Impact Assessment of Selected Pollution Sources on Groundwater Quality in Wells in Gambari Community, Ogbomoso, Nigeria

Adegbola, Adedayo Ayodele[1], Adewoye, Abosede Olufunmilayo[2]
Department of Civil Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria[1],
Department of Earth Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria[2]

Abstract : *This study focused primarily on the determination of heavy metal properties in water samples from selected hand dug wells in a rapidly urbanized Gambari Community in Ogbomoso, Oyo State, Nigeria. The purpose was to assess the quality of water from these sources. Twenty different water samples were taken and analyzed for physicochemical parameters including pH, electrical conductivity, Cyanide, heavy metals - Cu, Zn, Fe, Pb, CN and Mn. From the results of the analyses, most of the parameters were not found averagely to deviate from the standard or found to be present in high concentrations except for conductivity, pH and Cu. Also, most of the water samples were found to be at least at minimal satisfactory level except for GASP (located within a cassava processing and milling industry) that had ninety five percent (95%) of the parameters tested to be at unsatisfactory level. It is recommended that wells should be sited far away from pollution prone areas. Relevant governmental agencies should, in addition, regularly carry out routine inspection on wells marked for domestic use to safeguard the health of the teeming populace in Gambari Community.*

Keywords **:***Heavy Metals, Physicochemical Parameters, Pollution, Water Samples*

I. Introduction

Much of the current concern with regards to environmental protection is focused on water because of its importance in maintaining the human health and health of the ecosystem (Mahananda *et al.,* 2010). Inadequate provision of sufficient volume of drinking water continues to present major problems worldwide to public health (Postel, 1997; Adegbola, 2006). Rapid urbanization of rural areas, industrialization and population growth have been the major causes of stress on the environment leading to human health problems, eutrophication and fish death, coral reef destruction, biodiversity loss, ozone layer depletion and climatic changes (Sadiq, 2002; Bay *et al.*, 2003). Improper disposal of industrial effluents, which is most common in major African urban and rural centres, has led to heavy contamination of the available fresh water resources, reducing the volume of safe water for agricultural, domestic and commercial uses.

Water pollution has been suggested to be the leading worldwide cause of deaths and diseases (Pink, 2006), and that it accounts for the deaths of more than 14,000 people daily (West, 2006). Ground water, according to Ramachandraiah (2004), is the ultimate and most suitable fresh water resource for human consumption in both urban as well as rural areas. It supports drinking water supply; livestock needs; irrigation; industrial, and many commercial activities. Groundwater can be contaminated when rainwater carry impurities into streams as runoff or through leaching. Leaching is the downward movement of a dissolved substance through the soil. Also, groundwater is contaminated through the use of fertilizer in farming (Altman and Parizek, 1995). Pesticides and residual fertilizers in the soil, as noted by Adekunle (2009), can leach through the soil along with rainwater. Seepage from effluent bearing water body industrially discharged without proper treatment, also results in the contamination of ground water (Jinwal and Dixit, 2008).

Water of good drinking quality is of basic importance to human physiology and man's continued existence depends very much on its availability (Lamikanra, 1999). The safe portable water is absolutely essential for healthy living. The provision of portable water to the rural and urban population is necessary to prevent health hazards (Nikoladze and Akastal, 1989; Lemo, 2002). Potable water is defined as water that is free from disease producing microorganisms and chemical substances deleterious to health (Ihekoronye and Ngoddy, 1985).

The primary aim of this study is to investigate the impacts of selected pollution sources on the quality of water in hand dug wells in Gambari, Ogbomoso, Nigeria. The study area is underlain by Precambrian rocks of the Nigerian Basement Complex where aquifers are both isolated and compartmentalized. Groundwater localization in this region is controlled by a number of factors which include the parent rock type, the depth, extent and pattern of weathering, thickness of weathered materials, and the degree, frequency and connectivity of fracturing, fissuring and jointing, as well as the type and nature of the fillings in the joint apertures. The study area is characterized by an alternation of two distinct seasons; the rainy season and the dry season. The rainy season lasts for the seven months of April to October with mean annual rainfall of 1000-1400mm, while the dry season begins in November and ends in March.

II. Methodology

A reconnaissance survey was carried out at the study area in order to locate the major sources of pollution. Twenty hand dug wells were randomly selected based on their proximity or closeness to pollution sources. The major pollution sources considered are: cassava mill industry, waste dumpsites and automobile mechanic workshops.

The wells that were sampled were those designated for domestic use and commercial purposes, most especially in preparation of some street vended foods and food canteens. The pH of the samples was measured with a pH meter (PHEP HANNA 98107) that had been previously calibrated with buffer solution. Electrical conductivity was measured with a conductivity meter (Hitachi 2180) calibrated with potassium chloride.

Heavy metals were determined by digesting a known volume of water sample with HNO_3 (analytical grade). The digested sample was filtered into a 50ml standard flask, made up to the mark with distilled-deionized water. This was stored in a nitric acid prewashed polyethylene bottle in the refrigerator, prior to the instrumental analysis.

The water-extract was analyzed for presence of heavy metals (Pb, Fe, Zn, Cu, CN) by Atomic Absorption Spectrometer. Each sample was analysed in triplicate so as to ascertain the validity of the method, and the average of the results reported. General laboratory quality assurance measures were observed to prevent sample contamination and instrumental errors.

III. Results And Discussion

The pH of a water body is very important in the determination of water quality since it affects other chemical reactions such as solubility and metal toxicity (Fakayode, 2005). The pH of the samples (Figure 1) was between 5.57 (from GA02) and 7.1 (from GASP). Eight (8) of the samples, that is 40%, have pH values below 6.5-8.5 which is the permissible limit of the World Health Organization (WHO), and they are slightly acidic, while the remaining 60% are within the admissible limit, which can be regarded as neutral and unpolluted. The mean value for the potential hydrogen concentration in all the samples analysed is 6.454, which is slightly below the WHO standard.

POTENTIAL HYDROGEN (pH)

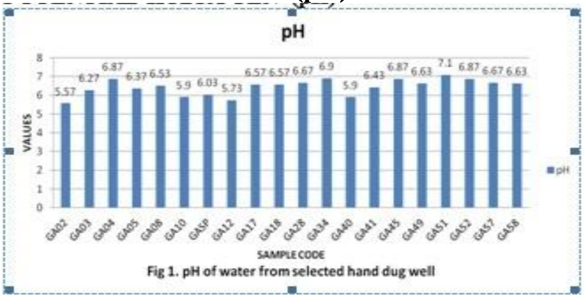

Fig 1. pH of water from selected hand dug well

Electrical conductivity is a measure of water's ability to conduct an electric current and it is related to the amount of dissolved minerals in the water. It does not give an indication of which element is present but higher value of conductivity is a good indicator of the presence of contaminants such as sodium, potassium, chloride or sulphate, and also the amount of total dissolved salts (Orebiyi *et al.,* 2010; Sudhir and Amarjeet, 1999). Conductivity is a good and rapid method to measure the total dissolved ions and is directly related to the total solids in the water sample (Singh *et al.,* 2010). The higher the value of dissolved solids, the greater the amount of ions in water (Bhatt *et al.,* 1999).

Analysis of the results (Figure 2) showed that 50% of the samples have conductivity values above 400 µS/cm which is the WHO Standard (1995). The range of conductivity of the samples was from 225.67 µS/cm – 1353 µS/cm, with the minimum (225.67 µS/cm) obtained from GA03 and maximum value (1353 µS/cm) obtained from GASP. High values of conductivity were recorded for GA51, GA12, GA45 and GA17. These indicate a high level of dissolved solids, and subsequently impurities in the water, which can render the water unfit for drinking.

ELECTRICAL CONDUCTIVITY

Fig 2. Conductivity of water from selected hand dug wells

Iron is the fourth most abundant element by mass in the earth's crust. In water, it occurs mainly in ferrous or ferric state (Ghulman *et al.*, 2008). It is an essential and non-conservative trace element found in significant concentration in drinking water because of its abundance in the earth's crust. Usually, iron occurring in ground water is in the form of ferric hydroxide, in concentration less than 500 µg/L (Oyeku and Eludoyin, 2010). Iron is an essential nutrient for erythroporesis. The shortage of iron causes disease called "anemia'' and prolonged consumption of drinking water with high concentration of iron may lead to liver disease called as haermosiderosis (Rajappa *et al.*, 2010; Bhaskar *et al.*, 2010).

In this study, iron content (Figure 3) varied from 0.1mg/l (GA05, GA08, GA17, GA49, GA52) to 0.5mg/l (GASP). Low iron concentration was recorded in 70% of the samples while the remaining 30% recorded high values for concentration of the iron content.

Although, iron is an important dietary requirement in humans needed by hemoglobin and good for several other functions, when high concentrations of iron are absorbed, iron is stored in the pancreas, the liver, the spleen and the heart. This may damage those vital organs. The presence of excess iron in water imparts the taste and it also promotes growth of iron bacteria that hasten rusting process of all the ferrous metals that come in contact with the water (Chukwu *et al.*, 2008).

IRON (Fe^{2+})

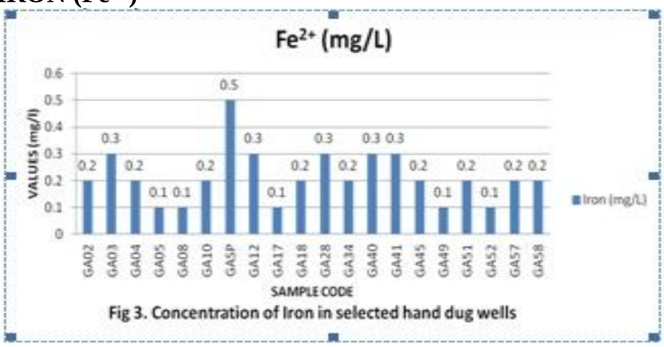

Fig 3. Concentration of Iron in selected hand dug wells

The concentration of manganese (Figure 4) ranged from 0.01mg/l (present in 30% of the samples) to 0.05mg/l (GASP). About 95% of the samples studied have values below the permissible levels for Manganese while the value recoded for sample collected from GASP was higher compared to the values from others. Excess manganese can interfere with absorption of dietary iron which can result in iron deficiency anemia. It also increase bacterial growth in water. Excessive manganese intake can also cause hypertension in patients older than 40 years.

MANGANESE (Mn^{2+})

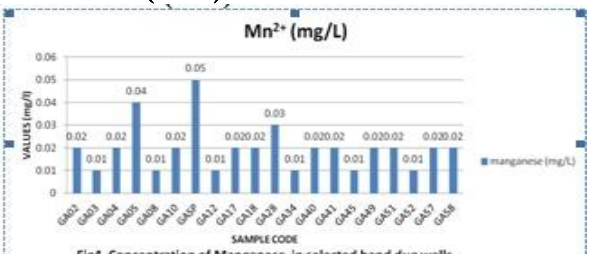

Fig4. Concentration of Manganese in selected hand dug wells

Lead is the most significant of all the heavy metals because it is toxic and harmful even in small amounts (Gregoriadou *et al.,* 2001). Lead enters the human body in many ways. It can be inhaled in dust from lead paints, or waste gases from leaded gasoline. It is found in trace amounts in various foods, notably in fish, which are heavily subjected to industrial pollution. Some old homes may have lead water pipes, which can then contaminate drinking water. Most of the lead taken by humans are removed from the body in urine. As exposure to lead is cumulative over time, there is risk of buildup, particularly in children. Acute effects of lead are inattention, hallucinations and delusions. Poor memory and irritability are symptoms of acute intoxication. Lead absorption in children may affect their development and also results in bone stores of lead (Siddiqui and Sharma, 2009). High concentration of lead in the body can cause death or permanent damage to the central nervous system, the brain, and kidneys (Hanaa *et al.*, 2000). In this study, maximum level of lead concentration (0.03mg/l) was found in water sampled from GASP (Figure 5), and a minimum concentration obtained was below detection level (0mg/l), from water sampled from GA04. The concentration of lead obtained from 95% of the samples are at low level of contamination while the concentration obtained from GASP was found to be slightly higher compared to the rest, indicating the highest level of lead contamination in the sampled wells.

LEAD (Pb^{2+})

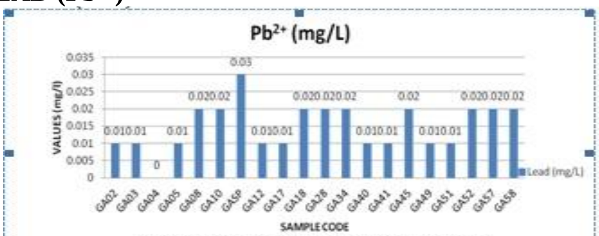

Fig 5. Concentration of Lead in selected hand dug wells

Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms. Zinc is a nutritionally essential metal, and its deficiency results in severe health consequences (Curtis *et al.*, 1996). Nevertheless, higher concentrations of zinc can be toxic to the organism (Rajkovic *et al.*, 2008).

Zinc plays an important role in protein synthesis and is a metal which shows fairly low concentration in surface water due to its restricted mobility from the place of rock weathering or from its natural sources (Rajappa *et al.*, 2010). In this study, a minimum of 0.01mg/l was recorded from five samples: GA08, GA10, GA41, GA49, and GA58 and maximum concentration of 0.05mg/l also recorded from five samples GA04,GASP,GA12, GA45, and GA51. This indicates that the concentration of zinc in the samples (Figure 6) is both at highest and lowest at 23% while the concentration recorded from the remaining 50% ranged from 0.02mg/l to 0.04mg/l.

ZINC (Zn^{2+})

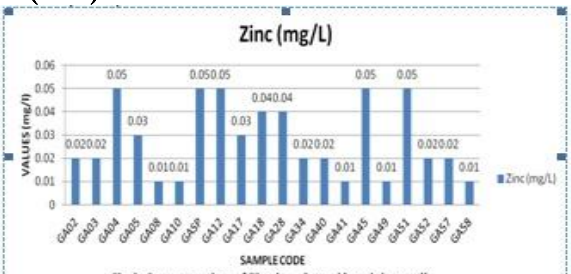

Fig 6. Concentration of Zinc in selected hand dug wells

Copper is an essential component of several enzymes. It is essential for utilization of iron (Curtis *et al.*, 1996). Contamination of drinking water with high level of copper may lead to chronic anemia (Acharya *et al.*, 2008). Copper in excess could impart a bitter taste to water and could promote the corrosion of galvanized iron and steel fittings (Chukwu *et al.*, 2008).

The concentration of copper detected in all the samples (Figure 7) in this study is above the permissible limits of the WHO. The range was from 0.1mg/l (found in 35% of the samples) to 0.3mg/l (found in 15% of the samples). About 50% of the samples have concentration of 0.02mg/l. This indicates that a variation of 0.1mg/l exists within the level of pollution obtained from the samples. GASP and GA28 showed the highest concentration indicating that they have the highest level of pollution from copper.

COPPER (Cu^{2+})

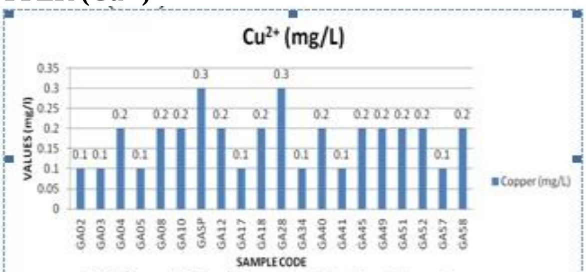

Fig 7. Concentration of Copper in selected hand dug wells

In this study, the concentration of cyanide (Figure 8) obtained ranged from 0.00mg/l (found in 95% of the samples) to 0.7mg/l. Cyanide was only present in water samples collected from GASP, which is located within the cassava processing and milling local industry and is subjected to heavy pollution from cassava waste water effluent. The concentration of cyanide found is ascertained to be far beyond the required limit.

Therefore, it is expedient that the well in GASP should not be used for both domestic and/or drinking purposes as cyanide is acutely toxic to humans. Relatively low concentrations of cyanide can be toxic to humans as it causes hypoxia, and lactate acidosis which can result in respiratory arrest. Cyanide poisoning also affects organs and systems in the body including the heart.

CYANIDE (CN^-)

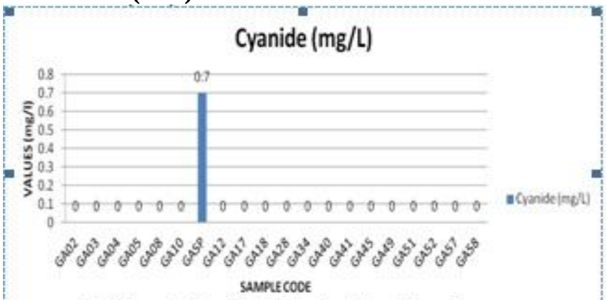

Fig 8. Concentration of Cyanide in selected hand dug wells

IV. Conclusions And Recommendations

The assessment of groundwater quality in the rapidly urbanized Gambari Community, Ogbomoso, Nigeria, was achieved by evaluating the concentrations of certain heavy metals from various locations within the community. From the results of the analyses, most of the parameters were not found averagely to deviate from the standard or found to be present in high concentrations, except for concentration of copper.

Also, most of the water samples were found to be at least at minimal satisfactory level except for GASP (located within a cassava processing and milling industry) that has ninety five percent (95%) of the parameters tested to be at unsatisfactory level.

It is recommended that water from sampled well (GASP) should not be used for domestic purpose in view of high level of contamination. The effects of the presence of heavy metals in the water samples revealed that rapid urbanization coupled with inadequate planning and monitoring are responsible for the pollution of groundwater in Gambari Community.

If the present trend of pollution is not abated, in the near future, consumption of water abstracted from shallow wells will pose a serious health hazard to the generality of the residents in Gambari Community.

In the interim, shallow wells should be sited far away from any visible pollution source. Also, regular inspection and monitoring of existing wells should be prompt, and be on the priority list of the relevant local authority.

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