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Leachate characterization and evaluating its impact on groundwa ter quality in vicinity of landfill site area

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Abstract: *An experimental study is performed for understanding the characteristics of leachate from the landfill site and groundwater in the vicinity area of sanitary landfill. Leachate and groundwater samples are collected from Narela- Bawana (New Delhi, India) landfill site. High Concentrations of various physicochemical parameters are observed in collected samples are reported including heavy metals (Cr, Cu, Fe, Ni, Fe and Zn). The present study deals with the determination of likely concentrations of hazardous contaminants in the groundwater over a period of time due to the discharge of such contaminants from landfill leachates to the nearby soil and finally to groundwater. Results clearly indicated that the likely contamination of groundwater due to leachate released from landfill. Results are further compared with Bureau of Indian Standards for drinking water. Presence of contaminants in groundwater particularly near the landfill sites warns its quality and thus renders the associated aquifer unreliable for domestic water supply and other uses.*
Keywords: *Delhi, Groundwater characteristics, Landfill, Leachate characteristics.*

I. Introduction

Rapid population growth and urbanization in developing countries have led to the generation of enormous quantities of Municipal Solid Wastes (MSW) and consequential environmental degradation. Safe and reliable disposal of MSW and residues is an important component of integrated waste management. One of the most common waste disposal methods is land filling due to its favorable economics, it may lead to the potential sources of groundwater contamination, which is practiced almost everywhere on large scale worldwide.

An MSW landfill is not a safe repository of discarded material; it is a biochemically active unit where toxic substances are leached or created from combinations of non-toxic or toxic precursors as a result of physical, chemical and biological processes in landfills combined with waste components and landfill water regime [1]. These are gradually released into the surrounding environment over a period of decade's and causes large amounts of hazardous and otherwise deleterious chemicals to reach nearby groundwater, surface water and soil also to the air, via leachate and landfill gas. The solid waste composition, particle size, degree of compaction, hydrology, and age of the landfill, moisture, temperature and available oxygen are the controlling factors that determine the rate of production and characteristics of the leachate [2, 3]. The effectiveness of landfill liner systems in preventing leachate migration is eventually compromised with time after installation and deteriorates over time allowing increasing amounts of leachate to pass through the liner into the groundwater system hydraulically connected to the bottom of the landfill.

In recent times, the impact of leachate on groundwater and other water resources such as surface water has attracted a lot of attention because of its overwhelming environmental significance and has given rise to a number of studies in recent years [2, 4, 5, 6, 7].

II. Materials and Methods

2.1 Site description

The Narela - Bawana landfill site is located in Delhi, the capital city of India. Delhi sprawls over 1483 km2 area and ranks second in population among other Indian metropolitan cities and is situated in North India at an altitude of 293 m above mean sea level [2]. Delhi is estimated to generate about 7000 metric tons of MSW daily [8]. Per capita generation of solid waste in Delhi ranging from 150 gm/d to 600 gm/d [5] depending upon the economic status of the community involved and mainly includes waste from household, industries and medical establishments.

Narela-Bawana is a sanitary landfill which came in operation from July 2011. Specific co-ordinates of t he site are 28048□ 21□ □ Nand 77004□ 14□ □ E(Google map) located in Northern part of Delhi along Haryana border. MSW site is constructed of the in different phases. Currently second phase of construction is being under taken, once fully functional 4000 tonnes/day of waste would be dumped in concerned landfill site. The site is being claimed to be efficiently installed with instrument which leads to effective management of waste produced and waste reduction and generation of electricity from waste. It has area approximately of 40 ha, out of which material recovery facility, including Refuse Derived Fuel (RDF) recovery which covers an area of 0.27 ha [9]. Compost Plant and Recyclables storage area are said to be placed in 2.7 ha and 0.27 ha respectively. Power plant

has an area of 13.1 ha and landfill occupy majority of land which is around 16.1 ha. It is claimed that the landfill is lined with two layers of clay and a High Density Polythene layer in between. Once the RDF plant becomes operational, there is a place to collect the harmful gases and flare it before releasing in the atmosphere which will be produced when RDF would be burned.

2.2 Leachate sample collection

Leachate sample were collected on 20th March 2014 from the slump pond in the center of the MSW landfill site. The leachate treatment plant was not operational at the time of sample collection, thus leachate sample post treatment could not be collected. Leachate samples were collected in BOD bottles which were sterilized before use by heating at 180°C together with their stoppers for some time. After collection, all samples were properly labeled with details of the source, date of sampling, time of sampling.

2.3 Groundwater sample collection

Six ground water samples (GW-1, GW-2, GW-3, GW-4, GW-5 and GW-6) were collected from specific tube wells, bore wells and hand pumps.

Figure 1: location of various existing landfills in Delhi. [10]

GW-1 was collected from a Hand Pump located in a house located at 28º48□ 20.4□ □ N and 77º04□ 36.6□ □ E, GW-2 was collected from 28º48□ 27.5□ □ N and 77º03□ 19.6□ □ E, and similarly GW-3 was located at 28º49 □ 17.2 □ □ N and 77º03□ 28.4□ □ E. GW-4 was collected from 28º47□ 12.7□ □ N and 77º05□ 36.3□ □ E, coordinates of GW-5 and GW-6 28º49□ 49.6□ □ N and 77º05□ 49.6□ □ E and 28º46□ 45.1□ □ N and 77º05□ 45.8 □ □ E respectively. The sampling points were located at 0.725 km, 1.5 km, 2.32 km, 3.0 km, 3.4km and lastly at 3.8 km from the landfill dumping point.

Figure. 2: location of MSW landfill and GW sampling

Priority was kept to take sample nearest to landfill, as considered landfill is situated in industrial area; p recaution of not collecting sample nearby the industrial area was kept in mind. Landfill at one side was also confined by Yamuna canal thus it was kept in mind to not collect sample beyond Yamuna canal. For ground water sample collection, 500ml poly vinyl chloride sampling bottles for ground water were used, which were rinsed 2-3times with the sample water which was to be collected. To prevent the loss of certain cations such as Cd, Cu, Cr, Ni and Zn etc by adsorption, or ion exchange with the walls of glass containers, some sampling bottles were acidified with concentrated HCl to pH below 2.0. Fig. 2 indicates the location of groundwater samples and the

landfill on the google map.

2.4 Sample storage, shipment and preservation

The sample are tested is 16.1 km which takes about 45 minutes in transportation. As soon as the sample s reached the DTU laboratory, they were kept in a refrigerator at 4°C for preservation. The samples were tested in laboratory within 24 hours from the time of collection.

2.5 Laboratory analysis

The chemical analysis was done in accordance with the APHA methods [11]. The pH, EC and TDS was measured using conductivity meter; Sodium and potassium by Flame photometer; Calcium, Magnesium and Chlorine by Titration method; COD by Open reflux digestion method & titration; BOD by Winkler method; Sulphate, Phosphate and Iron by Spectrophotometer and Heavy metals (Cr, Cu, Zn, Ni) by Atomic Absorption Spectrometer.

III. Results

3.1 Leachate characteristics

Physicochemical characteristics of the leachate samples collected from the Narela-Bawana MSW landfill site are presented in TABLE 1.

Table 1 Physicochemical concentration in leachate sample

After collection, leachate	pH	EC	TDS	Cl	SO4	PO4	COD	BOD	Ca	Na	K	Mg
Units		µS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Value	8.4	965	26320	4466.10	N.D	251.92	47600	13094	133.6	3532	3218	330.7

Physicochemical characteristics of the leachate depend primarily upon the waste composition and water content of total waste. High value of pH is obtained for leachate sample, this indicates as phase of decomposition of wastes characterized by the production of volatile fatty acids and carbon dioxide [12]. Value of EC which is observed as 965µS/cm in given leachate sample reflects presence of anions or inorganic materials. High values of TDS of the order of 26320 mg/l is observed which indicates the presence of inorganic material in the samples. Value of BOD5 in leachate is observed around 13094 mg/l which tends to indicate the maturity of the landfill and shows that microbial activity in the decomposing leachate is yet to attain stability. Value of COD and BOD observed are 47600 and 13094 respectively, thus Ratio of BOD5/COD comes out to be 0.275. COD is an important parameter for its usefulness in determining the relative degree of solid waste decomposition, leachate treatment technique, detection of contaminant migration, and organic contamination. [13] Value of Chloride observed was very high of 4466.10mg/l. The presence of Phosphate (251.92 mg/l) in such a high concentration in leachate is dangerous as its presence in water promotes the growth of algae and correspondingly increases eutrophication.

Table 2 Heavy metals concentration in leachate sample

Parameter	Fe	Cr	Cu	Ni	Zn
Units	mg/l	mg/l	mg/l	mg/l	mg/l
Value	23.26	0.21	3.52	N.D	1.096

TABLE 2 shows Heavy metals contents of the leachate samples obtained from laboratory analysis inclu de Zinc, Iron, Copper, and Chromium. Iron has the highest concentration of all the heavy metals present in the leachate followed by Cu, Zn, Cr whereas the concentration levels of Ni went undetected. The high level of total iron (23.26mg/l), in the leachate samples is evidence of dumping of iron and steel scraps wastes in the dumpsite, which is justified as there is a huge industrial area called as Bawana industrial area in the proximity of landfill, although it is a MSW site. Concentration of Copper observed was 3.52mg/l and potential source of Cu is thought to have originated from the dumping of waste related to cement like bags in the dumpsite. On the other hand, the concentration of Zn which was around 1.096mg/l was less than permissible limit. It depicts that dumping of batteries and fluorescent lamps in the landfill could be a possible source of it. The presence of Cr (0.21 mg/l) in the leachate samples may have originated from the emission of automobile exhaust of diesel tanker vehicles which use Parameter the vicinity of the dumpsite as a garage and other vehicle which ply the road that leads to oil refinery in the city. The different heavy metals detected are indication that the Narela-Bawana landfill site receives variety of wastes from both industrial and residential sources.

3.2 Physicochemical characteristics of Ground Water

The ground water of the study area is used for domestic and agricultural purposes. TABLE 2 shows the concentration various parameters present in the groundwater samples from which the quality of groundwater can

be understood, as it is compared with the acceptable limit of BIS [14] and WHO [15] standards under normal circumstance there should be no variation in the concentration of the constituents of water. On the contrary variation in the ionic concentration of groundwater is expected in the direction of groundwater flow specifically nearby landfill site. The pH value for groundwater samples is slightly acidic to neutral in which the range is from 5.15-8.93. These values are exceeding WHO limits and the B.I.S standards permissible limit for portable drinking water.

The pH value of water has no obvious effects on the consumers, but gives an indication that water is sli ghtly acidic for GW-4 and GW-5 and was found basic for GW-1. The EC of water is reflection of the quantity of ionic constituents dissolved in it. The obtained EC ranges between 3360-4620µS/cm for groundwater samples. The maximum value of 4620µS/cm was measured for GW5; this value is higher than the recommended standard by WHO and B.I.S for potable water. Highest value was observed for GW1, which is a strong indication of contaminant through landfill site. The concentration of TDS in water gives assistance in knowing the nature of quality or its salinity.

Table 2 Physicochemical charactertics of groundwater in Bawana area

	Unit	GW1	GW2	GW3	GW4	GW5	GW6	BIS max Limit	WHO max limit
pH		8.93	6.37	7.47	5.15	5.77	6.04	6.5-8.5	9.2
EC	µS/cm	4583	4280	4440	4387	4620	3360	-	-
TDS	mg/l	2220	2160.67	2112.3	1542.96	1564.6	1685.3	2000	1500
Cl	mg/l	1585	1693.98	1108.74	1202.86	428.10	807.21	1000	600
SO4	mg/l	73.91	96.89	186.4	112.4	84.7	73.42	400	400
PO4	mg/l	0.572	0.44	0.256	0.10	0.34	0.62		
COD	mg/l	-	-	-	-	-	-	-	-
BOD	mg/l	-	-	-	-	-	-	-	-
Ca	mg/l	86.61	113.58	92.01	78.27	68.28	87.24	200	200
Na	mg/l	85.62	64.29	56.23	33.53	54.58	48.25	-	200
K	mg/l	28.67	18.66	15.93	14.91	13.86	9.47	-	200
Mg	mg/l	58.64	54.02	40.64	28.16	19.5	17.68	30	150
Fe	mg/l	0.542	0.660	0.342	0.101	0.090	0.070	0.3	0.3
Cr	mg/l	0.116	0.112	0.088	0.076	0.064	0.085	0.05	
Cu	mg/l	0.291	0.265	.250	0.219	0.092	N.D	1.5	
Ni	mg/l	N.D	N.D	N.D	N.D	N.D	N.D		
Zn	mg/l	0.861	N.D	0.363	N.D	N.D	N.D	5.0	5.0
	Unit	GW1	GW2	GW3	GW4	GW5	GW6	BIS max Limit	WHO max limit
pH		8.93	6.37	7.47	5.15	5.77	6.04	6.5-8.5	9.2
EC	µS/cm	4583	4280	4440	4387	4620	3360	-	-
TDS	mg/l	2220	2160.67	2112.3	1542.96	1564.6	1685.3	2000	1500
Cl	mg/l	1585	1693.98	1108.74	1202.86	428.10	807.21	1000	600
SO4	mg/l	73.91	96.89	186.4	112.4	84.7	73.42	400	400
PO4	mg/l	0.572	0.44	0.256	0.10	0.34	0.62		
COD	mg/l	-	-	-	-	-	-	-	-
BOD	mg/l	-	-	-	-	-	-	-	-
Ca	mg/l	86.61	113.58	92.01	78.27	68.28	87.24	200	200
Na	mg/l	85.62	64.29	56.23	33.53	54.58	48.25	-	200
K	mg/l	28.67	18.66	15.93	14.91	13.86	9.47	-	200
Mg	mg/l	58.64	54.02	40.64	28.16	19.5	17.68	30	150
Fe	mg/l	0.542	0.660	0.342	0.101	0.090	0.070	0.3	0.3
Cr	mg/l	0.116	0.112	0.088	0.076	0.064	0.085	0.05	
Cu	mg/l	0.291	0.265	.250	0.219	0.092	N.D	1.5	
Ni	mg/l	N.D	N.D	N.D	N.D	N.D	N.D		
Zn	mg/l	0.861	N.D	0.363	N.D	N.D	N.D	5.0	5.0

The obtained concentrations of TDS in GW in the study area vary between 1542.96- 2220mg/l. A high value of2220 mg/l is measured for GW1, followed by GW2 with a value of 2160 mg/l and least value is observe d of 1542.96 mg/l for GW4. According to WHO high level of TDS may be responsible for reduction in the palatability of water, inflict gastro-intestinal inconveniences in human and may also cause laxative effect particularly upon transits. These TDS values tend to decrease with distance of groundwater wells from the refuse dumpsite, along groundwater flow paths in down gradient direction. In addition, the work of [16] has established measurable high level of TDS concentration as an indication of contamination of groundwater near refused dumpsite. High concentrations of dissolved solids increases the density of water, affects regulation of fresh water organism, and reduces solubility of gases like oxygen and utility of water for drinking, irrigational and industrial purposes. The concentration of Ca^{2+} and Mg^{2+} ions in natural water influences its hardness, which is the ability of the water to form lather with soap. Total hardness actually reflects the total concentration of Ca^{2+} and Mg^{2+} in mg/l, equivalent $CaCO_3$. Source of calcium and magnesium can also be through weathering of underground rocks present. The value of Ca^{2+} ranged from 68.28 to 113.58 mg/l, the highest recorded value, is for GW2 and the least

value for GW4. The concentration of Ca2+ is below permissible range of WHO and BIS standards for potable groundwater, it has been known that consumption of water with very high concentration of Ca2+ may leads to concretion in kidney or bladder stone and also causes irritation in urinary passage [5]. Magnesium concentration is between 17.68 - 58.64 mg/l, highest at 1st, also at 2nd, 3rd location are more than BIS standard but are under WHO standards. The concentrations of Chloride is in the range of 1693.98 to 428.10 mg/l and significant proportion was found in GW2 and GW1 sampling location. High quantity of Chloride concentrations in water is indicator for pollution and as tracer for groundwater contamination [17]. Domestic effluents, fertilizers, septic tank and natural sources such as rainfall and dissolution of fluid inclusion are some of the sources that may contribute to high Chloride concentration in groundwater and thus causing pollution, other than leaching from landfill and high concentration of Cl- is detrimental to people with heart diseases and Kidney problem. The value of Na+ ions in the water samples varied from 85.62 to 33.53 mg/l. The highest value is associated with GW1 and lowest with GW4. Comparatively higher values are observed at GW5 that may have been due to geology of area or due to anthropogenic source. The consumption of water with high concentration of Na+ ions is inimical to people with cardiac, renal and circulatory diseases [5] Testing of sample has demonstrated the presence of potassium in groundwater sample. The value of K+ in the groundwater samples varied from 28.67 to 9.4 mg/l, highest at GW1 and lowest being at GW6. Phosphate is found to be present in minimal quantity of 0.62 to 0.1 mg/l, with GW6 having the maximum value of 0.62mg/l, source of it might the agricultural activities which being carried out in the area on small scale GW4 with a minimum value of 0.1. A minute value of phosphate as low as 0.01mg/l in groundwater may result in the water being slimy and also promotes the growth of algal [18]. The range of the concentration of sulphate in ground water samples varied from 186.40mg/l to 73.42 mg/l and was significantly higher in GW3 than the other. High quantity of sulphate in water is dangerous as it causes dehydration and diarrhea in children than adults [19]. COD concentration was not detected in any location.

Among the heavy metals analyzed, Fe2+ has the maximum concentration of 0.66 mg/l. The obtained va lue for GW1, GW2 are evidently higher than the 0.3mg/l standard requirement for portable drinking water but GW4, GW5 and GW6 fall within the standard stipulated by the B.I.S and WHO standards. The colour of ground water samples at all locations was colorless this however conforms to [20] findings, that a change in colour is often expected in groundwater which contains Fe2+. Total chromium present, varied from 0.116 to 0.085mg/l and concentration in groundwater is above permissible limit at all locations, highest is observed at GW1. Heavy doses of chromium salts even though are rapidly eliminated from human body, could corrode the intestinal tract [14]. There is minute concentrations of the following heavy metals are detected in the groundwater samples and are below the required standard for portable drinking water of B.I.S and WHO. This includes Cu with a concentration of 0.259mg/l and went undetected for GW6, at all location is well under limits. Consumption of high levels of copper can cause nausea, vomiting, diarrhea, gastric complaints and headaches. Long term exposure over many months and years can cause liver damage and death's was detected at only 1st and 3rd location of sample locations and are 0.861 and 0.363 mg/l respectively. These are in the minute concentrations and assumption has been made that they have come from the underground soil stratum. Nickel was not detected at any locations nearby landfill, which is acceptable as there was no concentration achieved in leachate also. The groundwater samples analyzed indicated trend of reducing contaminant concentration at increasing radial distances away from the landfill site for all contaminants studied but variation of concentration is totally justified as the concerned area is confined by various industries of plastic, metals etc.

3.3 Correlation Coefficient analysis

Pearson correlation is a descriptive method used to evaluate the degree of interrelation and association between two different variables. A correlation of positive sign indicates a perfect positive relationship between two variables. A correlation of negative sign indicates that one variable changes inversely with relation to the other.

Table 2. Correlation matrix for different ground water quality parameters

Parameter	pH	EC	TDS	Cl	Ca	Mg	Po4	Na	K	COD	BOD	Fe	Cu	Cr	Zn
pH	1														
EC	-0.96	1													
TDS	0.19	0.102	1												
Cl	0.083	0.21	0.994	1											
Ca	0.668	-0.42	0.857	0.796	1										
Mg	0.797	-0.59	0.745	0.668	0.982	1									
Po4	-0.84	0.961	0.371	0.47	-0.159	-0.342	1								
Na	0.87	-0.98	-0.317	-0.418	0.215	0.396	-0.998	1							
K	0.858	-0.97	-0.339	-0.439	0.192	0.374	-0.999	0.999	1						
COD	-0.68	0.434	-0.851	-0.789	-0.999	-0.984	0.17	-0.226	-0.2	1					
BOD	-0.48	0.203	-0.952	-0.914	-0.973	-0.912	-0.072	0.015	0.039	0.97	1				
Fe	0.28	0.011	0.995	0.979	0.901	0.803	0.284	-0.229	-0.25	-0.896	-0.98	1			
Cu	-0.54	0.76	-0.425	0.794	-0.83	-0.92	0.682	-0.723	-0.71	-0.254	0.679	-0.5	1		
Cr	0.687	-0.87	0.581	0.666	0.08	-0.109	0.971	-0.956	-0.96	-0.068	-0.31	0.5	0.49	1	
Zn	-0.72	0.88	0.55	0.637	0.042	-0.147	0.979	-0.966	-0.97	-0.03	-0.27	0.5	0.52	1	1

A correlation of zero indicates that there is no relationship between the two variables. TABLE 2 represents the correlation matrix table among fifteen ground water quality parameters of groundwater of the study area. TDS showed a higher significant positive correlation with most of water quality parameters like Cl (r=0.994), Ca (r=0.857), Mg (r=0.745), Fe (0.995), which indicates that presence of TDS in leachate effects presence of above parameters also. Similarly positive correlation of chlorine with magnesium, iron, copper, chromium, zinc was obtained. This suggested that presence of TDS, pH strongly influences the presence of chloride, calcium, iron, copper and various other compounds whose value is obtained more than 0.55. Most of the parameters were found to bear statistically significant correlation with each other indicating close association of these parameter with each other.

IV. Conclusion

The study primarily indicated that Narela-Bawana landfill cumulatively generates significant amount of leachate which contains higher concentration of heavy metals and other cations. The groundwater samples around all these landfills is also contaminated having heavy metals and other cations and anions more than recommended by BIS and WHO standard for drinking water. The spatial, distributions of all these heavy metals indicate possible leaching of contaminant from landfill. The analyzed groundwater samples obtained from the vicinity of the landfill dump site did not evidently reflect water quality that is affected by the leachates collected from the refuse landfill site.

Nevertheless the elevated values of EC, TDS, chloride, iron, copper and chromium obtained, strongly depict the influence of leachates on the groundwater quality and may pose serious threat to groundwater quality in the distant future. The groundwater sample analysis result clearly indicated that the trend of reducing contaminant concentration at increasing radial distances away from the landfill site for all contaminates studied.

REFERENCES

[1]. Naveen, A.K. Sharma, P.V. Sivapullaiah, Sitharam, Characteristics of the leachate from MSW landfill, Bangalore, journal of Geosynthetics India, 2013, 23-29.

[2]. Ohwoghere–Asuma, Leachate Characterization and Assessment of Groundwater and Surface Water Qualities Near Municipal Solid Waste Dump Site in Effurun, Delta State, Nigeria, Journal of Environment and Earth Science 2013 3(9)

[3]. Bharat J. and Singh S. Groundwater contamination due to Bhalaswa landfill site in New Delhi, International Conference on energy and environment. India, 2009, 2070-3740.

[4]. S. Kanmani, R. Gandhimathi, Investigation of physicochemical characteristics and heavy metal distribution in ground water system around open dump site, Appl Water Sci 2013, 10, 1-13

[5]. Suman Mor, Khaiwal Ravindra, R. P. Dahiya and A. Chandra, Leachate Characterization and assessment of groundwater pollution near municipal solid waste landfill site, Waste Manage 2006, 26(4):381–388.

[6]. Vijaya Singh and A.K.Mittal, Toxicity analysis and public health aspects of municipal landfill leachate: a case study of Okhla landfill, Delhi, 2009, 8 World Wide Workshop for Young Environmental Scientists

[7]. Rajkumar Nagarajan, Subramani Thirumalaisamy and Elango Lakshumanan, Impact of leachate on groundwater pollution due to non-engineered municipal solid waste landfill sites of erode city, Tamil Nadu, India, Iranian journal of Environmental Health Science &Engineering 2012, 9, 35.

[8]. Vikash Talyan , R.P. Dahiya , T.R. Sreekrishnan, State of municipal solid waste management in Delhi, the capital of India, Waste Management , 2008, 28, 1276–1287

[9]. [Ramky Enviro Engineers limited Establishment of integrated municipal solid waste management facility" at Narela- Bawana notified site, Delhi, 2010

[10]. Delhi urban environment and infrastructure improvement project. Government of National Capital Territory of Delhi, 2001.

[11]. APHA Standard methods for the examination of water and wastewater Washington, American Public Health Assoc 1994, 20th ed

[12]. Kjeldsen, P., Barlaz, M.A., Rooker, A.P., Baun, A., Ledin, A. and Christensen, T.H. Present and long-term composition of MSW landfill leachate. Env. Sci. Technol., 2002, 32, 4, 297-336.

[13]. Stephen C. James, BS, MSCE; Metals in Municipal Landfill Leachate and Their Health Effects, AJPH 1977, 67, 5

[14]. Bureau of Indian Standards (BIS), Indian standard specification for drinking water, IS 1991, 10500, 2-4.

[15]. WHO (World Health Organization), Guideline for drinking water quality, 1997, 2(2), Geneva, pp 940-949

[16]. Olaniya, M.S. and K.L. Saxena.: Groundwater pollution by open refuse dumps at Jaipur. Environ. Hlth.1977, 19, 176-188.
[17]. Loizidou, M., and E. Kapetanios, Effect of leachate from landfills on underground water quality, Sci. Total Environ, 1993 128, 69–81.
[18]. Adekunle, I.M., M.T. Adetunji, A.M. Gbadebo, and O.B. Banjoko, Assessment of Groundwater Quality in a Typical Rural Settlement in Southwest, Nigeria. Int. Journal of Environment and Public Health, 2007, 4(4), 307-318.
[19]. Longe, E.O. and M.R. Balogun., Groundwater Quality Assessment near a Municipal Landfill, Lagos, Nigeri., Research J. of Applied Sci, Eng and Technology, 2010, 2(1): 39-44.
[20]. Rowe, R. K., R. Q. Quigley and J. R. Booker, 1995. Clay Barrier Systems for Waste Disposal Facilities, E & FN Spon, London, UK