

## **Poor Handling of Municipal Solid Wastes: Pollution of Groundwater by Heavy Metals in Omagba, Onitsha, Anambra State, Nigeria**

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### **ABSTRACT**

*Municipal solid wastes generated in cities of developing democracies are risks to the environment and public health merely because they are poorly handled. Thus, this study was focused on groundwater pollution by infiltration of heavy metals arising from poor handling of municipal solid wastes climaxed at dump sites in Omagba, Onitsha, Anambra State, Nigeria. The objective of the study was to assess the extent of groundwater pollution by the heavy metals. The method of data collection was through laboratory analysis of water samples collected from boreholes. Data generated by this method was analyzed using tables, line graphs and single-factor index analysis. The result of the study showed that water samples collected from boreholes proximal to municipal solid waste dumpsites have higher concentrations of heavy metals compared with water sample collected from a borehole far away from the dumpsites. Pollution by the heavy metals is in the order of Cr > As > Cd > Hg > Cu > Zn > Pb. Public awareness on the consequences of poor handling of municipal solid wastes, monitoring of boreholes and regular collection and disposal of municipal solid wastes on equitable basis are needed in Omagba as some elements of sustainable solid waste management, which is an integral component of sustainable development to redress this problem.*

**Keywords:** Groundwater; Pollution; Heavy metals; Municipal solid wastes; Dumpsites.

### **INTRODUCTION**

Anthropogenic activities of man everywhere in homes, markets, offices, hotels/restaurants, farms, industries, schools, tourist areas hospitals and social gatherings result in overall generation of large amounts of municipal solid wastes in cities all over the world which are risks to the environment and public health if poorly handled. The waste production increases on daily basis (Ojiegbe, 2005), and its risks are compounded by rapid increase in human numbers, particularly in developing democracies with bad governance, inadequate technology and low level of environmental awareness. Although municipal solid wastes are still problematic the world over, their poor handling is climaxed at dumpsites in the cities of developing democracies, where they block drains, mount roadblocks, cause flooding leading to soil erosion and odour, pollute underlying soil/ground water and breed vectors of diseases (Igwe, 2012a).

This poor handling of municipal solid wastes is a characteristic of all Nigeria cities, including Abuja, Lagos, Kano, Port Harcourt, Enugu and Onitsha which one of its quarters is Omagba. Except the trend changes, sustainable development of these cities will continue to be a mirage. It calls for integration of sustainable solid waste management into development processes. The problem of poor handling of municipal solid wastes in Nigerian cities has received the attention of many researchers such as Igwe (2012a,b), Okonkwo (2010), Okoye (2008), Uwaegbelun (2004), Onwurah, Ogugua and Otitogu (2006), Longe and Balogun (2010) and Amadi, Olasehinde, Okosun, Okoye, Okuntola, Akali and Dan-Hassan (2012) who decried the throw-away attitude syndrome and the inability of the municipal authorities to provide adequate solid waste management services on equitable basis to the residents that has resulted in environmental and public health risks.

Municipal solid wastes (MSW) from urban areas are blends of residential, commercial, institutional, industrial and tourist activities (UNEP, 2004). The accumulation of municipal solid wastes is inseparable from human numbers. A number of studies have emphasized that the problem of wastes, especially solid wastes is closely associated with increasing human population and the attendant human activities--domestic, agricultural, commercial and industrial (Timoh, 2005). Thus, it is the rise in human numbers and its accompanying socio-economic activities that leads to

production of large amounts of municipal solid wastes that is now converging with other urban blights in dangerous ways to impact adversely on the urban environment, people's lives and their livelihoods.

The study area, Omagba is a fast growing quarter in Onitsha associated with generation of large amounts of municipal solid wastes which are not properly handled. These wastes are indiscriminately dumped in all nooks and crannies in the study area where they constitute environmental and public health risks. The climax of this poor handling of municipal solid wastes is most evident at the uncontrolled dumpsites (an example is shown in Plate 1) that are characterized by high environmental unfriendliness and sited in close proximity to boreholes which are sources of drinking water for the residents. Metals, being one component of municipal solid wastes undergo biodegradation with time and can infiltrate into groundwater to degrade its quality. This study is, therefore, focused on pollution of groundwater by heavy metals found in municipal solid wastes that are poorly handled in the study area.



Plate 1: An example of many unwholesome municipal solid waste dumpsites in Omagba  
Source: Authors' field-work, 2013

### **Conceptual Framework: Sustainable Waste Management**

This research is rooted in the concept of sustainable waste management so as to achieve the optimum priority of solid waste management system which is to ensure human health and safety. Sustainable waste management is an integral part of sustainable development (the Brundtland Commission's Approach) defined as development which seeks to meet the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). Thus, in line with the objectives of sustainable development, sustainable waste management can be regarded as an approach to waste management that, in addition to protecting human health and the environment, ensures that scarce resources of the earth are conserved for both present and future generations of humanity. It therefore, becomes important to minimize natural resources extraction and consumption by recycling waste materials, and conduct waste management efficiently to curtail the environmental impacts of waste disposal and protect ecosystem services for both current and future generations (MAR, 2005). Rural solid wastes can be sustainably managed. Reducing the amounts of wastes, we produce, in line with waste management hierarchy, is the best way to achieve sustainable waste management (Girling, 2005) in rural settings. Where waste generation is unavoidable, a sustainable approach to management is to reuse and recycle products to prevent them from getting into the waste stream. If waste prevention/reduction, reuse and recycle become economically impossible, waste is processed to recover their intrinsic value such as energy.

### **The Study Area**

Omagba is located within latitude  $6^{\circ} 9' 5''N$  and  $6^{\circ} 8' 5''N$  and longitudes  $6^{\circ} 5' 0'' E$  and  $6^{\circ} 5' 2''E$  in Onitsha North Local Government Area of Anambra State, Nigeria (Figure 1). It is bordered by Nkpor to the east and south, Inland Town to the west, and Nkwelle-Ezunaka to the north. The study area was developed in two phases: Omagba Phase I and Omagba Phase II in that order. Geologically, the study area is located within the sedimentary basins of the Niger-Benin Trough of the upper middle Eocene strata known as the Bende-Ameke Group. The geology of Omagba is characterized by the Orlu cuesta, which terminates at the River Niger bank. This upland area, which

varies between 150 and 240 meters' high is dissected by a number of small rivers/streams like Nkissi and Idemili Rivers.

Topographically, Omagba has a hilly and lowland (undulating) terrains that drain into Nkissi River which is one of the tributaries to the River Niger just like Anambra River that lends Anambra State its name. Due to the peculiar topography of the study area, municipal solid wastes that are indiscriminately disposed of can easily be carried by runoff into the Nkissi River, Ekulo and Abo lakes. Omagba has a wide plain of alluvial soil which favours agriculture (cropping and animal husbandry), except for the high rate of urbanization. The vegetation of the study area is light primary forest interspersed with tall trees which are fast disappearing as a result of human settlements that have destroyed the original rainforest of the area. The trees found in some of the remaining forests are not too tall and include both hardwood and softwood varieties; domesticated trees such as the mango (*Mangifera indica*), palm trees (*Elasis guineensis*), guava (*Psidium guajave*), orange (*Citrus sineensis*), and almond (*Amygdalus coommunis*) are also found.

The climate of the study area which is of tropical (equatorial) type is influenced by two major trade winds – the warm moist south west trade wind during the rainy season (April – October) and the east trade wind during the dry season (November – March). Annual rainfall varies from 1400mm to 2500mm per annum which is reasonably high and helps in the decomposition of biodegradable components of municipal solid wastes. Most of the precipitation occurs between mid-March and mid-November. However, there could be rains during the dry season in the form of dew. The temperature is generally high with maximum ranging from 27–34°C.

The population of Omagba by 1991 National Population Census was 71,000. By projection from the 1991 figures with the approved 3.2% annual population growth rate by the National Population Commission (NPC), as the 2006 census was not reflective of the population of the area due to the disruption of the exercise by members of Movement for the Actualization of the Sovereign State of Biafra (MASSOB), the population in 2014 is 123,256. The socio-economic activities of residents of the area include trading, production from their small-, medium-, and large-scale enterprises, transportation and subsistence farming from which municipal solid wastes are generated.

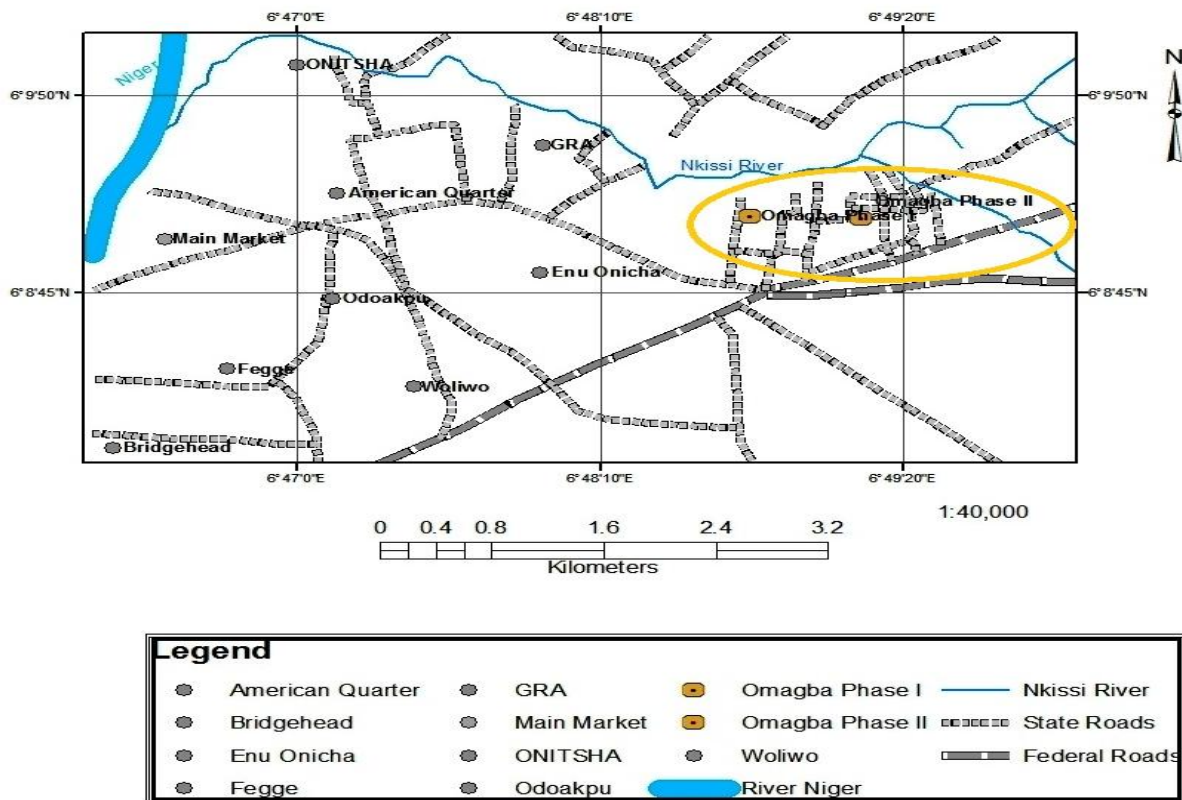


Figure 1: Location of Omagba in the map of Onitsha  
Source: National Geohazards Monitoring Centre, Awka, 2013.

## MATERIALS AND METHOD

### Field Techniques

The method of study was experimentation. Three different borehole water samples were collected, namely: sample A, sample B and sample C. Sample A was collected from a borehole located at Adazi-enu street with coordinates:  $6^{\circ} 09' 01''\text{N}$  and  $6^{\circ} 49' 08''\text{E}$ , 50.10 meters away from a municipal solid waste dumpsite in the same street which coordinates are  $6^{\circ} 09' 00''$  and  $6^{\circ} 49' 05''\text{E}$ . Sample B was taken from a borehole at Anam street with coordinates:  $6^{\circ} 09' 04''\text{N}$  and  $6^{\circ} 49' 02''\text{E}$ , 103.20 metres away from the same dumpsite. Then sample C, which served as the background/control was collected from a borehole at Onyeacholam street with coordinates:  $6^{\circ} 08' 52''\text{N}$  and  $6^{\circ} 48' 41''\text{E}$ , 769.89metres away from the dumpsite (Table 1). The samples A and B were collected from boreholes located proximal to the municipal solid waste dumpsite for the study. The average depth of boreholes in the study areas is 100 meters (Akudinobi and Okoli, 2013).

In each of the boreholes, one water sample was collected, using a pre-clean, dry and labeled polythene plastic bottle. In order to obtain these samples, the nozzle of each of the boreholes was cleaned with cotton wool soaked in ethanol to avoid any contamination.

Table 1: Distance of sampled boreholes from the dumpsites

| Dumpsite                         | Sampled boreholes and their locations                    | Distance from dumpsite |
|----------------------------------|--|------------------------|
| Adazi-enu street, Omagba Phase 2 | Sample A<br>Adazi-enu street, Omagba Phase 2             | 50.10 meters           |
| Adazi-enu street, Omagba Phase 2 | Sample B<br>Anam street, Omagba Phase 2                  | 103.20 meters          |
| Adazi-enu street, Omagba Phase 2 | Sample C (control)<br>Onyeachonam street, Omagba Phase 1 | 796.89 meters          |

Source: Authors' filed-work, 2015.

### Laboratory Analysis

The water samples were analyzed for their heavy metals concentrations at the water laboratory, Department of Soil Science, Federal University of Technology, Owerri as follows:

- Lead (Pb) by placing 5ml of the water samples in a reaction cell and 5 drops of lead Pb – ik reagent was added and mixed. The concentration of lead was determined in the spectrophotometer at a wavelength of  $620\mu\text{m}$ .
- Zinc (Zn), by placing 0.5ml of zinc reagent Zn-ik in a reaction cell. Then 0.5ml of the water samples were added and shaken to mix. Finally, zinc reagent (Zn – 2ik) was added, shaken and allowed to stand for 15mins. The zinc concentration was determined at a wavelength of  $720\mu\text{m}$
- Copper (Cu), by placing 5ml of the water samples in a WTW spectrophotometre reaction cell and 5 drops of copper reagent Cu-ik was added into it and shaken. The reaction time of 5mins was allowed before the reading was taken in the spectrophotometre at  $420\mu\text{m}$  wavelength.
- Mercury, total mercury (Hg) concentrations were determined by EPA method. Analysis of total mercury in the samples involved the following: (1) digesting 0.5g – 1.5g of the samples and refluxing with 10ml of concentrated nitric acid ( $\text{HNO}_3$ ), then diluting the digestate to volume (50ml or 100ml) with 0.02 NBrCl to ensure complete oxidation of methyl mercury (2) pipetting the aliquots of the diluted digestate into pre-purged  $\text{SnCl}_2$  containing water. After that, Hg(0) was purged into the gold trap and transferred into florescent spectrophotometre for qualification.
- Arsenic (As), by using a Perking–Elmer Model 460 atomic absorption spectrophotometre equipped with a MHS-10 mercury/hydride system and a HGA–2100 graphic furnace. A Perking–Elmer Arsenic Electrodes discharge lamp was used as a light source. To determine total arsenic in the water samples, 1ml of 10% potassium iodide solution was added to 10ml of sample or an aliquot diluted to 10ml after 60 minutes. Arsenic was determined by hydride evolution method with sodium borohydride and the mercury hydride system.
- Cadmium (Cd) and Chromium (Cr) measured by using atomic absorption spectrophotometer method. A Perking-Elmer Model was also used and procedure similar to that of arsenic.

### Statistical Techniques: Single-Factor Index Analysis

The evaluation grading standards of the single-factor method (Table 2) to determine the degree of pollution by the heavy metals found in municipal solid wastes were conducted using the single-factor model developed by Deng, Gu, Li and Deng (2012), mathematically expressed as:  $P_{ij} = C_{ij} / S_j$ .

where,  $P_{ij}$  is the pollution index of heavy metals  $j$  in the  $i$ -th functional area soil,  $C_{ij}$  is the measured contamination value of heavy metals  $j$  in the  $i$ -th function area soil, and  $S_j$  is the background/control contamination of heavy metals. Deng *et al*'s (2012) model was used because it is the pollutional levels of the heavy metals in soil that infiltrate into ground water.

Table 2: The evaluation grading standards for single-factor index method

| Sub-index     | $P_{ij} < 1$ | $1 \leq P_{ij} < 2$ | $2 \leq P_{ij} < 3$ | $3 \leq P_{ij}$ |
|---------------|--------------|---------------------|---------------------|-----------------|
| Quality grade | Clean        | Potential pollution | Slight pollution    | Heavy pollution |

Source: Deng *et al*, 2012.

## RESULTS AND DISCUSSION

The results of heavy metals analysis of ground water impacted by poor handling of municipal solid wastes at the dumpsites in Omagba are presented in Tables 3 – 5 and Figures 2a – 2g. The concentrations of heavy metals in the water samples taken from the boreholes in close proximity to the municipal solid waste dumpsites show an ample evidence in relative increase compared with those of background/control values. On the premise of the results obtained, there was a significant difference between the concentration levels of all heavy metals in the boreholes near the poorly handled municipal solid waste (MSW) dumpsites and their background /control values.

The concentrations of lead in the boreholes near the MSW dumpsites range from 0.11mg/l to 0.01mg/l, but at the background/control, the concentration is 0.005mg/l (Table 3). Statistically, its concentration levels are significant with a mean pollution index of 2.1 (Table 5) which grades it as slight pollution ( $2 \leq P_{ij} \leq 3$ ) as depicted in Table 2. Lead (Pb) ranks the least (7<sup>th</sup>) in the pollution order. The disposal of used batteries and paints at the MSW dumpsites accounts for the presence of lead in the groundwater. Zinc also shows slight pollution ( $2 \leq P_{ij} < 3$ ), with a mean pollution index of 2.5 (Table 5). Its concentration ranges between 7mg/l and 8mg/l as against its 3mg/l concentration in the background/control. The presence of zinc in the groundwater is attributed to the disposal of used zinc containing waste materials such as roofing sheets and electronic utility at the MSW dumpsites. It is the 6<sup>th</sup> in the order of pollution.

There is a significant difference between the concentrations of cadmium in the sampled boreholes near the dumpsites compared to its background/control value. Its concentration levels range between 0.006mg/l and 0.0065mg/l in the boreholes near the MSW dumpsites, but the background/control value is 0.002mg/l (Table 3). Cadmium shows heavy pollution ( $3 \leq P_{ij}$ ), with a mean pollution index of 3.13. The concentration could be attributed to the disposal of pesticides containers, electric batteries and other electrical materials that contain cadmium. It ranks 3<sup>rd</sup> in the order of pollution. Chromium shows heavy pollution ( $3 \leq P_{ij}$ ), with concentrations that range between 0.01mg/l and 0.08mg/l as against the background/control value of 0.001mg/l (Table 3). Its mean pollution index is 9 (Table 5), ranking 1 in the order of pollution.

Copper has slight pollution ( $2 \leq P_{ij} > 3$ ), with a mean pollution index of 2.88 (Table 5). Its concentrations range from 0.6mg/l to 0.55mg/l as against the background/control value of 0.2mg/l (Table 3). It ranks 5<sup>th</sup> in the order of pollution. The presence of copper in the groundwater could be attributed to the disposal of waste materials containing copper such as wire made of copper. Mercury concentrations range from 0.00113mg/l to 0.00099mg/l (Table 3), higher than its background/control value of 0.00035mg/l. It has heavy pollution ( $3 \leq P_{ij}$ ), with a mean pollution index of 3.03 (Table 5). The high concentration of mercury could be as a result of disposal of waste materials containing mercury like fluorescent tubes. Mercury is the 4<sup>th</sup> in the order of pollution.

The concentrations of arsenic range between 0.00166mg/l and 0.00105mg/l, but the background/control value is 0.00025mg/l (Table 3). It has a heavy pollution ( $3 \leq P_{ij}$ ), with a mean pollution index of 4.42, ranking 2<sup>th</sup> in the order of pollution. The presence of arsenic could be attributed to the disposal of waste materials containing arsenic such as at the MSW dumpsites.

Table 3: Heavy metal concentrations in mg/l at the boreholes

| Parameter     | Sample A (mg/l) | Sample B (mg/l) | Sample C (mg/l) | WHO standard, 2004 (mg/l) | SON standard, 2007 (mg/l) |
|---------------|-----------------|-----------------|-----------------|---------------------------|---------------------------|
| Lead (Pb)     | 0.011           | 0.01            | 0.005           | 0.01                      | 0.01                      |
| Zinc (Zn)     | 7               | 8               | 3               | 3.0                       | 3.0                       |
| Cadmium (Cd)  | 0.006           | 0.0065          | 0.002           | 0.003                     | 0.003                     |
| Chromium (Cr) | 0.01            | 0.008           | 0.001           | 0.05                      | 0.05                      |
| Copper (Cu)   | 0.6             | 0.55            | 0.2             | 2.0                       | 2.0                       |
| Mercury (Hg)  | 0.00113         | 0.00099         | 0.00035         | 0.01                      | 0.01                      |
| Arsenic (As)  | 0.00116         | 0.00105         | 0.00025         | 0.01                      | 0.01                      |

Source: Authors' field-work, 2015

Table 4: Pollution index of each heavy metal in the boreholes

| Sample   | Sub-index       | Pb               | Zn               | Cd             | Cr             | Cu               | Hg               | As             |
|----------|-----------------|------------------|------------------|----------------|----------------|------------------|------------------|----------------|
| Sample A | C <sub>ij</sub> | 0.011            | 7                | 0.006          | 0.01           | 0.6              | 0.00113          | 0.00116        |
|          | S <sub>i</sub>  | 0.005            | 3                | 0.002          | 0.001          | 0.2              | 0.00035          | 0.00025        |
|          | P <sub>ij</sub> | 2.2              | 2.33             | 3              | 10             | 3                | 3.23             | 4.64           |
|          | Quality grade   | Slight pollution | Slight pollution | High pollution | High pollution | High pollution   | High pollution   | High pollution |
| Sample B | Sub-index       | Pb               | Zn               | Cd             | Cr             | Cu               | Hg               | As             |
|          | C <sub>ij</sub> | 0.01             | 8                | 0.0065         | 0.008          | 0.55             | 0.00099          | 0.00105        |
|          | S <sub>i</sub>  | 0.005            | 3                | 0.002          | 0.001          | 0.2              | 0.00035          | 0.00025        |
|          | P <sub>ij</sub> | 2                | 2.67             | 3.25           | 8              | 2.75             | 2.83             | 4.2            |
|          | Quality grade   | Slight pollution | Slight pollution | High pollution | High pollution | Slight pollution | Slight pollution | High pollution |

Source: Authors' computation, 2015

Table 5: Mean pollution index of each heavy metals in the boreholes

| Sample   | Pb  | Zn   | Cd   | Cr | Cu   | Hg   | As   |
|----------|-----|------|------|----|------|------|------|
| Sample A | 2.2 | 2.33 | 3    | 10 | 3    | 3.23 | 4.64 |
| Sample B | 2   | 2.67 | 3.25 | 8  | 2.75 | 2.83 | 4.2  |
| Mean     | 2.1 | 2.5  | 3.13 | 9  | 2.88 | 3.03 | 4.42 |

Source: Authors' computation, 2015.

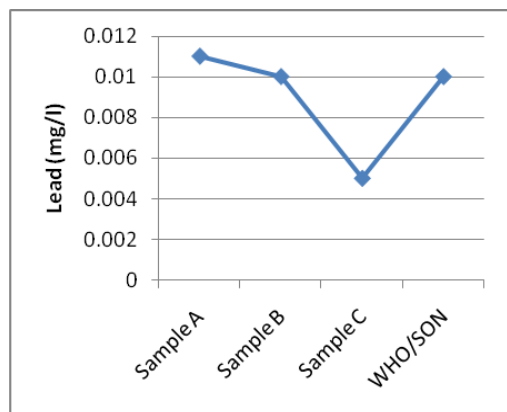


Fig. 2a: Line graph of Pb values

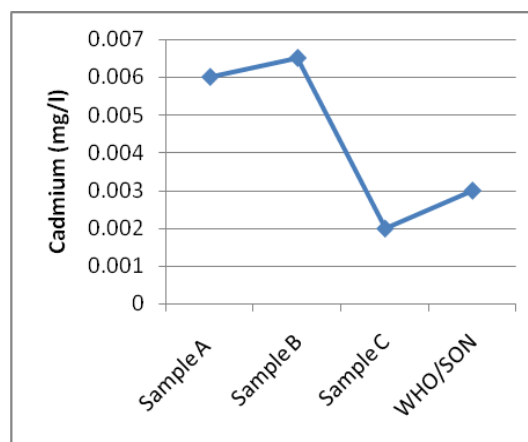


Fig. 2b: Line graph of Cd values

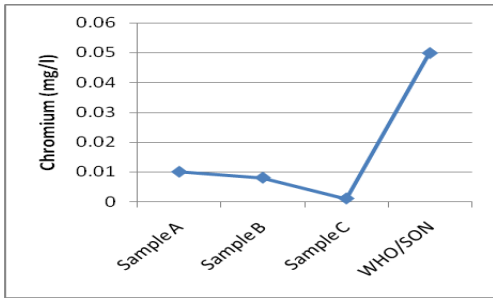


Fig. 2c: Line graph of Cr values

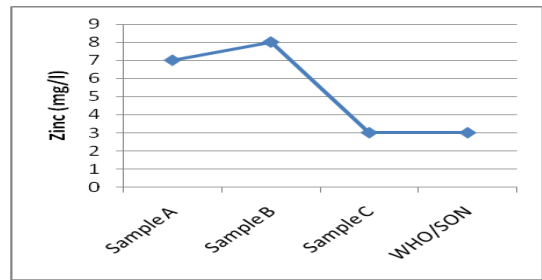


Fig. 2d: Line graph of Zn values

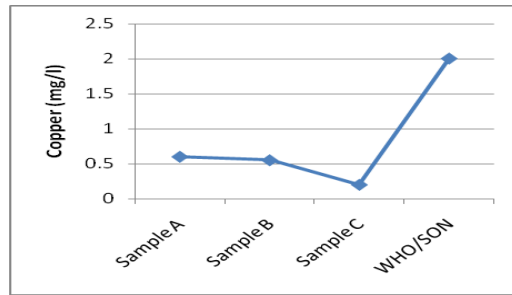


Fig. 2e: Line graph of Cu values

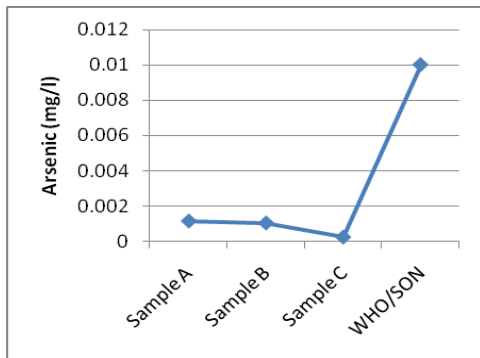


Fig. 2g: Line graph of As value

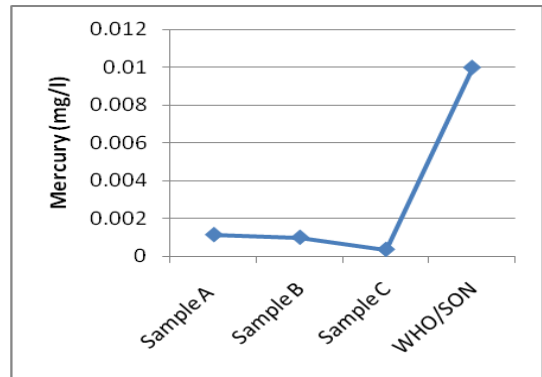


Fig. 2f: Line graph of Hg value

## CONCLUSION

The poor handling of municipal solid wastes in Omagba climaxed at the dumpsites has impaired the groundwater quality. All the heavy metals: lead, zinc, cadmium, chromium, copper, mercury and arsenic were observed to be of higher concentrations in the two studied boreholes proximal to the two municipal solid waste dumpsites compared with the values obtained from the background/control borehole far away from the dumpsites. The metals are polluting the ground water in the order of  $Cr > As > Cd > Hg > Cu > Zn > Pb$ . Some of these metals have heavy pollution level, while others have slight pollution. However, those with slight pollution or within the standards set by the World Health Organization (WHO) (2004) and the Standard Organization of Nigeria (SON) (2007) for drinking water will bio-accumulate in the groundwater in future and pose serious public health risks such as typhoid, diarrhea, cancer and death just like those metals that were observed to have heavy pollution and above the permissible limits set by WHO and SON for drinking water. Municipal solid waste dumpsites should be sited from 5km away from residences, Public awareness on the consequences of poor handling of rural solid wastes,

monitoring of boreholes and regular collection and disposal of rural solid wastes are needed in Omagba as broader elements in sustainable solid waste management which is an integral component of sustainable development.

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