



World Scientific News

An International Scientific Journal

WSN 186 (2023) 53-66

EISSN 2392-2192

Assessment of dumpsites within Owerri North LGA Imo State, Nigeria

Nnaemeka Leo Ike* and **Blessing Onuoha**

Department of Animal and Environmental Biology, Faculty of Science, Imo State University,
Owerri, Nigeria

*E-mail address: ikeleo442@gmail.com

ABSTRACT

Open dumpsites and its waste management is one of the major problems in most developing nations like Nigeria and poses a serious environmental and health issues to those living around such waste management facilities. This study sought to evaluate the environmental impacts of open dumpsites on the residents living near the three dumpsites that were purposely selected for this study. The dumpsites that were selected are Aladimma dumpsite, Akwakuma dumpsite and Orië-Uratta dumpsite. In this descriptive cross-sectional study using non-probability sampling, a total of 90 respondents who were living close to the dumpsites were randomly selected and included in this study, of which 46.7% were male and 53.3% were female. Their knowledge about the dumpsite and environmental issues faced due to the dumpsite were ascertained using a well sectioned questionnaire and was analyzed using statistical package for social sciences (SPSS) software. The results from their responses show that a good number of the respondents have experienced negative environmental issues due to the dumpsites. 77.8% of the respondents have experienced air pollution due to bad odor oozing from the dumpsite, 76.7% complained of environmental litter, 85.6% of the respondents complained about vermin and pests increase, while 38.9% of the respondents attested that the dumpsites have caused road accidents. The Calculated t-value (4.3224) was greater than (>) the Critical t-value (3.1824), hence there is a significant negative environmental impact of dumpsites on the residents living near the dumpsites in the study area. It could be concluded from this study that open dumping poses a serious threat to human health, the environment, and aesthetic values. This study recommends proper monitoring of dumpsites, establishment of modern dumpsites, proper compacting of wastes and tidiness of dumpsites in the study area.

Keywords: Assessment, Dumpsites, Wastes, Environmental impacts, Pollution

1. INTRODUCTION

Waste can be explained as those materials are no longer required by an individual, institution or industry. Waste is thus regarded as by-products or end products of the production and consumption process respectively. Solid waste can be defined as: ‘The useless and unwanted products in the solid state derived from the activities of society and hence discarded off by the society’. Solid waste results from various sources, such as animal wastes, hazardous wastes, industrial and medical wastes, food wastes, mineral waste, and nonhazardous wastes (Ali and Ahmed, 2021).

In the late 1990s, it was estimated that each person in the world generated 200kg of solid waste per year (UNCHS, 2001) and this was forecasted to increase with the growth in population. Thousands of tons of waste are generated daily in African countries (Besufed et al., 2020). The quality and generation rate of solid wastes in Nigeria have increased at an alarming rate over the years with lack of efficient and modern technology for their management (Babayemi and Dauda, 2009). Solid waste management has remained an intractable environmental sanitation problem in Nigeria. This problem has manifested in the form of piles of indiscriminately disposed heaps of uncovered waste and illegal dumpsites along major roads and at street corners in cities and urban areas (Charles et al., 2013). This problem is compounded by the rapid urbanization and population growth which has led to the generation of enormous quantities of solid waste which are often discarded by open dumping (Azuma and Ekeu-wei, 2017). The rate of increase in the quantity of waste generated in relation to the population size can only worsen urban environmental issues and planning as a whole (Kayal et al., 2021).

Solid waste is mainly disposed of to dumpsite, because it is the simplest and cheapest method of disposing of waste (Barret and Lawler, 1995). Rushbroke (2001) describes open dumping of municipal solid waste (MSW) as a primitive stage of waste disposal, practiced by three fourths of countries and territories round the world. Open dumps are the major causes of environmental degradation and public health concerns in many developing countries including Nigeria (Mokuolu et al 2017; Victoria et al, 2023; Verla, et al., 2017).

These waste dumps may contain a mixture of general waste and toxic, infectious or radioactive wastes and are susceptible to burning and exposure to scavengers. There are several major risks and impacts of the dumpsites on the environment. For instance, air pollution from open burning, due to emission of greenhouse gases such as methane and carbon dioxide; the air emissions and leachates generated because of decomposition of waste may contaminate air, surface and groundwater sources; fire hazards and explosions cause public health risks as well (Mugo and Gatebe, 2015). The emission of greenhouse gases, rats and fly infestation and nuisance effects are among the health and environmental impacts of poor solid waste management (Onibokun, 1999). In addition, scattering of waste by wind and scavenging by birds, animals and waste pickers creates aesthetic nuisance. Bad odor emanating due to the degradation of the waste in the dumpsite has nuisance effect and decreases the economic and social values in the locality. In many dumpsites, the waste is directly exposed due to the absence of daily cover on the dumped waste, and this attracts animal and human scavengers (Kurian et al, 2004).

According to DEAT (2001), the life and dumpsite and landfill can be managed if wastes disposed to dumpsites are minimized through waste recycling and resource recovery and the vision of the Polokwane declaration is to reduce solid wastes landfilled to 50% of current levels by 2012 and to zero by 2022. If resources (both renewable and nonrenewable) are salvaged, dumpsites air space will be more effectively utilized, and pollution and environmental degradation will be reduced.

Over the last three decades there has been increasing global concern over the public health impacts attributed to environmental pollution, in particular, the environmental quality and human health risks associated with the waste dumps. The World Health Organization estimated that about a quarter of the diseases facing mankind today occur due to prolonged exposure to environmental pollution (UNEP, 2006). Unfortunately, there seems to be no clear-cut guidelines at the national or state levels on how to deal with these dumpsites in a sustainable manner, particularly in the developing where ironically the burden of environmental pollution seems to be highest. It is suggested that the first task would be to decide on one of three options: whether the dumpsite should be closed, remediated, or rehabilitated (Kurian et al, 2005). To determine whether to rehabilitate and close or remediate, upgrade, and operate a dumpsite may require an environmental impact assessments studies (EIAs) including consultation with the interested and affected parties, specifically the adjacent communities. In countries like Nigeria where the number of existing dumpsites (both legal and illegal) are many, economic considerations of the evaluation process must be taken into consideration in recommending a suitable approach or methodology (Vincent and Ebenezer, 2012).

Assessing the relative health and environmental hazards posed by the dumpsites existing throughout the developing countries could help prioritize, plan and initiate dumpsite rehabilitation (Kurian et al, 2005). To prolong the life of the current dumpsites and landfills in the country and optimally manage the new ones, they need to be redesigned and reconstructed, following the internationally acceptable standards and regulations. Landfills (dumps) in the case study (Imo State) generally were not subject to the regulations governing modern landfills and were usually sited for convenience such as the presence of a preexisting hole into which wastes could be deposited. This research seeks to assess the suitability of dumpsites location within Owerri North Local Government area of Imo state with a view of identifying suitable areas across the state for future landfill projects using site selection criteria.

The lack of effective waste management strategy is a potential threat to achieving sustainable development in Nigeria (Elijah and Steve, 2010). Studies that would bring about strategies to manage these wastes are urgently needed. Hence, the purpose of this study is to provide a scientific assessment of an existing dumpsite in Imo state. Landfills offer promising potential for both energy as well as raw material recovery. In addition, they offer the easiest and cheapest way of waste disposal. While the predominant reasons for dumpsite deconstruction and reclamation in the past have been environmental pollution and degradation (Alfaifi et al, 2021). At present and in the future, the motivation should be their proper location through constraint mapping, using site selection criteria. If properly located and constructed, dump sites have many environmental benefits besides economic benefits. Revenues from recyclable and re-useable materials (e.g., ferrous metals, aluminum, plastic, and glass) provide people with sustained income, reclaimed soil used as cover material or sold as construction fill or sold for other uses (Aiyesanmi and Imoisi, 2011). The recovery of metals from old dumpsites also seems reasonable in respect to the strongly increasing prices of raw materials (EUWID, 2008).

Internationally, landfills have significant waste management potentials. Proper site selection for dumpsites has potentials for increasing dumpsite life span protecting the environment from further pollution from indiscriminate waste dumping and enhancing conservation of natural resources and virgin materials so as to eradicate poverty through income generation (Steve et al, 2010). However, these benefits are still not fully taken into advantage in Nigeria due to poor site location for the dumpsites/landfills. This is partly because the major issues that determine the success of dumpsites selection and construction have not been earnestly addressed. That is environmental impact assessment and audit of each dump site has not been given the much attention it deserved. It will also provide necessary information for appropriate/suitable site which in the long run increase the life span of these sites and reduce the necessity for reclamation in the future. At present there are hardly any documented experiences with the use of risk based approaches for the management of dumpsites in Nigeria.

The need for a risk based tool that is suited to the peculiarities of a developing country and that has been tested and proven to be useful, scientifically sound and easy to apply is therefore urgently required, given the number of waste dumps in Nigeria and the march towards the achievement of vision 20-20-20 (the vision of the Nigerian state to become one of the twentieth largest economies in the world by the year 2020). This study will therefore provide basis for action and suggest modification for better result.

2. MATERIALS AND METHODS

2. 1. Study Area



Figure 1. Dumpsites at (a) Aladimma, (b) Akwakuma, and (c) Orié-Uratta

The study was conducted within Owerri North Local Government Area of Imo State. Owerri North is a Local Government Area in Imo State Nigeria. The headquarters is in the town of Orie Uratta. Owerri North is a semi-urban government area. It encircles Owerri Municipal like a Peninsular. Six major roads that lead out of the municipal cuts across Owerri North communities. In the east, Okigwe road leads to Orji community. In the west, MCC road off Wetheral to Obibi Uratta and Ihitaocha communities. In the south, Mbase road leads to Egbu and Emekuku communities, while Aba roads leads to Nazi, Agbala, and Ulakwo communities. Owerri North has an area of 198 square km and a population of 175,395 at the 2006 census. The postal code of the area is 460. The dumpsites in the three locations are shown in Figure 1.

Owerri North is located on latitude $5^{\circ}30'N$ and Longitude $70^{\circ}10'E$ in the Rainforest region of Southeastern Nigeria. It has a tropical climate with two distinct seasons namely the dry season from November to March, and rainy season from April to October. The temperature variation is observed to range from $25^{\circ}C - 32^{\circ}C$ and from one season to another. Annual rainfall is moderately high with a relative humidity of 85-90 percent. Three locations were used in this study, which are: Aladimma, Akwakuma and Orie-Uratta. A map of the study area is shown in Figure 2.

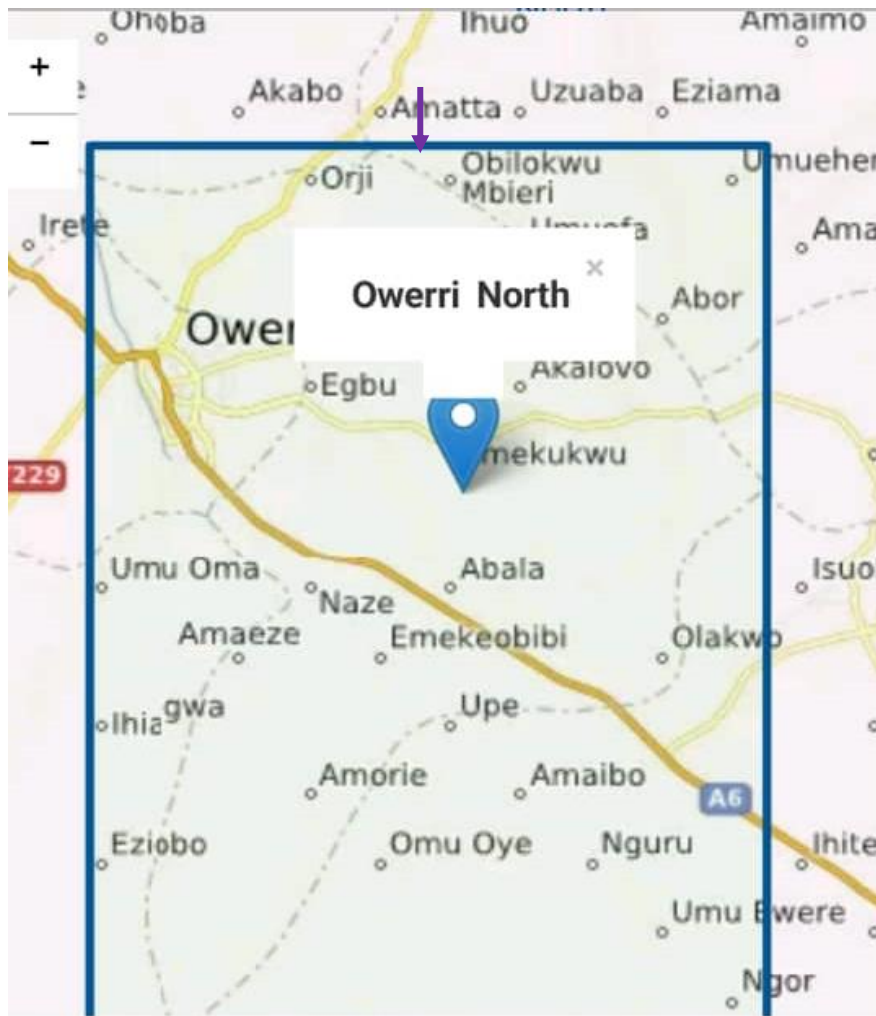


Figure 2. Map of the Study Area

2. 2. Study Design

Descriptive and cross-sectional survey design have been adopted for this study. The study was carried out on field based on limited work in scope in all the

2. 3. Study Population

A total of 90 respondents were included in this study, of which 30 respondents were residents of each dumpsite. Purposive sampling method was used to select all the old, designated dump sites in Owerri North L.G.A. Imo State for the study. The dumpsites that were selected for this study are Aladimma dumpsite, Akwakuma dumpsite, and Orié Uratta dumpsite.

2. 4. Methods of Data Collection

The data collection method used was a well sectioned questionnaire, which contained all the necessary information relating to the study, explanations were given, and the respondents were guided on how well to fill the questionnaire.

2. 5. Methods of Data Analysis

The statistical tool used for this analysis is statistical package for social sciences (SPSS) version 20. This statistical tool was used to carry out the following test: hypothesis testing, measures of central tendency, distribution and dispersion, and paired t-test. The results were arranged in a table showing the percentages of responses.

3. RESULTS

The result in **Table 1** gives details on socio-demographic characteristics of respondents (Table 1). It shows that the age interval of 20-29 has the highest response 37(41.1%), while the age interval of 70 and above had the least response 6(6.7%). The result also shows that more female respondents 48 (53.3%) were included in the study, compared to lesser male respondents 42(46.7%). The result also shows that 42(46.7%) of the respondents were married individuals recording the highest response amongst other marital categories, while 7(7.8%) of the respondents were widowed individuals recording the least response.

Table 1. Socio-Demographic Distribution of Respondents.

Variables	Statistics of respondents				
	Aladimma	Akwakuma	Orie-Uratta	Grand total	Grand percentage(%)
Age					
20-29	15(50.0%)	11(36.7%)	11(36.6%)	37	41.1
30-39	2(6.7%)	4(13.3%)	1(3.3%)	7	7.7

40-49	4(13.3%)	4(13.3%)	6(20.0%)	14	15.6
50-59	6(20.0%)	5(16.7%)	5(16.7%)	16	17.8
60-69	3(10.0%)	4(13.3%)	3(10.0%)	10	11.1
70 and above	0(0%)	2(6.7%)	4(13.3%)	6	6.7
Total	30(100%)	30(100%)	30(100%)	90	100
Gender					
Male	8(26.7%)	16(53.3%)	18(60.0%)	42	46.7
Female	22(73.3%)	14(46.7%)	12(40.0%)	48	53.3
Total	30(100%)	30(100%)	30(100%)	90	100
Marital Status					
Widowed	3(10.0%)	3(10.0%)	1(3.3%)	7	7.8
Divorced	4(13.3%)	3(10.0%)	1(3.3%)	8	8.8
Married	10(33.4%)	13(43.3%)	19(63.3%)	42	46.7
Single	13(43.3%)	11(4.0%)	9(30.0%)	33	36.7
Total	30(100%)	30(100%)	30(100%)	90	100

The results presented in Table 2 show that most of the respondents 84(93.3%) knew their dumpsite very well. 77(85.6%) of the respondents agreed that their dumpsites were accessible to them while (14.4%) of the respondents disagreed. From the result, 25(27.8%) of the respondents agreed that they dump their wastes along the road, instead of taking it to the dumpsite, of which 16(64%) of these respondents who dispose their waste wrongly gave their reasons to be fear of being attacked by animals and harmful insects while the remaining 9(36%) gave their reasons to be difficulty in carrying their waste to the dumpsites.

Table 2. Assessment on Knowledge and Waste disposal Around the Dumpsite.

QUESTIONS	Statistics of respondent				
	Aladimma	Akwakuma	Orie-Uratta	Grand Total	Grand percentage(%)
Do you know the dumpsite very well?					
Yes	25(83.3%)	30(100%)	29(96.7%)	84	93.3

No	5(16.7%)	0(0%)	1(3.3%)	6	6.7
Total	30(100.0%)	30(100.0%)	30(100.0%)	90	100
The dumpsite is accessible to me					
Yes	25(83.3%)	26(86.7%)	26(86.7%)	77	85.6
No	5(16.7%)	4(13.3%)	4(13.3%)	13	14.4
Total					
I dump waste along the road instead of at the dumpsite					
Yes	13(43.3%)	7(23.3%)	5(10.7%)	25	27.8
No	17(56.7%)	23(76.7%)	25(83.3%)	65	72.2
Total	30(100.0%)	30(100.0%)	30(100.0%)	90	100
If yes,why?					
i. Fear of being attacked by animals and harmful insects	8(61.5%)	5(71.43%)	3(60.0%)	16	64
ii. Difficulty in carrying the waste to the dumpsite	5(38.5%)	2(28.57)	2(40.0%)	9	36
iii. Other Reasons	0(0%)	0(0%)	0(0%)	0	0
TOTAL	13(100.0%)	7(100.0%)	5(100.0%)	25	100

Results in Table 3 show that 70(77.8%) of the respondents have experienced air pollution due to bad odor coming from the dumpsites. The result also shows that 69(76.7%) of the respondents agree that their dumpsites have caused environmental litter increase. 77(85.6%) of the respondents agree that there is vermin and pest increase due to the dumpsite. From the result, 35(38.9%) of the respondents agreed that their dumpsites have caused road accidents.

Table 3. Assessment of Environmental Impacts.

QUESTIONS	Statistics of respondents				
	Aladimma	Akwakuma	Orie-Uratta	Grand TOTAL	Grand Percentage (%)
I experience air pollution due to the dumpsite					
Yes	22(73.3%)	20(66.7%)	28(93.3%)	70	77.8
No	8(26.0%)	10(33.3%)	2(6.7%)	20	22.2
Total	30(100.0%)	30(100.0%)	30(100.0%)	90	100
There is environmental litter increase due to the dumpsite					
Yes	18(60.0%)	24(80.0%)	27(90.0%)	69	76.7
No	12(40.0%)	6(20.0%)	3(10%)	21	23.3
Total	30(100.0%)	30(100.0%)	30(100.0%)	90	100
There is vermin and pest increase caused by the dumpsite					
Yes	22(73.3%)	27(90.0%)	28(93.3%)	77	85.6
No	8(26.7%)	3(10.0%)	2(6.7%)	13	14.4
Total	30(100.0%)	30(100.0%)	30(100.0%)	90	100
The dumpsite has caused road accident					
Yes	12(40.0%)	12(40.0%)	11(36.7%)	35	38.9
No	18(60.0%)	18(60.0%)	19(63.3%)	55	61.1
Total	30(100.0%)	30(100.0%)	30(100.0%)	90	100

Testing of hypothesis was conducted with Paired t-test. The Procedures/Summary of the Hypothesis. Assumption of hypothesis was as follows:

H_0 : There is no significant environment impact of dumpsites wastes on the residents living near the dumpsite.

H_i : There is significant environment impact of dumpsites waste on the residents living near the dumpsite

Level of significance = 0.05 (5%). Statistical significance: True. $P = 0.00157$ (Significance). Calculated t value = 4.3224. Critical t Value(t-tabulated) = 3.1824

Decision Rule: If the absolute value of the calculated t-value is greater than (>) the Critical t Value, we reject the null hypothesis. if the absolute value of the t-value is less than (<) the critical value, we fail to reject the null hypothesis. Since the absolute value of the Calculated t-value (= 4.3224) is greater than the Critical t-value (= 3.1824), we reject the null hypothesis. To investigate Environmental impacts of dumpsites wastes on the study area. Hence, we ascertain that there is significant environmental and health impact of dumpsites wastes on the residents living near the dumpsites (Tables 4 and 5).

Table 4. Nonparametric Tests

Variables	Range	No.	Mean±SD
Aladimma dumpsite	1.0	30	1.6000±0.49827
Akwakuma dumpsite	20.0	30	2.4667±3.52071
Orie-Uratta dumpsite	1.0	30	1.9000±0.30513

No. = number, SD = Standard Deviation

Table 5. Hypothesis measures

	Yes	No
Mean	27.25	26.75
SD	18.8392	18.8392
SEM	9.4196	9.4196
95% CI of mean	(32.77)-(97.73)	(-2.73)-(57.23)

Since most dumpsites in Owerri North Local Government were not subject to the regulations governing modern landfills, and were usually sited for convenience, such as the

presence of pre-existing hole into which the waste could be deposited. This study then assessed existing dumpsites in Owerri North Local Government Area of Imo State. The study therefore critically assessed the environmental impacts of dumpsite waste at selected dumpsites in Owerri North Local Government. Descriptive exploratory and cross-sectional survey design were adopted for this study which was carried out in a field based on limited work done in scope in all the designated dump site in Owerri North L.G.A in Imo State. Three dumpsites were purposely considered in this study which includes: Aladimma dumpsite, Akwakuma dumpsite and Ori uratta dumpsite. 90 respondents were included in the study of which 30 resides in each dumpsite. In Aladimma dumpsite, the respondents were (26.7%) male and (73.3%) female. In Akwakuma dumpsite, the male respondents were (53.3%) and (46.7%) were female, while in Ori-Uratta dumpsite (60%) were male and (40%) were female. In summary, the study involved 52.3% female respondents and 42.7% male.

The respondents selected for this study were within the age intervals of 20-29 (41.1%), 30-39 (7.7%), 40-49 (15.6%), 50 -59 (17.8%), 60-69 (11.1%), and 70 and above (6.7%). The respondents also had varied marital statuses which includes Widowed (7.8%), Divorced (8.8%), Married (46.7%) and Single respondents which were (36.7%) of the total population of respondents.

From this study, it was discovered that these designated dumpsites were not accessible to (14.4%) of the respondents. It was also discovered that a fraction of the study population (27.8%) usually dumped their waste along the road instead of taking it to the dumpsite, (64%) of this person gave their reasons to be that they fear being attacked by animals and harmful insects, while (36%) gave their reasons to be difficulty in carrying waste to the dumpsite. This tallies with the study of Dauda et al. (2009).

This study discovered that dumpsites located within Owerri North Local Government Area in Imo State poses serious threat to environment, health, and aesthetic value. About (77.8%) of the respondents have experienced air pollution due to bad odor oozing from the dumpsites. (76.7%) of the respondents agree that their dumpsites have caused environmental litter increase, which negatively affected the aesthetics of the ambient environment. This discovery is in correspondence with the study of Babayemi et al (2009). A good number of the respondents (85.6%) attested that their dumpsites have caused a rapid increase in the number of vermin, pests, and harmful insects. This will also affect humans negatively causing a decline in agricultural outputs due to the increase of pests and insects that destroy crops plus other health and environmental issues. (38.9%) of the respondents agreed that their dumpsites have caused road accidents, which must have caused loss of human lives, properties and other environmental and health issues which corresponds with the study of UNEP (2006).

Analysis of results shows that the variables of the 3 (three) dumpsites which are Aladimma, Akwakuma, and Ori-Uratta dumpsites have a ratio of mean and standard deviation consecutively (1.6000 ± 0.49827 ; 2.4667 ± 3.52071 ; 1.9000 ± 0.30513). The investigation on the assessment of dumpsites within Owerri North L.G.A, which evaluated the environmental impacts of Aladimma, Akwakuma and Ori Uratta dumpsites waste on the study area, hence we ascertain that there are significant negative environmental and health impacts of dumpsite wastes on the residents living near the dumpsites. It could be concluded from this study that open dumping poses a serious threat to human health, environment, and aesthetic values. Therefore, this study on environmental hazards posed by the dumpsites on the residents living near the dumpsite would help to prioritize, plan and initiate management, maintenance, and rehabilitation of dumpsites within Owerri North L.G.A in Imo State.

4. CONCLUSION

Modern dumpsites must be made available. A modern dumpsite which should be carefully designed and built into or on top of the ground in which waste is isolated from the surrounding environment (groundwater, air, soil). The modern dumpsite should offer much more protection for the environment and for the residents than traditional dumps did. Problems with bad odour, litter, vermin, etc., will be greatly reduced by the careful management of the site. Dumpsites must be monitored on a regular basis to make sure they are being run efficiently and safely. The responsibility for this monitoring rests with the government and dumpsite operators themselves. While the government and other environmental agencies carry out routine inspections on dump sites and provides guidance for dumpsite operators on the best practices for maintaining their sites, the operators themselves are required to constantly monitor various aspects of their site to ensure they remain in compliance with their license. Different sites will be required to monitor for different pollutants, depending on the location and potential environmental and health impact of their sites. Dumpsite gases, such as methane, carbon dioxide and sulphur dioxide are produced by the breaking down of waste and can cause pollution and odour problems. Proper compacting of waste, litter control, surface water control and general tidiness are all necessary parts of a dumpsite's management plan. Poor organization of a dumpsite can lead to problems with odours, flies, vermin, and litter, which, in turn, will lead to complaints. Many problems in dumpsites have been identified by many researchers, so the coming research should focus on finding solutions for these problems. The researcher recommends that additional studies should be done on the characteristics of dumpsites like seasonal variations, laboratory experiments, volume of components, chemical constituents etc.

References

- [1] Besufekad M., Alamayehu V., and Wuhib Z, Assessment of the effect of solid waste Dumpsite on surrounding soil and river water quality in Tepi Town, South Ethiopia. *Journal of Environmental and Public Health* 13 (2020) 108-116
- [2] Kahal A.Y., Abdelrahman K., Alfaify H.J., Qaysi S., Aldossari A.N, Geophysical assessment of an open dumpsite nearby Khamis Mushait industrial zone, Southwestern Saudi Arabia. *Journal of King Saud University Science* 33 (2021) 98-108
- [3] Ekeu-wei I.T., Azuma K.I., Ogunmuyiwa F.B.B), Assessment of environmental impact of solid waste dumpsites using remote sensing. *Nigerian journal of technology* 37 (2018) 443-152
- [4] Mokuolu O.A., Jacob S.O., Anyanshola A.M., Groundwater quality Assessment near a Nigerian dumpsite. *Ethopian Journal of Environmental Studies and Management* 10(5) (2017) 588-596
- [5] Vincent K.N., Ebenezer K.H., Smile K.A., Assessment of the impact of solid waste dumpsites on some surface water systems in the Accra Metropolitan Area, Ghana. *Journal of water Resource and Protection* 4 (2012) 388-402

- [6] Mugo K.K., Gichanga J.M., Gatebe E., Njogu R.M. , Assessment of safety and health hazards in existing dumpsite in Kenya. *Sustainable Research and Innovation (SRI) Conference 10* (2015) 46-49
- [7] Charles O.A., Olabanji O.A., Abimbola A.J., Olamide A.O., Assessing the effect of a dumpsite on Groundwater quality: A case study of Aduramigba Estate within Osogbo Metropolis. *Journal of Environment and Earth Science 3* (2013) 120-130. .
- [8] Aiyesanmi A.F., Imoisi O.B., Understanding Leaching behavior of landfill leachate in Benin City, Edo state, Nigeria through dumpsite monitoring. *British Journal of Environment and Climate Change. 1* (2011) 190-200
- [9] Steve O.A., Elijah I.O., Assessment of rehabilitation potential using the integrated risk based approach: a case study of Eneka, Nigeria. *Word Applied Sciences Journal 8*(4) (2010) 436-442
- [10] Ali, S., Ahmad, A., Suitability analysis for municipal landfill site selection using fuzzy analytic hierarchy and geospatial technique. *Environmental Earth Sciences 79* (2021) 1-27
- [11] Allen, A.R., Containment landfills: The myth of sustainability. *Journal of Engineering Geology 60* (2021) 3-19
- [12] Barrett, A., Lawlor, J., The economics of waste management in Ireland. Economic and Social Research Institute, Dublin 7 (1995) 129-138.
- [13] Blight, G.E , Ground-water pollution from a landfill in a semi-arid climate. In:Christensen, T.H., Cossu, R., Stegmann, R. (Eds.), *Proceedings Sardinia 95, Fifth International Landfill Symposium. CISA Publisher 3* (1995) 593-599.
- [14] Christensen, J.B., Jensen, D.L., Grøn, C., Filip, Z. and Christensen, T.H., Characterisation of the dissolved organic carbon fraction in landfill leachate-polluted groundwater. *Water Research 32*(1) (1998) 125-135
- [15] Christensen, T.H., Kjeldsen, P., Albrechtsen H-J., Heron, G., Bjerg, P.L., Holm, P. , Attenuation of landfill leachate pollution in aquifers. *Critical Reviews in Environmental Science & Technology 24* (1994) 119-202
- [16] Christensen, T.H., Nielsen, P.H., Bjerg, P.L , Degradation of organic chemicals in a leachate pollution plume: an in-situ experiment. In: Christensen, T.H., Cossu, R. ,Stegmann, R. (Eds.), *Proceedings Sardinia 95, Fifth International Landfill Symposium. CISA Publisher 3* (1995) 21-628
- [17] Corry, J.E.L , Possible sources of ethanol ante- and post-mortem: its relationship to the biochemistry and microbiology of decomposition. *Journal of Applied Bacteriology, 44* (1978) 1-56
- [18] Council of European Communities, Directive on the protection of groundwater from certain dangerous substances. *Official Journal of the European Communities 20* (1980) 43-52
- [19] EEA (European Environment Agency) Europe's environment: the third assessment. *Environmental Assessment Journal 7* (2003) 151-164. ISBN 92-9167-574-1

- [20] Ehrig, H.J., Quality and quantity of sanitary landfill leachate. *Waste Management and Research* 1 (1982) 53-68
- [21] Fourie, A.B., Morris, J.W.F. , The irrelevance of time as a criterion for aftercare provision. In: Christensen, T.H., Cossu R., Stegmann, R. (Eds.), Proceedings Sardinia 03, Ninth International Waste Management and Landfill Symposium, CISA Publisher 9 (2003) 10-19
- [22] Hancock, J.S., Phillips, J.R., Seignior, M. In: Christensen, T.H., Cossu, R., Stegmann, R. (Eds.), Proceedings Sardinia 95, Fifth International Landfill Symposium. CISA Publisher 3 (1995) 611-620
- [23] Hjelmar, O., Johannsen, L.M., Knox, K., Ehrig, H.J., Flyvbjerg, J., Winther, P., Christensen, T.H., Composition and management of leachate from landfills within the EU. In: Christensen, T.H., Cossu, R., Stegmann, R. (Eds.) Proceedings Sardinia 95, Fifth International Landfill Symposium. CISA Publisher 1 (1995) 243-262
- [24] Jefferis, S.A., Old landfills: perceptions and remediation of problem sites. In: R.W. Sarsby (Ed.) *Waste Disposal by Landfill* (Balkema) 1 (1993) 93-106
- [25] Johnson, C.A., Richner, G.A., Vitvar, T., Schittli, N. and Eberhard, M., Hydrological and geochemical factors affecting leachate composition in municipal solid waste incinerator bottom ash Part I: The hydrology of landfill Lostorf, Switzerland. *Journal of Contaminant Hydrology* 33 (1998) 361-376
- [26] Kerndorff, H., Schleyer, R., Milde, G., and Plumb Jr., R.H., Geochemistry of groundwater pollutants at German waste disposal sites. In: S. Lesage and R. Jackson(Eds.), *Groundwater contamination and analysis at hazardous waste sites. Environmental Science and Pollution Control Series* 4 (1992) 245-271
- [27] Koukoulas, S., O'Donnell, V., Robalo, C., Vendas, D., The Development of a GIS Model for the Location of Landfill Sites in Ireland and Portugal. *Final Report Interreg 2C Atlantic Region* 2 (2001) 193- 204
- [28] Kruempelbeck, I., Ehrig, H-J. , Long-term behaviour of municipal solid waste landfill in Germany. In: Christensen, T.H., Cossu R., Stegmann, R. (Eds.), Proceedings Sardinia 99, Seventh International Waste Management and Landfill Symposium. CISA Publisher, 1 (1999) 27-36
- [29] Mackenzie, D., If you can't treat it, ship it. *The New Scientist*, 122 (1989) 10-18
- [30] Sangodoyin, A.Y., Considerations on contamination of groundwater by waste disposal systems in Nigeria. *Environmental Technology* 14 (1993) 957-964
- [31] Victoria Amarachi Chinedu, Ifechukwu Enyinnaya Adieze, Justina Chibuogwu Orji, Seasonal variation and health risk assessment of groundwater quality in the vicinity of dumpsites in Owerri, Southeastern Nigeria. *World News of Natural Sciences* 51 (2023) 147-168
- [32] Verla Andrew Wirnkor, Enyoh Christian Ebere, Okonkwo Felix Chukwunonso, Verla Evelyn Ngozi, Radiation levels of dumpsites within Imo State University, Owerri, Imo State, Nigeria. *World News of Natural Sciences* 11 (2017) 45-64