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Impact of Municipal Solid Waste Landfill Leachate on Soil Properties in the Dumpsite

(A Case Study of Eket Local Government Area of Akwa Ibom State, Nigeria)

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***Abstract**-A field study was conducted to investigate the effect of municipal solid waste landfill leachate on soil properties in the dumpsite. Soils samples were randomly taken from the waste dumpsite and away from the waste dump site at a depth of 15cm. pH, electrical conductivity, organic carbon, available phosphorus, total nitrogen, K, Ca, Na, Mg, Total hardness, Cl, and Sulphate were determined. Data obtained were subjected to statistical analyses of variance (ANOVA). From the results obtained there were marked effects of the leachate on the parameters measured, when compared with those from the control site. These were higher at the waste dumpsite than the control site. And this show that, municipal solid waste landfill leachate considerably degrade the soil quality, the worst being soil organic carbon (7.56g/kg), available phosphorous (24.70mg/kg), Ca (1.79Cmol/kg), K (0.69Cmol/kg), Mg (0.29Cmol/kg), total hardness (0.56Cmol/kg) and sulphate (0.478mg/kg). The implications of these results on soil qualities are discussed. It is concluded that, environmental control measures should be put in place in sitting of waste dumpsite.*

***Keywords:** Leachate, Municipal solid waste, Physio-chemical properties of soil.*

I. INTRODUCTION

Present day waste disposal is far more advanced than the indiscriminate dumping that occurred in the past, employing modern techniques to better manage a wide range of anthropogenic wastes. Open and unscientific dumping of municipal solid waste is one of the most common methods adopted since years in almost all the cities. One of the main objectives in the design of a landfill site should be the proper management of polluted water and leachate migration, therefore mitigating the risk of health and environmental damage. Leachate typically possesses high concentrations of suspended organic matter and acids, which can degrade ground and surface water unless precautions are taken. Suitable sites should be specially selected with attention being given to the soil, to ensure that it does not become overloaded and unable to attenuate or retain the potential pollutants. Landfill sites are considered a major threat to groundwater resources, either through waste materials coming into contact with groundwater underflow, or through infiltration from precipitation (Taylor and Allen 2006). The landfilled solid waste often releases interstitial water and by-products that contaminate the water moving through the deposit, as well as liquids containing several different organic and inorganic compounds that sit at the bottom of the deposit and seep into the soil, affecting its physical and chemical properties (Al-Yaqout & Hamoda 2003). Major elements like calcium, magnesium, potassium, nitrogen and ammonia, trace metals like iron, copper, manganese, chromium, nickel, lead and organic compounds like phenols, poly-aromatic hydrocarbons, acetone, benzene, toluene, chloroform are generally found in leachate from a solid waste dumpsite. The concentration of these in the leachate depends on the composition of waste. Such leachate generated from landfill sites pose serious environmental risks to the surrounding soil (Freeze and Cherry, 1979; Alker *et al*. 1995; Nayak *et al*. 2007). The chemicals contained in leachate from the landfill may undergo a variety of conversion and destruction reactions as they pass through the soil and into the underlying formations. The effectiveness of each soil to attenuate leachate is different, and not all elements or compounds are equally removed or reduced in concentration. Some of the pollutants may be adsorbed on to the soil media during the flow of leachate through the soil (Suad and Mustafa, 2013). Several scholars have reported on the characterization and management of municipal solid waste in Nigeria (Agunwamba *et al*. 2003; Ogwueleka, 2004; 2009; Nabegu, 2010; Nkwachukwu *et al*. 2010) and their effect on groundwater, little attention has been given to the effect of these wastes on the physico-chemical properties of soils. The efforts made by the authorities in the study site still need some expertise to solve the problems arising out of the municipal solid waste disposal. The objective of this study was to investigate the effect of leachate on physico-chemical properties of the soil in Eket Local Government Area of Akwa Ibom State, Nigeria.

II. METHODOLOGY

Study Site

The study area is local in Edebuk Eket Local Government Area of Akwa Ibom State, Nigeria. Eket occupies the South Central portion of Akwa Ibom State territorial expanses spanning Northwards between Latitudes 4° 33’ and 4° 45’ and Eastwards between Longitudes 7° 52’ and 5° 02’. Eket has tropical climate marked by two distinct season (November - March), and the wet season is usually interrupted by a short dry period in August. Average temperature of the Eket ranges from 23 to 31°C and Precipitation averages 3044mm.

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III. SAMPLE COLLECTION

Soil samples were randomly taken, three from the waste dumpsite and three away from waste dumpsite at a depth of between 0 to15cm using a soil auger. The sharp end of the soil auger was carefully screwed in a vertical position and it was ensured that there was uniform entry to the desired depth. The samples were transferred to a tray for homogenizing before storing in sample bags. Each sample was labeled immediately after collection and taken to Agronomy laboratory of the University of Ibadan for laboratory analysis.

Determination of Soil Properties

Analytical methods used for soil samples were adopted depending on the parameters of interest. The collected soil samples were air-dried for five (5) days. This was done to halt all the microbial activities in the soil. The air-dried samples were sieved using a 2mm sieve mesh size to remove debris and stones. The air-dried and sieved samples were used to analyze for various parameters. The following parameters were analyzed; soil pH, EC, organic carbon, available phosphorus, total nitrogen, Potassium, Calcium, Sodium, Magnesium, Total hardness, Chloride, and Sulphate. Soil pH was measured out by the potentiometric method as described by Brady and Weil [1990]. A glass electrode Testronic digital pH meter [Model 511] was used for the measurement. Organic carbon measurement was carried out by the method of Kalembasa and Jenkinson [1973]. Total nitrogen assay was carried out by the Kjeldahl method as described by Bremner and Mulvaney [1982]. Available phosphorus was determined by the method described by I.I.T.A. [1979] and Olsen and Sommers [1982]. Exchangeable Cations determination: About 100 ml of concentrated ammonium acetate was added to a 10gram measurement of air-dried soil and shaken for 30mins. The preparation was then filtered and taken to the flame analyzer for reading. Calcium, Sodium and Potassium were read on the flame photometer. Readings for Magnesium was obtained from a further titrated with sodium EDT A as flame photometers cannot be used. Available phosphorus was determined by the method described by I.I.T.A. [1979] and Olsen and Sommers [1982]. Total hardness was determined by titrimetry as earlier described AOAC International, [1998]. The electrical conductivity (EC) is used to measure the ability of an aqueous solution to carry an electric current. The EC was determined using a conductivity cell containing a platinized electrode and following APHA 2510B [2005]. The chloride (Cl-) and Sulphate content were measured using APHA 4500B [2005]. The Cl- and Sulphate were determined in terms of Mg/l when the color of titrated solution changed to a pinkish yellow end point.

Statistical analysis

Data generated from the study were analyzed using the parametric test of analysis of variance (ANOVA), at $P \lesssim 0.05$ confidence limits for the waste dumpsite and control site.

IV. RESULTS AND DISCUSSION

Soil Properties

The mean and standard deviation of soil physical and chemical properties for samples taken from the two sites (dumpsite and control site) are presented in table I. Soil samples from both sites were alkaline. The total organic carbon and total nitrogen were higher at the control site than at the dumpsite. Available P and electrical conductivity were higher at the dumpsite than the control site. The Ca, K, Mg, Na and total hardness were all generally higher at the control site than the dumpsite.

TABLE I. Mean and standard deviation values of chemical and physical properties constituent of soils at the two experimental sites (Municipal solid waste dumpsite and the control site).

Samples		p H	E.C	Organic Carbon	Total Nitrogen	Avai. Phosphorous	Ca	K	Mg	Na	Total hardness	Chloride	Sulphate
A	Mean	7.45	600.00*	7.560*	.690	24.700*	1.790*	.690*	.290*	.320	.560*	5760000.00	.478*
	Std. Deviation	.106	35.355	.141	.141	.141	.141	.141	.141	.014	.156	3664227.340	.141
B	Mean	7.20	200.00*	25.200*	2.080	7..360*	14.520*	1.830*	.940*	.410	4.860*	450000.00	4.610*
	Std. Deviation	.141	35.355	.141	.	.014	.14142	.141	.014	.141	.141	1414.214	.141
Total	Mean	7.412	425.00	16.480	1.220	16.085	8.255	1.360	.670	.420	2.815	1810000.00	2.644
	Std. Deviation	.165	232.737	10.185	.751	10.064	7.351	.668	.335	.132	2.480	2634013.920	2.388

Values are Means and Standard Deviation of Triplicate
* Significant different ($\lesssim$ 0.05)

Soil Chemical Properties

Soil pH is extremely important on the decomposition of mineral rock into essential elements that plants can use. The pH of the soils studied was slightly alkaline, and the order of increase is dumpsite higher than the control site. The samples were significantly different from each other. The alkaline nature of the soil samples collected from the dumpsite and away from the dumping activity showed increasing pH level which is very often encountered at landfills aging 10 years after disposal [El-fadel *et al*. 2002]. However the increase in soil pH decreases the soil micro-nutrient availability to the plants. While either of the extreme pH conditions can affect the survival of plants which has to be modified for specific crops. Electrical conductivity is a measure of ability of a material to transmit charges. The electrical conductivity of the soils collected at the dumpsite was higher than that of the control site and they were significantly different from each other. The high electrical conductivity at the dumpsite is due to the increase in the salts and ions. Conductivity value of less than 0.5milliScm^{-1} is perfectly safe and it doesn't have any

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negative effect on plant growth. The study identified that the soil samples both at the dumpsite and the control site are above the permissible range which is toxic to plants and may prevent them from obtaining water from soil [Goswami and Sarma 2008]. The soil organic carbon recorded at the dumpsite was lower than that of the control and it was insignificantly different from each other. The higher value at the dumpsite was due to decomposition of organic matter. The total nitrogen was higher at the control site than at the dumpsite. The phosphorus content at dumpsite was higher than the control. The high phosphorus content recorded in dump site soil could be attributed to high organic matter found in dump soil [Soheil *et al*. 2012]. Though potassium is a soil nutrient helpful for the plant growth the anthropogenic activities could result in increase in the potassium levels which is source of groundwater contamination. Exchangeable bases (Ca, K, Mg and Na) where generally lowered at the dumpsite and they were significantly different from each other except Ca which was insignificant. The concentration of chloride in control soil was found to be much less than that of the dumpsite. The total hardness of the control sample was found to be much higher than the hardness of the polluted samples. There is a slight increase in the hardness of the soil samples; this may be attributed to the increasing calcium concentration in leachate.

V. CONCLUSION

Results from this study revealed that open and unscientific dumping of municipal solid waste degrade soil qualities in the dump site. The study also show that, almost all the parameters measured are in high concentration when compared with the control site which could be deteriorated further by further dumping of municipal solid waste thereby increasing the toxic substances in the dump site soils. Unmanaged dumping outside dedicated waste disposal areas leads to landfill leachate penetration of the ground, which directly affects the soil quality and ground water supply.

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