MERIT RESEARCH JOURNALS
www.meritresearchjournals.org

Merit Research Journal of Environmental Science and Toxicology (ISSN: 2350-2266) Vol. 5(2) pp. 018-024, August, 2017
Available online http://www.meritresearchjournals.org/est/index.htm

Original Research Article

Groundwater Quality Attrition by Mechanic Workshop Activities in Abeokuta Metropolis, Ogun State, Nigeria

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Abstract

The influence of groundwater contamination is on the rise especially within the industrial vicinity as a result of carelessness as observed in many mechanic villages in Nigeria. The objective of this study is to determine the presence and concentration of heavy metals within the demonstrated area so as to ascertain the long term effect of those activities on the resultant environment. The study was carried out at mechanic villages at Kotopo and Ajebo around Abeokuta, Ogun state. Water sample was collected from each location making up for a total of 10 samples and was analysed for the physical, chemical and heavy metals using standard procedures. The study revealed that all physical and chemical parameters are within the W.H.O standard except for nitrate. Also, of all the eight heavy metals analysed, only cadmium (0.059 mg/L) and cobalt (0.106 mg/L) exceeds the W.H.O standard. Lead, copper, nickel and iron were below the detection limit in the water samples in many cases. The study concludes that the rate of heavy metal leaching into groundwater is relatively slow compared to the workload that involved heavy metals in the study area and this is because of lack of permeability of the substance through the soil because of oil surfaces. Except for nitrate (21.88 mg/L), other chemical parameters also are within the W.H.O recommended standard. Nevertheless, precautions must be taken in order to prevent the excess leaching of heavy metal in the nearest future.

Keyword: Concentration, Groundwater, Heavy Metal, Lead, Soil, Mechanic Village

INTRODUCTION

Fresh drinking water makes up only 6% of the total water on Earth and 100% of the world's population relies on it, while only 0.3% of the water on Earth is usable for drinking and the majority of that is groundwater. Millions of people in the developing world rely heavily on groundwater, mostly through shallow dug wells. These can easily become polluted, primarily because of anthropogenic activities. Such activities can be categorized mainly into four groups namely agriculture, municipal, industrial, and as well as individual sources.

Leaching is the natural process by which water soluble substances from agricultural, domestication and industrial activities are washed out from soil or waste and carried downward through permeable soil called leachates and subsequently pollutes of surface and subsurface water.

Groundwaters are waters located beneath the surface in soil pore spaces and in permeable geological formations and are sourced from seepage from the land surface such as rainwater, snowmelt and water also that permeates down from the bottom of some lakes and rivers. Groundwater can be contaminated by naturally occurring sources as well as through human influence such as agriculture and industrialization. Groundwater can also be contaminated through soil and geographical

Table 1. W.H.O Standards for the Parameters Analyzed

Parameter	W.H.O Standard
Turbidity	5NTU
pH	6.5 – 8.5
Electrical Conductivity	100 μ cm^{-1} at 25^{o}C
Total Dissolved Solid	500mg/L
Total Alkalinity	100mg/L
Nitrate	10mg/L
Chloride	250mg/L
Total hardness	100mg/L
Sulphate	250mg/L
Dissolved Oxygen	2.0mg/L(min)
Total acidity	100mg/L
Lead	0.015mg/L
Cadmium	0.002mg/L
Zinc	1.5mg/L
Manganese	0.5mg/L
Iron	0.03mg/L
Copper	0.002mg/L
Nickel	0.02mg/L
Chromium	0.10mg/L
Cobalt	0.15mg/L

Source: W.H.O Standard, 2011.

formation which contains high level of heavy metals and I leached through erosion and other means and could be compounded through agricultural means by over pumping such wells.

Heavy metals are natural components of the earth's crust. They cannot be degraded or destroyed. To a small extent they accumulate to our body via food, drinking water and air. As trace elements, some heavy metals are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance from drinking water contamination (e.g. lead pipes), high ambient air concentrations near emissions or intake via the food chain. In the soil system, pollution by toxic metals is due to both biogenic processes (weathering of minerals) and anthropogenic activities (agriculture, burning of fossil fuels, industry, scrap yards, vehicular emissions, mining and metallurgical processes and waste disposal) as investigated by Kumar, 2005, Biasioli *et al.,* 2006, and Martin *et al.,*1998 while concluding that heavy metal contamination in the soil-water-plant ecosystem is of great importance because of possible influence on food chain(Gray *et al*.,2003)

Heavy metal contaminants could bechemicaland biological processesin nature with a potential impact on human health and environmental welfare (Giuliano *et al.,* 2007). The presence of heavy metals in and around urban areas has been an area of great concern due to their long persistent nature and long biological half–lives within the human system when taken. Negative effects due to heavy metal contamination in surface and underground water are well established by Tumuklu, 2007 for Manganese, Chromium and Zinc causing neurosis and chlorosis while Nickel, Cobalt and Cadmium hinder stomata activity and decrease photosynthesis in plants (Prasad and Sangita, 2008). Aluminum, Cobalt, Copper, Iron, Lead, Manganese, Nickel and Zinc were reported to causepotential hazards in water *Grigalavicience et al.,* 2005, and Tumuklu *et al.,* 2007).

Heavy metals are dangerous because they tend bio-accumulate. Bio-accumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things anytime they are taken up and stored faster than they are broken down (metabolized) or excreted.

This study tends to determine the concentration of heavy metals in ground water at mechanic villages around Abeokuta (Mechanic village at Kotopo camp and mechanic village at Ajebo, Abeokuta, Ogun State) and to this effect, it considered the presence and concentration of heavy metals within the demonstrated area by assessing the physical and chemical and heavy metal constituents in the two mechanic villages by ascertaining the long term effect of those activities on the resultant environment thereby finding similarities in pollution within them. (Table 1)

General environment of study area

The study was carried out in Abeokuta, capital of Ogun state and the traditional home of the Egbas. Geographically, Abeokuta lies in latitude 7^{o}9'39''N and

Table 2. Showing Methods of Different Samples Analysis

S/N	Parameter	Equipment And Method Description
1	Dissolved oxygen	Titration
2	Temperature	Thermometer
3	pH	pH meter
4	Electrical conductivity	EC meter
5	Total dissolved solid	TDS meter
6	Acidity	Titration (phenolphthalein)
7	Alkalinity	Titration (methyl Orange)
8	Total hardness	Titration method
9	Turbidity	Turbidimetric
10	Chloride	Titration method
11	Sulphate	Spectrophotometer
12	Nitrate	Spectrophotometer
13	Lead	Atomic absorption spectrophotometer
14	Cadmium	Atomic absorption spectrophotometer
15	Copper	Atomic absorption spectrophotometer
16	Iron	Atomic absorption spectrophotometer
17	Zinc	Atomic absorption spectrophotometer
18	Manganese	Atomic absorption spectrophotometer

Source: Standard laboratory procedure, 2014

longitude 3°20'54''E. The town is about 81km south-west of Ibadan, Oyo state capital. Abeokuta lies at an altitude of about 157metres above sea level amidst isolated out crop of natural formation of granite rocks which gives the towns landscape its undulated characteristics. The two major locations where the samples are collected is Mechanic Village, Ajebo, Abeokuta Ogun State which lies in latitude of 7°9'38.999N'', and longitude of 3°20'53.998''E, and altitude of 79metres and Mechanic Village, Camp, Abeokuta Ogun State which lies in latitude of 7°10'59.59''N and longitude of 3°25'24.346''E, and altitude of 124metres.

Sources and sample collection (water samples)

Water was collected at mechanic village in camp Kotopo and Ajebo Abeokuta, Ogun state with a 2L white clean plastic kegs for physical and chemical analysis, sample kegs were labeled with the location time of collection and sources of the water. The plastic kegs used in sample collection were rinsed with distilled water and water samples that were to be collected. After the collection of the 10 water samples (5 each from the two locations) the samples were transferred to the laboratory for further analysis.

Sample analysis

The laboratory analysis conducted on the water samples is a comprehensive analysis which includes;

- Physical parameters
- Chemical parameter
- Heavy metals determination

METHODS OF ANALYSIS/DETERMINATION

Some of the analytical methods used for the analysis of the water samples collected in the study area include (Table 2);

RESULT AND DISCUSSION

Table 3-7 shows the results of the mean physical, chemical and heavy metal characteristics of water samples collected at two different mechanic villages in Abeokuta, Ogun State. All samples are colourless except for sample 1 has a faint colour (using visual aid), all sample are odourless except for sample 4 has a foul odour. Other water samples except for sample 1 and 4 were colourless and odourless.

The pH of samples 1-10 of the water sample was between 7.42-7.75 which fell within the range of 6.5- 8.5 as specified by W.H.O (2011). According to the pH values obtained, majority were in the range of slightly alkaline. Therefore, the water samples were unlikely to cause health problems like acidosis (Asamoah, 2011). pH is one of the parameter that addresses the aesthetic quality of water such as taste which has no serious health significance (WHO, 1996).

The temperature reading of the water sample 1-10 was between 27.00- 28.90°C. The temperature values obtained in the water samples fell within the optimal growth range for mesophilic bacteria including human pathogens. The microbiological characteristics of drinking

Table 3. Statistical Analysis of Result to the Mean Values of pH, Temperature, Electrical Conductivity and Total Suspended Solids

Samples	pH	Temperature (^oC)	EC (μ cm^{-1}) at 25^{o}C	TDS (mg/L)
1	7.65	28.60	210.00	105.00
2	7.42	28.40	376.00	188.00
3	7.63	28.50	339.00	169.50
4	7.74	28.90	227.00	113.50
5	7.56	28.30	354.00	177.00
6	7.75	27.50	290.00	145.00
7	7.67	27.20	114.00	57.00
8	7.71	27.00	265.00	132.50
9	7.72	27.90	208.00	104.00
10	7.70	27.60	194.00	97.00
Average ± S.D	7.66 ± 0.10	27.99 ± 0.64	257.70 ± 82.58	128.85 ± 41.29

S.D = Standard Deviation
Sources: Author's Laboratory Computation, 2014.

Table 4. Statistical Analysis Result to the Mean Values of Total Acidity, Total Alkalinity, Total Hardness and Dissolved Oxygen

Samples	Total acidity (mg/L)	Total alkalinity(mg/L)	Total hardness (mg/L)	D.O (mg/L)
1	20.00	30.00	55.00	3.90
2	17.00	22.00	40.00	4.40
3	23.00	40.00	67.00	5.20
4	21.00	15.00	36.00	4.80
5	24.00	38.00	42.00	4.61
6	13.00	17.00	20.00	2.80
7	16.00	16.00	27.00	2.00
8	19.00	17.00	35.00	1.90
9	16.00	17.00	40.00	1.80
10	13.00	15.00	24.00	2.20
Average ± S.D	18.20 ± 3.85	22.70 ± 9.71	38.60 ± 14.16	3.36 ± 1.35

S.D = Standard Deviation
Sources: Author's Laboratory Computation, 2014.

Table 5. Statistical Analysis Result to the mean values of Nitrate, Sulphate, Chloride and phosphate

Samples	Nitrate (mg/L)	Sulphate (mg/L)	Chloride (mg/L)	Phosphate (mg/L)
1	14.42	13.23	25.00	1.47
2	34.56	15.26	41.00	0.29
3	11.88	8.87	35.00	1.23
4	10.25	10.81	42.00	1.60
5	18.32	5.00	38.00	0.94
6	8.89	4.35	30.00	2.19
7	24.13	6.13	30.00	0.48
8	23.49	20.32	70.00	4.23
9	32.56	12.74	50.00	1.11
10	40.27	4.52	46.00	7.05
Average ± S.D	21.88 ± 11.02	10.12 ± 5.33	40.7 0± 12.87	2.06 ± 2.07

S.D = Standard Deviation
Sources: Author's Laboratory Computation, 2014.

Table 6. Statistical Analysis Result to the Mean Values for Lead, Cadmium, Copper and Manganese

Samples	Lead	Cadmium	Copper	Manganese
1	N.D	0.0628	N.D	N.D
2	N.D	0.0636	N.D	N.D
3	N.D	0.0592	N.D	0.0378
4	N.D	0.0583	N.D	0.0693
5	N.D	0.0558	N.D	N.D
6	N.D	0.0576	N.D	N.D
7	N.D	0.0563	N.D	N.D
8	N.D	0.0588	N.D	0.0249
9	N.D	0.0529	N.D	0.0528
10	N.D	0.0576	N.D	N.D
Average ± S.D	N.D	0.0583 ± 0.0032	N.D	0.0462 ± 0.0192

N.D = Not Detected, S.D = Standard Deviation
Sources: Author's Laboratory Computation, 2014

Table 7. Statistical Analysis Result of the Mean Values for Iron, Zinc, Nickel and Cobalt

Samples	Iron	Zinc	Nickel	Cobalt
1	N.D	N.D	N.D	±0.0211
2	N.D	±0.0050	N.D	±0.6057
3	N.D	N.D	N.D	±0.0551
4	N.D	N.D	N.D	±0.0216
5	N.D	N.D	N.D	±0.0897
6	N.D	±0.0013	N.D	±0.0893
7	N.D	N.D	N.D	±0.0059
8	N.D	±0.0059	N.D	±0.0875
9	N.D	±0.0072	N.D	±0.0063
10	N.D	±0.0113	N.D	±0.0781
Average ± S.D	N.D	0.0061 ± 0.0036	N.D	0.1060 ± 0.1790

N.D = Not Detected, S.D = Standard Deviation
Source: Author's Laboratory Computation, 2014.

water are related to temperature through its effects on both growth and survival of microorganisms (WHO, 1996). Consequently, the growth of microorganism is enhanced by warm temperature conditions and could lead to development of unpleasant taste and odour.

Electrical conductivity values express the amount of dissolved solids in the water sample. Dissolution of solid minerals in water enhances its conductivity of electricity via soluble ions of minerals. The electrical conductivity of the water samples collected at different mechanic villages fell between 114.00 –376.00 μ cm^{-1} at 25°C which fell within the recommended standard by WHO and NAFDAC.

The values of dissolved oxygen obtained from the analysed sample ranged from 1.80 and 5.20 mg/L. Growth of aerobic and facultative anaerobic bacteria is enhanced by the presence of dissolved oxygen.

The chemical characteristics of all brands of water samples evaluated fell within the range of standards values recommended for chloride, total hardness, phosphate, nitrate, sulphate, total acidity and total alkalinity by WHO and NAFDAC. The implication of this result is that the analysed water sample is a good source and is not affected by any geological formation or previous land use of the area.

Level of chloride in the analysed sample ranges from 25.00-70.00mg/L. Chloride ions are non- cumulative toxins an excess of which if taken over a period of time will constitute a health hazard. W.H.O 2011 recommended 250mg/L as the maximum chloride ion level allowable in drinking water. It is believed that higher concentration of chloride ion may result in taste problems. High level of chloride is known to impact taste problems particularly when sodium is the predominant cation (APHA, 1998).

The value of total hardness in the analysed sample ranges from 20.00- 67.00mg/L. However, the level of total hardness in the samples fell within the range of total hardness (100mg/L) as recommended by W.H.O and NAFDAC. However, Calcium contributes appreciable to total harness and it presence could be attributed to the geological formation of the area.

The level of anions such as phosphate, calcium and sulphate in the analysed water samples also meet the recommended standards. The value of phosphate ranges from 0.29 -7.05mg/L. Only sample 10 has a value which is above the recommended standard by W.H.O (5.0mg/L) and sample 2 has the lowest value of 0.29mg/L. The value of nitrate ranges from 8.89 – 40.27mg/L which fell far above the recommended standard (10 mg/L) .Decrease in the value of nitrate is attributed to their utilization by microorganisms for growth and reproduction (Prescott et al., 1999).

Heavy metals

Heavy metals such as Zinc, Cobalt, Cadmium and Manganese were detected in the water sample. Other heavy metals such as Lead, Copper, Iron and Nickel were below the detectable limits of the metals; hence they were not detected in the water sample.

The value of Zinc in the analysed sample ranges from 0.0013- 0.0113 mg/L which is below the recommended standard by WHO (1.5mg/L). This however has no health and environmental implications. Excess amount of Zinc can cause dysfunctioning that result in the impairment of growth and reproduction (INECAR, 2000). The clinical signs include vomiting, diarrhea, bloody urine, icterus, liver failure, kidney failure and anemia (Fosmire, 1990).

The value of Cobalt in the analysed sample ranges from 0.0063 – 0.6057 mg/L which falls above the recommended standard by W.H.O (0.15mg/L). Excess amount of cobalt intake result in convulsion, stomatitis and gastrointestinal disorder and other environmental damages (McCluggage, 1991).

The value of Cadmium in the analysed sample ranges from 0.0529- 0.0636mg/L which fell above the recommended standard of W.H.O (0.002mg/L). The implication of this when it builds up in the kidney, it hinders the filtration system which eventually lead to kidney failure and other health effects such as stomach pain and infertility and it is considered carcinogenic. It also harms the central nervous system as well as damage to DNA. Inhalation of cadmium can lead to severe damage of the lungs and even death (Lenntech, 2011).

The value of manganese in the analysed sample ranges from 0.0249-0.0693mg/L which fell below the recommended standard of W.H.O (0.5mg/L). The intake of such elements results to gingivitis, stomatitis, neurological disorder, total damage to the brain and central nervous system (Ferner, 2011).

The other heavy metals were not detected in the water sample. However, when those metals exceed the recommended standard, the result in different problems such as nausea, vomiting, fatigue, high blood pressure and in more extreme cases, brain damages and death amongst others (chemistry explained, 2011)

CONCLUSION

The study concluded that heavy metals such as Zinc, Cobalt, Cadmium and Manganese were detected in the water sample. Other heavy metals such as Lead, Copper, Iron and Nickel were below the detectable limits of the metals; hence they were not detected in the water sample.

Chemical parameters such as total acidity, total alkalinity, total hardness, dissolved oxygen, chloride, phosphate, sulphate, and nitrate were also detected in the samples but only exceed the recommended standard of W.H.O.

From the studies which has wide implication to other mechanic villages, it can also be concluded that the rate of heavy metal leaching into groundwater is slow compared to the workload that involved heavy metals in the area as most of the analysed heavy metal were not detected and might has be deconcentrated to extinction within the soil or prevented from getting to the groundwater water because of impermeability of the soil by oil substances blocking the pores of the soil thereby preventing entrance.

As a result of continuous mechanical and industrial activities, the rate of heavy metals leaching into the ground water will with time contribute to ground water contamination and more so, when the groundwater is contaminated, it becomes very difficult to remediate unless in small defined areas where more emphasis is on the prevention rather than the treatment.

More importantly, mechanics, and individuals that deals with heavy metals should be enlighten about the likely damages that may occur as a result of their actions to the environment as a whole and to them as individuals. Protection of sensitive and nearby water bodies should also be of great concern; they should learn to treat the metals to the acceptable standards before discharging it into water bodies.

Laws should be enacted by able governmental bodies and environmental officers should be assigned to mechanic villages to monitor their activities and compliance to the rules and regulations set by the government

Proper drainage, sanitation and self cleanliness practices should also be employed by individuals and members of the same mechanic villages.

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