Environmental Assessment of Solid Waste Management in Nigeria: A case study of Ikere Ekiti, Ekiti state.

Ogunmodede O.T1, Adewole, E1, Ajayi, O.O2, Onifade, A,k3

1. Department of Chemical Sciences, Afe Babalola University.
2. Chemistry Department Federal University of Technology Akure.
3. Microbiology Department Federal University of Technology Akure.

*Corresponding author: Ogunmodede O.T
Department of Chemical Sciences,
Afe Babalola University,
Ado-Ekiti, Nigeria.
E-mail: femtay_tayo@yahoo.com

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ABSTRACT

Following apparent increase in population and with a corresponding increase in solid waste generation in Ikere Ekiti, Ekiti State of Nigeria, this study was initiated to assess the level of environmental pollution and potential impact of wastes. Health risk assessment was determined by a survey of existing facilities for solid waste management. Microbiological and physicochemical analyses of decomposing waste, soil, and well water were carried out using standard procedures. Prevalent bacteria besides fungi isolated from solid waste, soil, and well water were Staphylococcus 36(25.85%), Escherichia 49 (19.61%), Pseudomonas 40 (34.11%) and each of Shigella/Salmonella 32 (21.82%), respectively. Solid waste followed by soil, had the highest count at 5% level of probability. These findings, coupled with the high aerial bacterial counts, indicate a high risk of microbial infection from the waste dump. There is also a high risk of diseases and potential destruction of biodiversity from toxic chemicals from the waste. All the physicochemical attributes determined were within the consent limits except the heavy metal levels in leachate. In view of the economy and high technology involved, it is recommended that both governments and private sectors should review the present waste management practice in relation to traditional methods.

Keywords: Environment, Bacteria, Fungi, Heavy metals.

INTRODUCTION

The intensity of man’s activities has led to increasing volume of solid waste worldwide despite the current level of technological advancement and industrialization. Explosive population growth is one other major factor responsible for increased municipal solid waste (MSW). Land filling of municipal solid waste is a common waste management practice and one of the cheapest methods for organized waste management in many parts of the world [1, 2, 3]. In most low to medium income developing nations, almost 100 per cent of MSW generated goes to landfills. Landfill operations are most feasible in these countries as land is vastly available and moderately inexpensive. Even in many developed countries where land is scarce and where policies of reduction, reuse and diversion from landfills are strongly promoted, great percentage of their generated MSW are still land filled. For instance, in 2006, out of the 251 million tons of MSW generated in the United States of America, 138.2 million tons representing 55% was disposed of in landfills [4]. In England, out of the 29.1million tons of municipal solid waste generated between 2003 and 2004, 72% was land filled [5]. The scenario is similar in Northern Ireland and Scotland where82.9% and 85.4% of their generated MSW were land filled in 2005 and 2007 respectively [6, 7]. Today, however, there is a progressive decrease in the volume of MSW being land filled in these developed countries on a yearly basis as great efforts in solid waste management are today directed towards waste reduction and recycling programmes which is a real giant step in environmental improvements [4, 8]. Landfills may however pose serious threat to the quality of the environment if incorrectly secured and improperly operated. The threat to surface and ground waters could be deleterious. The scale of this threat depends on the composition and quantity of leachate and the distance of a landfill from water sources [9]. Municipal landfill leachate are highly concentrated complex effluents which contain dissolved organic matters; inorganic compounds, such as ammonium, calcium, magnesium, sodium, potassium, iron, sulphates, chlorides and heavy metals such as cadmium, chromium, copper, lead, nickel, zinc; and xenobiotic organic substances [10, 11, 12, 13]. The rate and characteristics of leachate production depends on a number of factors such as solid waste composition, particle size, degree of
compaction, hydrology of site, age of landfill, moisture and temperature conditions, and available oxygen. During the course of stabilization of land filled wastes, non-conservative constituents of leachate (primarily organic in nature) tend to decompose and stabilize with time, whereas conservative constituents remain long after waste stabilization occurs [14]. Such conservative constituents include various heavy metals, chlorides and sulphides. The age of a landfill also significantly affects the quantity of leachate formed. The ageing of a landfill is accompanied by increased quantity of leachate. Leachate generated in the initial period of waste deposition (up to 5 years) in landfills has pH-value range of 3.7 to 6.5 indicating the presence of carboxylic acids and bicarbonate ions. With time, pH of leachate becomes neutral or weakly alkaline ranging between 7.0 and 7.6. Landfills exploited for long period of time give rise to alkaline leachate with pH range of 8.0 to 8.5 [9].

This study was undertaken to assess the level of environmental contamination and potential impact on public health in relation to solid waste management in Ikere Ekiti, Ekiti State, Nigeria. Ikere Ekiti whose current population is about one million is situated on Latitudes 50°14.048’E and Longitudes 70°30.401’N.

MATERIALS AND METHODS

Health Risk assessment of the Solid Waste management

A survey was undertaken to find out the existing facilities for solid waste management in Ikere Ekiti. The facilities included types of waste generated and provision of waste bins at residential, market, industrial and office places; types of depots if any; mode of transportation of waste to disposal site (in open or cover trucks) and final disposal (open dumping or landfill).

Solid Waste sample collection

Using a large wooden spatula properly rinsed with distilled water, the decomposing wastes were collected into sterile glass petridishes, and sealed with masking tape, and properly labeled. The samples labeled, SW1, SW2, SW3 and SW4 were collected from four sampling points at Ikere Central Waste Dump sites. All samples were either transported to the laboratory for analysis or refrigerated at 4oC until they were needed.

Leachate collection

At the base of the dumpsite, the brownish to yellowish-brown liquid that percolates through the waste dump was sampled as the leachate. The leachate was collected by a sterile large kitchen scooping spoon into a sterile conical flask stopper with cotton wool and aluminum foil. The leachate samples were collected from the same points where the waste samples were collected and labeled L1, L2, L3 and L4. The samples were carried to the laboratory for microbiological and physicochemical analyses at 4oC.

Soil sample collection

With a garden rake, the waste was removed to expose the soil under the waste dumps from where waste and leachate samples were collected. Two sets of soil samples were collected from each of the sites. One of the sample sets was analyzed microbiologically, while the other set was for physicochemical analysis. The soil samples were taken at about 15cm depth by the use of hand-driven auger, and taken to the laboratory in labeled polyethylene bags stored in ice packed boxes at approximately 4oC for analysis.

Water sample collection from hand dug well water.

Water samples for bacteriological and physicochemical analyses were collected from four sampling points (W1, W2, W3 and W4) from hand dug well into which run-off from the waste dump flows. The sampling points consisted of two upstream and two downstream stations. The water samples were collected in accordance with recommended procedures and precautions [15]. All samples were collected in previously sterilized containers and stored in iced boxes at 4oC and conveyed to the laboratory for analysis within 1 to 8 hours, or refrigerated until required for analysis. Water samples for physicochemical analysis were collected using one litre plastic containers. All samples were carried in frozen ice packed box at 4oC to the laboratory for analysis.

Microbiological Analysis of the Decomposing Solid Waste, Soil and Hand dug well water samples Total bacterial count

The decomposing waste (1g) was dissolved in 9ml sterile distilled water. From the solution, ten-fold serial dilutions in the ranges 10-1 to 10-9 were prepared [16, 17]. 1ml aliquots of sample dilutions of from 10-3 to 10-6 were seeded in sterile petri dishes and total heterotrophic bacterial count was determined by pour plate technique using tryptone soya agar which can support the growth of aerobes and anaerobes(5). For the recovery of aerobes, tryptone soya agar was used, while tryptone soya agar was supplemented with 1% (w/v) cysteine hydrochloride (BDH chemicals, U.K.) for anaerobes. Aerobic cultures were incubated at 35oC for 48 hours, while anaerobic cultures were incubated in Baird and Tatoch anaerobic jar at 30oC for 48 to 72 hours. Visible numbers of growth colonies (between 30 and 300) were multiplied by the reciprocal of the dilution factors, and recorded as colony-forming units per gram (cfu/g) of waste [18, 15]. The same treatment was given to the soil samples and water samples. Each of the dilutions was cultured in triplicates and mean counts were obtained. Characteristic colonies on the tryptone soya agar were picked using a sterile wire loop and streaked on nutrient agar and incubated at 37oC for 24 hours. This process was repeated until pure cultures of bacterial isolates were obtained. The isolates were maintained on agar slants and stored in the refrigerator at 4oC until required for characterization.

Fungal count

The procedure earlier described for bacterial count was adopted for fungi count of the waste and soil samples. However, the medium of choice was sabouraud dextrose agar, while incubation period was 2 to 3 days at room temperature.

Discrete colonies were subcultured on malt extract agar (oxoid), acidified to a pH of 4.8 to suppress the growth of bacteria and incubated at room temperature for about 3 – 5 days until pure cultures were obtained. The isolates were identified by the use of standard identification keys [15, 19, 20].

Microbiological Analysis of air at dumpsite

The method described by Lynch and Poole [21] was adopted. Triplicate nutrient agar plates were exposed at waste dumpsite (1m from the dump) and 100m away from the site for 1 hour between 10 and 12 noon. The plates were then covered and incubated at 37oC for 24 hours. The bacterial colonies that appeared on the agar were counted. The counts on the plates of 1m and 100m away from the dumpsites were compared to give an idea of the levels of air pollution [21].

Microbiological Analysis of Leachate

In view of the highly turbid nature of the leachate, tenfold serial dilution was made. 1ml was dissolved in 9ml of sterile
isolates

Characterization and identification of the pure microbial isolates

The pure cultures were again inoculated onto nutrient agar for the purpose of obtaining purer isolates. MacConkey agar (Oxoid, England) was used for the isolation of coli-aerogenes-like enteric organisms [22], Xylose Lysine Deoxycholate (XLD) agar for the presumptive identification of both Salmonella and Shigella, and incubated at 37°C for 24 hours [23].

On MacConkey agar (a differential medium), Escherichia coli colonies appeared red and nonmucoid; Aerobacter aerogenes colonies appeared pink and mucoid; Enterococcus (faecal Streptococcus) appeared red, minute and round; Staphylococcus colonies appeared pale-pink and apple, while Pseudomonas aeruginosa colonies appeared greenish brown with a fluorescent growth [24].

On XLD agar (a selective medium for the isolation of salmonellae and shigellae), Shigellaformed red colonies because they can ferment xyllose, lactose or sucrose [23]. Salmonellae also formed red colonies even though they do ferment xyllose with acid production. Proteus strains (Arizona and Edwardsiella species) formed red colonies with black centres [24]. The purified isolates were characterized and identified using a modified form of John L’s bacterial identification scheme [25, 26]. In this scheme, some chemoheterotrophic bacterial genera were sorted out based on various primary tests, such as Gram staining and shape of bacteria along with the results of glucose fermentation tests, catalase and oxidase reactions, motility, and possession of endospores, aerobic and anaerobic growth. Coagulase test was performed on Staphylococcus isolates and those which were coagulase positive were cultured on mannitol salt agar to confirm Staphylococcus aureus, based on their growth pattern. Suspected Escherichia isolates were further subjected to differential tests using Eijkmann test and indole, methyl red, Voges Proskauer, and citrate utilization (Im Vic) tests.

Physicochemical Analysis of Soil and Decomposing Solid Waste

In the laboratory, the moisture content of the soil samples was immediately determined by determining the difference in weight before and after drying in the oven at 120°C to constant weight. Soil samples were then air-dried, ground with a wooden roller and sieved through a2mm mesh. The pH was determined using Coring pH meter (Model 5) [27]. The method of Fawole and Osu (1980) was used in determining the organic carbon. This was done by igniting the dried sieved soil sample (2.5g) in a pre-weighed crucible, and calculating the loss in weight by difference, followed by the calculation of the organic carbon in soil sample. Available phosphorus was determined by the method of Bray and Kurtz [28]. Nitrite was measured spectrophotometrically by the diazotization method after filtering the sample at low vacuum through a 0.4μm pore size membrane filter. After filtering the sample as above, nitrite was measured as nitrate after reduction in a cadmium reduction system [29]. Ammonium (NH4+) was measured by determining the NH3 liberated by the action of alkali (MgO) with NH4+ in the soil extract.

Total nitrogen was determined by the micro-kjeldahl digestion method [30]. Total hydrocarbon (THC) was determined following extraction with redistilled n-hexane before measuring the total hydrocarbon content colorimetrically at 430nm using a DR/3000 HACH spectrophotometer (England). Particle size measurement was determined by the Bouyoucos hydrometer method [31] and modified by Gee and Bauder [32]. This involved weighing about 100g of air-dried soil sample into a container and adding 50ml of sodium hexametaphosphate solution followed by stirring for 30 minutes. The mixture was left overnight in a 250ml measuring cylinder followed by shaking and inverting the cylinder several times. After 40 Seconds, the first reading which gave the percentage of clay and silt was recorded [32], while the second reading was taken after two hours as the percentage of sand. The decomposing solid waste samples were air-dried as was the case with soil, following which it was ground with a wooden roller and sieved through a 2mm mesh. The pH, electrical conductivity, total organic carbon, available phosphorus, total hydrocarbon (THC), sodium, potassium, magnesium, and calcium were measured using the same procedure applied in analyzing the soil samples.

Physicochemical Analysis of Leachate

Turbidity (NTU) was measured spectrophotometrically using standards according to HACH. Biochemical Oxygen Demand (BOD5) was measured as the difference between initial oxygen concentration in sample and concentration after 5 days incubation in DO bottles at 20°C. Nitrite and Nitrate were determined using the method already described for soil. Sulphate (SO4) was measured spectrophotometrically by turbidimetry using Barium chloride. Chloride (Cl-) was measured titrimetrically using silver nitrate and potassium dichromate as indicator [33]. Temperature was measured using Celsius thermometer.

Physicochemical Analysis of Water from Hand dug well

Water temperature, pH Dissolved Oxygen (DO) and conductivity were measured on site. The DO and water temperature were measured with WTW-pH electronic meter, (sensitivity + 0.1%). Electrical conductivity was measured with WTWLF-90 conductivity meter, (sensitivity + 1.0%). Salinity was determined by argentometric method. In the laboratory, turbidity (NTU), BOD5, Nitrite (NO2-), Nitrate (NO3 -), Chloride (Cl-) and Sulphate (SO4 -2) were measured using the methods earlier described for leachate.

Analysis for Heavy Metals in Leachate and Water

The concentration of each metal in leachate was determined from the samples after due calibration runs using appropriate salts of the metals (Cr, Cd, Zn, Ni, Pb, Co, Mn, Cu and Fe). Atomic Absorption Spectrophotometer (ASS Model 2380) was used for the analysis [34].

Statistical Analysis

Statistical analysis using a two-way analysis of variance (ANOVA) was applied to determine the association of attributes between the months of May to August on one hand, and sources of samples on the other, with respect to mean bacterial and fungal counts [35].
The facilities which were considered as the operational factors of solid waste that relate to public health are presented in Table 1. The results have revealed the sources of solid wastes, whether the wastes were sorted or not before disposal and whether households possessed dustbins or not. It is also obvious, the type of waste and collection, mode of transportation, disposal method and type of disposal sites. Generally, the factors are not satisfactory, except that wastes loaded in trucks were covered with tarpaulin on transportation to the disposal site. Tables 2 and 3 show the mean total bacterial and fungal counts at waste dumpsite in Ikere Ekiti. There was no significant difference (P>0.05) between the sources of samples and between the months of sampling with respect to bacterial counts. On the other hand, fungal counts showed highly significant differences (P<0.01) between the sources of sampling and between the months of sampling. The frequency of occurrence of bacterial and fungal species isolated from sources of samples is represented in Tables 4 and 5. Streptococcus 30(21.10%) followed by Escherichia 31(20.40%) were the most prevalent bacteria in the decomposing solid waste. However, Bacillus 46(17.70%), Pseudomonas 40(34.11%), Salmonella 32(21.82%) were most prevalent in soil, leachate and hand dug well, respectively. Of the fungal species, Saccharomyces 22(20.84%), Penicillium 28(24.80%), Aspergillus 23(20.20%) and Rhizopus 26(22.95%) were most frequently isolated in the decomposing solid waste, soil, leachates and hand dug well, respectively. Figure 2 shows the number of bacteria per plate during the aerial sampling around the wastedump in the months of May to August 2013. The chart shows that particulate substances in the air nearer the dumpsite have more bacteria than those farther away. Moreover, bacterial level decreased from May to August. The mean levels of physicochemical parameters of solid waste at Ikere Ekiti waste dump, leachate and soil at dumpsite are shown in Table 6. Observably, only slightly high level of THC (11.10mg/kg) for soil and 9.0mg/g for decomposing solid waste were encountered. The level of THC for soil was slightly above the Department of Petroleum Resources consent limit of 10mg/kg. Most of the physical properties of the hand dug well were within acceptable limits as shown in Table 7. A few others e.g., BOD5 which ranged from 5.3 (+ 1.20) to 9.1 (+ 1.30) mg/l show levels above consent limits. The leachate however, shows very low and acceptable level of BOD5. The heavy metal levels in leachate were far above consent limits (Table 8).

### Table 1: operational factors of solid waste management in Ikere Ekiti in relation to public health

| Sources of solid wastes          | Description of waste                                                                 | Type of collection                                                                 | Type of disposal site and method                  |
|---------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|--------------------------------------------------|
| 1. Residences, stores, restaurants and market | Wastes from preparation, cooking and serving of food mainly, garbage. | Vehicular collection from centralized points and depots with the use of truck. | Open dumping into erosion gullies and some time burn. |
| 2. Municipal, e.g., streets, sidewalks alleys | Wastes are bulky. Mainly street refuse, dead animals and abandon vehicles. | Vehicular collection from centralized points and depots at designated areas with the use of truck. | Open dumping into erosion gullies and some time burn. |
| 3. Industrial, e.g., construction site, vacant sites, small scale industries. | (a) Industrial refuse mainly solid wastes resulting from industrial processes and Manufacturing operations such as food processing wastes, wood, plastic and metal Scraps, etc.
(b) Construction and demolition wastes, e.g., lumber, roofing and sheathing scraps, broken concrete etc.
(d) Animal and agricultural wastes such as manures and crop residues
(e) Special wastes, mainly hazardous wastes such as pathological wastes, explosives, radioactive materials, security Wastes, confidential documents and papers. |                                                                                     |                                                   |

### Table 2: mean total bacterial counts at Ikere Ekiti dumpsite

| Source of sample | Mean bacterial Count (x10<sup>6</sup>) | Colony-forming Units (cfu) |
|------------------|----------------------------------------|-----------------------------|
| May              |                                        |                             |
| June             |                                        |                             |
| July             |                                        |                             |
| August           |                                        |                             |
| Source of sample | Mean bacterial Count (x10⁶) | Colony-forming Units (cfu) |
|------------------|-----------------------------|-----------------------------|
|                  | May | June | July | August |
| Decomposing solid waste | 8.6 ± 3.70 | 6.1 ± 2.63 | 11.8 ± 5.09 | 15.30 ± 2.01 |
| Soil at dump site | 7.80 ± 2.50 | 6.4 ± 2.46 | 6.50 ± 3.01 | 6.2 ± 2.10 |
| Leachate | 2.4 ± 2.02 | 13.50 ± 4.10 | 3.60 ± 1.44 | 2.6 ± 1.16 |
| Hand dug well | 3.05 ± 1.60 | 4.0 ± 2.10 | 5.25 ± 4.10 | 9.75 ± 4.10 |

| Bacterial species | Number (%) of bacterial species from sources of sampling |
|-------------------|--------------------------------------------------------|
|                  | Solid waste | Soil | Leachate | Hand dug well |
| Staphylococcus    | 36(25.85)   | 24(10.77) | 11(8.53) | 12(8.48) |
| Streptococcus     | 30(21.10)   | 33(12.70) | 8(6.20)  | 14(8.48) |
| Shigella          | 13(5.48)    | 8(3.08)   | 3(1.55)  | 32(21.82) |
| Salmonella        | 7(6.44)     | 32(12.31) | 10(7.75) | 32(21.82) |
| Escherichia       | 31(20.40)   | 49(19.61) | 12(10.85)| 14(8.48) |
| Bacillus          | 8(5.44)     | 46(17.70) | 2(16.28) | 7(4.24)  |
| Proteus           | 3(3.04)     | 32(13.06) | 20(14.73)| 15(8.48) |
| Pseudomonas       | 17(12.25)   | 28(10.77) | 40(34.11)| 29(18.20)|
| Total             | 145          | 254       | 106      | 155      |

| Bacterial species | Number (%) of fungal species from sources of sampling |
|-------------------|------------------------------------------------------|
|                  | Solid waste | Soil | Leachate | Hand dug well |
| Aspergillus       | 12(12.14)   | 16(14.00) | 23(20.20) | 0 |
| Penicillium       | 17(11.77)   | 28(22.80) | 13(17.76)| 0 |
| Mucor 2           | 21(19.12)   | 24(20.60) | 0 | 13(23.02) |
| Rhizopus          | 18(16.94)   | 13(10.40) | 21(18.34)| 26(22.95) |
| Zygorrhynchus     | 0           | 0 | 0 | 11(12.30) |
| Neurospora        | 6(4.80)     | 0 | 0 | 9(15.74) |
| Alternaria        | 0           | 0 | 6(7.43) | 0 |
| Cephalosporum     | 13(10.59)   | 9(7.80)   | 10(11.01) | 0 |
| Absidia           | 0           | 0 | 0 | 19(14.75) |
| Trichoderma       | 9(3.80)     | 0 | 9(7.34) | 18(14.75) |
| Fusarium          | 0           | 0 | 11(11.01) | 0 |
| Saccharomyces     | 22(20.84)   | 25(24.40) | 0 | 23(19.67) |
| Helminthosporium  | 0           | 0 | 5(5.50) | 0 |
| Pullularia        | 0           | 0 | 0 | 0 |
| Triamnium         | 0           | 0 | 4(5.50) | 8(4.92) |
| Total             | 118          | 117 | 102 | 127 |
### Table 6: Physicochemical parameters of Ikere Ekiti solid waste at dumpsite, leachate and dumpsite soil

| Parameters                          | Mean levels of Decomposing solid waste | Parameters obtained | Soil at dump site |
|-------------------------------------|----------------------------------------|---------------------|-------------------|
| pH                                  | 6.79 ± 1.80                            | 6.38 ± 1.30         | 7.42 ± 2.62       |
| Total moisture (%)                  | -                                      | -                   | 12.04 ± 0.10      |
| Electrical conductivity (s/cm)      | 12.10 ± 0.10                           | 13.32 ± 1.20        | 24.00 ± 0.15      |
| Total organic carbon (%)            | 2.30 ± 1.90                            | -                   | -                 |
| Biochemical oxygen demand (mg/l)    | -                                      | 0.09 ± 1.20         | -                 |
| Available phosphorus (mg/kg)        | 1.70 ± 0.9                             | -                   | 1.30 ± 0.14       |
| Nitrite (mg/l)                      | 1.00 ± 0.02                            | 1.20 ± 0.02         | -                 |
| THC (mg/kg)                         | 9.0 ± 0.8                              | -                   | 11.10 ± 0.40      |
| Sodium (Na) (mg/kg)                 | 0.89 ± 0.40                            | 2.40 ± 0.02         | -                 |
| Chloride (mg/l)                     | -                                      | -                   | 0.81 ± 0.20       |
| Potassium (K) (mg/kg)               | 0.40 ± 0.40                            | -                   | 0.6 ± 0.10        |
| Magnesium (Mg) (mg/kg)              | 1.2 ± 0.10                             | -                   | 1.0 ± 0.01        |
| Nitrate (mg/l)                      | -                                      | 3.10 ± 0.04         | -                 |
| Calcium (Ca) (mg/kg)                | -                                      | 1.6 ± 0.01          | -                 |
| Dissolved oxygen (mg/kg)            | 9.2 ± 0.03                             | 29.3 ± 0.02         | -                 |
| Clay (%)                            | 7.0 ± 0.01                             | -                   | 16.10 ± 0.01      |
| Silt (%)                            | 70.0 ± 0.04                            | -                   | 60.02 ± 0.02      |

### Table 7: Physicochemical parameters of Ikere Ekiti hand dug well water.

| Parameters                          | Mean levels of Parameters obtained | Parameters obtained |
|-------------------------------------|-------------------------------------|---------------------|
| pH                                  | HDW1                                | HDW2                | HDW3                |
| Temperature(°C)                     | 7.4 ± 2.10                          | 7.2 ± 2.1           | 7.1 ± 1.0          |
| Turbidity (NTU)                     | 28.6 ± 0.01                         | 26 ± 0.12           | 28.3 ± 0.9         |
| Total dissolved solids (mg/l)       | 33.2 ± 1.08                         | 24.1 ± 1.20         | 18.1 ± 1.50        |
| Dissolved oxygen (mg/l)             | 2.6 ± 0.01                          | 3.6 ± 0.10          | 5.2 ± 1.20         |
| Biochemical oxygen demand (BOD5) (mg/l) | 9.4 ± 2.30                         | 7.0 ± 2.21          | 6.5 ± 0.10         |
| Sulphate (SO4²⁻) (mg/l)             | 2.4 ± 1.3                           | 3.91 ± 1.36         | 5.82 ± 1.60        |
| Nitrite (NO2⁻) (mg/l)               | 1.6 ± 0.01                          | 1.00 ± 0.01         | 0                  |
| Nitrate (NO3⁻) (mg/l)               | 5.7 ± 1.3                           | 4.1 ± 1.32          | 3.4 ± 1.20         |
| Chloride (Cl⁻) (mg/l)               | 21.12 ± 0.03                        | 18.4 ± 0.25         | 23.1 ± 0.20        |
| Conductivity (s/cm)                 | 24.20 ± 0.01                        | 34.1 ± 0.02         | 31.20 ± 2.10       |

### Table 8: Mean levels of heavy metals in the leachate and water samples

| Heavy metal      | Leachate          | Water            |
|------------------|-------------------|------------------|
| Cadmium (Cd) (mg/l) | 0.01 ± 0.03       | 0.01 ± 0.0      |
| Chromium (Cr) (mg/l) | 0.01 ± 0.02       | -                |
| Zinc (mg/l)       | 31.09 ± 6.03      | 3.09 ± 1.03     |
| Nickel (Ni) (mg/l) | 0.17 ± 0.01       | -                |
| Iron (Fe) (mg/l)  | 8.80 ± 0.31       | 1.80 ± 0.01     |
| Manganese (Mn) (mg/l) | 1.56 ± 0.16     | 0.56 ± 0.10     |
| Copper (Cu) (mg/l) | 0.61 ± 0.01       | -                |
| Cobalt (Co) (mg/l) | -                 | -                |
| Lead (Pb) (mg/l)  | 0.04 ± 0.09       | -                |

**DISCUSSION**

This study revealed that the composition, storage and disposal of solid waste in Ikere Ekiti potentially have environmental and public health implications. Only about 60% of households have appropriate containers as dustbins. Moreover, central depots where each household can deposit wastes for collection later by...
garbage trucks are either not evenly located along the streets, or located very far away from most households. Consequently, most households throw their refuse in any available space [36]. This has been the situation in most Nigerian cities including Abuja till date, as reported by The Nation Group of Newspapers [37]. Solid wastes are not separated or sorted into biodegradable and non-biodegradable wastes as is the practice in developed countries. In this respect, bottles and tins are also separated at the point of collection in order to facilitate proper handling by authorities [36] while some of the separated wastes could be recycled. Industrial wastes which usually contain toxic chemicals and sometimes radio-active substances including electronic wastes are lumped together with domestic and or market/commercial wastes. This poses very serious health consequences. It was noted in this study that wastes conveyed in trucks to disposal sites were covered with tarpaulin. This reduced aerial spread of particulate substances and odour. However, the disposal site is an open dump where aerial pollution may be very high as wastes are being discharged from the trucks, especially at distances within a few meters from the dumpsite. This implies that residents living near the dumpsite are at a high risk of contracting air borne infection by bacterial or toxic chemical substances.

Total bacterial and fungal counts from decomposing solid waste, soil at the waste dumpsite, leachate and Hand dug well were generally high during the four months of sampling from May to August 2010 (Tables 2 and 3). Fungal counts showed highly significant difference (P<0.01) between the sources of samples and between the months of sampling, unlike bacterial counts which showed no significant difference (P>0.05). Least significant difference (LSD) test at 5% level of probability showed the decomposing waste had the highest fungal counts followed by soil at dumpsite, Hand dug well and leachate in that order. Similarly, fungal growth was highest in August followed by July, June and May in that order. This indicates a high risk of contracting fungal infection from solid waste dumps during the months of August and July, probably as a result of dampness arising from slight rain showers during the two months.

The potential for disease epidemics from the open dumping of solid waste in Ikere Ekiti is high. Most of the bacterial and fungal isolates from the solid waste, soil at dumpsite, leachate and Hand dug well are pathogenic (Tables 4 and 5). In particular, the presence of Staphylococcus 36(25.85%), Streptococcus 31(21.10%) and Escherichia 30(20.41%) in the solid waste, points to health risk associated with solid waste. Other pathogens show high frequencies in soil, leachate and particularly Hand dug well. The reports that as long as solid wastes disposal is essentially of simple dumping type, its land pollution effects need to be strongly stressed PAI Associate International.

Some of the most common contaminants contributing to land pollution around urban centres are household refuse especially food remnants, packing materials such as paper, cartons, boxes and plastics, tyre residuals, cans and ash resulting from burning; also, organic industrial residuals such as those from canny operations like pulp, pits and culls, etc. contribute to urban land pollution.

From environmental point of view, the pollution from open dumping of waste could result in the production of not only unsightliness but also bad odours. From public health point of view, such improper waste disposal technique can become a serious health hazard through creating suitable environments from which diseases can be transmitted.

The physicochemical properties of solid waste, soil and Hand dug well were generally within acceptable limits [39] (Tables 6 and 7). However, the THC of the soil at dumpsite was above the maximum permissible limit [40, 41] indicating the presence of petroleum probably leaching into the soil from the solid waste. BOD5 in water was apparently high [42] indicating organic pollution from anthropogenic sources especially through run-off input from the waste dump.

This may destabilize the ecological balance of the aquatic ecosystem through depletion of dissolved oxygen [40].

The physicochemical properties of the leachate (Table 6) appear to be generally within acceptable limits, but the levels of some of the heavy metals are not within permissible limits (Table 8). Except chromium, cadmium, nickel and lead all other heavy metals tested were above the permissible limits (41). Excess of some heavy metals in the environment can cause serious environmental health consequences. Metals Zn, Cd, Cu, Cr, Pb and Ni are well known toxicants that can occur in a variety of wastes and cause either acute or chronic effects on organisms in receiving water [41,43]. Others may kill valuable and rare vegetations and wildlife by dumping of tailings, oil, rubber and similar materials. Besides, some health hazards resulting from improper disposal of solid wastes are known.

CONCLUSION

In conclusion, the open waste dump at the dumpsites could constitute sources of microbial and toxic chemical contamination of the dumpsite soil and hand dug well. This could pose serious health risk and destruction of biodiversity in the environment. The situation could be aggravated by the poor storage systems in homes and establishments thus constituting good channels for disease transmission by flies, mosquitoes and rats.

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