irrigation-A case study of Mettupalyamtaluk, Madras school of economics, Chenni, India working paper 7-*www.msc.ac.in/pub/mukpra.pdf.*

World Health Organization (2004). *World Health Organization. Guidelines for Drinking-Water Quality* (3rd Edn.) Vol. 1: Recommendations. Geneva, Switzerland: WHO.

World Health Organization (1985). World Health Organization. Guidelines for Drinking-Water Quality (2nd Edn.) Vol. 1: Recommendations. WHO, Geneva.