Hydrological Implication of Solid Waste Disposal on Groundwater Quality in Urbanized Area of Lagos State, Nigeria

Afolayan, O.S

Ogundele F.O

Odewumi, S.G

Department of Geography and Planning
Lagos State University
Ojo, Lagos State, Nigeria.

Abstract

Waste is discarded materials of no further use to the owners and the pattern of its generation is a function of the level of urbanization, industrialization and economic status of society. The most convenient strategy of solid waste disposal is landfill which are usually sited in abandoned excavated sites. The quality of the groundwater which is the major source of potable water are affected by the waste disposal sites. The objective of this work is to examine the impact of solid waste disposal sites on the ground water quality of the residential areas boundary the sites. For empirical and experimental examination of the concentration of contaminant in the groundwater of the studied area, fifteen(15) wells were sampled for laboratory analysis. The results were analyzed with standard statistical package and compared with WHO,2004 and NSDWQ,2007 standard limit. The statistic correlation analysis indicated the that pH of the water has close relationship with many heavy metals and physicochemical parameters. Temporal variation between closed and operational landfills were compared. Therefore, concentration of some parameters like TSS, ^{0}C, pH, and Nl are more concentrated around closed landfill than operational and parameters like Cl, Cd, Fe, and Pb are higher around the operational landfills than old one even above the standard limit around existing landfill. Concentration of pH is averagely neutral around Solous and 2 while alkaline around Solous 3.Closed landfill has the capability of generating certain pollutants than existing landfill, conversely some pollutants can also be highly generated in operational landfill than the former. In conclusion, groundwater contamination is the function of types of waste, season, topography, soil, underlying geology, surface water ingression and direction of groundwater flow.

Keywords: Heavy metal, landfill, leachate, physicochemical, waste.

Introduction

Waste is generated universally and is a direct consequence of all human activities. The disposal of solid waste into the landfill has been recognized as the major source of underground water contermination.Waste disposal by landfill has led to the pollution of groundwater resources under a wide range of condition around the globe(Afzal et al,.2000). Realistically, there are no ways of dealing with waste that have not been known for many years. Essentially, incineration, source reduction, recycling, composting and landfills usually common with potential technology and capability of the concern society. The depression into which solid wastes are often dumped include valleys, old quarries sites, excavations, or a selected portion within the residential and commercial areas in many urban settlement where the capacity to collect, process, dispose of, or re-use solid waste in a cost-efficient, safer manner is limited.(Eludoyin and Oyeku,2010) Landfills have historically been the primary method of waste disposal due to its convenience and the threat of groundwater contamination was not initially recognized. However, the landfill of today is far different from a simple hole in the ground into which garbage is dump in developed nations. A landfill is a system that is designed and constructed to dispose of discarded waste by burial in land to minimize the release of contaminants to the environment. Hence, waste is generated universally and is a direct consequence of all human activities. Also whenever people exist, waste must be generated and managed either fully or partially. And its rate of generation corresponds roughly with levels of income(Taylor et al,.2006).According to (NPC,2006),Nigerian accounted for over 140 million people with more than 9 million of them in Lagos.

If population growth, standard of living ,and productivity are in line with consumption and waste generation, waste receiving reservoir (landfill) is likely to remain and continue to be a crucial point source of groundwater pollution, unless sanitary landfills are provided. Landfill is a practice adopted as a substitute to ocean outfall of sewage, domestic and industrial waste, after the outlawing and termination of the latter due to its effect on the lives in the ocean.(Ogundiran and Afolabi,2008). Rapid population growth through urbanization and industrialization is one of the major factor responsible for increased Municipal Solid Waste(MSW).Increasing population, industrialization and changing consumption pattern are resulting in the generation of increasing amounts of solid waste and diversification of the type of the solid waste generated. According to Visvanathan and Ulrich,2006,the environmental degradation caused by inadequate disposal of waste can be expressed by the contamination of surface and groundwater through leachate, soil contamination through direct waste contact or leachate, air pollution by burning of wastes, spreading of diseases by different vectors like birds, insects, rodents or uncontrolled release of methane by anaerobic decomposition of waste. In less developed countries, almost 100 per cent of their Municipal Solid Waste is land filled.

Also about 70 per cent and above of the generated wastes is land filled globally. Land filling of municipal solid waste is a common waste management practice and one of the cheapest methods for organized waste management in many parts of the world (Longe and Balogun,2010).Therefore, migration of this generated leachate in conjunction with groundwater automatically limit the quality of groundwater around the landfill site, because once groundwater is contaminated, it remains polluted permanently and extremely difficult to rectify. The rate and characteristic of leachate production depends on a number of factors such as solid waste composition, particle size, degree of compaction, hydrology of site, age of landfill, moisture and temperature condition, and available oxygen(Papadopoulou et al.,2007; Esmaeili et al.,2010;Longe and Balogun2010;). According to Taylor R. and Allen A.(2006),waste deposited in landfills or in refuse dumps immediately becomes part of the prevailing hydrological system. Fluid derived from rainfall, snowmelt and groundwater, together with liquids generated by the waste itself through processes of hydrolysis and solubilisation, brought about by a whole series of complex biochemical reactions during degradation of organic wastes, percolate through the deposit and mobilize other components within the wastes.

The resulting leachate subsequently migrates either through direct infiltration on site or by infiltration of leachate-laden runoff offsite. EPA (1972),defines solid waste as useless, unwanted or discarded material with insufficient liquid content to be free flowing. But Adedibu (1985) grouped solid wastes into eight classes, namely domestic, municipal, industrial, agricultural, ,pesticides, residential and hazardous wastes. However, solid waste can be classified as biodegradable or non-biodegradable, soluble or insoluble, organic or inorganic, liquid or solid, toxic or nontoxic (Kostova,2006:Ajadike,2007).Irrespective of the classification of solid wastes, most of the urban wastes are degradable which aid the rate of leachate formation and migration compare to non-biodegradable that can last for many years without any sign of decomposition. Therefore, there is possibility of leachate generation, plume extension and migration at the base of urban landfill owing to the composition of discarded materials and frequent surface water ingression from urban precipitation. According to Irina.K 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).Groundwater may not be contaminated at the inception of waste deposition in the landfill. 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). 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. Therefore, migration of this generated leachate in conjunction with groundwater automatically limit the quality of groundwater around the landfill site, because once groundwater is contaminated, it remains polluted permanently and extremely difficult to rectify. Naturally, depth from surface, soil type, bedrock geology, permeability of sediment and climatic variation affect groundwater quality.

Remedial actions of groundwater pollution from landfills are often very costly, and prolong pump-and-treat solutions have in many case been the only alternative, since treatment of the high volume of waste contained in landfills is not cost-effective(Kjeldsen et al.,1995). Water is never pure in a chemical sense, naturally it contains impurities of various kinds such as gases, dissolved minerals, suspended matter and microbes. These are natural impurities derived from atmosphere, catchment areas and soil. Groundwater is source of water for domestic and industrial purposes in many parts of Nigeria especially in coastal area due to surface water pollution base on human activities.

The main aim of this study is to examine the hydrological implication of solid waste disposal on groundwater quality in Solous landfills in Lagos State. This study will particularly: (1) Examine the spatial variation in the concentration of heavy metals and physico-chemical parameters in surrounding wells,(2) Compare the concentration of parameters in groundwater around the closed landfills with respect to time and(3) Compare the quality of sampled water with WHO and NSDWQ standard limit.

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 6'28^0N to 6'42^0N (Akoteyon et al., 2011). It commenced operation in the year 1996 with a projected lifespan of between 5 and 6 years(LAWMA,2010). As a result of urban pull and push situation, 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 above. Alimosho has a total population of about 1,362,077 population, and land area of 185.km^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 28^0C to 33^0C.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** landfill. The landfill is located within $6^0$33'0N and $3^0$15'0E,and ranks 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.

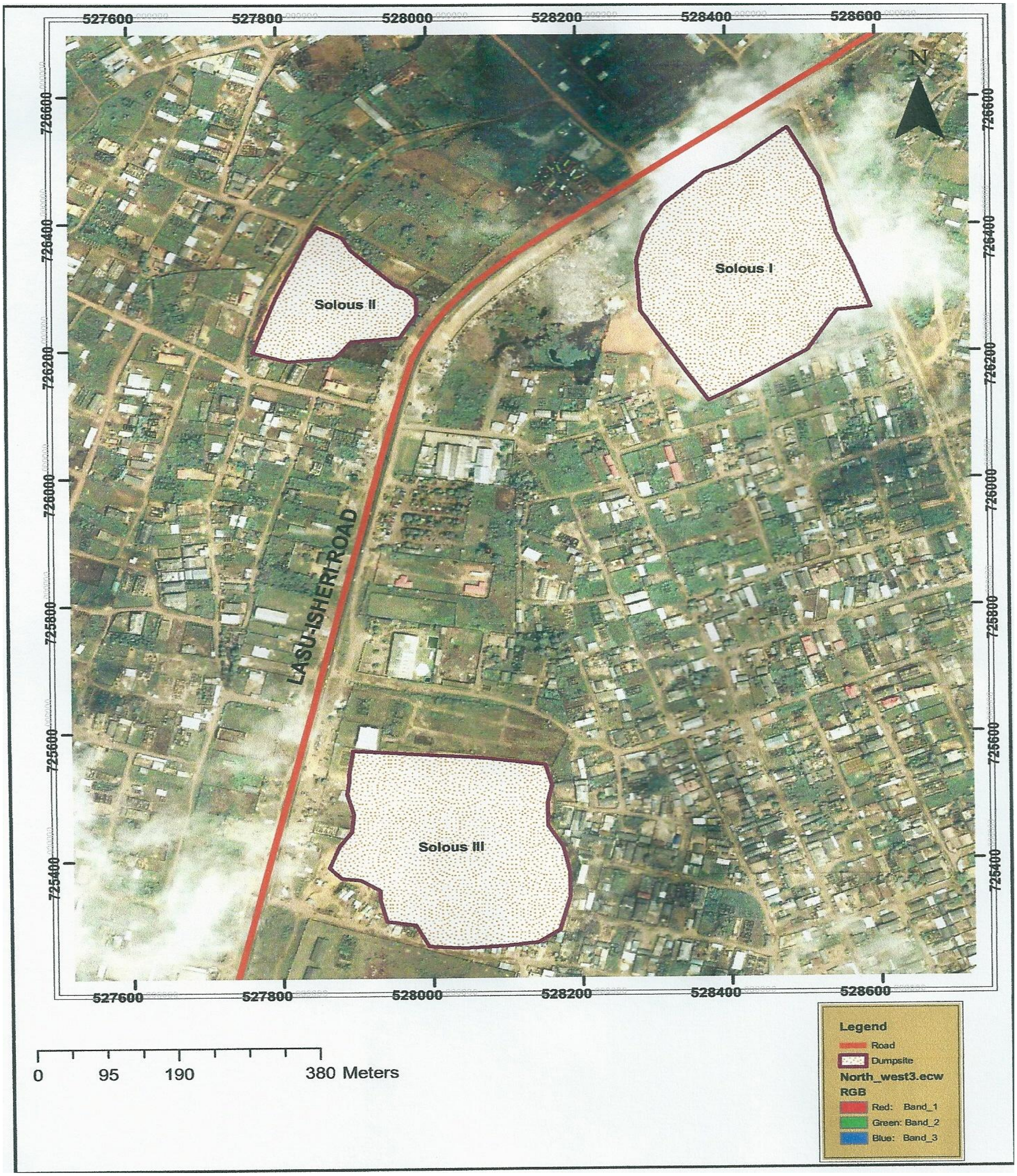


Fig. 1: Satellite Image of the Study Area

Materials and Methods

Fifteen (15) water samples from the wells and three (3) leachate samples were collected inside well-labeled 5 litres polyethylene bottles after severe mixing of the water in the well and composite mixture of leachate to get the true and same representative sample. The label used the format code of GW_{11} to GW_{15} for closed landfill , GW_{21} to GW_{25} for Solous 3, and GW_{31} to GW $_{35}$ for Solous 2, existing landfills. Leachates were labeled as LE_{01}(closed), LE_{02} and LE_{03} (existing).

Water samples 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. With respect to NPC 2006,the total number of inhabitants in Lagos State were 9,013,534. However 2010 household survey put Alimosho(the largest Local Government in Lagos State) to be 1,319,571 with population density of 712.5 per square kilometer on185.2km^2 area of land.
This study utilized fifteen (13) variables of physicochemical and heavy metal namely Zinc, Iron, Chromium, Cadmium, Lead, Temperature, pH, Nitrate, Chloride, Total Hardness, Total Suspended Solid, Dissolved Oxygen and Electrical conductivity. The criteria behind the selection of these variables is based on being the common pollutants element in groundwater around landfill. Three different landfills were used in the same location, one closed and two (2) existing. Sampling points around each landfill were five (5). The selected landfill sites (Solous) is one of the three (3) major landfill in Lagos, where both closed and existing dumpsites are located spatially. Within the geographical extent of about seven hundred and fifty metres (750m) from the landfill, about thirty (30) wells were identified. Out of these, fifteen (15) of them were used for the study in relation to their location and distance from the sites.

Data were gathered through field survey and experimental method around landfills during the month of August,2011. Fifteen (15) groundwater samples (five around each landfill) were strategically selected for the study. The area were delineated into two diagonal each within each dumpsite. The depth and static water level of each well were determined with the aid of rope and graduated tape. 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 landfills were photographed at vantage points with the aid of digital camera (Sony 14.1 megapixel model). The satellite image of the study area were scanned and overlaid with sampling points with the aid of Arcview 3.0 and sofer software.

Laboratory Analysis

The adopted analysis methods for the examination of all parameters in potable and wastewater were in accordance with APHA,2005 standard recommendation. All samples were analyzed for selected physico-chemical and heavy metals parameters. Various physico-chemical parameters examined in groundwater samples include: pH, Electrical conductivity (EC), Temperature (^oC),Total Suspended Solid (TSS),Total hardness (TH),Nitrate (NO_3) Dissolved Oxygen and Chloride at **Lagos State Environmental Protection Agency** (LASEPA). Sampled water were analyzed for potable water at potable water laboratory. Initially, all containers to be used were dionized with reagent water before being rinsed with sample and properly clean with tissue paper before the reading from Spectrometer. Samples (100ml each) were digested with 5ml of nitric acid (HNO_3) to liberate organic molecule from the samples, and heated at the temperature range of 45^0C to 65^0C before taken to sensitive laboratory. Atomic Absorption Spectrophotometer were used to determine the concentration of each heavy metal under specific wavelength as Chromium (357.9nm), Lead (217nm),Zinc (324.8nm), Iron (248.3nm), Cadmium (228.8nm).Chemical parameters were detected through different titration applicable to each variable. Dissolved Oxygen were measured with the aid of D.O meter, Orion 3 star model and pH were determined by pH 211 microprocessor meter model, of which both have in-built thermometer for temperature. Also, Electrical Conductivity and pH were measured with the aid of conductivity/EC meters. Other chemical parameters were determined with the best method suitable for each. Also, determination of microbial activity were carried-out at microbiology laboratory for both leachate and potable water.

Statistical Data Analysis

The obtained data were subjected to descriptive statistical analysis , table, as well as inferential statistic like correlation. Correlation analysis were used to verify the relationship between examined variables with the aid of SPSS package. The concentration of examined parameters in both closed landfills were compared with the result from Balogun and Longe , 2008 in close landfill to verify the rate of variation in relation to time. Concentration of the examined parameters were arranged in tabular form separately to examine the spatial variation in the concentration of heavy metals and physicochemical parameters in surrounding wells around the closed and operational landfill. The result of each sample were compared with WHO,2004 and NSDQW,2007 standard limit.

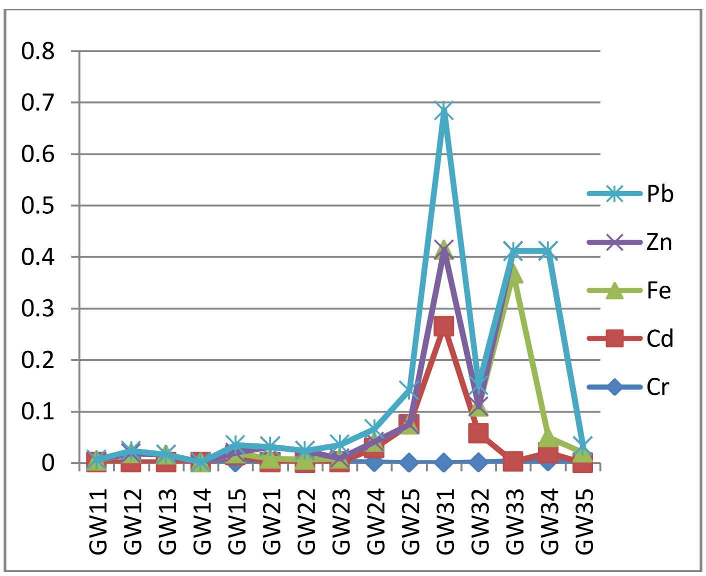
Results and Discussion

Table 1.1:Physicochemical and Heavy Metals in Solous Groundwater Versus WHO and NSDWQ

	0C	pH	EC	TSS	TH	NI	CI	DO	Cr	Cd	Fe	Zn	Pb
WHO	25	6.5-8.5	1.0	3.0	100	10	250	3.0	0.05	0.002	0.3	1.5	0.01
NSDWQ	NS	6.5-8.5	1000	NS	150	50	250	NS	0.05	0.003	0.3	3	0.01
Solous1													
GW_{11}	26.8	7.3	0.58	5	98	1.8	5	3.41	0.0008	ND	0.0035	0.0014	ND
GW_{12}	25.1	7.74	0.44	5	36	ND	10	4.34	0.0013	ND	0.0174	ND	0.0049
GW_{13}	26.6	7.14	0.68	3	34	9.5	10	3.75	0.0012	ND	0.0149	0.1005	ND
GW_{14}	26.1	7.06	0.27	ND	16	2.9	24	4.19	0.0011	ND	ND	ND	ND
GW_{15}	26.7	6.85	0.17	2	16	1.9	5	3.19	0.0006	0.0145	0.0032	0.0009	0.0157
Solous2													
GW_{31}	26.8	6.91	0.30	2	24	3.2	5	3.65	0.0009	ND	0.0072	0.0234	ND
GW_{32}	26.8	7.20	0.64	1	46	0.5	25	3.50	0.0006	ND	0.0053	0.0178	ND
GW_{33}	26.7	7.36	0.33	ND	16	1.1	10	3.82	0.0018	ND	0.0064	ND	0.027
GW_{34}	25.0	5.81	0.27	ND	8	1.9	5	4.29	0.0011	0.0275	0.0123	ND	0.0244
GW_{35}	26.7	7.05	0.51	5	22	0.5	22	4.24	ND	0.0747	ND	ND	0.0664
Solous3													
GW_{21}	24.8	10.99	4.53	ND	22	0.5	228	4.09	ND	0.2657	0.1483	ND	0.2710
GW_{22}	24.9	5.98	0.93	ND	60	1.4	50	3.74	0.0005	0.0567	0.0520	ND	0.0418
GW_{23}	24.9	11.86	9.94	ND	6	1.0	471	3.29	0.0025	ND	0.3654	0.0043	ND
GW_{24}	24.9	12.19	6.10	ND	126	0.7	340	3.18	0.0027	0.1655	0.0306	0.3617	ND
GW_{25}	24.8	6.18	0.98	ND	26	1.9	43	4.21	ND	ND	0.0201	0.0116	ND

Note: ND: Not Detected, NS: Not Specify

Fifteen wells and three leachates were sampled. Five samples were taken around each landfill. From GW11-GW15 were samples around Solous 1,GW21-GW25 were samples around Solous 3 and GW31-GW35 were around Solou2. Static Water Level(SWL) of the sampled well ranged from 4.06m-19.93m while the depth also between 14.62m-21.76m



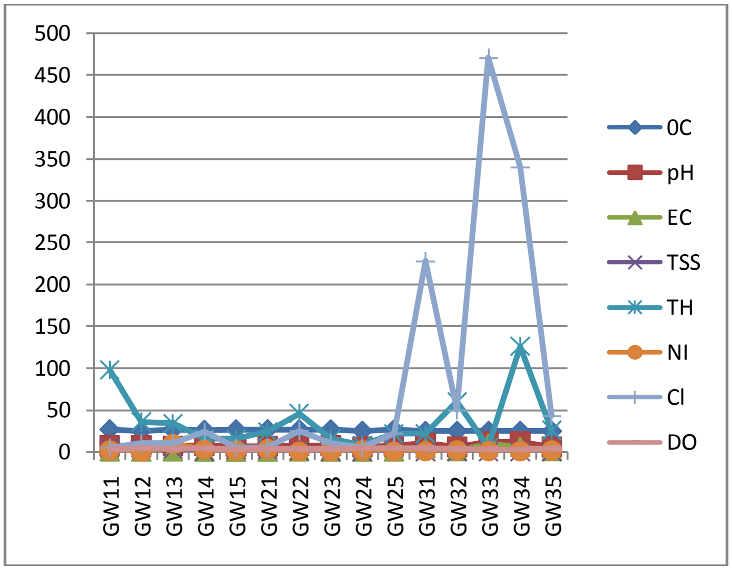


Fig.2 Concentration of heavy metals physicochemical line graph

From Gw25 to Gw35 has high concentration of heavy metals compare to Gw11 to Gw24.Gw13 has the highest concentration of Iron(Fe) above the standard limit. Sampling point Gw34 has high concentration of Zinc(Zn) but less than the limit.Gw11 is the point with the highest concentration of Cadmium and Lead above the WHO limit. However, the concentration of heavy metals are more around Solous 3 which is operational landfill compare to Solous 1 and 2(closed and operational)landfills.

Also Chlorine recorded 371mg/l and 340mg/l at GW34 and 35 respectively, higher than standard limit. All Dissolved Oxygen were above standard limit while others parameters were within the limit.

Groundwater Physico-chemical and Heavy Metals Characteristics in Solous Landfills

The underground water of the studied area is used for domestic and other purposes. Table 1.1 shows the desirable and maximum permissible limit recommended by World Health Organisation (WHO,2004). The temperature of the groundwater samples ranged from 24.8^{0}C to 26.7^{0}C.The pH of the groundwater samples was almost neutral with the exception of GW_{11},GW_{23} and GW_{24} around Solous 3 that were alkaline. It ranged from 5.98 to 12.19.Acidity increases as pH values decreases ,and alkalinity increases as pH values increase. As acidity increases, most metals become more water soluble and more toxic. The EC is a valuable indicator of the amount of material dissolved in water. The EC in the studied area ranged between 0.17 and 9.94uScm^{-1} and was found to be high around Solous 3 especially at sites $GW_{21,}$ GW_{23},GW_{24},also in relation to high concentration of pH .Conductivity is the ability of a substance to conduct electricity. The conductivity of water is a more-or-less linear function of the concentration of dissolved ions.

Sediment is usually measured as a concentration of Total Suspended Solid(TSS).The TSS concentration was found to be remarkably high at sites GW_{11},GW_{12} and GW_{35}.TSS were not detected in seven and remaining are average and less than standard limit. Total Hardness is normally expressed as the total concentration of Ca^{2+} and Mg^{2+} in mg1^{-1},equivalent $CaCO_3$.Total hardness ranged from 6 to 126.From all examined wells,GW_{24} was the only well above the standard limit. Nitrate was generally less that WHO standard limit. An excess of CI^- in water is usually taken as an index of pollution and considered as tracer for groundwater contaminant(Loizidou and Kapetanious,1993).The concentration of CI^- in the groundwater samples ranged between 5mg1^{-1} to 474mg1^{-1} .At sites GW_{33} and GW_{34},the chloride concentration was found to be comparatively high. Increase in CI^{-1} level is injurious to people suffering from diseases of heart or kidney(WHO,1997).The concentration of Dissolved Oxygen(DO) ranged from 3.18mgl^{-1} to 4.41mg1^{-1}.

The groundwater samples were analyzed for heavy metal such as Chromium(Cr) ,Cadmium (Cd), Iron(Fe), Zinc(Zn) and Lead(Pb) which are characterized as undesirable metals in drinking water. WHO(2004) has proposed their permissible value of 0.05,0.002,0.3,1.5 and 0.01$mg1^{-1}$ respectively in drinking water.

The concentration of Cr in the studied area was greater than the WHO standard limit in detected samples. Out of all samples, Cr was not detected in six of them while the remaining were above the standard limit. It ranged from 0.0006 to 0.0027$mg1^{-1}$.Cd ranged from 0.0064 to 0.3654$mg1^{-1}$.Hence,wells with the present of Cd were higher than standard limit. Cadmium is widely used in industry and is often found in solution in industrial waste discharge. It replaces Zinc in the body and long term consumption of cadmium may lead to body disorders. Presence of Iron in water can lead to change of colour of groundwater. Iron levels ranged from 0.0201 to 0.3654$mgmg^{-1}$.Concentration of high iron in well water is the characteristics of groundwater in Lagos environment which is due to the local geology (Longe,2010).Extreme dissolved of iron concentration result to taste problem. Zinc concentration varied from 0.0014 to 0.3617$mg1^{-1}$.Its presence in the studied sites was negligible. The presence of Pb in GW_{15},GW_{33},GW_{34},GW_{35},GW_{21},GW_{22} was higher than WHO standard limit.

Table 3 Temporal Comparison in Parameters Concentration of Closed Landfill

Variable	Max	Min	Mean	Range	S.D	Variation
pH	7.07	5.30	6.13	1.77	0.67	0.45
	7.74	6.85	7.22	0.89	0.30	0.04
DO	3.94	2.9	3.19	1.03	0.38	0.14
	4.34	3.41	3.87	0.93	3.46	0.89
NI	60.50	17.40	38.50	43.10	18.77	352.17
	9.5	0	3.22	9.5	3.28	1.02
Cl	13.43	2.84	7.80	27.31	5.80	8.23
	24	5	10.8	19	6.97	0.65
Fe	0.15	0.02	0.08	0.13	0.05	0.003
	0.02	0	0.01	0.02	0.01	0.88
Zn	0.23	0.00	0.08	0.23	0.08	0.006
	0.10	0	0.02	0.10	0.04	1.937
Cr	0.71	0.20	0.45	0.51	0.26	0.065
	0.001	0	0.004	0.02	0.006	1.488

Source: Balogun M.R and Longe E.O(2008) and Authors fieldwork August(2011)

_____Balogun and longe results _____Author results

In November,2008,Balogun and longe examined six(6) wells and fourteen parameters around Solous 1(closed) and in August,2011,five(5) wells and thirteen parameters were also examined around the same landfill. From both works seven(7) common examined variables were compared to verify the degree of temporal variation in relation to time. The mean concentration of hydrogen ion(pH) of the site in 2008 increased from 6.13mg/l to 7.22mg/l, with difference of 1.09(17.78%). This clarified the reduction in groundwater acidity. Dissolved Oxygen increased from 3.19m/l to 3.87mg/l, with difference of 0.68 (21.32%). Nitrate reduced from 38.50 to 3.22 with interval difference of 35.28 (91.64%). Mean concentration of Chloride increased from 7.80mg/l to 10.8mg/l, with difference of 3 (38.46%).Heavy metals(Fe, Zn, and Cr) drastically depleted faster than physicochemical parameters from 2008 to 2011.The mean concentration of iron(Fe) diminished from 0.08mg/l to 0.01mg/l with difference of 0.875 (87.5%). Zinc (Zn) reduced from 0.08mg/l to 0.02mg/l, with difference of 0.006 (75%) and Chromium from 0.45mg/l to 0.0041mg/l, with difference of 0.45(99.1%). However, from the above analysis, heavy metals have tendency and capability of depletion with time compare to physicochemical parameters. The rate of their reduction were more than 70% in every three(3) years. Therefore, means annual reduction of heavy metal in Solous 1 landfill is approximately 87%.

In conclusion, the concentration of pH were gradual, Nitrate were rapid, Dissolved Oxygen and Chloride increased gradual and heavy metal concentration rapidly reduced with respect to time in closed landfill. It was discovered from the analysis that most parameters were significantly correlated with pH. Heavy metals(Fe, Zn, and Cr) drastically depleted faster than physicochemical parameters from 2008 to 2011.

Both Federal and State Government need to pay absolute attention to Lagos State Waste Management Authority through provision of alternative waste disposal facilities such as Modern Sanitary Landfills, Incinerators and Recycling. Establishment of “Buffer Zone” around the existing landfills in terms of groundwater exploitation is highly recommended.

Comprehensive water quality test on all wells and bore holes within the buffer zone range need to be carried out in order to detect others that have affected and likely to be affected sooner or later to avoid associated health problems. There is need to address water pollution globally especially groundwater as the hope and alternative to polluted surface water in order to avoid another world war that may cause by water quantity and quality.

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