



# **An Assessment of Solid Waste Composition and Management in Agbor and Its Implication on Human Health**

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Author ENE designed the study while author VNO performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ENE and VNO managed the analyses of the study. Author VNO managed the literature searches. Both authors read and approved the final manuscript.*

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## **ABSTRACT**

The study assessed solid waste composition and how it is being managed in relation to health implications in Agbor, a nordal town in Delta State Nigeria. Survey design was used and both primary and secondary data were collected through stratified sampling technique. Solid waste management practices of respondents were generated through the use of six hundred and twenty five (625) copies of questionnaires in 8 sampling unit. The hospital report on malaria and typhoid were obtained from the medical records of central hospital, Agbor covering 1997-2011, and the solid waste composition was obtained through waste characterization and measurement. The data on solid waste management and composition were from the sanitary records of the Local Government Council, and private waste firm in Agbor called Total Resource Management Limited. The study results show 34.14% were traders, 22.14% were civil servants, 14.34% were farmers, and 29.38% were business men and women. The waste generated is 1594.11 kilogram. This

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shows that the total respondents of five thousand generated 1594.11 kilogram of solid waste daily. Baleke area has the highest rate of waste generated which was 223.43 kilogram; followed by Dr. Whyte area which generated 214.46 kilogram of solid waste daily. Edike area generated the highest amount of solid waste in the entire sampled areas, having 180.34 kilogram of solid waste generated daily. Food items were the greatest amount generated daily, with 1135.21 kilograms per day. Eighty five percent (85%) of malaria cases and 98.6% of typhoid cases in Agbor was consequent on solid waste composition. To enhance effectiveness in solid waste management in Agbor, the Local Government Authority should subsidize the amount of money paid for the services of private waste managers. The promulgation of punishable laws on the indiscriminate dumping of solid waste will help avoid the dumping of waste waterfront at road side and street drains.

*Keywords: Solid waste management; malaria; typhoid; Agbor; Nigeria.*

## 1. INTRODUCTION

The cornerstone to any successful planning for a waste management programme is the availability of reliable information about the quality and the type of material being generated and an understanding about how much of that material that the collection-programme managers can expect to prevent or capture [1]. Most municipalities in developing countries spend a large proportion of their budgets on the collection, transport, and disposal of solid wastes [2]. Solid waste generation has been encouraged by rapid increase in population, changes or improvement in wages, massive expansion of the urban areas and the changing lifestyle or better standard of living as well as improvement in technology [3].

According to Ajadi and Tunde [4], increase in population and income brings about an increase in the production of goods and services and thus effluents are discharged into the environment. Gidarakos, et al. [1] noted that the effective waste management through municipal solid waste composition studies is important for numerous reasons; including the need to estimate material recovery potential, to identify sources of component generation, to facilitate design of processing equipment, to estimate physical, chemical and thermal properties of the waste and to maintain compliance with national law. The composition of generated waste is extremely a consequence of seasonal, lifestyle, demographic, geographic and legislation impacts. This variability makes defining and measuring the composition of waste more difficult and at the same time more essential.

The solid waste management in most cities of developing countries consumes 20-50% of municipal revenues, yet collection service levels remain low with only 50-70% of residents

receiving service and most disposals being unsafe. Poor solid waste management is a threat to public health and reduces the quality of life for urban residents. Moreover, the situation is likely to worsen due to continuing population growth and urbanization in developing countries [5].

According to United Nation International Children Educational Fund [6], waste is any material that is thrown away as unwanted. Adedibu [7] defined solid waste as all non-gaseous, non-liquid waste resulting from a wide range of community, industrial, commercial and agricultural activities. The composition or generation of waste at alarming rate constitutes a huge problem to the governments as well as individuals in large urban area especially in developing countries like Nigeria. This is as a result of residues of products used which are not always destroyed but discarded, and these contribute greatly to land pollution [8].

Waste management is the collection, transport, processing, recycling or disposal, and monitoring of waste materials. Waste management can involve solid, gaseous or retroactive substances, with different methods and fields expertise for each [9]. The manner of solid waste composition and management in Agbor is a problem which resulted from lack of waste minimization and illegal dumping respectively. Solid waste has occasioned diverse problems in the environment. Uncollected solid waste obstructs storm water runoff, resulting in the formation of stagnant water bodies that become the breeding ground of disease vectors.

Solid waste dumped near water sources could cause the contamination of the water body or the ground water source and when the water is consumed, this could lead to the spread of typhoid fever. Typhoid fever is a type of enteric fever, along with paratyphoid fever. The cause is

the bacterium *Salmonella Typhi*, also known as *Salmonella enterica* serotype Typhi, growing in the intestines and blood. Typhoid is spread by eating or drinking food or water contaminated with the feces of an infected person. The direct dumping of untreated waste in rivers near cities result in the accumulation of toxic substance in the food chain through plants and animals that feed on them [10]. Addo et al. [11] reported in their study in Kumasi Metropolis of Ghana that about 41.4% cited stench of the dumpsites to justify this claim while others link the poor management of waste to the causes of numerous diseases (catarrh, cough and chest pains, diarrhea, intestinal worms, typhoid fever and cancer) prevalent in the communities. According to Akindutire and Alebiosu [12], some risk-factors of indiscriminate refuse disposal include breeding of arthropod borne-diseases. They noted that indiscriminate dumping of refuse promote the prolific breeding of arthropod-borne diseases like mosquitoes, houseflies, lice, tsetse flies, cockroaches which transmit diseases like malaria, viral encephalitis, typhoid, paratyphoid fever, diarrhea, dysentery, cholera, gastro-enteritis, amoebiasis, conjunctivitis, sleeping sickness, relapsing fever, scabies, filariasis, enteric pathogens etc [13]. In their research in Senegal, African Population and Health Research Center (APHRC) [14] reported that improved solid waste management (SWM) will lead to a reduction in infectious diseases (e.g. diarrhoea, typhoid, malaria) and chronic diseases (such as asthma) in addition to promoting the wellbeing of vulnerable populations (women and children).

Similarly, the prevalence of malaria in most cities in Africa has been linked to waste dumpsites near sources of water consumed in cities. According to Nasir et al. [15], Malaria is a widely explored public health topic which has been documented to constitute more burden among communities residing in proximity to environmental waste dumpsites and poor drainage systems. Findings from the study of [15] showed that 82 (82.0%) of test subject who lived near waste dumpsites were positive to the malaria parasite and only 26 (26.0%) of the control subjects who lived outside solid waste dump site in the Gwagwala area of Abuja were malaria parasite positive. This invariably affirms that poor environmental sanitary conditions could be a major risk factor for a high prevalence of mosquito bite and malaria in a community [16]. This is also in agreement with a study done at South Western Nigeria, which shows that

incessant dumping of refuse by Ijebu-Ode citizens in different parts of the town is highly unpleasant as this has been a major factor in the prevalence of malaria in Ijebu-Ode as reported by Fasunwon et al. [17]. In 2010, an estimated 216 million cases of malaria occurred worldwide and 655,000 people died of which a whopping proportion (91%) was in the African region [18]. Malaria has been the cause of 25% of child deaths and 9.4% of deaths in pregnant women [19].

According to Kurniawan [20], in addition to global warming, open dumps pose a serious threat to the aquatic environment. One of the greatest environmental concerns associated with solid waste landfilling is the generation of leachate. Depending on rainfall conditions, the colour of leachate varies from black to brown. A landfill site may still produce leachate with a high concentration of NH<sub>3</sub>-N for over 50 years after filling operations have ceased. The leachate that seeps from a landfill can infiltrate the surface water, posing potentially serious hazard not only to aquatic organisms, but also to public health in the long-run. For this reason, landfill leachate from solid waste represents a potentially serious environment threat with regard to the pollutants introduced into the aquatic environment.

Solid waste blocks open street drains and is often dumped into sewers through missing manhole covers. The non-biodegradable shopping bags get inflated and block sewer pipes [21]. And hazardous solid wastes that are radioactive cause loss of vegetable and plant life, loss of animal life, and mutations of species over time.

The decomposition of solid waste has resulted to the emission of methane gas and carbon dioxide. Methane has a 21-fold global potential as compared to carbon dioxide. According to the intergovernmental panel on climate change, such emissions contribute to 18 per cent of the total Methane emissions to the atmosphere, ranging from 9 to 70 Tg (Megatonnes) annually. This Methane emission has led to global warming. The changing temperature and rainfall patterns will bring a variety of pressure upon plant and animal life, leading to migration or extinction [22]. Solid wastes found in urban areas are sources of contamination due to the incubation and proliferation of flies, mosquitoes, and rodents, which, in turn, are disease transmitters that affect population health, which has its organic defenses in a formative and creative

state. This situation leads to malaria, cholera and diarrhea [23].

More so, in Agbor, a nortal town in Delta state, most of these solid wastes are dumped in street drains even near sewer pipes in residential buildings. The street drains are blocked by the solid waste, and when it rains, the run-off easily overflows the drain thereby causing flood and erosion activities which are global environmental hazard. Some of these solid wastes are carried to the roads thereby distorting flow of traffic, and even destruction of automobiles tyres and tubes. Pedestrians are not left out as they come in contact with sharp waste objects. These scenarios have been made very much active due to the large composition of solid waste physically seen in the area. Arising from the above, there is therefore need to study solid waste composition and management, as a means of throwing light to solid waste minimization and management. Therefore, this study is aimed at assessing the solid waste composition and management in Agbor and its implication on human health. To achieve this aim, the specific objectives are to; assess composition of solid waste, examine solid waste management practices in the area and examine the effects of solid waste management on human health.

## 2. MATERIALS AND METHODS

### 2.1 Study Area Location and Size

Ika South Local Government lies within  $06^{\circ} 7^1$  and  $06^{\circ} 25^1$  North of the Equator, and Longitudes  $06^{\circ}$  and  $8^1$  and  $06^{\circ} 18^1$  East of the Greenwich Meridian [24]. Agbor town, which is the Headquarters of the Local Government Area, is located at Latitude  $6^{\circ} 08^1$  North and Longitude  $6^{\circ} 07^1$  East. It is bounded in the North by Otah village, in the South West by Owa-Ofien, in the South East by Boji-Boji Owa, in the East by Emuhu village, and in the West by Alihame village. The topography of the area is of a gentle slope with the Orogodo River having its course through the shallow valley [24].

The study area is characterized by tropical equatorial climate with a daily rainfall total of 175 mm in the wettest month of July and September. The mean maximum rainfall is 240 mm during the wet season and 50-70 mm during the dry season. November to April is dry, intercepted by the "August Break" in August. There is harmattan from December to February caused by the North East trade wind blowing across the area from the

Sahara Desert. The temperature does not vary much during the year. There is an average minimum temperature of  $22^{\circ}\text{C}$  and maximum of  $34^{\circ}\text{C}$ . The diurnal variation is less in the wet season than in the dry season when it is as much as  $4^{\circ}\text{C}$  [25].

The natural vegetation of the study area lies within rainforest belt and hence the dominant features of the vegetation are deciduous and evergreen forest [26]. The forest is rich in palm trees, fruit trees and few timber trees. However, the vegetation has been greatly hampered as a result of human activities such as farming, fetching of firewood, buildings development, road construction, etc.

The Southwestern ends of the area are watered by a River which runs from Mbiri across Agbor, Owa, Abavo, before it flows into a lake of Urhomehe between Urhonigbe and Umutu. It is called Atova River at its source in Mbiri, Orogodo river of Agbor, Owanta Stream of Owa, and Igbogili Stream of Abavo. A confluence is formed near the bridge by the Express highway where Yi-Ekpen flows into the Orogodo River [25].

The population of Agbor was 54,850 in 1991 (NPC, [26]. In 2006, the population was 49,401 [26]. In 2011, the population was projected to 51,278 using the 3.8% Nigeria standard growth rate but, the projection for 2014 was 52,404. The population of the area is not evenly distributed as people prefer living in the commercial areas to the Government Reserved Area.

Agbor is an administrative, educational and commercial centre. It is a nodal town linking the south west, south east and north central part of Nigeria. The socio-economic activities of the people in Agbor are grouped into primary, secondary and tertiary activities. The primary activities include subsistence agriculture, rearing of pigs, and poultry farming. The secondary activities include Tailoring and Carpentry. The tertiary activities include the service industries such as the financial institution, educational institutions and transport services. The financial institutions consist of the banks and local insurance firms. The educational institutions include the college of education, secondary schools, primary and nursery schools. Public and private transport operators render transport services. There are hospitals, health centers and clinics that render health services in Agbor.

**2.2 Methods**

The study was based on field survey. The data used were primary and secondary sources of data. The primary data was based on solid waste management practice, which was generated from respondents through the use of questionnaire and the solid waste composition obtained through waste characterization and measurement. The secondary data on solid waste management and composition were from the sanitary records from the Local Government Council, and a private waste management firm in Agbor called Total Resource Management Limited. The other secondary data are the hospital report on malaria and typhoid from the government central hospital.

The stratified sampling technique was adopted for the distribution and collection of questionnaire, and solid waste measurement. The stratified sampling technique deals with the breaking down of overall sample size into strata or units to ease effectiveness. Based on this, the study area was divided into eight (8) smaller areas simply for effectiveness in the distribution of questionnaire and actual measurement of solid waste. The eight areas are shown in the Table 1.

**Table 1. Sampled areas**

SN	Areas
1	Dr. Whyte
2	Charles
3	Prof. Ebie
4	Mariere
5	Balake
6	Umudein
7	Edike
8	College Junction

*Source: Reconnaissance Survey, (2012)*

From the above, a total of eight areas were sampled. Six hundred and twenty five (625) questionnaires were distributed to respondents in each area, thereby rounding up the total questionnaires distributed in the study area to be 5,000 based on the ten per cent of the entire population. The sampled areas were also based on its already existence. To ensure affective distribution of the questionnaire in each sampled area, the systematic sampling procedure was utilized. An interval scale of six buildings was observed, that is, the questionnaires were administered to the 1<sup>st</sup>, 7<sup>th</sup>, 13<sup>th</sup> etc respondents in each sampling unit. A respondent assumed to be head of a building was given a copy of the

questionnaire. In the case where a building has more than one household, every third household head in the building was giving the questionnaire starting from the first household in the compound; the questionnaires were retrieved after three days of administration.

The administration of questionnaire was the ultimate method used to collect data on solid waste management practice, mostly on disposal method. The data on solid waste composition was collected through solid waste categorization and actual measurement by the researcher and research assistants. The solid waste generated per day by respondents were characterized and measured respectively. For the solid waste categorization, six polythene bags were labeled plastic, food items, cellophane, bottle, tin can and papers respectively. The respondent in each household was instructed to dump his/her solid waste in the polythene bag following the type of solid waste labeled. Thereafter, the solid waste in the various polythene bags was measured in kilogram using weighing scale.

The data on malaria and typhoid as the diseases being researched were obtained from the medical records of central hospital, Agbor. The use of the central hospital report was as a result of the whole study area primarily been served by the hospital, and also due to availability of data. The hospital's record on malaria and typhoid for both in-patient and out-patient covered a period of 14 years (1997-2011) as presented in Table 7. For relevant questions and meaningful conclusion, the research instrument was subjected to validity tests through various criticisms and amendment. The lecturers in the department helped to determine the facial content validity. The final copies after scrutiny were produced and sent to the field for administration. Percentages mean and charts were used for the data analysis and presentation. Two null hypotheses stated and tested for the study were;

HO<sub>1</sub>: There is no significant relationship between solid waste composition and human health.

HO<sub>2</sub>: There is no significant effect of solid waste management on human health.

The multiple correlation analysis was used to test the correlation between solid waste composition and solid waste management and malaria/typhoid respectively. The various analysis were run separately, that is, analysis of solid waste composition on malaria, solid waste

composition on typhoid, solid waste management on malaria, and solid waste management on typhoid respectively to achieve accurate results. The data for the hypotheses and their various analyses are shown and explained in the result section. Then the Pearson product moment correlation was used to test and analyze the correlation variables.

### 3. RESULTS AND DISCUSSION

#### 3.1 Socioeconomic Characteristics of Respondents

In Table 2, out of the 5,000 respondents (100%), 34.14% were traders, 22.14% were civil servants, 14.34% were farmers, and 29.38% were business men and women. The result from the table shows that there are more traders in Agbor. This is because Agbor is a commercial town due to the ever increasing population size

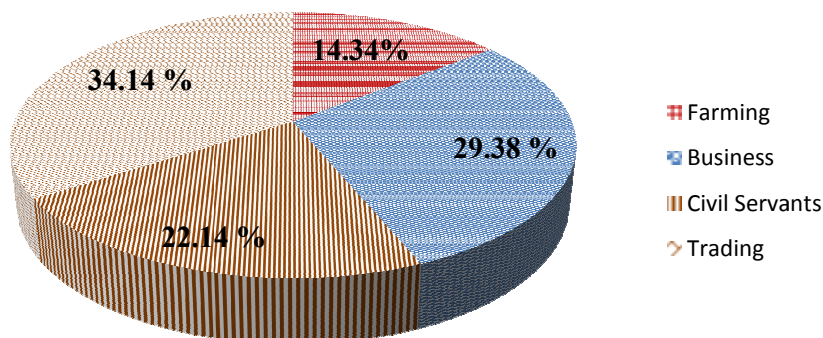
and numbers of immigrants. Most of the educated or learned and non-formally educated individuals engage in trading and business as a result of lack of companies and white callers' job for the educated ones. This is why the business occupation type is ranking second, being 29.38%, followed by civil servants (22.14%) and farming (14.34%) (Fig. 1, Table 3).

The educational status of respondents above shows that out of the five thousand (5,000) respondents, 1.9% had no formal education, 21.5% were primary school learners, 33.58% were secondary school certificate holders, 23.33% were national certificate examination (NCE) holders, and 19.34% were degree holders. From this finding, almost the entire populations are literate. This shows that the respondents can write, read and understand issues on solid waste management, composition and human health.

**Table 2. The occupational status of respondents**

Sampled areas	Trading	Civil servant	Farming	Business	No. of respondents	Percentage
Dr. Whyte	176	189	90	170	625	12.5%
Charles	217	142	57	209	625	12.5%
Prof. Ebie	195	164	49	217	625	12.5%
Mariere	244	111	90	180	625	12.5%
Baleke	210	100	143	172	625	12.5%
Umudein	227	89	166	143	625	12.5%
Edike	220	115	98	192	625	12.5%
College Junction	218	197	24	186	625	12.5%
<b>Total</b>	<b>1707</b>	<b>1107</b>	<b>717</b>	<b>1469</b>	<b>5000</b>	<b>100%</b>
<b>Percentage</b>	<b>34.14%</b>	<b>22.14%</b>	<b>14.34%</b>	<b>29.38%</b>	<b>100%</b>	

Source: Field Survey



**Fig. 1. Occupation of the respondents**

**Table 3. The educational status of the respondents**

Sampled areas	No. formal education	Pri. School	Sec. school	NCE	Degree	No of respondent	%
Dr. Whyte	8	100	300	101	116	625	12.5%
Charles	7	100	311	102	105	625	12.5%
Prof. Ebie	11	160	195	121	138	625	12.5%
Mariere	10	144	188	139	144	625	12.5%
Baleke	13	114	198	182	118	625	12.5%
Umudein	32	242	109	187	55	625	12.5%
Edike	9	139	191	146	140	625	12.5%
College Junction	5	66	187	216	151	625	12.5%
<b>Total</b>	<b>95</b>	<b>1075</b>	<b>1679</b>	<b>1194</b>	<b>967</b>	<b>5000</b>	<b>100%</b>
<b>Percentage</b>	<b>1.9%</b>	<b>21.5%</b>	<b>33.58%</b>	<b>23.88%</b>	<b>19.24%</b>		<b>12.5%</b>

Source: Field Survey

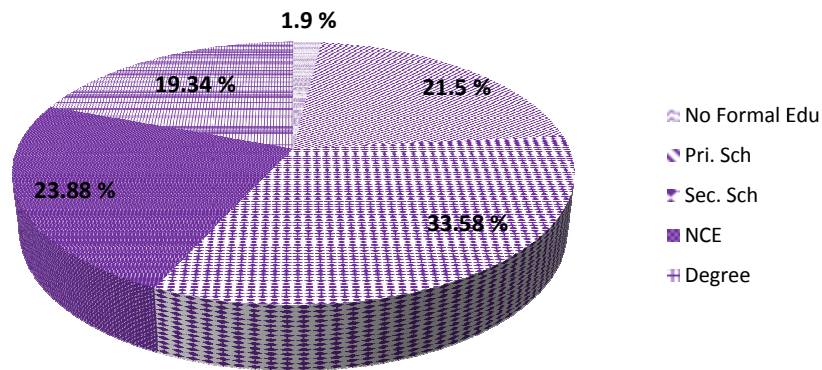


Fig. 2. Educational status of respondents

Table 4. Income distribution of respondents

Sampled areas	Below ₦20,000	₦21,000 - ₦40,000	₦41,000- ₦60,000	₦61,000- ₦100,000	Above ₦100,000	No. of respondents
Dr. Whyte	147	154	218	94	12	625
Charles	208	221	139	44	12	625
Prof. Ebie	241	209	120	45	10	625
Mariere	199	218	134	63	11	625
Baleke	198	249	140	31	7	625
Umudein	307	200	81	35	2	625
Edike	201	188	180	51	5	625
College Junction	278	205	111	27	4	625
<b>Total</b>	<b>1779</b>	<b>1644</b>	<b>1123</b>	<b>390</b>	<b>64</b>	<b>5000</b>
<b>Percentage</b>	<b>35.58%</b>	<b>32.88%</b>	<b>22.46%</b>	<b>7.8%</b>	<b>1.28%</b>	

Source: Field Survey

From Table 4, showing the income distribution of respondents on monthly basis, 35.58% of the respondents receive less than ₦20,000 monthly, 32.88% receive between twenty one to forty thousand naira (₦21,000- ₦40,000) monthly sixty thousand naira (₦41,000 – ₦60,000) monthly, 7.8% receive between sixty one to one hundred

thousand naira (₦61,000 – ₦100,000) monthly while, 1.28% receive above one hundred thousand naira monthly. This finding shows that the respondents in the study area are more of moderate income earners with four flamboyant income earners. With this, one can say that the study area is still a growing urban center.

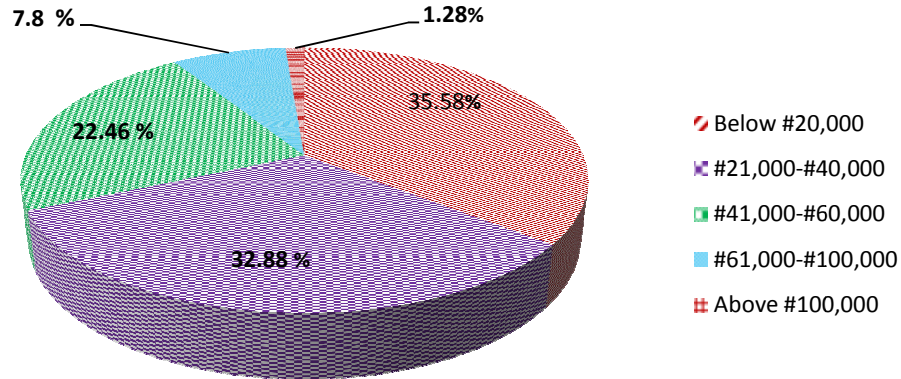


Fig. 3. Income distribution of respondents

Table 5. Solid waste composition and generation (per day) in Agbor

Sampled areas	Cellophane (kg)	Food items (kg)	Plastic (kg)	Papers (kg)	Tin cans (kg)	Bottles (kg)	Total rate of W.G
Dr. Whyte	10.05	150.41	12.11	10.00	19.09	11.81	214.46
Charles	12.61	152.37	10.11	15.41	14.41	9.14	214.05
Prof. Ebie	11.88	141.59	11.49	9.84	10.97	6.41	192.18
Mariere	11.76	143.52	12.37	14.00	12.48	11.00	205.13
Baleke	20.20	150.40	14.01	12.98	10.11	15.73	223.43
Umudein	10.41	138.87	7.14	7.49	9.42	3.13	180.46
Edike	11.18	134.91	9.41	8.98	8.98	7.08	180.34
College Junction	10.08	123.14	11.10	21.81	7.91	10.02	184.06
<b>Total</b>	<b>98.17</b>	<b>1135.21</b>	<b>87.74</b>	<b>101.30</b>	<b>93.37</b>	<b>78.32</b>	<b>1594.11</b>

Source: Field Survey

Table 6. Solid waste disposal system in Agbor

Areas	Disposal at water front	Disposal in street drains	Disposal on road side	Landfill	Open burning	Disposal of point of collection
1	-	210	124	4	82	205
3	-	199	112	1	100	213
4	-	214	60	18	92	200
5	27	313	41	8	87	149
6	121	209	83	13	99	100
7	45	204	32	11	134	199
8	-	218	14	3	178	212
<b>Total</b>	<b>193</b>	<b>1754</b>	<b>566</b>	<b>60</b>	<b>871</b>	<b>1515</b>

Table 5 shows the data on solid waste composition in a day. The data was based on the total number of respondents in each sampled area. From Table 5, the grand total of the waste generated was 1594.11 kilogram. This shows that all the respondents generated 1594.11 kilogram of solid waste daily. Baleke area has the highest rate of waste generated which is 223.43 kilogram followed by Dr. Whyte area which generate 214.46 kilogram of solid waste

daily. Edike area generates the harvest amount of solid waste in the entire sampled areas, having 180.34 kilogram of solid waste generated daily.

In the solid waste composition measurement of the sampled areas, food items have the greatest amount generated daily, with 1135.21 kilograms per day, followed by papers, cellophanes with 101.30 kilograms and 98.17 kilograms



respectively. Bottles constitute the smallest amount generated with 78.32 kilograms per day.

### 3.2 Solid Waste Management Practices in Agbor

The data on solid waste management practices on disposal system were obtained through the use of questionnaire. Table 6 shows raw data obtained from the respondents on solid waste disposal system in each sampled area.

From Table 6, a total number of 193 respondents disposed their solid waste at water front, 1754 respondents disposed their solid waste in street drains, 566 respondents disposed their solid waste by road side, 60 respondents disposed their solid waste in landfill, 871 respondents disposed their solid waste through open burning and 1515 respondents disposed their solid waste at the points of collection by private waste managers.

Table 7 shows the malaria and typhoid cases reported between 1997 and 2011. A total of 25,559 cases of malaria and 22,407 of typhoid were reported. The result also show that the number of reported has decreased from 1997 to 2011 for both health cases of malaria and typhoid (Fig. 4).

### 3.3 Relationship between Solid Waste Composition and Health in Agbor

#### 3.3.1 Multiple correlation analysis and ANOVA analysis of solid waste composition of malaria and typhoid

**Hypothesis 1:** There is no significant relationship between solid waste composition and human health.

Table 8 shows the weight of the categorized solid waste in the zoned areas, with the Hospital Record on malaria and typhoid from the year 1997 – 2011. In Table 9, the descriptive statistics of the waste composition and malaria is presented.

Table 10 shows the correlation between solid waste composition and reported malaria cases in Agbor. Cellophane has a mean of 12.2712, standard deviation of 3.33349 (Table 9) and a correlation of -0.070 with malaria. Food items have a mean of 141.9013, standard deviation of 9.76137 (Table 9) and correlation of 0.532

(52.2%) with malaria. Plastic has a mean of 10.9675, standard deviation of 2.09184 (Table 9) and a correlation of 0.417 (41.7%) with malaria. Papers have a mean of 12.6625, standard deviation of 4.56239 (Table 9) and a correlation of 0.166 (16.6%) with malaria. Tin can has a mean of 11.6713, standard deviation of 3.63672 (Table 9) and a correlation of .688 (68.8%) of malaria. Bottles have a mean of 9.7900, standard deviation of 3.09718 (Table 9) and a correlation of 0.123 (12.3%) with malaria. In Table 11, the model summary was presented.

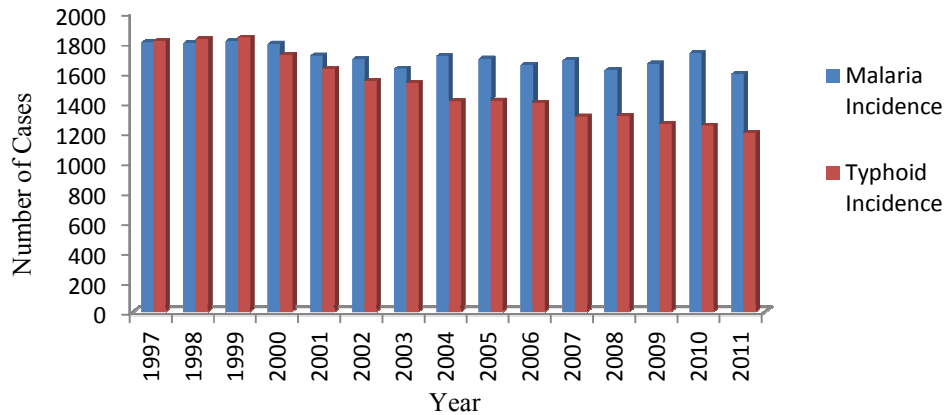
**Table 7. Hospital record of malaria and typhoid (1997-2011) in Agbor**

Year	Malaria (No. of cases)	Typhoid (No. of cases)
1997	1802	1811
1998	1799	1824
1999	1811	1834
2000	1792	1718
2001	1712	1625
2002	1689	1541
2003	1626	1529
2004	1711	1407
2005	1692	1411
2006	1649	1396
2007	1682	1305
2008	1617	1310
2009	1658	1256
2010	1729	1245
2011	1590	1195

Source: Medical Records Dept., Central Hospital, Agbor

From the model summary presented in Table 11, the R<sup>2</sup> of 0.850 indicates that 85% of malaria cases in Agbor were explained by the model to be related to solid waste composition in the area. In Table 12, the ANOVA statics of the model is presented.

Table 12 shows that ANOVA statistics of multiple correlation between solid waste composition and malaria incidence. Since the calculated value (12.945) is greater than table value (5.99) at P < 0.05 from the ANOVA statistics, we therefore reject the null hypothesis and accept the alternative hypothesis that there is significant relationship between solid waste composition and human health (Malaria) in Agbor. This means that the rate of solid waste composition has contributed to the occurrence of malaria in Agbor.



**Fig. 4. Malaria and typhoid cases in Agbor 1997-2011**

**Table 8. Waste composition and malaria/typhiod reported in Agbor**

Cellophane	Food items	Plastic	Papers	Tin can	Bottles	Malaria	Typhoid
10.05	150.41	12.11	10.99	19.09	11.81	1802	1811
12.61	152.37	10.11	15.41	14.41	9.14	1799	1824
11.88	141.59	11.49	9.84	10.97	6.41	1811	1834
11.76	143.52	12.37	14.00	12.48	11.00	1792	1718
20.20	150.40	14.01	12.98	10.11	15.73	1712	1625
10.41	138.87	7.14	7.49	9.42	7.13	1689	1541
11.18	134.91	9.41	8.78	8.98	7.08	1626	1529
10.08	123.14	11.10	21.81	7.91	10.02	1711	1407
						1692	1411
						1649	1396
						1682	1305
						1617	1310
						1658	1256
						1729	1245
						1590	1195

**Table 9. Descriptive statistics for solid waste composition and reported cases of malaria**

	Mean	Standard deviation	N
Malaria	1742.7500	67.85647	8
Cellophane	12.2712	3.33349	8
Food items	141.9013	9.76137	8
Plastic	10.9675	2.0184	8
Papers	12.6625	4.56239	8
Tin can	11.6713	3.63672	8
Bottles	9.7900	3.09718	8

Table 13 shows the descriptive statistics for solid waste composition and typhoid cases reported in Agbor. In Table 14, the correlation is between them is presented.

Table 14 presents the correlation analysis result. Cellophane has a mean of 12.2712, standard deviation of 3.33349 (Table 13) and a correlation of 0.071 (7.1%) with typhoid. Food items have a mean of 141.9013, standard deviation of 9.76137

(Table 13) and a correlation of 0.800 (80%) with typhoid. Plastic has a mean of 10.9675, standard deviation of 2.09183 (Table 13) and a correlation of (-0.277) with typhoid. Tin can have a mean of 11.6713, standard deviation of 3.63672 (Table 13) and a correlation of 0.765 (76.5%) with typhoid. Bottle have a mean of 9.7900, standard deviation of 3.09718 (Table 13) and a correlation of 0.025 (2.5%) with typhoid. The model summary is presented in Table 15.

**Table 10. Correlations of solid waste composition on malaria cases**

	Malaria	Cellophane	Food items	Plastic	Papers	Tin can	Bottles
Pearson correlation malaria	1.000	-.070	.532	.417	.166	.688	.123
Cellophane	- 0.070	1.000	0.464	0.592	0.013	-0.150	0.699
Food items	0.532	0.464	1.000	0.341	0.348	0.709	0.409
Plastic	0.417	0.592	0.341	1.000	-0.362	0.271	0.778
Papers	0.166	0.013	-0.348	0.362	1.000	-0.126	0.346
Tin cans	0.688	-0.150	0.709	0.271	-0.126	1.000	0.250
Bottles	0.123	0.699	0.409	0.778	0.346	0.250	1.000

**Table 11. Model summary**

Model	R	R square	Adjusted R square	Standard error of estimate	Durbin Watson
1	0.922	0.850	0.050	69. 5 2006	3.126

*Predictor: bottles, tin can, papers, plastic, food items, cellophane  
Dependent variable: malaria*

**Table 12. ANOVA**

Model	Sum of squares	Df	Mean square	F	T-value	Significance
1. Regression	27398.461	6	4566.410	12.945	5.99	0.657
Residual	4833.039	1	4833.039			
Total	32231.500	7				

*Predictor: bottles, tin can, papers, plastic, food items, cellophane  
Dependent variable: malaria*

**Table 13. Descriptive statistics for solid waste composition and typhoid cases**

	Mean	Standard deviation	N
Typhoid	1661.1250	160.30457	8
Cellophane	12.2712	3.33349	8
Food items	141.9013	9.76137	8
Plastic	10.9675	2.09184	8
Papers	12.6625	4.56239	8
Tin can	11.6713	3.63672	8
Bottles	9.7900	3.09718	8

**Table 14. Correlations of solid waste composition of typhoid cases**

	Typhoid	Cellophane	Food items	Plastic	Papers	Tin can	Bottles
Pearson correlation typhoid	1.000	0.071	0.800	0.308	-0.277	0.765	0.025
Cellophane	0.071	1.000	0.464	0.592	0.013	0.150	0.699
Food items	0.800	0.464	1.000	0.341	-0.348	0.709	0.409
Plastic	0.308	0.592	0.341	1.000	-0.362	0.271	0.778
Papers	-0.277	0.013	-0.348	0.362	1.000	-0.126	0.346
Tin can	0.765	-0.150	0.709	0.271	0.126	1.000	0.250
Bottles	0.025	0.699	0.409	0.778	0.346	0.250	1.000

**Table 15. Model summary**

Model	R	R square	Adjusted R square	Standard error of estimate	Durbin Waston
1	0.993	0.986	0.905	49. 42790	3.126

*Predictor: bottles, tin can, papers, plastic, food items, cellophane  
Dependent variable: malaria: typhoid*

Table 16. ANOVA

Model	Sum of squares	Df	Mean square	F	T-value	Significance
1. Regression	177439.788	6	29573.293	12.105	5.99	0.217
Residual	2443.117	1	2443,117			
<b>Total</b>	<b>179882.875</b>	<b>7</b>				

Table 17. Solid waste management system and human health (Reported cases of malaria and typhoid) in Agbor

Disposal at water front	Disposal in street drain	Disposal at road side	Landfill	Open burning	Disposal at collection point	Malaria	Typhoid
0.00	210	124	4	82	205	1802	1811
0.00	199	112	1	10	213	1799	1824
0.00	187	100	2	99	237	1811	1834
0.00	214	60	18	92	200	1792	1718
27	313	41	8	87	149	1712	1625
121	209	83	13	99	100	11689	1541
45	204	32	11	134	199	1626	1529
0.00	218	14	3	178	212	1711	1407
						1692	1411
						1649	1396
						1682	1305
						1617	1310
						1658	1256
						1729	1245
						1590	1195

Table 18. Descriptive statistics for solid waste management on malaria cases

	Mean	Standard deviation	N
Malaria	1742.7500	67.85647	8
Disposal on water front	24.1250	42.65957	8
Disposal on street drains	219.2500	39.08142	8
Disposal on road side	70.7500	40.11679	8
Landfill	7.500	6.07101	8
Open burning	108.8750	32.00195	8
Disposal at point collection	189.3750	43.76214	8

From the model summary presented in Table 15, the  $R^2$  value of 0.986 indicates that 98.6% of typhoid incidence in Agbor is explained by the model that it results from solid waste composition. The 98.6% of typhoid cases in Agbor that is consequent on solid waste composition is due to the dependence of Baleke, Umudein and Edike on the Orogodo River or Yi – Ekpon for water used domestically. Some residents in these areas even drink the river water. The issue is that the heaps of solid wastes dumped in the drains up – town, wash down into the river when it rains. This is in agreement with a study at South Western Nigeria by Fasunwon [17] which showed that incessant dumping of refuse by Ijebu-Ode parts of citizens in different

the town is highly unpleasant as this has been a major factor in the prevalence of malaria in Ijebu-Ode.

From the ANOVA statistics presented Table 16, the calculated value,  $F=12.105$ , is greater than our table of 5.99 at  $P < 0.05$ . The null hypothesis was rejected and the alternative hypothesis accepted, meaning that there was significant relationship between solid waste composition and human health in Agbor. This means that solid waste composition has contributed to occurrence of typhoid fever in Agbor.

**Hypothesis 2:** There is no significant effect of solid waste management on human health.

**Table 19. Correlations of solid waste management and reported cases of malaria**

	Malaria	Disposal on water front	Disposal on street drains	Disposal in road side	Landfill	Open burning	Disposal at point of collection
Pearson correlation malaria	1.000	-0.621	-0.251	0.710	-0.350	-0.495	0.492
Disposal on water front	-0.621	1.000	0.052	-0.089	0.461	-0.069	-0.878
Disposal on street drain	-0.251	0.052	1.000	-0.407	0.138	-0.181	-0.439
Disposal on road side	0.710	-0.089	-0.407	1.000	-0.326	-0.698	0.125
Landfill	-0.350	0.461	0.138	-0.326	1.000	-0.191	-0.505
Open burning	-0.495	-0.069	-0.181	-0.698	-0.191	1.000	0.234
Disposal at point of collection	0.492	-0.878	-0.439	0.125	-0.505	0.234	1.000

**Table 20. Model summary**

Model	R	R square	Adjusted R square	Standard error of estimate	Durbin Watson
1	0.987	0.973	0.813	29.34982	3.185

*Predictor: disposal point of collection, disposal on road side, disposal on street drains, landfill, disposal at water front, open burning, Dependent variable: malaria*

**Table 21. ANOVA**

Model	Sum of squares	Df	Mean square	F	T-value	Significance
1. Regression	31370.088	6	5228.348	6.070	5.99	-0.301
Residual	861.412	1	861.412			
<b>Total</b>	<b>32231.500</b>	<b>7</b>				

**Table 22. Descriptive statistics for solid waste management on typhoid cases**

	Mean	Std deviation	N
Typhoid	1661.1250	160.30567	8
Disposal on water front	24.1250	42.65957	8
Disposal on street drains	219.2500	39.08142	8
Disposal on road side	70.7500	40.11679	8
Landfill	7.5000	6.07101	8
Open burning	108.8750	32.00195	8
Disposal at point collection	189.3750	43.76214	8

Table 17 shows that waste management system and the health correlate as manifested in the number of reported cases of malaria and typhoid in Agbor used in testing hypothesis two. In Table 18, the descriptive statistics is presented while the correlations are presented in Table 19.

From Tables 18 and 19, Solid waste disposal at waterfront has the mean of 24.1250, standard deviation of 42.65957 and a correlation of (-0.621) with malaria. Disposal in street drains

has the mean of 219.2500 and standard deviation of 39.08142 and a correlation of (-0.251) with malaria. Disposal on road side has the mean of 70.7500, standard deviation of 40.11679 and a correlation of (0.710) with 40.11679 and a correlation of 7.500, standard deviation of 6.07101 and a correlation of (-0.350) with malaria. Open burning has a mean of 108.8750, standard deviation of 32.00195 and a correlation of (-0.495) with malaria. Disposal at point of collection has a mean of 189.3750,

standard deviation of 43.76214 and a correlation of (0.492) with malaria. This result is congruent with Akindutire and Alebiosu [12] who explained that some risk-factors of indiscriminate refuse disposal include breeding of arthropod borne-diseases and that indiscriminate dumping of refuse promote the prolific breeding of arthropod-borne diseases like mosquitoes, houseflies, lice, tsetse flies, cockroaches which transmit diseases like malaria, viral encephalitis, typhoid.

From the model summary, Table 20, R<sup>s</sup> of 0.973 indicates that 97.3% of malaria cases in Agbor are consequent on solid waste management, i.e how solid waste is handled in the area. The ANOVA model summary is presented in Fig. 21.

From the ANOVA table, the calculated value F = 6.070 is greater than the Table 21 value of 5.99 at P < 0.05. The null hypothesis was rejected and the alternative hypothesis accepted. This means that there was significant effect of solid waste management on human health in Agbor.

This shows that the waste management practices have contributed to the growth of malaria.

In Table 22, the descriptive statistics of solid waste management and the reported cases of typhoid is presented while in Table 23 the correlation matrix is presented.

Disposal at waterfront has a mean of 24.1250, standard deviation of 42.65957 (Table 22) and a correlation of (-0.448) with typhoid. Disposal in street drains has the mean of 219.2500, standard deviation of 39.08142 (Table 22) and a correlation of (-0.237) with typhoid. Disposal on roadside has a mean of 70.7500, standard deviation of 40.11679 (Table 22) and a correlation of (0.851) with typhoid. Land fill has a mean of 7.500, standard deviation of 6.07101 and a correlation of (-0.284) with typhoid. Open burning has a mean of 108.8750, standard deviation of 32.00195 (Table 22) and correlation of (-0.753) with typhoid. Disposal at point of

**Table 23. Correlation of solid waste management on typhoid**

	<b>Typhoid</b>	<b>Disposal on water front</b>	<b>Disposal on street drains</b>	<b>Disposal on road side</b>	<b>Landfill</b>	<b>Open burring</b>	<b>Disposal at point of collection</b>
Pearson correlation typhoid	1.000	-0.448	-0.237	0.851	-0.284	-0.753	0.411
Disposal on water front	-0.448	1.000	0.052	-0.089	0.461	-0.069	-0.878
Disposal on street drain	-0.237	0.052	1.000	-0.407	0.138	-0.181	-0.439
Disposal on road side	0.851	-0.089	-0.407	1.000	-0.326	-0.698	0.125
Landfill	-0.284	0.461	0.138	-0.326	1.000	-0.191	-0.505
Open burning	-0.753	-0.069	-0.181	-0.698	-0.191	1.000	0.234
Disposal at point of collection	0.411	-0.878	-0.439	0.125	-0.505	0.234	1.000

**Table 24. Model summary**

<b>Model</b>	<b>R</b>	<b>R square</b>	<b>Adjusted R square</b>	<b>Standard error of estimate</b>	<b>Durbin Watson</b>
1	0.998	0.996	0.974	26.01937	3.185

**Table 25. ANOVA**

<b>Model</b>	<b>Sum of squares</b>	<b>Df</b>	<b>Mean square</b>	<b>F</b>	<b>T-value</b>	<b>Significance</b>
1. Regression	179205.868	6	29867.645	44.117	5.99	0.115
Residual	677.077	1	677.007			
<b>Total</b>	<b>179882.875</b>	<b>7</b>				

**Table 26. Problems of solid waste management in Agbor as perceived by respondents**

Sampled areas	Lack of fund	Few labourers	Non challant attitude	Lack of waste bin	No. of respondent
Dr. Whyte	79	51	104	361	625
Charles	60	36	129	400	625
Prof. Ebie	85	52	99	389	625
Mariere	87	33	114	397	625
Baleke	41	57	126	401	625
Umudein	98	30	98	399	625
Edike	77	60	77	411	625
College Junction	55	95	61	414	625
<b>Total</b>	<b>576</b>	<b>444</b>	<b>808</b>	<b>3172</b>	<b>5000</b>
<b>Percentage</b>	<b>11.52%</b>	<b>8.88%</b>	<b>16.16%</b>	<b>63.44%</b>	

Source: Field survey

collection has a mean of 189.3750, standard deviation of 43.76214 (Table 22) and a correlation of (0.411) with typhoid. In Table 24, the model summary is presented.

From this model summary table, Table 24,  $R^2$  of 0.996 indicates that 99.6% of typhoid cases in Agbor were explained by the model to be consequent on solid waste management.

From the ANOVA statistics presented in Table 25, the calculated value  $F = 44.177$  is greater than the table value of 5.99 at  $P < 0.05$ . The null hypothesis was rejected and the alternative hypothesis accepted. This means that there was significant effect of solid waste management on human health (typhoid incidence) in Agbor. This result is congruent with Addo et al. [11] who reported in Kumasi Metropolis of Ghana that stench from the dumpsites and poor management of waste causes numerous diseases such as catarrh, cough and chest pains, diarrhea, intestinal worms, typhoid fever and cancer which were prevalent in the communities.

### 3.3.2 Problems of effective solid waste management in Agbor

The result of respondents' perception on the problems militating against effective solid waste management in Agbor is presented in Table 26.

From Table 26, out of 5000 respondents, 11.52% of the respondents indicated that the lack of fund is militating against the effectiveness of solid waste management. Also 8.88%, 16.16% and 63.44% of the respondents indicated that few labourers, non-challant attitudes and lack of waste bins respectively are the factors that are militating against effective solid waste management in Agbor. A study conducted by the

African Population and Health Research Center (APHRC) [14] in Senegal reported that improved solid waste management (SWM) will lead to a reduction in infectious diseases (e.g. diarrhoea, typhoid, malaria) and chronic diseases (such as asthma) in addition to promoting the wellbeing of vulnerable populations (women and children).

## 4. CONCLUSION

The study assessed the solid waste composition and management and its implication on human health in Agbor. The study reported the socio-economic characteristics of the respondents; and the findings showed that there is significant relationship between solid waste composition and human health, in this case malaria and typhoid cases and also there are significant effects of solid waste management on human health in Agbor. The problems associated with solid waste management in the area are lack of fund, lack of waste bin, non-challant attitudes and few labourers, while the solution to the problems are intensification of monthly sanitation, provision of waste bins, awareness campaign on waste reduction and recycling and so on.

### 4.1 Recommended Measures for Effective Solid Waste Management in Agbor

To enhance effectiveness in solid waste management in Agbor, the Local Government Authority should subsidize the amount of money paid for the services of private waste managers to enable the populace pay less for effective solid waste disposal system. And as this is done, the payment of some part of the salaries of the solid waste disposal personnel should also be considered and implemented. This will make the private solid waste managers to have more man power effectively dispose waste.

The promulgation of punishable laws on the indiscriminate dumping of solid waste will help avoid the dumping of waste at waterfront, road side and street drains. Anybody found working should be severely punished without discrimination. The provision of waste bin by the government and other philanthropists will seriously help in effective solid waste management.

Government bodies and non-governmental organization should create seminars, awareness programs and campaign to enlighten the populace on issues of solid reduction, segregation and recycling, and also the solid waste management practices. One-Saturday in a month environmental sanitation exercise should be intensified through law enforcement agencies.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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