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# Open solid waste leachate output and monthly rainfall variation in Ugwuaji, Enugu Nigeria

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## Abstract

The study examines solid waste leachate output and monthly rainfall variation in Ugwuaj area. Data on rainfall for Enugu for the period of May – August 2016 were collected from the archives of the Nigerian Meteorological Services Oshodi. The study also involved the collection and laboratory analyses of ten leachate samples from different locations in the solid waste dump site. The result of the laboratory analyses indicate that the leachates comprise of Arsenic (As), Cadmium (Cd), Iron (Fe), Mercury (Hg), Lead (Pb) and E-coli. Multiple regression was applied to determine the relationship between monthly rainfall within the sampling period and leachate output in the study area. The result of multiple correlation (R) value is 0.909. The coefficient of determination ($R^2$) value is 0.827 with p value of 0.00254. The value of R square shows high strength of relationship between monthly rainfall value within sampling period and leachate output ($R^2 = 0.827$, p value of 0.00254). The implication is that leachate processes from the waste dump could deteriorate the soil, surface and ground water quality in the study area. In that light, it became expedient to recommend the services of Meteorologists in the construction of a landfill in the study area. Application of waste management practices; encouragement of Environmental Management System (EMS); Environmental Impact Assessment (EIA) and Environmental Auditing in the area are also recommended strategies.

***Keywords:*** Lechate Output; Solid Waste; Rainfall; Hazardous Element



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## 1. Introduction

Solid waste constitutes a serious environmental problem in Enugu urban. Rainfall duration, intensity, pattern and amount increase the rate of infiltration of leachate materials from solid waste dump to ground and surface water in the area. Leachates are the liquid that seep from a waste dump or landfill. The large volume of waste from house hold, industries and commercial area has degenerate into serious degradation/deterioration in the quality of surface and ground water as well as biodiversity through leachate processes. A large volume of hazardous materials such as asbestos, sewage effluent, metal scraps, plastics, clothing materials, clinical waste among others, are dumped in the waste dump site on daily bases. Virtually, little or no waste sorting techniques are practices in the area (Daniel, 1999; Agunwamba, 1998). The rate at which these hazardous chemical react with each other and penetrates into the underground water through leachate process is more worrisome. Rainfall processes support the direct and constant leaching of these hazardous chemicals into the soil and ground water (Ogbuene, 2010a; Agarwal, 1998).

Some studies actually help to validate the serious effect of unimproved waste dump to our environment. Leachates collected from Ibadan and Lagos dump sites had appreciable levels of dissolved solid chloride, ammonia, chemical oxygen demand (COD), lead, iron, copper, and manganese. The study further established that it was attributed to indiscriminate dumping of lead acid car batteries and metal scraps in the dump site (Ikem et al., 2002). Agunwamba, (2001), opined that there is need to estimate the amount of leachate production in drainage system. However, estimation of this quality is difficult because of the extremely coarse texture of the solid wastes. This prevents the degree of moisture in waste from being homogeneous. The lack of homogeneity creates different drainage parts and partial saturations. The characteristics of the surface of each particular site affect the landfill water balance. For instance, depending on depressions and vegetative cover, some of the run-off does not percolate but drain from the waste. In addition, the moisture content determines the extent of degradation during which the retention capacity of the waste is altered. Despite all these problems, the leachate production may be estimated from the relationship (Dara, 2004; David, 1997; Windfield et al., 2015). There is a constant increase in leachate output in the study site (study area) because the site is not a sanitary land fill. This exposes the area to arrays of environmental hazard. Leachate can contaminate both ground and surface water. During floods, water mixed with leachate may flow out of the dumpsites and get into nearby ponds, streams, and rivers. Municipal Dump site and some of the waste from the site finds their way into the river. This of course poses health risk to the communities near the dump, and those in the downstream who may be using the water for various purposes (Ogbuene, 2010b; Rotich et al., 2006). Agunwamba, (2000), maintained that leachate can be treated in a series of waste stabilization ponds, designed to account for a gradual increase in leachate flow due to continued increase in land filling of wastes. Some other biological and physio-chemical system can be effectively use for treatment depending on the composition of the leachate. The study carried out at Kariba showed that waste sample taken from the vicinity of the dumpsite had a high level of concentration of Mercury (Hg), and lead (Pb) (Clitamba, 2007). Agunwamba, (2001), observed that leachate production can be minimized by limiting the entry of runoff, diversion of runoff, surface sealing by using low permeability materials such as clay and re-vegetation to prevent erosion of cover material. This will help promote evapotranspiration. The Ugwuaji waste dump site being an uncontrolled open waste dump is prone to serious environmental hazard and needs different urgent management attention.

Study area: The study area is a one hectare uncontrolled open dump site at Ugwuaji, Enugu in Nigeria. It falls within the Guinea savanna vegetation zone, which lies between the semi-arid north and wet southern part of Nigeria. The study area lies approximately between longitudes $7^0$ 26/ and $7^0$ 36/ E of prime meridian and latitude $6^0$ 21/ and $6^0$ 26/ N of the equator. Presently, the human population of Enugu urban is about 722,660 (Projected NPC, 2006). This rapid population constitutes a serious problem in effort to manage waste in the area. Temperature and rainfall in the zone is largely seasonal and varies highly from year to year. The area records annual rainfall which ranges between 937.2mm to 2243.3mm, while mean temperature range is usually between 26.8 $^0$C to 32.5 $^0$C over the year. Two distinct seasons are observed, dry and wet. The dry season extends over a period of about 6 to 7 months, from October to March or April while the wet season extends over a period of about 5 to 6 months, from May to September. However, these meteorological conditions vary wildly, thereby increasing leachate processes in the study area.

In light of the aforementioned problem, the objective of this paper is to evaluate the relationship between monthly rainfall within the sampling period (May – August, 2016) and leachate output in the sampling points.

## 2. Research methodology

Data generated for this study were results of leachate samples analysed in the Laboratory. The leachate samples were collected from open solid waste dump site located at Ugwuaji environs. The study employed stratified random sampling in the process of collecting ten (10) leachate samples in the height of the wet season (May to August, 2016). It entailed the collection of 2 samples per months. The wet season is a period of increased decomposition, dissolving, and chemical reaction of the waste and leachate seepage into the soil. Two (2) leachate sampling points outside the waste dump were taken as control among the ten (10) sampling points in the study area. The distance from the dump site to each control sampling point was 60 meters and at the highest gradients with least leachate seepage. The other sampling points are at equidistance of 40 meters. The leachate samples were collected with an auger which was drilled 30 cm into the soil. This is to enable the study justify the impact of leachate from waste dump site on ground water quality. It is important to note that the approximately one hectare Ugwuaji waste dump site is an uncontrolled open solid waste dump type. The site is prone to serious health challenges, such as epidemic outbreak. The leachate samples were analysed in National Food and Drug Administration Commission (NAFDAC) laboratory in Agulu, Anambra State, Nigeria.

In addition, monthly rainfall values of May – August 2015 were collected from the archives of the Nigerian Meteorological Services (NIMET), Oshodi Lagos and Enugu airport. NIMET used the Dines Tilting and the British Standard rainguage in the collection the rainfall data used in this study. The positions of these rainguages have not been tainted since the commencement of the record keeping. Therefore, the rainfall data may not have suffered from irregularity. The study also involved direct observation within the environment of study. This method was utilized to assess the present physical conditions of the waste dump site.

Multiple regression model was applied to evaluate the strength of relationship between monthly rainfall within sample collection period and leachate output (SPSS, 1990)

## 3. Result and discussion of findings

Data in Table 1 shows monthly rainfall variation and leachate output from the open waste dump site. The monthly rainfall values in Table 1 is rainfall records within the period of data collection (May – August, 2016).

**Table 1.** Monthly Rainfall and Level of Leachate output in the Sampling Locations

| Location | Monthly Rainfall | Months | Arsenic | Cadmium | Iron | Mercury | Lead | e-coli |
|---|---|---|---|---|---|---|---|---|
| 1 | 220.2 | May | 0.02 | 1.12 | 14.7 | 0.001 | 1.1 | 0 |
| 2 | 130.6 | August | 0.14 | 1.94 | 17.2 | 0.03 | 0.009 | 0 |
| 3 | 220.2 | May | 15.2 | 17.11 | 277.12 | 7.1 | 19.89 | 0 |
| 4 | 220.2 | May | 14.32 | 12.4 | 273.2 | 5.3 | 19.2 | 1 |
| 5 | 189.8 | June | 13.3 | 20.8 | 180.4 | 3.35 | 14.1 | 2 |
| 6 | 189.8 | June | 12.47 | 44.8 | 106.9 | 2.09 | 9.1 | 0.2 |
| 7 | 195.4 | July | 11.22 | 11.6 | 98.57 | 2.38 | 8.2 | 0.1 |
| 8 | 195.4 | July | 10.15 | 18.4 | 73.23 | 1.2 | 7.1 | 0.003 |
| 9 | 130.6 | August | 9.23 | 12.8 | 67.2 | 3.2 | 6.9 | 0 |
| 10 | 130.6 | August | 7.91 | 9.21 | 55.3 | 4.2 | 5.4 | 0 |

*(Source: Authors' Fieldwork 2015 and NIMET, Lagos, 2016)*

Locations 1 and 2 are for the control samples while 3 – 10 are for the experimental samples. The control samples (Location 1 and 2) which was 60 meters away from the dump site and at the highest gradients shows lowest level of leachate concentrations, while the experimental samples gave high values (Table 1).

The leachates pollutants comprises of arsenic, e-coli, cadmium, mercury, iron, and lead. The continuous seepage of these hazardous elements is worrisome, especially considering the fact that the study area is an uncontrolled open waste dump site. The hand-dug-wells in the vicinity are sources of domestic water supply and the presence of these leachates especially arsenic and e-coli make the area vulnerable to epidemic outbreak. This is related to the study conducted by Nannan et al., (2016). Their study emphasized that pollutant such as e-coli and arsenic pose a serious problem to water quality in developing nations.

Based on the objective of the paper, multiple regression was employed to determine the significant relationship between leachate output and monthly rainfall in various sampling locations of the study area (Table 2).

**Table 2.** Regression Model of Monthly Rainfall Variation and Leachate Output

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change |
| 1 | .909[a] | .827 | .481 | 14.45148 | .827 | 2.389 | 6 | 3 | .00254 |

*(Source: Authors' SPSS, 2017)*

The result of multiple correlation (R) value in Table 2 is 0.909. The result shows strong positive correlation between monthly rainfall value within sampling period and leachate output in the study area. The coefficient of determination ($R^2$) value is 0.827 with p value of 0.00254. The value of R square shows high strength of relationship between monthly rainfall value within sampling period and leachate output ($R^2 = 0.827$, p value of 0.00254).

The implication is that rainfall is a serious factor that increases the rate of leachate output into the soil and ground water ($R^2 = 0.827$, p value of 0.00254). Studies have shown that wet conditions enhance decomposition, dissolving and chemical reaction of the waste and leachate seepage into the soil. This increases the rate at which ground water and soil sample are contaminated with Arsenic (As), Cadmium (Cd), Iron (Fe), Mercury (Hg), Lead (Pb) and e-coli. Cabeja et al., (1996) emphasized that lead poison in children's nervous system can cause the following problems: encephalopathy (brain disease), alters the function of developing brain and electroencephalogram. Convulsions, cerebral palsy, neurotransmitter release disruption, peripheral nerve disturbances, slowed nerve conduction velocity, foot/ hand drop and dizziness are associated problems (Menkiti et al., 2012; Ogbuene et al., 2013; Elisa and Heiko, 2016; Clitamba, 2007; David, 1997; Lopex et al., 2002). The situation in the study is amenable to these problems considering the nature of the waste dump and associated increase in rainfall amount and leachate output. This calls for proactive attention to reduce the level of vulnerability of the uncontrolled open waste dump site (William and Sarker, 2011).

## 4. Conclusion and recommendations

The study observed the high strength of relationship between monthly rainfall value within sampling period and leachate output ($R^2 = 0.827$, p value of 0.00254). Hence, rainfall enhances leachate output. It also emphasized that Arsenic (As), Cadmium (Cd), Iron (Fe), Mercury (Hg) and Lead (Pb) are oxides of elements which penetrate and contaminate the soil, surface and ground water through leaching processes (Okeji et al., 2013; Eze et al., 2017). The study also observed that little or no waste management strategies are practiced in the area. It advanced the following waste management strategies: Involve the service of meteorologists in the construction of a landfill at Ugwuaji, Enugu Urban since rainfall has been discovered to be a driving force in leachate output; Waste management practice should be a must in the area, so as to reduce the hazardous effect on the environment; Encourage Environmental Management System (EMS); Environmental Impact Analysis and Environmental Auditing in the area.

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