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Investigation of Selected Heavy Metal Concentration in the Groundwater of Coal Camp and Abakpa Nike, Enugu, Nigeria

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ABSTRACT: The presence of heavy metals in water is widespread, affecting hundreds of cities. In high dosages, these heavy metals are toxic to human, even deadly. The study was therefore aimed at investigating the heavy metal concentration on the groundwater of Enugu. Three (3) groundwater samples each were collected from Coal Camp and Abakpa Nike and the samples acidified with drop of nitric acid before it was sent for analysis at Union Recycling Plant, Ibeto Group of Companies, Nnewi, Anambra State. The analyzed heavy metals are: As, Cr, Pb, Fe, Zn, Cu, Mg, Cd and Hg. The results revealed heavy metal contamination of the groundwater of the area. The study tested whether there is significant difference between the selected heavy metals concentration from that of W.H.O standard. When compared with WHO standard, As, Cr, Pb and Hg of the groundwater of Coal Camp showed significant difference, whereas that of Abakpa Nike showed no significant difference with the standard. To remediate the effects of the polluted water in some parts of the area, it is recommended that a systematic study of the heavy metals concentrations in groundwater sources should be carried out regularly. This is very imperative as the inhabitants of the area depend on groundwater for drinking purposes. More importantly, mass awareness should be generated about the effects of improper and careless waste disposal on water quality and human health.

KEYWORDS: industrial, Pollutants, contamination, health, safety.

1 INTRODUCTION

Water is a marvelous substance flowing, rippling, swirling around obstacles in its path, seeping, dripping, trickling, and constantly moving. According to Miller [1], we live on a water planet. Current estimate indicates that the total volume of water on earth is 1.4 x 10 km, 97.3% of which is ocean and seawater and the rest 2.7% is freshwater [2]. For all practical purposes, it is surface water and part of groundwater amounting to 1% of total freshwater that constitutes the basic available supply for man. Thus, it is one of the scarcest resources, it is one of the essential requirements of human life, without which survival is not possible.

Groundwater is essential for human survival [3]. Groundwater supplied for human consumption should not only be safe but also wholesome [4]. [4] defined safe and wholesome water as water that is free from pathogenic agents; free from harmful chemical substances, pleasant in appearance, odour and taste; and usable for domestic purposes. The negative aspects of water signify adversity, and its total absence, inadequacy or poor quality has a direct effect on the health of the people and the environment all over the world [1]. The primary adverse human impact on water is felt in the area of water quality.

Groundwater supply is contaminated from natural source and/or anthropogenic sources and can be interrupted by chemical, biological or physical contaminants from industries, agricultural wastes, non-point source pollution and spills [5]. The most chemicals involved are petroleum, hydrocarbons, solvents, pesticides, and heavy metals. The occurrence of this phenomenon is correlated with the degree of industrialization and intensities of chemical usage [6]. Consequently, various levels of wastes in different states, including solid, liquid and gaseous, are released into the environment at discrete intervals or on continuous basis. These pollutants and contaminants, which may have short or long half-lives in the environment, have continued to damage the environment, having defied many painstaking control programs [7].

1.1 STUDY PROBLEM

Coal Camp is an industrial area in Enugu State, with abundance of auto-repair and servicing outlets and their associated businesses. Metallic materials like engine blocks, pistons, rings, rim; plastic products like fan belts and other numerous associated automobile parts, motorcycles, tricycles, refrigerators and air conditioners abound. Thinners paints, and sprays which are made of lead, chromium, cadmium etc and used or spent fuel and oil are carelessly discarded and dumped on the soil and ground. Similarly, Abakpa Nike is the largest town in Enugu State with its attendant population and waste generation. Wastes are disposed carelessly in open dump and left to accumulate and pose serious threat to the environment. These include household wastes, medical wastes and others.

These products are left on the open space; rain continuously falls on them, resulting to rusting and corrosion. The resultant particles are washed by flowing rainwater giving rise to pollutants movement via the hydrologic environment. These seep or percolate into the groundwater or carried to the nearby surface water bodies giving rise to groundwater pollution. These materials are rich in heavy metals e.g. paint which is made of lead, a carcinogen and mutagen as well.

Detailed field visits to the areas revealed careless way of living and the handling of wastes by the people of the area. This poses a serious threat to the groundwater of the area and hence the health of the inhabitants. Refuse dumps with their numerous potential pollutants are scattered/littered around the place. These dumps are rich in both organic (rubbish and garbage) and inorganic wastes (chemicals, plastics, electronics, cosmetics containers, aerosols, rusted roofing materials, etc) with its attendant leachates. Pit toilets and septic/soakaway pits are sited near wells and boreholes, most times in the same compound without observing W.H.O recommendation of at least 30m distance from water sources. These pit toilets / soak away are serous pollution source as leakages normally find their way into the groundwater sources and pollute them, thereby affecting human health negatively.

Coal Camp and Abakpa Nike are underlain by Ajali Sandstone and Mamu Formation respectively. Each of them is a Sandstone formation of loose and unconsolidated particles and thus have high porosity and permeability. According to [8], the porosity of Ajali Sandstone is 28% with a hydraulic conductivity value of 0.0049cmk/sec. This means that the groundwater of the place must be under a serious threat, as pollutants, with time, will eventually flow with ease through these formations, considering the hydrogeopollution circle. Groundwater is the major source of domestic water supply in the place. This includes boreholes and wells. Sequel to the above, there is need to assess the quality of groundwater of the study area so as to know the suitability of ingesting it.

The aim of this paper is to investigate selected heavy metal concentration in the groundwater of Enugu. To achieve this aim, the following objectives must be pursued:

- to establish the concentration in mg/l of the selected heavy metal in the groundwater samples;
- to establish if there was significant difference between the groundwater samples from that of W.H.O standards
- to establish if there was significant difference between the groundwater concentrations of Coal Camp from that of Abakpa Nike.

1.2 AREA OF STUDY

Coal Camp is found in Enugu South Local Government Area of Enugu State in the Eastern part of Nigeria. It lies within Latitude $6^0$30N and Longitude $37^0$20E.it is bordered on the North by Ogbete, to the west by Garki, to the East by Uwani and to the south by Awkunanaw. Abakpa Nike is found in Enugu East Local Government Area. It lies within latitude $6^0$32N and longitude $7^0$32E and is bordered on the North by Trans-Ekulu, to the west by New Haven, to the East by Iji Nike and to the south by Emene (www.enugustate.gov.ng. accessed 23.11.2012). See fig 2 and 3

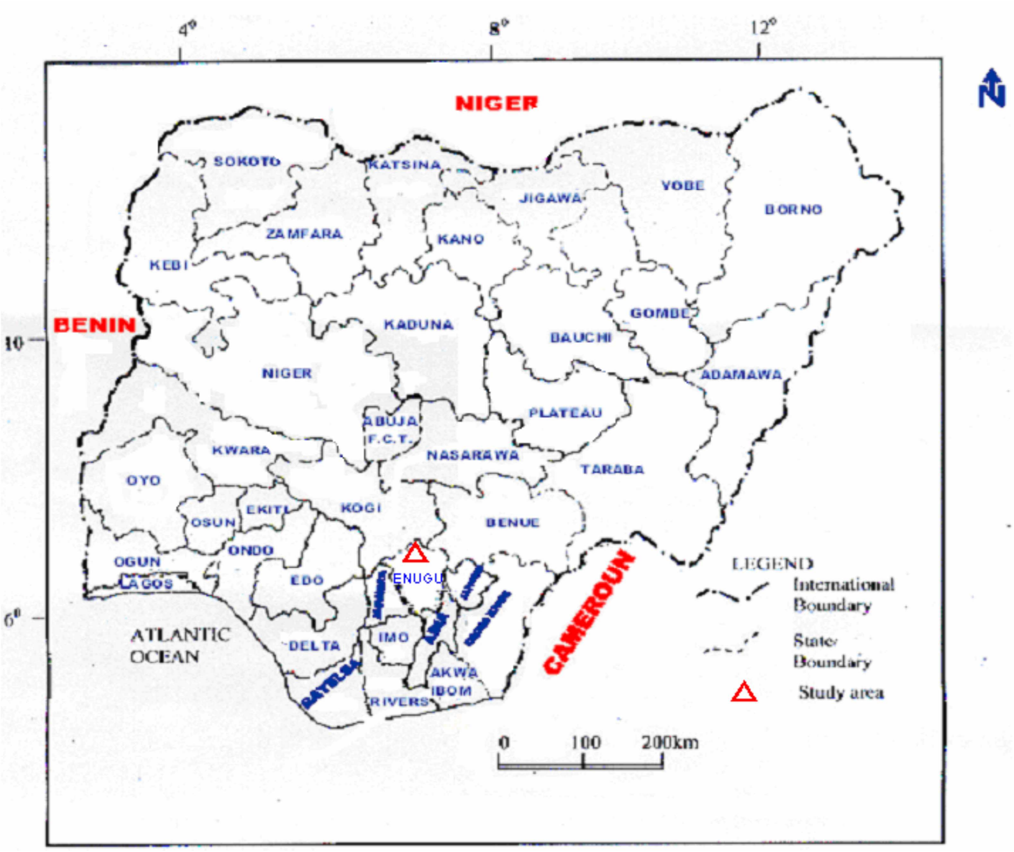

Figure 1: Map of Nigeria showing Enugu State.

Fig. 2: Map of Enugu State showing its LGAs

The town lies within the humid tropical rainforest belt, which has two climatic seasons; the wet season and the dry season. The wet season is experienced from the month of March to October while the dry season is November to February. The dry season is marked by dry and dusty air, which causes high evapo-transpiration rate and lowering of water tables. The rainy season is characterized by heavy downpour accompanied by thunderstorms, heavy flood, soil leaching, extensive sheet out wash, and groundwater infiltration and percolation [9]

The rainfall of the study area is tropical with an average yearly rainfall of 1478mm. the average daily minimum temperature is 32^{o}C. The relative humidity for wet months is 90% while the dry months of November – February have 60 – 70% [9].

1.3 Hydrogeology of the Area

The hydrologic units within the study area includes confined, semi-confined water table and perched aquifers. Confined conditions exist over the Ajali Sandstones and also in the Mamu Formation where overlying Ajali Sandstones are considerably reduced in thickness or eroded. Semi-confined situation exist in places and usually comprises inter-bedded thick sequence of sand (aquifer) and sandy clayey-sand aquicludes. Unconfined aquifers units in the study area occur mostly in the Ajali Sandstone and represent sections of the Formation where semi-permeable or impermeable cap beds have either been eroded or they are absent. The thickness of these aquifer units vary from shallow to deep in some places (www.enugustate.gov.ng// geology; assessed 28.09.2012). Coal Camp and Abakpa Nike are underlain by Ajali Sandstone and Mamu Formation respectively. Each of them is a Sandstone formation of loose and unconsolidated particles and thus have high porosity and permeability.

1.4 Theoretical/Conceptual Framework of the Study

The theoretical basis of this paper takes a cue from the hydrogeopollution cycle. This encompasses hydrologic and geologic cycle and emphasizes structure, interrelationships within and between different aspects of the environment. Hydrologic cycle is an open system with the input of energy from the sun and matter it has eight sub-systems namely: precipitation, interception, percolation, overland flow, evapotranspiration, evaporation and condensation [7].

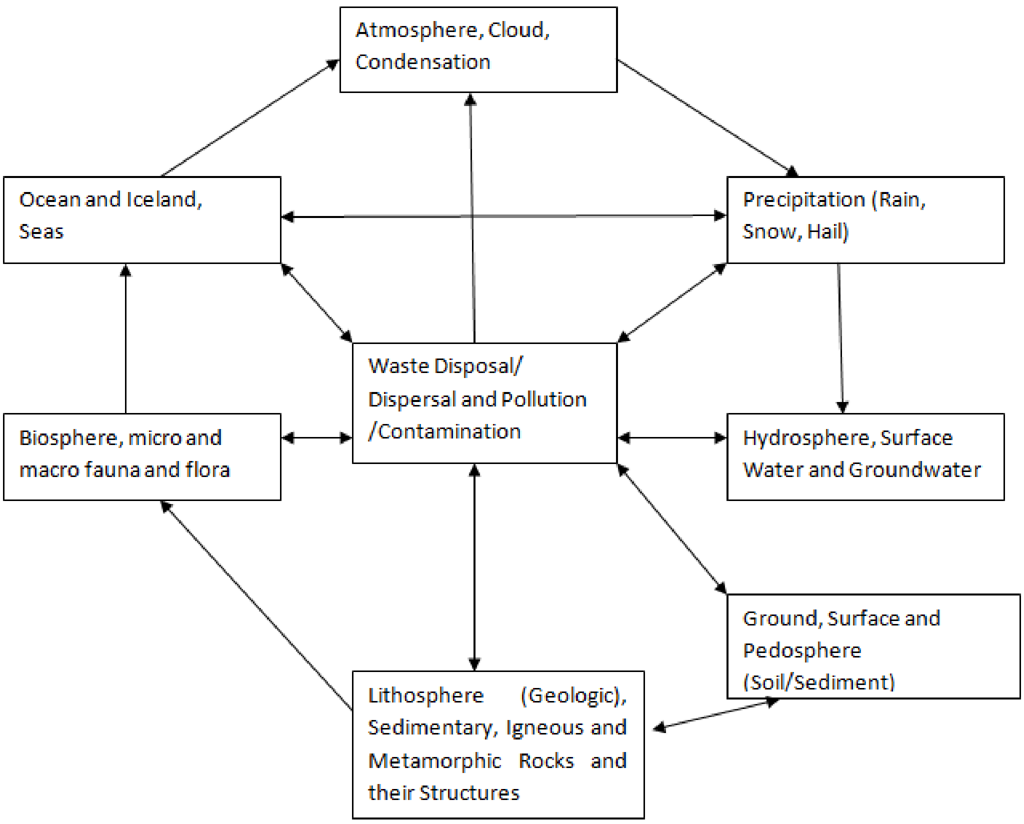

Fig.3: The Hydrogeopollution Cycle (after Egboka et al, 1989)

The mismanagement of the system means the entry of pollutants into the hydrologic cycle from the geologic cycle through leaching (percolation), precipitation of atmospheric pollutants as acid rain, etc. According to [10], the cycle is the endless circulation of water between the ocean, atmosphere and land, which is driven by sun's energy. Some of the evaporated water is returned as precipitation, part of which is rapidly evaporated back into the atmosphere. Some drain into lakes and rivers to commence a journey back to the sea. Some infiltrates into the soil and later percolates to become groundwater. Groundwater is subsurface water that fills voids in geologic formations [7]. The hydrodynamics of the surface and groundwater are linked inextricably. In all the stages of the hydrological cycle; pollutants and contaminants may be introduced and cyclically dispersed from one point to another. Sources of pollution are either point source or distributed (diffused). Point sources of contamination are geographically defined; can be mapped; and are discernible in size, shape and location. Distributed sources are usually widespread throughout a large area with difficult boundaries to define. From the foregoing, therefore it is quite clear that the proper understanding of the migration of pollutants/contaminants will stem from the understanding of the hydrogeopollution cycle, part of which is the lithosphere.

2 Materials And Methods

In selecting water samples for laboratory analysis, samples of water (well) were collected from 3 points along the mechanic workshops in Coal Camp. Also, 3 water samples were collected from the area chosen in Abakpa Nike, Enugu. The sampling points were selected based on the settlement pattern, that is on the location of wells around the site. Samples of water were preserved by adding drops of nitric acid at PH<2 (APHA,1995) and stored below 4^0C in a refrigerator prior to analysis. All collected samples were transported to Union Recycling Plant, Ibeto Group of Companies, Nnewi, Anambra State laboratory for analysis.

Students T-test was used to test whether there is significant difference between the heavy metal concentrations of the area from that of W.H.O Standard for drinking water and also, whether there is significant difference between the groundwater concentrations of Coal Camp from that of Abakpa Nike.

3 Results

The distribution of heavy metal of the groundwater samples are presented below:

Table 1: Heavy Metal concentration of Coal Camp groundwater samples of Coal Camp

Parameters	SS1	SS2	SS3	Mean	Max acceptable conc. (WHO)	Max. acceptable conc. (NAFDAC)
Arsenic	0.05	0.08	0.03	0.05	0.01	0.0
Chromium	0.90	0.79	0.829	0.836	0.05	-
Lead	0.41	0.87	0.78	0.673	0.01	0.0
Iron	0.11	0.91	0.02	0.346	0.3	-
Zinc	2.02	3.89	1.97	2.646	5	5
Copper	0.98	1.25	0.43	0.886	1	-
Magnesium	8.22	12.11	11.94	10.75	50	30
Cadmium	0.005	0.028	0.001	0.011	0.003	0.0
Mercury	0.028	0.057	0.036	0.211	0.001	0.0

Source: Author's Field Work (2012)

Table 1 shows that the arsenic values were above WHO stipulated standard with SS1 having a concentration of 0.05mg/l; SS2 0.08mg/l and SS3 0.03mg/l. the readings for chromium were all beyond acceptable threshold with SS1 having 0.90mg/l, followed by SS3 at 0.82mg/l and SS2 0.7mg/l. Lead, iron, copper, cadmium and mercury were found to be above the standard, with SS2 having the highest concentration at 0.87, 0.91, 1.25, 0.028 and 0.057 respectively. zinc and magnesium were found to be below the standard in all three sites. Values for zinc are 2.02, 3.89 and 1.97 respectively for SS1, SS2 and SS3. Magnesium concentration were 8.22, 12.11 and 11.94 respectively for SS1, SS2 and SS3.

Table 2: Heavy Metal concentration of groundwater samples of Abakpa Nike

Parameters	SS1	SS2	SS3	Mean	Max acceptable conc. (WHO)	Max. acceptable conc. (NAFDAC)
Arsenic	0.05	0.02	0.01	0.026	0.01	0.0
Chromium	0.62	0.18	0.04	0.28	0.05	-
Lead	0.98	0.09	0.34	0.47	0.01	0.0
Iron	0.88	0.18	0.42	0.49	0.3	-
Zinc	2.03	3.69	2.67	2.796	5	5
Copper	0.52	0.38	0.92	0.606	1	-
Magnesium	22.48	8.27	16.08	6.373	50	30
Cadmium	0.006	0.001	0.003	0.003	0.003	0.0
Mercury	0.09	0.01	0.03	0.043	0.001	0.0

Source: Author's Field Work (2012)

Table 2 again shows that the arsenic values were above WHO stipulated standard, with SS1 and SS2 having a concentration of 0.05mg/l; SS2 0.02mg/l and is equal to the standard in SS3 with 0.01mg/l. The readings for chromium were all beyond acceptable threshold in SS1 and SS2 having a concentration of 0.62 and 0.18mg/l and is below in SS3 with 0.04mg/l. Lead, iron, cadmium and mercury were found to be above standard with SS2 having the highest concentration at 0.98, 0.88, 0.006 and 0.09 respectively. zinc, Copper and magnesium concentrations were below the WHO standard in the three sites. Zinc concentrations were with 0.52mg/l, 0.38mg/l and 0.92mg/l for SS1, SS2 and SS3 respectively. zinc and magnesium were found to be below the standard in all three sites. Values for zinc are 2.03mg/l, 3.69mg/l and 2.26mg/l; copper are 2.02mg/l, 3.89mg/l and 1.97mg/l; and magnesium 22.48mg/l, 8.827mg/l and 16.08mg/l respectively for SS1, SS2 and SS3.

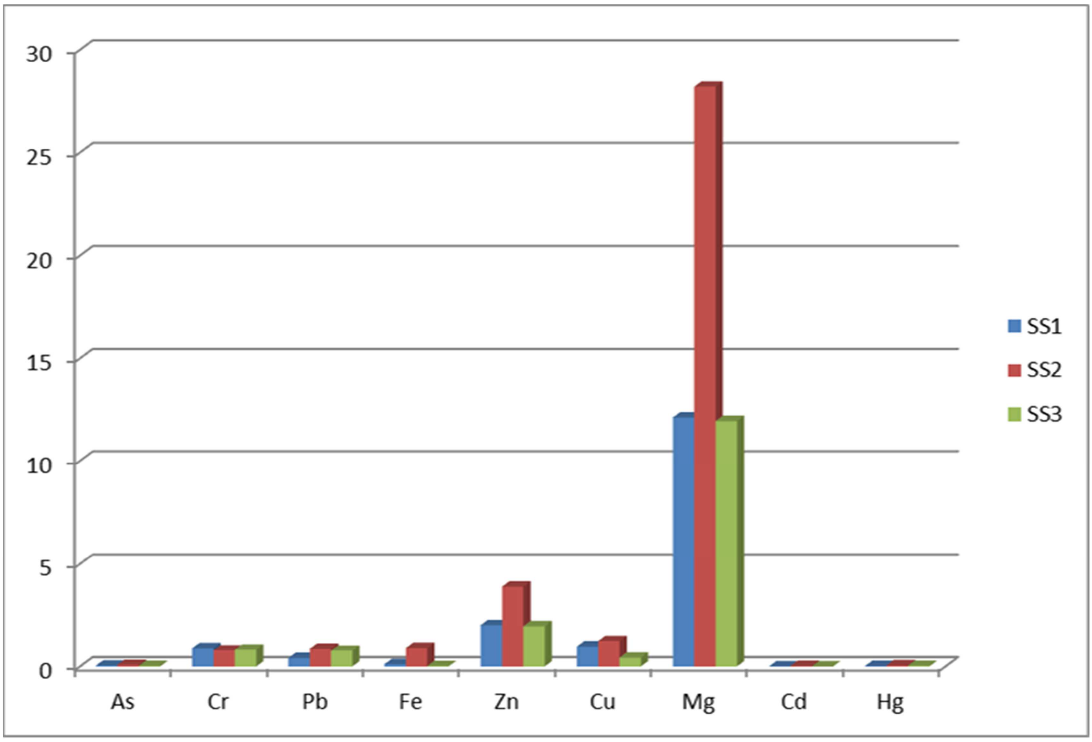

Fig 4. Heavy Metal distribution of Coal Camp Groundwater.

Source: Author's Field Work. Laboratory Analysis(2012)

Fig.4 shows that in the groundwater of Coal Camp, magnesium was shown to have the highest concentration, followed by Zinc, Copper, Iron, lead, chromium, arsenic, mercury and cadmium.

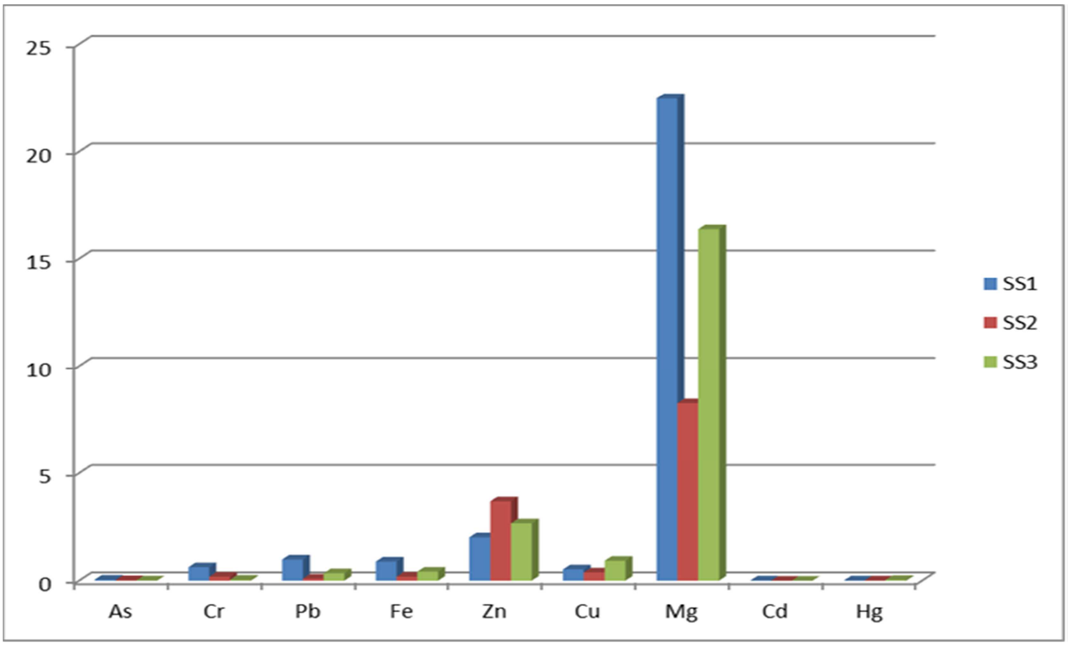

Fig. 5 Heavy Metal distribution of Abakpa Nike Groundwater.

Source: Author's Field Work. Laboratory Analysis(2012).

Fig.5 shows that in the groundwater of Abakpa Nike, magnesium has the highest concentration, followed by zinc, lead, copper, iron, chromium, arsenic, mercury and cadmium.

4 DISCUSSION OF FINDINGS

From hypothesis 1,In Coal Camp, arsenic, chromium, lead and mercury were significantly above WHO standard (t_{cal}>t_{tab}), thus we reject Ho and accept the alternative hypothesis (H_I) for them, all at 95% confidence limit. We accept Ho for iron, zinc, copper, magnesium and cadmium as there was no significant difference with WHO standards (t_{cal}<t_{tab}). However, in Abakpa Nike, however, we accept Ho for all the other analyzed elements as there was no significant difference with WHO standards.

The empirical higher concentration of the metals in the groundwater signifies contamination and hence implies its unfitness for consumption, as groundwater seems to be the main supply of domestic water in developing countries [8]. The distribution showed

Mg>Zn>Fe>Pb>Cu>As>Cr>Hg>Cd in Coal Camp, while it is as follows:

Mg>Zn>Fe>Pb>Cu>Cr>As>Cd>Hg in Abakpa Nike. The consistent higher concentrations of the sampled heavy metals in the groundwater of Coal Camp compared to that of Abakpa Nike, and hence, increasing concentration of the metals in the ground water can be attributed to automobile wastes being more concentrated with heavy metal than that of household, medical wastes as seen in that of Abakpa Nike dumpsite. From hypothesis 2, there was significant difference in the heavy metal properties of Coal Camp from that of Abakpa Nike at (P<0.05), thus we reject the null hypothesis and accept the alternate hypothesis. The presence of metals such as arsenic, lead, chromium, mercury calls for serious concern as these metals are highly deleterious to human health and safety [11], [12].

5 CONCLUSION

The results of the study reveal that some of the heavy metal concentration in the groundwater sources in the area is high in some locations. This calls for serious concern, as the levels of contamination needs remediation. To remediate the effects of the polluted water on the health of the inhabitants, the authorities concerned should designate a properly engineered landfill in the area, putting into consideration the groundwater and its flow directions. There is need to also establish functional and operational waste disposal mechanisms in the area with sanitation inspectors recruited with strict enforcement of sanitary bye-laws. More importantly, systematic study of the heavy metals concentrations in groundwater sources in the area should be carried out regularly. This is imperative since groundwater is the main supply of domestic water supply in developing countries, of which Nigeria is one. The practice of 3Rs of waste management – reuse, reduce, recycle should be encouraged by the mechanic shops and government and industries to minimize the amount of metallic wastes generated by this auto-repair outlets.

Moreso, mass awareness should be generated about the effects of waste disposals on water quality and human health

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