Global Journal of Earth and Environmental Science
Volume 5(2), pages 37-50, June 2020
Article Number: 9D9BD1032
ISSN: 2636-6002
https://doi.org/10.31248/GJEES2020.069
https://integrityresjournals.org/journal/GJEES

Full Length Research

The impacts of poor solid waste management practices on Ala river water quality in Akure, Nigeria

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Received 16th April, 2020; Accepted 1st June, 2020

ABSTRACT: The present study assessed solid waste management practices and impact on Ala River water quality in Akure, Ondo state, Nigeria. The primary data were obtained through field observation, interviews and questionnaire while secondary data were obtained from desk review of use of journals, articles, seminar papers, internet sources, government official publications. Simple random sampling technique was used to obtain required information for the study. Results showed that 37.8% of the solid waste generated is of vegetable and food remains origin, polythene and plastics wastes are 28.3 and 19.1% respectively. The result shows that 66% of the respondents do not segregate their waste before disposal and knowledge on waste recycling was low. The major limitations at household and community levels are inadequacies of collection and storage facilities. Similarly, perception towards municipal solid waste management was generally low. The major effects of poor waste management in the study area were land pollution, flooding and water pollution of River Ala in Oke-Aro district of the study area. This is evident in the high levels of turbidity, biochemical oxygen demand, dissolved oxygen and fecal coliform bacteria of the water quality of River Ala, all of which suggests the presence of microbial organisms which may have been introduced to the water body via diffuse pollution aided by urban storm water runoff and leachate. It is therefore recommended that government should provide more waste receptacles in at both residential and commercial areas across the study area. Finally, government should consider waste-to-wealth initiatives. The first step in realizing this would involve encouraging the residents on the need to sort their waste before disposal and, secondly, waste characterization to determine the energy potentials of waste streams in the study area.

Keywords: Awareness, community participation, solid waste management, water quality.

INTRODUCTION

The increasing rate of uncontrolled and unplanned urbanization in the developing world, particularly in Africa, has resulted in environmental decay and degradation. Part of the underlying causes of this problem is inefficient waste management services. In fact, one of the main concerns of urban expansion in developing countries, particularly in Nigeria, has been the issue of urban solid waste management, current activities in major cities in the country demonstrate that the issue of urban solid waste management has become more significant than ever (Momoh et al., 2010; Abila and Kantola 2013; Purity et al., 2016; Ebikapade and Baird, 2017). Since independence, like with most countries of the world, Nigeria has witnessed growing populations and economies both of which are putting pressure on the environment. It is projected that from 2017 to 2050, nine countries including Nigeria are expected to account for half of the world's projected population increase (United Nations Department of Economic and Social Affairs, 2019), and about 70% of this population is expected to dwell in urban centers. Urbanization will normally bring about changes in consumption patterns and lifestyle, and one implication of these changes is increased urban solid waste generation and associated management problems. In fact, the link between urbanization and municipal solid waste management problems have been established by previous authors. For example, Ugwuanyi and Isife (2012), Vij (2012), Joshi and Ahmed (2016) and Chithra et al. (2016) have all shown that the growing trend of urban population has direct link with accumulation and decomposition of the waste in public places with adverse effects on public health. Previous studies have shown that cities in Nigeria grew by 5.8% per annum between Independence in 1960 and 1993. This is more than twice the rate of increase of the total population (UNDP, 1998; NPC, 1998). By 1999, 36.2% of Nigeria's population lived in urban areas, up from 19% in 1963 (Ugwuanyi and Isife, 2012). This growth rate implies that the amount of solid wastes generated in the cities would also be on the increase. The 2006 census records on distribution of regular households in Nigeria by method of solid waste disposal (NPC, 2006) showed that, of 28,197,085 tonnes of solid waste generated in Nigeria, 5,439,274 were collected, 2716,037 were buried, 5,759,200 were disposed at the public approved dump site, 7,965,527 were disposed at the unapproved dump site, 5615,273 were disposed by burning, while 701,774 were disposed by other unknown methods. Improper municipal solid waste management system may create serious negative environmental impacts like infectious diseases, land and water pollution, obstruction of drains and loss of biodiversity (Ejaz et al., 2010; Ezeah, 2010). In Akure, Ondo State capital, Nigeria, many areas around the home are littered with domestic sewage waste, garbage and other wastes from various land uses found within the city. The city is characterized by the generation of large volume of wastes, some of which are toxic with negative impacts on the environment.

To ensure a clean and safe environment, the Ondo State Government established Ondo State Waste Management Authority (ODSWMA) in 1999, to monitor the environmental quality and to ensure a waste free environment (Ondo State of Nigeria, 1999). Despite these efforts, improper municipal solid waste management continues to be a source of concern to policy makers and researchers. The existing waste management system in the state has not been able to keep pace with the demand for the present and ever-growing population of the area. Thus, the common practices include conversion of unused lands by government into dumpsites, considered as approved dumpsites, and the unapproved dumpsite involving indiscriminate refuse disposal in any available open space, inside drainage and river bodies, uncompleted building, and abandoned sites by residents. Even the approved dumpsites are at best described as unsustainable, as the waste disposal trucks and other vehicle that deliver waste to the sites only drive into the dumpsite through the access road and dump their waste. Thereafter, scavengers descend on the waste to pick up recyclable materials for sale and the remains is set on open fire for volume reduction. The present practices, thus expose the residents of the town to different health hazards associated with air pollution and water contamination (Oduwaye, and Ilechukwu, 2012; Salami et al., 2018). Ezemonye et al. (2016), Butu and Sadiq (2016) and Butu et al. (2020) have also established relationship between indiscrimated solid waste and water pollution in some Nigerian cites. Apart from management deficiencies, lack of legislative implementation and poor funding on the part of municipal authority, lack of social awareness of the effect of polluted environment and community involvement in solid waste management as have also been confirmed in other studies (WHO, 2006; Ejaz et al., 2010) are major hindrance to effective municipal solid waste management in Akure. In view of this, the present study aims to assess the pattern and practice of solid waste management in Akure, level of awareness/community involment and implications for water quality of River Ala in Oke-Aro district of the study area.

MATERIALS AND METHODS

Study area

Akure is located between latitude $7^{0}15^{II}$ north of the equator and between longitude 5^{0} and 15^{II} east of the Greenwich Meridian and covers a total area of about $41.2km^{2.}$ Akure (Figure 1) is bounded on the west by Ibule town in Ifedore Local Government Area, in the South, by Idanre town in Idanre Local Government Area, in both the East and North; Akure shares a common boundary with Ogbese and Itaogbolu towns both in Akure North Local Government Area. The study area is, approximately, 700 km southwest of Abuja, Nigeria the Federal Capital Territory (FCT) and about 350 km to Lagos, Nigeria's commercial center. The relative increase in the political influence of Akure as a state capital since 1976 has greatly promoted its rapid population and areal extent growth. This has increased her socio-economic activities. The 1991 national population census, puts the population of Akure at 239,124 and its estimated population in 1996 was 269,207 (National Population Commission, 2006), population of Akure in 2006 population census was 360,268. According to National Population Commission of Nigeria, Bureau of Statistics, the population of Akure was projected to be 486,300 in 2017 (using 3.18% annual growth rate) (Ondo State Bureau of Statistics, 2018) and 544,707 in 2019 at a growth rate of 3.8%.

Types and sources of data

Primary data used for this research were information on waste - generation, segregation, collection, recycling and disposal. The primary data were obtained through organized field observation, personal interviews and questionnaire administration to the residents of the study area. The secondary data include materials from desk

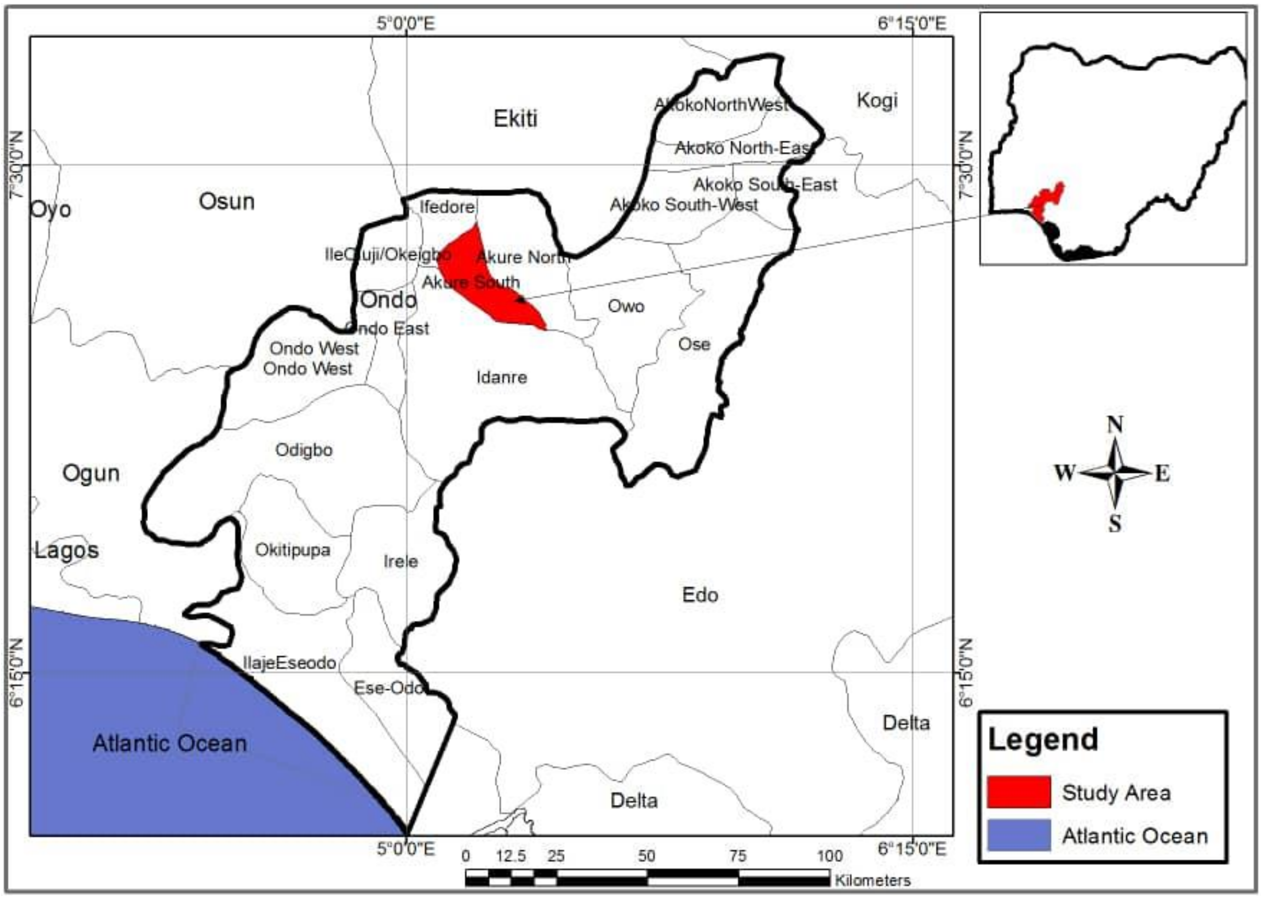

Figure 1. Ondo State map showing Akure.

Table 1. Number of questionnaire administered.

Districts	Sample size	No of samples administered
Alagbaka	24315	20
Arakale	77808	64
Ayedun	43767	36
Ijoka	106986	88
Ijapo	68082	56
Ojo-Oba	29178	24
Oke-Aro	38904	32
Isolo	97260	80
Total	486300	400

review such as journals, articles, seminar papers, internet sources, and government official publications. The sample frame was drawn from eight residential districts (Alagbaka, Arakale, Ayedun, Ijoka, Ijapo, Ojo-Oba, Oke-Aro and Isolo) with a total population of 486,300, according to Ondo State Bureau of Statistics (OSBS, 2018). This study utilized the Yamane (1967) statistical technique to determine the sample size in each district for questionnaire administration. On the whole, total of 400 questionnaires were randomly administered to the residents of the study area as shown in Table 1 and Figure 2. Out of this number, a total of three hundred and ninety-two (392) copies of questionnaires were retrieved. This represents 98% of the total questionnaires distributed and this was found to be adequate for the analysis.

Water sampling procedure

To determine the impact of observed municipal solid waste management practices in the study area, River Ala in Oke-Aro district was chosen which traverse the study area and serve as an important source of water for some residents of the study area. The river is considered as a receiving body for diffuse pollution in the study including contaminants from waste dumps especially due to proximity to dump sites. Water samples were collected from the various sources along the river (designated as station 1, 2 and 3). In collecting water samples, a distance of 50 meters interval was maintained between the stations in line with similar approach used in Ogbomida and Emeribe (2013). Samples were collected once in every

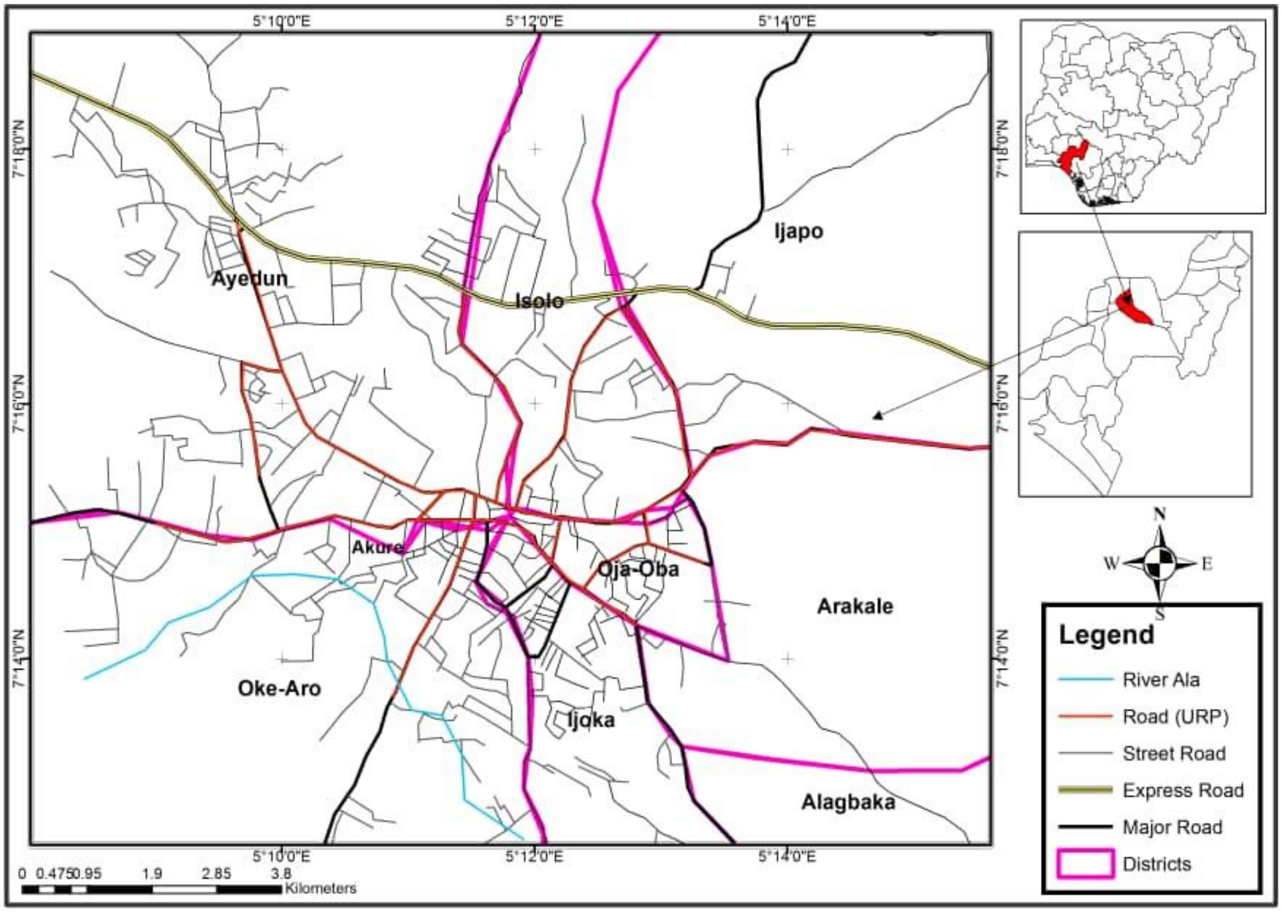

Figure 2. Sampled districts and River Ala in the study area.

months from March and July, 2018, representing dry and rainy season respectively. Samples were analyzed for changes in pH, conductivity, biochemical oxygen demand, dissolve oxygen, total dissolve solids, turbidity, nitrate, phosphate and total coliform count.

Determination of turbidity

This was determined using a standardized Hanna H198703 Turbidimeter. The samples were poured into the measuring bottle and the surface of the bottle was wiped with silicon oil. The bottle was then inserted into the turbidimeter and the reading was obtained and recorded in Nephelometer Turbidity Units (NUT). Turbidity is an expression of the optical property which causes light to scattered and absorb settler than transmitted in a straight line through the situation.

Determination of pH

The pH value indicates whether water is acidic or alkaline. The pH of the water samples was determined using the Hanna microprocessor pH meter. It was standardized with a buffer solution of pH range between 4 and 9.

Determination of electrolytic conductivity

The water conductivity values were determined *in situ* using the suntex 120 conductivity meter. The meter probe was immersed into the surface water and the values were read from the conductivity meter.

Determination of dissolved oxygen

Dissolved oxygen (DO) was determined by the Azide modification of Winkler's method adapted for the HACH DR 2010 equipment for standard methods. Clean 60 ml glass-stopper BOD bottle was filled to over flowing with water samples directly from source. Fixation in the field was carried out by adding the contents of Dissolved Oxygen 2 powder pillows. The bottle stoppers were restored and the content was thoroughly mixed by rotation and inversion until a flocculent brownish precipitate was produced. The bottles were stored away in darkened containers under water until their contents were titrated in the laboratory. Before titration, the contents Dissolved Oxygen 3 powdered pillow (sulphamic acid) was added, thoroughly mixed, and aliquots of 20 ml with 0.200 n sodium thiosulphate using the HACH Digital Titration, until the sample changed from yellow to colourless. Using starch indicator towards the end of the titration remarkably improved the end point from deep blue to colourless. The number of digits from the digital counter window multiplied by 0.1 gave the concentration of dissolved oxygen in mg/l.

Determination of biochemical oxygen demand

A darkened bottle was used to collect the water sample. The sample was incubated for 5 days at 20 to 23.5°C (i.e. room temperature) in a light-tight drawer. After 5 days, the level of dissolved oxygen was determined by conducting the dissolved oxygen test. The biochemical oxygen demand level was then determined by subtracting this dissolved oxygen from the dissolved oxygen level found in the original sample taken 5 days previously.

Determination of total dissolved solids (TDS)

Total dissolved solids was determined by Gravimetric Method. A portion of water was filtered out and 10 mL of the filtrate measured into a pre-weighed evaporating dish. Following the procedure for the determination of total solids, the total dissolved solids content of the water was calculated:

$$\text{Total dissolve Solids (mg/l)} \frac{\text{W2} - \text{W1)mg x 100}}{\text{Ml of filtrate used}}$$

Where: W1 = initial weight of evaporating dish, W2 = final weight of the dish (evaporating dish + residue) and Ml = milliliters of water.

Microbial analysis

Total coliforms are a group of bacteria commonly found in the environment. Total coliform bacteria are not likely to cause illness, but their presence indicates that the water supply may be vulnerable to contamination by more harmful microorganisms. The three-tube procedure using lactose broth (Hammad and Dirar 1982, Fawole et al., 2002) was used for the detection of coliform and determination of the Most Probable Number (MPN) of coliform bacilli, 0.1, 1.0 and 10 ml of each sample were used to inoculate the lactose broth in five replicates using the McCrady table following standard methods (APHA, 1985). For the detection of faecal coliform bacteria, production of acid and gas reflected through the colour change of the indicator incorporated into the lactose broth and accumulation of gas in the inverted Durham tube inserted in the broth was taken as positive indication (d'Auriac et al. 2000). Inocula from tubes showing positive results were cultured into MacConkey broth and incubated at 37°C for 48 hours. These tubes were placed on Eosin-Methylene Blue (EMB) agar and incubated as before. Colonies grown on EMB plates were selected and finally identified on the basis of morphological, cultural and biochemical characteristics for the isolation of Escherichia coli (APHA, 1998). At the end of incubation, distinct colonies of bacteria reflected through the colonial morphology were picked and purified to obtain pure cultures. They were then subjected to routine primary and biochemical tests. The isolates were identified based on the schemes and description of Bergey's methods (Buchanan and Gibbons, 1974) for bacteria and Mislivec et al. (1992) for fungi. The colonies were identified on plates based on morphological features.

Determination of nitrate

The brucine method was used for the estimation of Nitrate - Nitrogen (APHA, 1998). The method is based on the principle that brucine in acidic medium reacts with Nitrate (NO_3) to produce a yellow colour at elevated temperatures. Ten millimeters of water to be tested was measured into a test tube before gently adding sulphuric acid, H_2SO_4. The test tube content was cooled in a water bath for twenty minutes and 0.2 mL of brucine sulphate was added and properly mixed. The sample was then allowed to boil for 25 minutes in a water bath. The boiled sample was removed and allowed to cool in a cold bath. Four millimeters of this sample was placed in a corvette and values read off at 410 nm using a spectrophotometer model 121D. This procedure was repeated using a blank sample of distilled water which was used as the reference reading to compare. The quantity of Nitrate (NO_3) was calculated as follows:

$$C = \frac{A}{a}\ (APHA, 1998)$$

Where: C = Concentration of N-NO3 in sample, A = Measured absorbance for the sample and a = Molar absorptivity.

Determination of phosphate

Water and Sulfuric Acid were added to a 50 ml flask and it was swirled; then Ammonium Persulfate was added and boiled. Sodium hydroxide was added and it was swirled until it turned faint pink. Sulfuric acid was added until the pink colour disappeared. The solution was then diluted using deionized water. Phosphate Acid Regent was added and mixed. The test tub was placed in the phosphate comparator with Axial. The sample colour was matched to a colour standard and the result was recorded in mg/l.

Statistical analysis

Data collected through questionnaire on the study were entered and processed using Statistical Packages for Social Sciences (SPSS, Version 20). The data were summarized with the use of descriptive statistics such as frequency tables, bar and pie charts. All the physico-chemical analyses were performed at the Forensic Laboratory of the National Centre for Energy and Environment, University of Benin, Edo State, using standard analytical methods for the examination of water and wastewater (American Public Health Association, 1998). Results of water quality were compared with WHO standard for drinking water (WHO, 2004).

RESULTS AND DISCUSSION

Table 2 shows respondents' views on the different types of solid waste generated. Majority of the respondents 37.8% generated waste from vegetable and food remains. This was followed by 28.3% of respondents who generated polythene bags waste, 19.1% generated plastic waste, 8.2% that generated paper waste and 6.6% that generated metal waste in Akure. It can be inferred that vegetable and food remains were the most common waste generated by the respondents. This may be as a result of the lifestyle of the residents of the study area, who prefer to consume foods like agidi, moinmoin and leaf rice. The results also demonstrate that about 28.3 and 19.1% of solid waste generated is largely polythene and plastics, respectively. This is largely caused by changing lifestyles whereby most of the urban residents use packed product, such as water, juice, butter, cooking oils and tomato paste. Mato (2002) stated that the current trade liberalization policy and increase in consumption are a little changing the waste composition in urban areas, resulting in high level plastic and cans generation. Waste generation rates per person depend upon the socio-economic condition of the particular urban society, its cultural background, climatic conditions and seasonal variations. Seasonal variation may increase fresh vegetables and fruits availability, thus giving rise to varying rates of waste generation. According to Gidde et al. (2008), it is expected that every person generates 0.5 kg of solid waste daily. Figure 3 shows respondents' attitude towards waste segregation before disposal. It can be revealed that majority of the respondents 66% do not sort their waste before disposal, while 34% carry out sorting waste before disposal in the study area. According Scheinberg et al. (2010) and USAID (2009) at the household level, in developing countries, there is no mechanism for waste sorting as seen on Plate 1. The results suggest that lack of adequate separation techniques and facilities could also compound solid waste management problems.

Due to the heterogeneous nature of waste generated in Akure, majority of the respondents find it difficult to segregate their waste before disposal. These have strong implications for waste recycling and reuse. This is because the disposed materials are either contaminated or mixed up with other materials that their recycling and reuse

Table 2. Mean respondent's response on the different types of solid waste generated.

Solid waste generated	Frequency	Percent
Paper waste	32	8.2
Polythene bags	111	28.3
Plastic waste	75	19.1
Metal waste	26	6.6
Vegetable and food remains	148	37.8
Total	392	100

Source: Author's Field survey (2018).

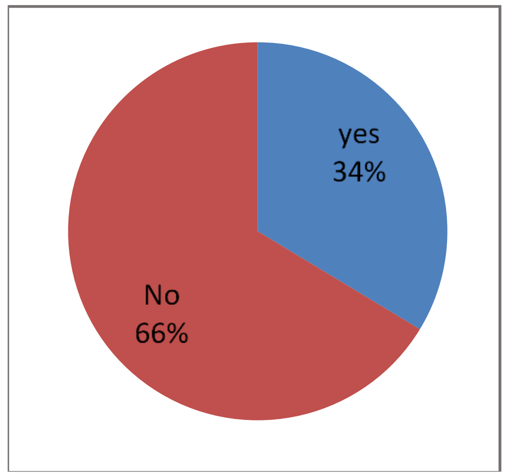

Figure 3. Waste segregation before disposal.

Plate 1. Heterogeneous Nature of Waste at Avenue 6 in Orita Obele Estate, Akure.
Source: Author's Fieldwork (2018).

becomes more expensive and even impossible. It can be seen in Table 3 that 37.8% of the respondents used waste basket to collect waste, 23.5% of the respondents used polythene waste bag, 22.4% of the respondents used government issued containers while 16.3% used metal drum in collecting waste in the study area. The fact that majority of the respondents use waste basket is an indication that it is most likely convenient and more affordable to use considering their level of income. Plate 2 shows a standard waste container ideal for waste collection provided by the Ondo State Waste Management Authority (OSWMA). This is the size of the waste bin provided by the Ondo State Government (dimension 0.24 cubic metre (240 litres) in the volume, length, width and height are 660, 585, 1060 mm respectively) and it maximum load weight is 96 kg. It is a standard waste container for waste collection because it is durable, it has a cover that prevents the odour of waste from escaping to the atmosphere. It also prevents wastes from littering the environment which causes outbreak of diseases and becomes a breeding ground for mosquitoes, rodents and flies. However, waste bins are not evenly distributed because of its cost.

The result in Figure 4 shows the frequency of municipal solid waste disposal in the study area. Almost all the respondents dispose their waste at least once a week. The inconsistency may have negative effect on the environment as it creates unsightly environment, environmental nuisance, stinky environment, storm or run off may scatter the waste, littering the entire landscape before the collection time, forms conducive habitats for rodents, reptiles like snakes, lizards and insects like flies, cockroaches, mosquitoes as well as breeding of micro-organisms which may be dangerous to human health (Njoroge et al., 2014). Although there is no remarkable difference between the proportion of respondents that are aware and those that are not aware of waste recycling as shown in Figure 5, It can still be established that majority of the respondents were knowledgeable about waste recycling in the study area. Thus, it will not be difficulty to educate the respondents on the procedures for sorting of their wastes at the individual home. About half (49%) of the respondents (Table 4) prefer to burn their combustible waste. This method reduces the quantity, labour and time to manage household waste. However, because the open dumping leaves nobody account for the problems associated with the dumped waste, 35.7% of the respondents use the open dumping. Therefore, most of the respondents used the spaces within their compound and open space around their plots for disposing waste in Akure. Furthermore, the burning method has negative implications on the environment because of the release of pollutants like smoke and carbon monoxide into the atmosphere thereby affecting the lungs, eyes and the skin of humans. Awareness is a key factor for effective participation and successful implementation of community activities. According to Taneja (2006), inadequate

Table 3. Reponses on types of containers used in waste collection.

Types of waste container	Frequency	Percent
Waste Basket	148	37.8
Metal drum	64	16.3
Polythene waste bag	92	23.5
Government issued containers	88	22.4
Total	392	100

Source: Author's fieldwork (2018).

Plate 2. Waste bin provided by Ondo State Government in the study area.
Source: Author's Fieldwork (2018).

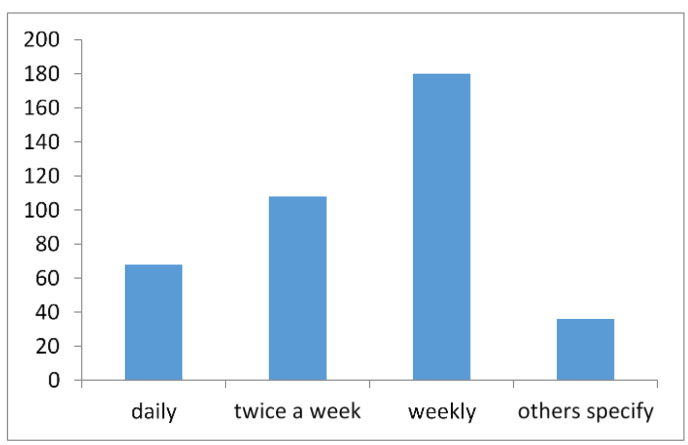

Figure 4. Frequency of waste disposal.
Source: Author's fieldwork (2018).

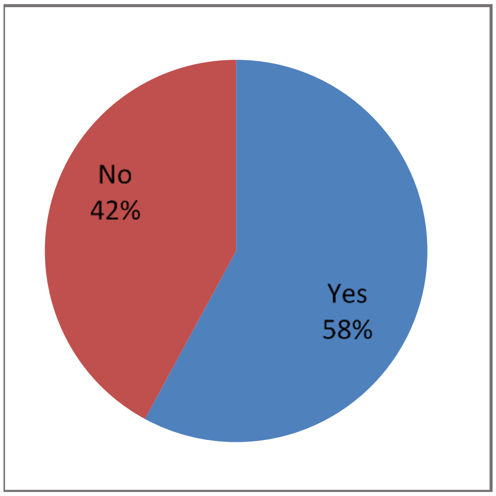

Figure 5. Knowledge about waste recycling.
Source: Author's Fieldwork (2018).

Table 4. Different methods of waste disposal.

Methods	Frequency	Percent
Burning	192	49.0
Burying	32	8.2
Open dumping	140	35.7
Others	28	7.1
Total	**392**	**100**

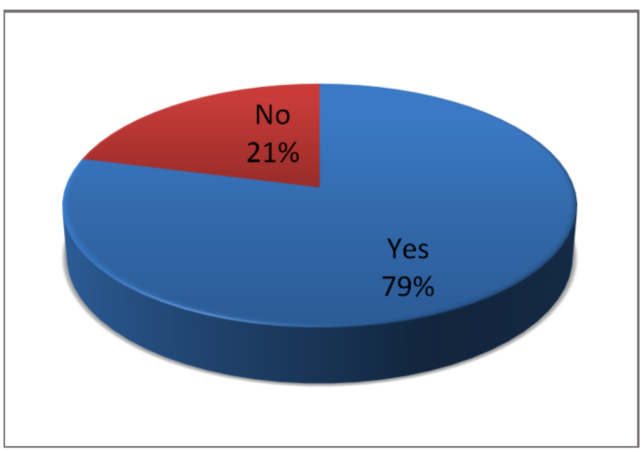

Figure 6. Awareness on municipal solid waste management.
Source: Author's Fieldwork (2018).

awareness is one of the barriers to effective community participation. The level of awareness of respondents on solid waste management in the study area is quite encouraging as shown in Figure 6. About 79% of the respondents have heard about the solid waste management. It can be observed that majority of the

Table 5. Awareness sources on waste management.

Sources of awareness	Responses	
	Frequency	Percent
Radio jingle	292	17.5
Neighbours	204	12.2
Friends	228	13.7
Television Cable networks	224	13.4
Newspaper	104	6.2
Flyers	132	7.9
Internet	108	6.5
Street cleaning	228	13.7
Lectures	148	8.9
Total	1668	100

Source: Author's fieldwork (2018).

Plate 3. OSWMA Street cleaner at work in Odo-Ikoyi Area, Akure.
Source: Author's Field survey (2018).

respondents have heard about solid waste management in the study area. Table 5 shows different sources of dissemination of awareness campaigns amongst the respondents in the study area. The radio jingle is most popular means of reaching the public. It is necessary to increase the frequencies and timings of radio jingles. The other sources of awareness came through friends (13.7%), street cleaning (13.7%), television cable networks (13.4%), neighbours (12.2%), flyers (7.9%) and through internet (6.5%). Street cleaning exercise was another method for popularizing resident's awareness of waste management activities in Akure. Respondents that resided in Akure had contact with street cleaners in their uniform whenever they are in the municipality. Plate 3 shows OSWMA Street cleaner on uniform collecting waste at Odo-Ikoyi Area, Akure. It is the responsibility of OSWMA to ensure the street is always cleaned. It also ensures the observation of the bi-weekly compulsory sanitation exercise at all market sites within the city, during which market traders are required to clear all the wastes generated in the market into the collection vehicles with the full participation of the staff of the authority. This is in addition to the mandatory monthly environmental sanitation exercise which takes place between the hours of 7 to 10:00 am every last Saturday of the month. This exercise is supervised by the OSWMA.

Figure 7 shows that more than half of the respondents were of the view that waste bins are inadequate, 24.5% indicated that the waste bins are not in good state. About 19.4% were of the opinion that most of the waste bin is rusting while 4.1% of the respondents indicated other states such as inappropriate location of the waste bin, not accessible, and poorly maintained. It can be inferred that most of the waste bins that were available for use in Akure were not sufficient enough compared with the size of the population and the average per capita waste generation per households. In support of the above result, Plate 4 shows the type of waste bin being distributed as well as the indiscriminate dumping of refuse as a result of the size of waste bins in the study area. However, most of the respondents were of the views that the size of the waste bin was too small compared with the rate of waste generation. This apart from altering the beauty of the City, habour some insects such as cockroaches, mosquitoes, houseflies, and caused offensive smell in the streets of Akure. Figure 8 shows the level of residents' participation in community waste management in the area. The study shows that 61% of the respondents do not participate in the community solid waste management while 39% of the respondents participate in community waste management. This shows that despite the level of awareness in solid waste management in Akure, the level of participation is rather very low. Awareness is a key factor for effective participation and successful implementation of community activities. Taneja (2006) suggests that inadequate awareness is one of the barriers to effective community participation. Figure 8 show that about 39% of the respondents have low perception towards solid waste management. This can be attributed to the fact that most of the residents are of the opinion that solid waste management is the sole responsibility of the municipal authorities. In addition, they seem not to take up this responsibility due to wrong perception, inadequate by-laws and poor enforcement of existing environmental laws. In an attempt to address the above limitations of conventional waste management systems, studies have found that a community-based approach to waste management, also known as participatory solid waste management, can be very effective as been initiated in several developing cities (Sekito et al., 2013; Malik et al., 2015; Rigasa et al., 2017; Xiao et al., 2017).

Table 6 shows different factors militating against efficient management of municipal solid waste in Akure. The result shows that insufficient fund (40.8%) was the major factors militating against efficient management of municipal solid waste. Others factors include people's attitude (30.6%),

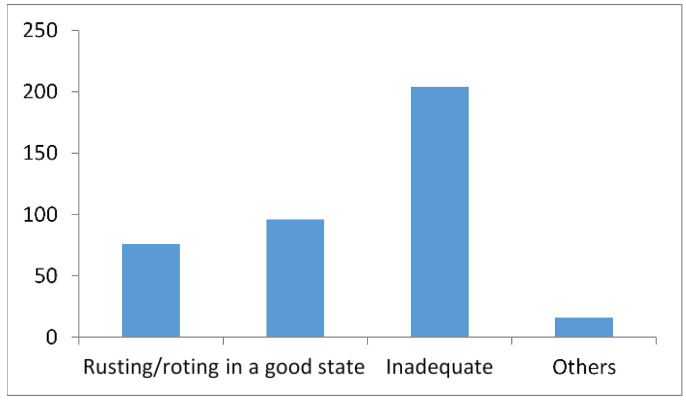

Figure 7. Description of the state of public waste bins in the study area.
Source: Author's fieldwork (2018).

Plate 4. Small size of the waste bin showing littered waste at Oba Adesida.
Source: Author's Fieldwork (2018).

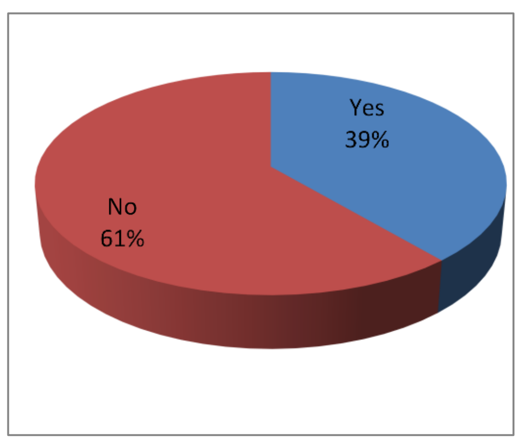

Figure 8. Responses on participation in community solid waste management.
Source: Author's fieldwork (2018).

Table 6. Factors militating against efficient management of municipal solid waste.

Factor	Responses	
	Frequency	Percent (%)
Insufficient funds	20	40.8
Town Planning structure	6	12.2
Legal structure	2	4.1
Political influence	6	12.2
People attitude	15	30.6
Total	49	100

Source: Author's fieldwork (2018).

Table 7. Effects of poor waste management on the environment.

Effects	Frequency	Percent
Water contamination	102	26.0
Land pollution	198	50.5
Outbreak of diseases	85	21.7
Others	7	1.8
Total	392	100

Source: Author's fieldwork (2018).

Plate 5. Blockage of Drainage - Poor waste management at Ijoka Area, Akure.
Source: Author's Fieldwork (2018).

Plate 6. Land Pollution - poor waste management at Oda Road, Akure.
Source: Author's Fieldwork (2018).

waste. Others factors include people's attitude (30.6%), town planning structure (12.2%), political influence (12.2%) and legal structure (4.1%). Insufficient fund was the major factor militating against efficient management of municipal solid waste, mainly because the municipal authorities do not have sufficient financial resources to acquire the necessary equipment and to hire or train skilled manpower to effectively carry out their operations. Another factor militating against SWM is inadequate collection points. This is probably due to the increasing urban population resulting into increased generation of solid waste. This is consistent with findings by Onibokun and Kumuyi (1999) where they observed that, due to rapid urbanization, the population increase exerts pressure on waste facilities thus making it difficult for authorities to effectively manage waste. Malisa (2007) observed refuse trucks do not easily access most parts of urban areas, because they are unplanned and this accounts for about 50 to 60% of the urban population in Akure. This means that, the remaining solid waste has to be managed by other means like disposal pits, incineration and disposal in open spaces. This also confirms the findings by Ali et al. (2014) and Subramani et al. (2017) that open dumping of MSW is a common practice in developing countries and which poses serious threat to groundwater resources and soil. The contamination of soil by heavy metal can cause adverse effects on human health, animals and soil productivity (Smith et al., 1996, Butu et al., 2010). Waste carries different metals which are then transferred to plants by different ways (Voutsa et al., 1996). Depending on the tendency of the contaminants, they end up either in water held in the soil or leached to the underground water. Contaminants like Cd, Cu, Ni, Pb and Zn can alter the soil chemistry and have an impact on the organisms and plants depending on the soil for nutrition (Shaylor et al., 2009).

Table 7 shows the effect of poor waste management in residents' environment. It revealed that more than half of the respondents (50.5%) agreed that land pollution as the major effect. This was followed by water contamination (26%), out-break of diseases (21.7%) and other effects such as flooding, odours from uncollected waste and breeding of mosquitoes and flies (1.8%). This means that land pollution was the major effect of improper management of waste in the study area, as shown in Table 7, Plates 5 and 6. Indiscriminate dumping of refuse along drainage lines can cause flooding as shown in Plate 5. Floods have large consequences on the environment, such as loss of human lives, damage to properties, environmental degradation, destruction of economic and

Table 8. Mean result of Physico-chemical characteristics of River Ala Oke-Aro district.

Parameters	Stations			Mean	WHO
	Station 1 (upstream)	Station 2 (middle stream)	Station 3 (downstream)		
pH	6.8	6.4	6.1	6.4	6.5-8.5
EC (mS/m)	66.50	118.0	123.0	102.5	N/A
BOD (mg/l)	4.6	6.3	8.2	6.4	2.0
DO (mg/l)	5.1	7.9	10.2	7.7	3.0
TDS (mg/l)	11.9	18	20.3	16.7	500
Turbidity (NTU)	12.0	23	29	21.3	5.0
Nitrate (mg/l)	0.02	0.024	0.04	0.028	10.0
Phosphate (mg/l)	0.23	0.58	2.05	0.95	5.0
Fecal coli form bacteria (cf/100ml)	5.00	22.00	32.00	19.7	0.0

social activities of the people, deterioration of health conditions owing to waterborne diseases, decay of organic matter, leading to growths of infection and spreading of germs. Also, agricultural lands are destroyed due to crops being submerged in water, this causes a lot of economic loss to farmers and bring economic hardship to the farmers.

The result of water quality of River Ala is presented in Table 8. The pH of the river ranged from pH 6.1 to 6.80 (slightly acidic). The downstream station of River Ala was slightly more acidic. The pH values recorded at these stations may be consequence of biodegradation, resulting in accumulation of free carbon dioxide and bi-carbonates ions. Water with a low pH (< 6.5) is considered acidic, soft, and corrosive. Thus, the water could leach metal ions such as iron, manganese, copper, lead, and zinc from the aquifer, plumbing fixtures, and piping thereby presenting some health concerns. Similarly, a water with a low pH could contain elevated levels of toxic metals, cause premature damage to metal piping, and have associated aesthetic problems such as a metallic or sour taste, staining of laundry, and the characteristic "blue-green" staining of sinks and drains (Kirmeyer et al., 2002; Melchers and Wells, 2006; Ismail et al., 2014). Extreme levels of pH have been linked to some health effects, including irritation of the skin and eyes. The most significant impact of pH on health is indirect and related to exposure to metals leached from the distribution system and to disinfection by-products formed as a result of treatment processes (Government of Canada, 2016).

Electrical conductivity (EC) is the capacity of water to conduct electrical current. EC values for River Ala ranged from 66.5 to 123 mS/m in the sampled stations. Levels of EC is within WHO standard for drinking water. The biochemical oxygen demand (BOD) which is an expression of oxygen requirement for biological degradation (BOD) and ranged from 4.6 to 8.2mg/l in the study area. With BOD values above 4mg/l, River Ala can be described as slightly polluted (Bjerg et al., 2014; Ko´s, 2016). Leachate from dumpsite is considered the main source of changes in BOD of surface water (Gworek et al., 2016). This leachate gets to surface water usually via diffuse pollution as may be the case with the study area. BOD indicator has a significant meaning in environmental studies because of its ability to indicate the pollutant strength of polluted water (Kalenik, 2014; Ngang and Agbazue, 2016). The dissolved oxygen (DO) level recorded shows that, the water body was slightly well oxygenated with a range of 5.1 (upstream) to 10.2mg/l (downstream). Water is considered to be healthy when DO concentration is 6.5 to 8 mg/l (Horne and Goldman, 1994). This observation is expected as DO is directly related with BOD. Generally, when BOD levels are high, there is decline in DO levels. This is because the demand for oxygen by bacteria is high and they are taking that oxygen from the dissolved oxygen in the water. At high BOD levels, organisms such as micro invertebrates that are more tolerant of low dissolved oxygen (leeches and sludge worms) may appear and become numerous (Revelle and Revelle, 1988). The values of total suspended solid (TDS), was very low and within WHO standards, however turbidity level exceeded standard for drinking water. TDS in water supplies originate from natural sources, sewage, urban and agricultural run-off, and industrial wastewater (WHO, 1996). Their concentration in natural waters is determined by the geology of the drainage, atmospheric precipitation and the water balance (evaporation-precipitation) (Weber and Jacobs, 2001). An elevated total dissolved solids concentration is not a health hazard, however it has been found to make water to be corrosive, salty or brackish taste, resulting in scale formation, and interfere and decrease efficiency of hot water heaters (WHO, 2011).

Turbidity on the other hand ranged between 12.0 to 29.0 NTU. Mean turbidity was above drinking water standard. Turbidity describes the cloudiness of water caused by suspended particles such as clay and silts, chemical precipitates such as manganese and iron, and organic particles such as plant debris and organisms (APHA/AWWA/WEF, 2012; Health Canada, 2012). Higher levels of suspended materials may be from discharge, erosion and storm water, and biological growth in the water, is indicative of water contamination as has also been reported in other studies (Ezemonye et al., 2016; Butu and Sadiq, 2016). The high value of turbidity recorded in the study area may be linked to diffuse pollution wherein contaminants present in dumpsites are carried by storm water and discharged into River Ala. Nitrogen in the form of nitrate is one of the important nutrients in water that stimulate growth of phytoplankton. Nitrate occurs in water chiefly as a result of biochemical oxidation of ammonia or the reduction of nitrate and it is indicative of pollution. The values of nitrate recorded for all the stations were low ranging from 0.02 to 0.04mg/l. The low levels of nitrate nitrogen observed is a confirmation of the fact that African waters are generally low in this ion (Kebede et al., 1994). Nitrate is the most stable and easily utilizable form of nitrogen in water by aquatic biota. Phosphorous is a basic element in living matter and occurs in natural waters and waste waters almost solely as phosphate. This major component of agricultural fertilizer is a limiting nutrient in many river systems. Total phosphorous values recorded for all the stations varied between 0.23 and 2.05 mg/l in the study stations. The values are higher than what was recorded for Nitrate. Fecal Coliform Bacteria are microscopic animals that live in the intestine of warm-blooded animals (Mitchell et al., 2000). They also live in the waste material or feces excreted from the intestinal tract. When fecal coliform bacteria are present in high numbers in a water sample, it indicates that the water may have received fecal matter from point or diffuse pollution. Table 8 shows fecal coliform counts that ranging from 5.0 to 32.0 cfu/100ml. The presence of Fecal Coliform in water sample may indicate recent contamination of the surface water by human sewage or animal droppings which could contain either bacteria, viruses, or disease causing organisms. Many coliform bacteria, including *Escherichia coli* (*E. coli*), can survive for a considerable time in water, making them a good indicator for the presence of other disease causing pathogenic bacteria.

Conclusion

This study investigated municipal solid waste management practices in Akure, Ondo State, Nigeria. Generally, there is low knowledge of waste segregation, waste recycling and the environmental effect of poor sanitation on the environment. Similarly, the services rendered by the waste management authority in Akure city, such as frequency of waste collection and street cleaning are not sufficient when compared with the rate of waste generation. Factors militating against efficient waste management in the area are insufficient financial resources, rapid urbanization, uncontrolled use of packaging materials, poor responses to waste management and inadequate qualified private contractor on waste management. The observed municipal solid waste management problem in the study area has implication for the environment including water quality. This is evident in physico-chemical characteristics of River Ala which is a receptor of pollutants in Oke-Aro via urban storm water. On the whole, the observed levels of turbidity, biochemical oxygen demand, dissolved oxygen and fecal coliform bacteria are indication of the presence of microbial pollution which may have been introduced to the water body via diffuse pollution aided by urban storm water runoff. In view of the study findings, it is recommended that government should provide waste receptacles in large quantity in both residential and commercial areas. Bill boards that enlighten the people on the need to keep the environment clean and the implications of indiscriminate waste dump should be mounted in strategic places in Akure city and make environmental education part of educational curriculum at all school levels. Similarly, mobile courts should be established to try offenders of indiscriminate waste dump and if found guilty, the offender should be fine a relatively substantial amount. Finally, government should consider waste-to-wealth initiative for the state. The first step in realizing this would involve encouraging the residents on the need to sort their waste before disposal and secondly waste characterization to determine the energy potentials of waste streams.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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