Spatial Variation in Landfills Leachate Solution in Urbanized Area of Lagos State, Nigeria

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Abstract

Liquid that formed through decomposed and degenerated solid waste into a solution at the base of a landfill known as leachate is the general characteristics of any dumpsite .Its formation, toxicity and migration is the function of waste type and management strategy, topography, underlying geology and season. The aim of this paper is to compare the concentration of physicochemical, chemical and biological parameters in three samples of leachate from different landfills. Collected data were subjected to descriptive statistical analysis and compared with Lagos State Environmental Protection Agency(LASEPA) standard limit for waste water. Analyzed results indicate the higher concentration of Fe, Mn, K, TSS, EC in Solous 1 leachate which was closed dump site and TDS,NI and BOD in Solous 2,an operational and open dumpsite. The study concluded that leachate of different landfills vary in parameters concentration. Most of the parameters reduced in quantity, toxicity and concentration with respect to time and type of landfill either operational and open or old and closed.

Keywords: contamination, groundwater, heavy metals, hazardous, leachate, landfill, physicochemical, waste.

Introduction

The degradation of the municipal solid waste over time and space results to the production of leachate that easily migrate within the water-table in underground. Leachate is the liquid that has seeped through solid waste in a landfill and has extracted soluble dissolved/suspended material in the process. It is composed of water, organic and inorganic chemicals from the decomposition of waste. Leachate is the pollutant from the landfill site which migrate and pollute near and adjacent groundwater with respect to liquid flow mechanism. Leachate formation is the function of the type of waste, season, climate, time, and management strategy while its degree and intensity of migration and pollution depend on surface water ingression (precipitation), topography, distance, underlying geology, soil and depth of the landfill in relation to Piezometric level. Also, various criteria are usually taken into consideration before the selection, location, construction, design of an ideal sanitary landfill with respect to concerned community health in present and future.Onibokun,1999 and Allen 2001 note that landfills and dumps in Africa commonly occur in poorer areas, where residents are often less able to prevent landfill in their own ”backyard” are unlikely to benefit from waste collection services, and invariably depend upon local, often poorly protected sources of water.

According to Peter and Thomas,1995,assessing the variability in leachate composition and leachate migration from old landfills needs an integrated approach. Historical information (including old maps, aerial photograph, interviews, e. t. c) create a very valuable basis for understanding the variability. Also, information on the hydrology of the landfill and the adjacent part of the polluted aquifer is needed. Landfills have historically been the primary method of waste disposal because this method is the most convenient and because the threat of groundwater contamination was not initially recognized (Smith and Edger,2006).The major environmental problem experienced around the landfill is the subsequent contamination of groundwater via discharged leachate.

The greatest contamination threat to groundwater comes from the leachate generated from the material which most often contain toxic substances especially when wastes of industrial origins are land filled.(Longe and Enekwechi,2007) However, it has been widely reported that leachates from landfills for non-hazardous waste could as well contain complex organic compound, chlorinated hydrocarbons and metals at concentrations which pose a threat to both surface and groundwater. The produced leachate is normally composed of organic and inorganic compositions. In addition, with elapse of a time, the produced leachate permeates into ground systems leading to change of physical and chemical properties of groundwater. Sang-il Lee et. al.,1986 stated that heavy metals such as cadmium, arsenic, chromium have been reported at excessive level in groundwater due to landfills operation. With respect to Enekwechi and Longe,2007,the volume of leachate depends principally on the area of the landfill, the meteorological and hydrogeological factors and effectiveness of capping.

The volume of leachate generated is therefore expected to be very high in humid regions with high rainfall, or high runoff and shallow water table (Chapman,1992). Classical unlined sanitary landfills and open dump are all known to release large amounts of hazardous and otherwise deleterious chemicals into nearby groundwater, surface water and soil as well to the air, via leachate and landfill gas. Waste placed in landfills or open dumps are subjected to either underflow or infiltration from precipitation. Areas near landfills have great possibility of groundwater contamination because of the potential pollution source of leachate originating from the nearby site. Such contamination of groundwater resource poses a substantial risk to local resource users and to the natural environment (Allen,2001).Specific elements may be detected in the examination of leachate attributed to industrial, medical, and construction waste due to identified (point) sources and types of decomposed materials compare to non-point source and different materials that form leachate under urban solid waste. Decomposition and degradation of wastes are in phases while its migration is seasonally determined.

According to Irina, 2006,concentration(mg/L) of leachate constituent are in phases namely transition(0-5years),acid-formation (5-10years),methane fermentation (10-20years) and final maturity (>20years). The age of a landfill also significantly affects the quantity of leachate formed. The ageing of a landfill is accompanied by increased quantity of leachate. Leachate generated in the initial period of waste deposition (up to 5 years) in landfills have pH-value range of 3.7 to 6.5 indicating the presence of carboxylic acids and bicarbonate ions. With time, pH of leachate becomes neutral or weakly alkaline ranging between 7.0 and 7.6.Landfills exploited for long period of time give rise to alkaline leachate with pH range of 8.0 to 8.55 (Slomczynska and Slomczynski, 2004; Longe and Balogun,2010).

Concentrations of both reactive and conservative contaminants decrease with the distance along the groundwater flow path. However, leachate migration is in line with the distance decay principle. It should be noted that the concentration of a pollutant at any point removed from its source may vary throughout the year due to seasonal influences on recharge and release of the contamination, or reaction times governed by variations in factors such as temperature(Allen,2001).Hence, seasonal variation differentiates the concentration of leachate in groundwater. Also, the behaviour of the leachate pollution plume generated in the groundwater zone is governed by the variability in leachate concentrations and groundwater flow directions (Joseph et. al.,1995).

However Sang-il Lee et al,.1993 stated that leachate migration from disposal sites can be influenced by site design, waste type, hydrogeology, geochemistry and climatological conditions. However, groundwater pollution by leachate is an unconscious strategy of resuscitating and reactivating once eradicated diseases and epidemics in environment. Ability of concern pathogens to sporadically complete its cycle in conjunction with waste decomposition and degeneration either aerobically or anaerobically would definitely bring about regeneration and recuperation when in contact with favourable habitat and host.

Study Area

The Solous landfill is situated at Igando in Alimosho Local Government Area of Lagos State, Nigeria. It lies approximately between longitude $3^0$13'30"E to $3^0$17'15"E and latitude 6'28^{0}N to 6'42^{0}N . It commenced operation in the year 1996 with a projected lifespan of between 5 and 6 years(LAWMA,2010). As a result of urbanization, this landfill is now surrounded by residential, commercial and industrial activities. According to NPC,2006, Lagos State which covers an area of 3,577km^2 accounted for about 9,013,534(6.43%) with 3.2% annual growth rate, out of Nigeria total population of 140million and above.

Alimosho has a total population of about 1,362,077 population, and land area of 185km^2 approximately with average density of 712.5km^2 and as at 2008, estimated household survey, Alimosho was 309,347 with annual waste generation of 773.37tones. The northern and western part of the study area are River Owo and Ifako Ijaiye, Agege,and Ikeja Local Government Area towards the eastern side. It is bounded in the southern part by Oshodi/Isolo,Amuwo Odofin and Ojo local Government Area of Lagos State.

Lagos State climate is generally classified under tropical region with alternate dry and wet seasons. It has temperature range of 28^{0}C to 33^{0}C.It is characterized by swamp forest and coastal plants especially riverine and coastal part. The study area comprises both of closed and existing landfills and is the authorized dumpsites for Lagos State Waste Management Authority(LAWMA) known as **Solous** landfills. The landfill is ranked the second largest after Olusosun dumpsite in Ojota area of Lagos State. Solous landfill is sub-divided into three(3) section namely; **Solous I** (closed),**Solous II and III** (existing).This work is specifically emphasized on three of them Solous. The existing landfill(Solous II) covered about 7.8 hectares of land with an average life span of 5 years and receives an average waste of about 2,250m^2 per day while the closed landfill covered about three(3) hectares of land. According to Longe and Balogun2010, soil stratigraphy of Solous landfill consists of intercalated with lateritic clay that is capable of protecting underlying confined aquifer from leachate contamination.

Fig.1 Pools of Leachate

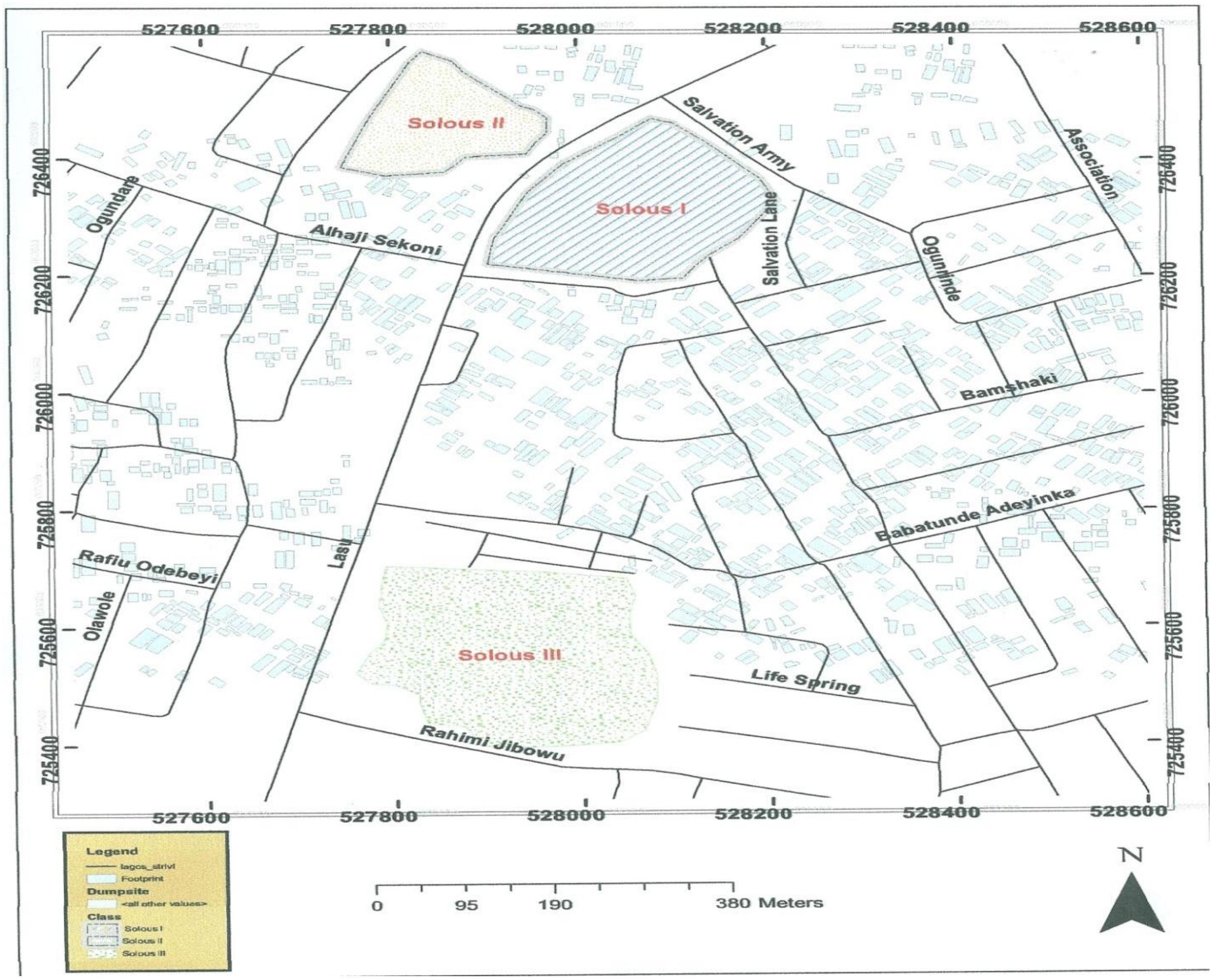

Fig.2 Landuse map of the study area.

Materials and Methods

Leachates were collected from the base of three landfill sites at Solous and labeled as LE_1 (closed), LE_2 and LE_3(existing).They were immediately transferred to Lagos State Environmental Protection Agency (LASEPA) laboratory, Alausa Ikeja, for laboratory analysis. All these were done with respect to APHA recommendation. Also information were gathered from Lagos State Waste Management Authority head office, Ijora Lagos about the detail of landfill in Lagos State especially Solous. This study examined physicochemical and heavy metals parameters from the sampled leachates namely Zinc(Zn), Iron(Fe), Chromium(Cr^{3+}), Cadmium, Lead(Pb), Temperature(0^c) pH, Nitrate($N0_2^-$), Chloride(Cl^-), Total Solid(TS), Total Dissolved Solid(TDS), Total Suspended Solid(TSS), Dissolved Oxygen(DO), and Electrical conductivity(μScm^{-1}), Phosphate(PO_4^+), Sulphate(SO_4^+), Chloride(Cl^-), Biochemical Oxygen Demand(BOD),Chemical Oxygen Demand(COD), Manganese(Mn), Silver. The criteria behind the selection of these variables is based on being the common pollutants element in landfill leachate. Three different landfills were used in the same location, a closed and two (2) operational. Geographic location (x, y, z coordinate) of all sampling points were identified through the use of hand -held Global Positioning System (GPS channel 76CSx Garmin model),which measures in 2-3m accuracy level. Aerial view of the leachate pools were photographed at vantage points with the aid of digital camera (Sony 14.1 megapixel model). The satellite image of the study area were overlaid with sampling points with the aid of Arcview 3.0 and sofer software. Leachates sampled were analyzed at wastewater laboratory for physicochemical, heavy and trace metals and biological parameters. The obtained data were subjected to descriptive statistical analysis, graph, table, bar chart and coefficient of variation to verify the degree of different within the leachates parameters concentration as well as inferential statistic like correlation .

Results and Discussion

Table 1. Descriptive Analysis of leachate parameter

	LASEPA	LE1	LE2	LE3	Max	Min	Mean	Range	S.D	CV	C.V%
0C	40	25.3	27.3	25.2	27.3	25.2	25.9	2.1	8.95	0.3456	34.56
pH	5.59.0	**9.9**	**9.7**	**9.5**	9.9	9.5	9.7	0.4	0.16	0.0165	1.65
EC	-	457	1957	2129	2129	457	1514.33	1672	750.94	0.4959	49.59
TSS	100	**376**	68	**862**	862	68	345.33	794	326.85	0.7508	75.08
TDS	2100	624	1732	1338	1732	624	1231.33	1108	458.58	0.3724	37.24
TS	2200	1000	1800	2200	2200	1000	1666.67	1200	498.89	0.2993	29.93
NI	-	12.4	430	5.4	430	5.4	149.27	424.6	198.52	1.3299	132.99
PP	-	1.77	17.9	11.4	17.9	1.77	10.36	16.13	6.63	0.6399	63.99
SP	-	17	16.7	0	17	0	11.23	0.3	7.94	0.707	70.7
DO	2	1.39	0.1	1.56	1.56	0.1	1.02	1.46	0.65	0.6473	64.73
COD	200	**382**	1.52	219	382	1.52	200.84	380.48	155.86	0.776	77.6
BOD	50	**95.5**	**229.5**	**54.75**	229.5	54.75	126.58	174.75	74.65	0.5897	58.97
Mg	200	0.0227	0	0.0422	0.0422	0	0.0216	0.0195	0.0172	0.7963	79.63
Zn	5.0	0.0175	0.0038	0.0224	0.0224	0.0038	0.0146	0.0186	0.0079	0.5411	54.11
Fe	10.0	0.6108	0.136	0.9649	0.9649	0.136	0.5706	0.8289	0.3396	0.5952	59.52
Cr	0.1	0.0092	0.0055	0.0131	0.0131	0.0055	0.0093	0.0076	0.0031	0.3333	33.33
Mn	5.0	0.906	0.4844	1.6798	1.6798	0.4844	1.0234	1.1954	0.4954	0.4837	48.37
Pb	0.1	0.0009	0.0027	0.0003	0.0027	0.0003	0.0013	0.0024	0.0019	1.4615	146.15
K	2.0	1.5288	1.6818	**3.8739**	3.8739	1.5288	2.3615	2.3451	1.07	0.4531	45.31

Source: Author fieldwork.August,2011.

Coefficient of Variation of the examined parameter ranged from 1.65 to146.15%.Nearly all physicochemical parameters were less than 100% except nitrate(132.99%).Same applicable to heavy metals apart from lead(146.15%).Solous 3 with the indication of LE_3 has the highest number of examined parameters ,may be due to its state as operational, surface water ingression and age. Concentration of hydrogen ion(pH) and BOD were higher than LASEPA standard limit in all samples, Solous 1; TSS and COD, Solous 3; TSS and K

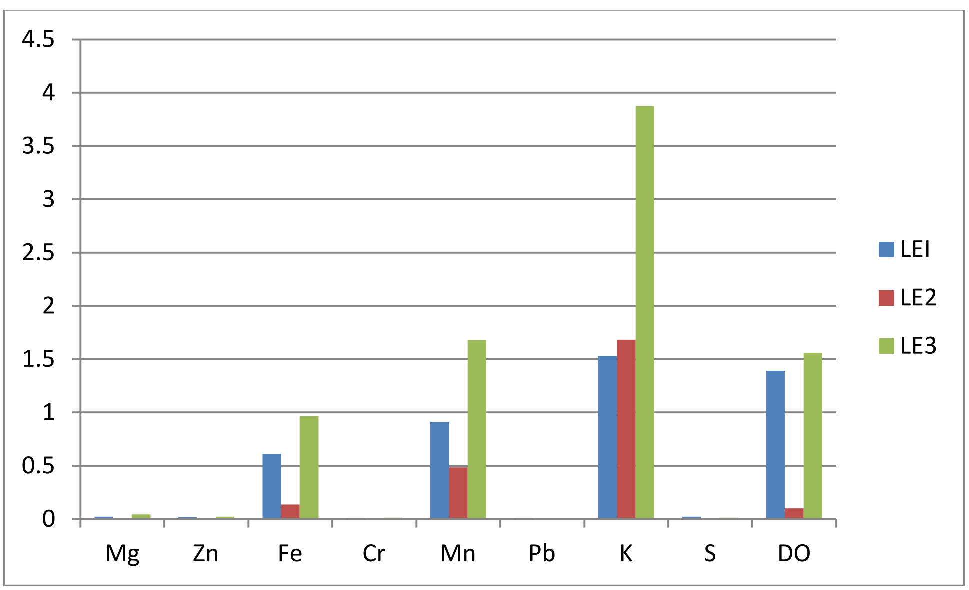

Fig .3 Concentration of Mg, Zn, Fe, Cr, Mn, Pb, K, S, DO

Concentration of magnesium, zinc, chromium, lead and silver were low in the samples from the landfills leachate. Leachate from LE_3(Solous3) has high concentration of manganese, potassium and dissolved oxygen followed by LE_1(Solous1).

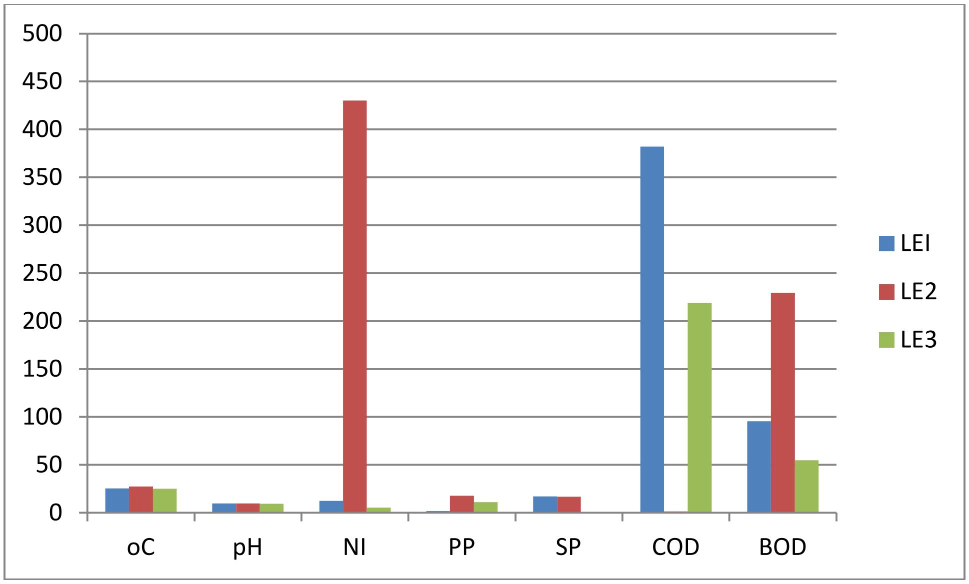

Fig.4 Concentration of ^{0}C, pH, NI, Pp, Sp, COD & BOD

Leachate from Solous 2 recorded the highest concentration of nitrate, biochemical oxygen demand while Solous 1(closed landfill) and 2 were high in terms of chemical oxygen demand. However, temperature, pH, phosphate and sulphate were all low and less than 30mgl^{-1}.

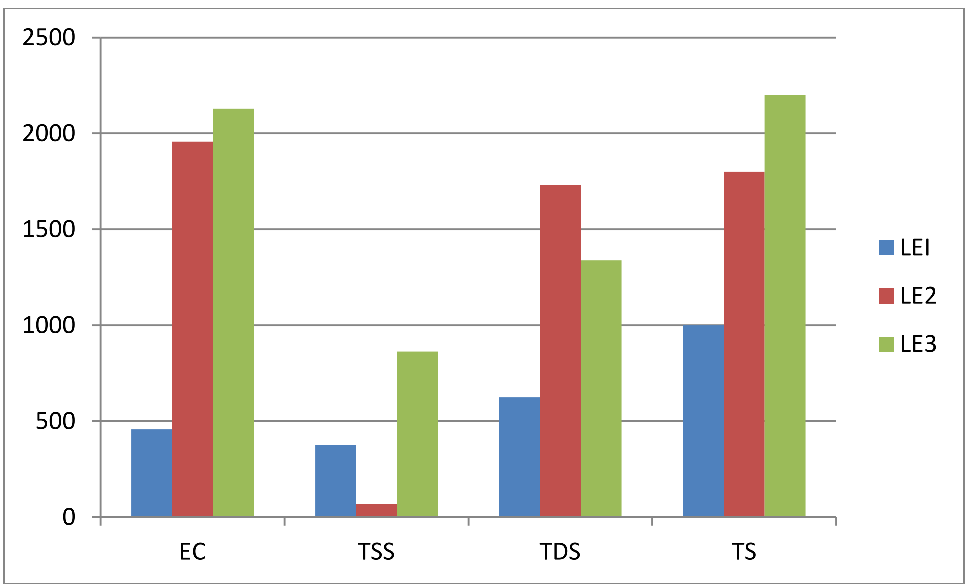

Fig.5 Concentration of EC,TSS,TDS & TS

Finally, leachate from Solous 1 has highest concentration of pH (9.9 mgl^{-1}), sulphate (17mgl^{-1}) and COD (382mgl^{-1}).From Solous 2 leachate ,temperature (27.3^{0}C),TDS (1732mgI^{-1}), nitrate (430mgI^{-1}), phosphate (17.9mgl^{-1}), BOD (229.5mgl^{-1}), lead (0.0027mgl^{-1}) while Solous 3 has highest concentration of EC (2129 µScm^{-1}),TSS (862mgl^{-1}), TS (2200mgl^{-1}), DO (1.56mgl^{-1}), Mg (0.0422mgl^{-1}),Fe (0.9649mgl^{-1}),Cr (0.0131mgl^{-1}), Mn (1.6798mgl^{-1}) and K (3.8739mgl^{-1}). But the mean concentration of the examined variables were more in Solous 3 leachate than the others. This may be attributed to it age because open and landfill has the possibility of generating some element due to surface infiltration of precipitation than old and closed landfills.

However, groundwater with the influence of these pollutants would be direct source of carcinogenic disease and damage of CNS especially heavy or trace metals due to bioaccumulation and biomagnifications while others physicochemical result to the development of gastro-intestinal diseases.

Accumulation of nitrate is attributed to cyanosis-blue baby syndrome, manganese to impotency, zinc to stomach cramp and anaemia.

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