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Effect of Leachate on Surrounding Surface Water: Case Study in Rajbandh Sanitary Landfill Site in Khulna City, Bangladesh

By Md. Rafiqul Islam, Km Alim Al Razi, Md. Rokon Hasan, Md. Hasibul Hasan & Salma Alam
Khulna University of Engineering & Technology, Bangladesh

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Md. Rafiqul Islam [α], Km Alim Al Razi [σ], Md. Rokon Hasan [ρ], Md. Hasibul Hasan [ω] & Salma Alam [¥]

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I. Introduction

Municipal Solid waste landfill has many adverse effects on surrounding environment. Such landfills often produce leachate, i.e. the liquid that usually drains from landfills due to infiltration by water and/or biogeochemical decomposition processes, which serves as an important point source of pollution in many environmental media around the world. The constituents in leachate, some of which may be toxic, have often posed serious challenges in terms of cost of treatment, accumulation of metal or species, remediation and, in particular, possible eco-toxicological implications resulting from both short- and long-term exposure or bio- accumulation of leachate constituents. (Nyame et al). Leachate is a high strength wastewater that contains high concentrations of organic matter and ammonium nitrogen which results from precipitation entering the landfill and from moisture that exists in the waste when it is disposed. The composition of leachate varies greatly from site to site, and can vary within a particular site. Some of the factors affecting composition include age of landfill, types of waste, degree of decomposition; and physical modification of the waste.

II. Generation of Leachate

Rainfall is the main contributor to generation of leachate. The precipitation percolates through the waste and gains dissolved and suspended components from the biodegrading waste through several physical and chemical reactions. Other contributors to leachate generation include groundwater inflow, surface water runoff, and biological decomposition. Liquid fractions in the waste will also add to the leachate as well as moisture in the cover material (Abbas, 2009).

III. Composition of Leachate

The composition of the landfill leachate varies greatly depending on the age of the landfill. As landfill age increased, organic concentration (COD) in leachate decreased and increase of ammonia nitrogen concentration. The existing relation between the age of the landfill and the organic matter composition may provide useful criteria to choose a suited treatment process (Amalendu, 2004). Bagchi (2004) has tabulated the range of concentration of different parameters in leachate of municipal waste which is shown in table 1. The table describes the lower limits and upper limits that can be expected from the landfill leachates.

Author α σ ρ ω ¥ : Undergraduate student, Department of Civil Engineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh. E-mails : mrafiq31@gmail.com, rrr.civil.kuet@gmail.com, semui91@gmail.com, hasibul999@yahoo.com, semui73@gmail.com

Table 1 : Different characteristics of leachate generated from deposited MSW

Physical	Organic constituent	Inorganic constituent	Biological
Appearance pH Oxidation-reduction potential Conductivity Turbidity Temperature Odor	Organic chemicals Phenols Chemical oxygen demand (COD) Total organic (TOC) Volatile acids Tannins , lignin's Organic-N Ether soluble (nil & grease) Methylene blue Organic functional groups as required Chlorinated Hydrocarbon	Suspended solid (SS),total solid(TDS) Volatile suspended solid(VSS) Volatile dissolved solid(VDS) Chloride Sulfate Phosphate Alkalinity & acidity Nitrite-N Ammonia-N Sodium Potassium Calcium Magnesium Hardness Heavy metals(Pb, Cd, Ni,Cr,Co,Zn etc) Arsenic Cyanide Fluoride selenium	Biochemical oxygen demand (BOD) Coli form bacteria (total, fecal, fecal streptococci)

Table 2 : Typical data on the composition of leachate from new and maturation landfill

Constituents	Value (unit)		
	New landfill (less than 2 years)		Mature landfill (greater than 10 years)
	Range	Typical	
TOC(total organic carbon)	1500-20000	6000	80-60
Chemical oxygen demand(COD)	3000-60000	18000	100-500
TSS(total suspended solid)	200-2000	500	100-400
Organic nitrogen	10-800	200	80-120
Ammonia nitrogen	10-800	200	20-40
Nitrate	5-40	25	5-10
Total phosphorus	5-100	30	5-10
Alkalinity as $CaCO_3$	1000-10000	3000	200-1000
pH	4.5-7.5	6	6.6-7.5
Total hardness as $CaCO_3$	300-10000	3500	200-500
Calcium	200-3000	1000	100-400
Magnesium	50-150	250	50-200
Potassium	200-1000	300	50-400
Sodium	200-2500	500	100-200
Chloride	200-3000	500	100-400
Sulfate	50-1000	300	20-50
Total iron	50-1200	60	20-200

There are two options for MSW dumping all over the world, one is crude landfill (open dumping) and the other is sanitary landfill. Sanitary landfill is one of the secure and safe facilities for the disposal of MSW.A pilot scale sanitary landfill is situated at Rajbandh, Khulna in the north side of Khulna-Satkhira Highway and 8 km far from the city center. In Khulna metropolitan city, municipal solid wastes are disposed of at Rajbandh landfill site. In order to pre treat the produced leachate of landfill, firstly it goes to an anaerobic pond for oxidation. Afterwards, it is passed to 15' deep and 4'x4' sized well through pipes. Finally, it is thrown to the adjacent water surfaces. This pretreated leachate mixes with the surrounding water bodies either directly or by rainfall. Despite the pretreatment of leachate, it effects adversely to the surrounding environment and water bodies. So the aim of this study is to evaluate the impact of this pretreated leachate on the surrounding water bodies and characterize the surface water adjacent to the landfill.

The most common pathway for leachate to the environment is from the bottom of the landfill through the unsaturated soil layers to the ground water, then by groundwater through hydraulic connections to surface water. However, pollution may also result from discharge of leachate through treatment plants or direct discharge of untreated or partially treated leachate. The main factors influencing the pollution potential from leachate are:

- The concentration and flux of the leachate
- The landfill sitting, i.e., the hydro geological setting and the degree of protection provided.
- The basic quality, volume, and sensitivity of the receiving groundwater and surface water.

IV. Methodology

a) Field Work

Sample was collected weekly during July to December 2012 for six months. At Each time, total of 8 liters sample was collected in 4, two liters bottles from a distance of 0.25 m at four adjacent sides of the finally pumping out point. Temperature was maintained at 4^0C in each bottle before performing the required tests. Finally, different parameters of the collected sample were determined by performing the laboratory tests.

Table 3 : Location and description of leachate and surface water samples relative to landfill site

Sample No.	Description of Sample Point	Sample Type	Distance (m) from landfill (Reference Pt.)
1	Leachate collection point	Leachate	5m
2	North side of landfill	Surface water	150m
3	East side of landfill	Surface water	150m
4	South side of landfill	Surface water	150m
5	West side of landfill	Surface water	150m

b) Analysis of Leachate and Water Sample

Analytical methods used for leachate and water samples varied depending on the parameters of interest. All field and laboratory determinations were done according to standard methods for the examination of waste and waste water. For every sample, physiochemical, nutrients and oxygen demand parameters were determined. Physiochemical parameters were determined at the Environmental Engineering Laboratory of Khulna University of Engineering and Technology (KUET). Fe and Cadmium were determined by spectrometer.

Biochemical Oxygen Demand (BOD) was determined by diluting portions of the sample and incubating for 5 days at 20°C. The BOD exerted over the 5 days deter-mined as follows:

Calculations

$BOD_5 = BOD \times S1 \times S2$

Where,

BOD_5 = BOD recorded on the fifth day from the Oxitop

S1 = Dilution factor

S2 = Factor dependent on total volume of diluted sample put in Oxitop bottle.

In determining the Chemical Oxygen Demand (COD), the sample was refluxed in concentrated sulphuric acid with a known excess of potassium dichromate ($K_2Cr_2O_7$) for two hours. After digestion, the remaining reduced $K_2Cr_2O_7$ was titrated with ferrous ammonium sulphate to determine the amount of $K_2Cr_2O_7$ consumed and the oxidizable matter calculated in terms of the oxygen equivalent.

V. Results & Discussions

a) Physicochemical Data For Landfill Leachate

Data on parameters from leachate samples taken during the study are presented in Table 4. Average pH value of leachate obtained is 8.15 at a distance of 150 m from the landfill. Throughout the sampling period as well as outwards from the landfill, the pH of leachate remained fairly uniform. Temperature value range from a minimum of 17°C in December at distance 150 m to a maximum of 34.3°C in July at the same sampling site, i.e. 200 m from the landfill. The average value of conductivity 25256µS/cm was obtained in leachate taken respectively in July (distance 150 m) and December (distance 150 m) from the landfill. Average value for total dissolved solids (TDS) was 8906 mg/l at about 150 m from the landfill; Values of other parameters are shown in the following table.

Table 4 : Different parameters of pretreated leachate & the limiting value according to WHO

Pollutant parameters	Average values	Limiting values (according to WHO)
pH	8.15	6.5-8.5
COD	10897 (mg/l)	250
BOD	26000 (mg/l)	50
TDS	8906 (mg/l)	1000
Iron	3.8 (mg/l)	3
Cadmium	4.3(mg/l)	0.003
Sulphate	2960 (mg/l)	400
Nitrate	20(mg/l)	10
Total coliform(TC)	2735 (Nos./100ml)	<400
Conductivity	30000 (µS/cm)	
Chloride	3106(mg/l)	250
Hardness	3789(mg/l)	500

Table 5 : Physico-chemical data from surrounding surface water from 1 week to 26 weeks

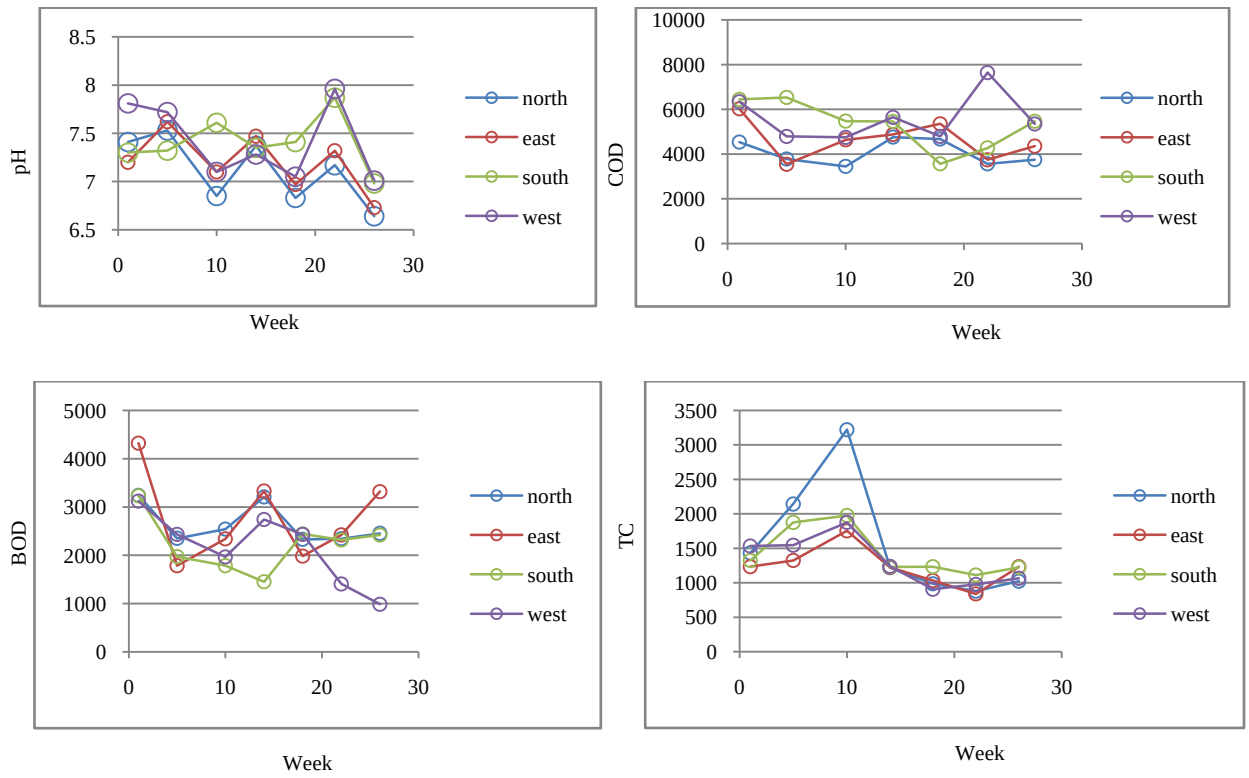
Weeks	1				5				10				14			
Sample	North	East	South	West	North	East	South	West	North	East	South	West	North	East	South	West
pH	7.41	7.2	7.3	7.81	7.53	7.62	7.32	7.72	6.85	7.1	7.61	7.1	7.37	7.47	7.35	7.28
Cond. $*10^3$ (µS/cm)	11.21	13.65	12.54	13.3	15.3	13.78	16.42	14.52	9.78	10.63	13.4	13.1	16.3	17.53	19.23	15.07
TDS (mg/l)	2534	4323	3112	2535	3454	3423	2313	3472	2354	4235	2213	4326	4532	3322	4143	4342
Fe (mg/l)	1.9	2.1	0.7	2.4	3.1	4	0.6	1.3	2.9	1.8	1.4	1.2	1.8	2.3	0.8	1.9
Cd (mg/l)	0.78	0.9	0.47	0.56	0.9	0.78	0.36	0.51	0.89	0.86	0.78	0.73	0.56	0.43	0.45	0.43
Cl^- (mg/l)	1324	1026	1022	987	1026	1132	1423	1324	1862	1322	1324	982	1425	1724	1435	875
Hardness (mg/l)	2453	2422	2212	1244	3321	3473	1212	3266	3533	4552	3215	2166	2313	3453	2533	4233
SO_4^{-2} (mg/l)	1042	1076	1234	876	986	1322	1212	1189	957	1119	1089	1011	1062	1023	975	1342
NO_3^- (mg/l)	14	13.6	14.3	11.6	7.8	10.9	9.9	13.4	15.2	14.8	14.4	11.1	9.6	14.2	11.7	8.9
COD (mg/l)	4536	6023	6443	6342	3780	3546	6532	4785	3450	4636	5472	4745	4759	4875	5458	5643
BOD (mg/l)	3243	4323	3234	3124	2353	1787	1974	2435	2543	2342	1786	1968	3211	3332	1453	2743
TC Nos./100 ml	1432	1234	1323	1533	2143	1323	1875	1545	3221	1754	1976	1876	1221	1223	1231	1238

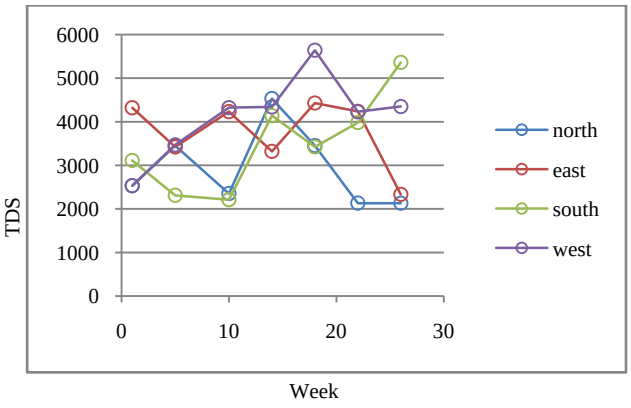
18				22				26			
North	East	South	West	North	East	South	West	North	East	South	West
6.83	6.97	7.41	7.05	7.17	7.32	7.87	7.96	6.64	6.73	6.98	7.01
19.7	20.01	22.12	14.23	17.24	15.53	16.43	12.32	13.98	12.34	13.43	13.96
3453	4431	3425	5643	2134	4241	3983	4231	2133	2334	5364	4352
0.9	0.9	1.3	3.6	1.1	1.4	2.1	2.3	2.1	1.9	2.5	2.4
0.45	0.76	0.65	0.47	0.8	0.59	0.56	0.35	0.67	0.72	0.68	0.57
1973	1231	1224	1425	986	1322	1423	1325	1423	1422	1342	1342
1023	2124	3132	1212	1239	2311	2331	1223	2123	3211	2331	1543
983	1323	878	1067	1211	1078	979	1083	1089	1028	1094	1312
8.7	12.4	10.7	12.5	12.3	13.2	15.3	13.4	15.2	13.8	12.3	12.9
4673	5354	3564	4787	3564	3745	4275	7642	3752	4356	5467	5345
2332	1985	2442	2435	2345	2424	2319	1407	2456	3321	2422	987
986	1032	1233	906	879	838	1112	975	1023	1232	1223	1065

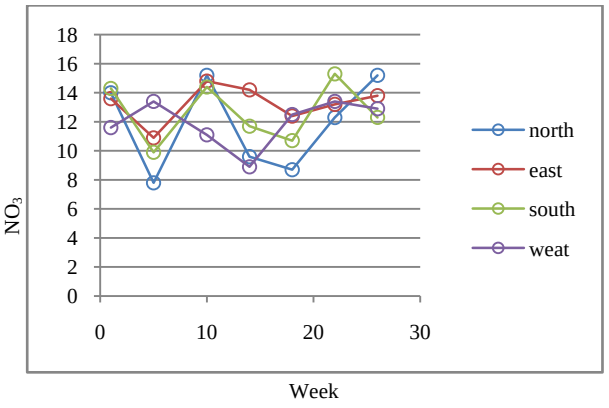
b) Physicochemical Data for Surrounding Surface Water

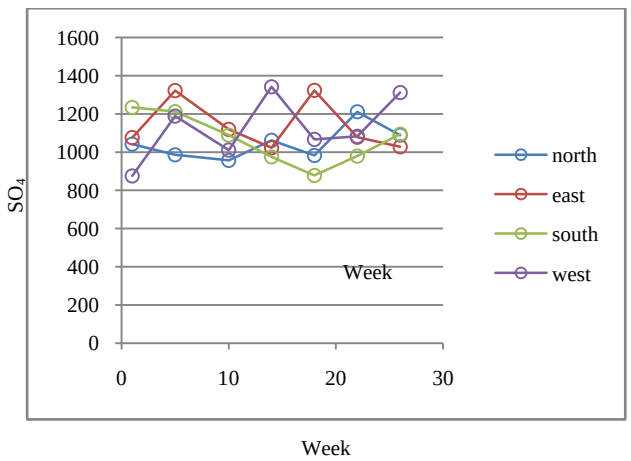
From the above table values obtained for pH ranged from 6.64 – 7.81 temperature 27.8°C - 31.2°C, conductivity 610 - 1903 µS/cm, TDS 2213 - 4532 mg/l. Fe ranged from 0.9 – 4mg/liter. Chloride and total hardness also ranged from 987 - 1724 mg/l, 1000 - 5000 mg/l, respectively.

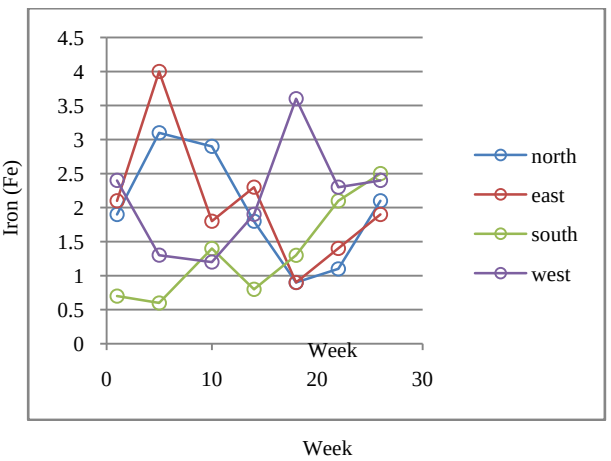
Graphical Representation

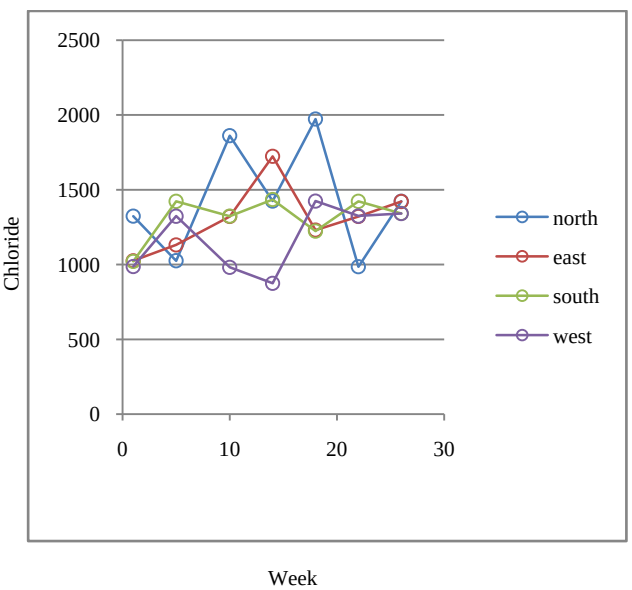


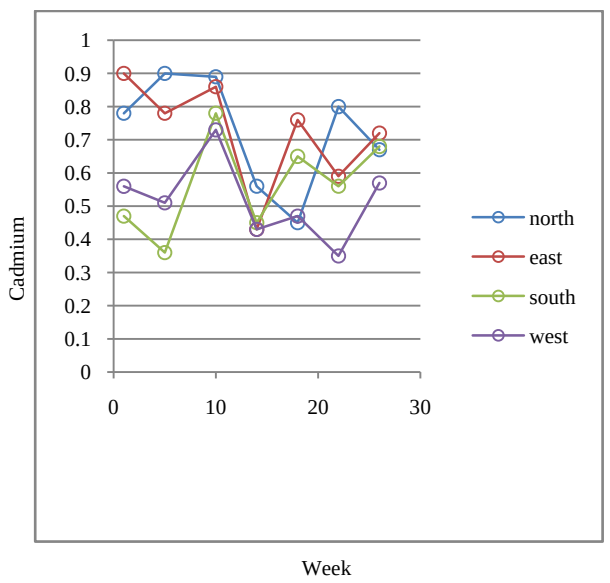


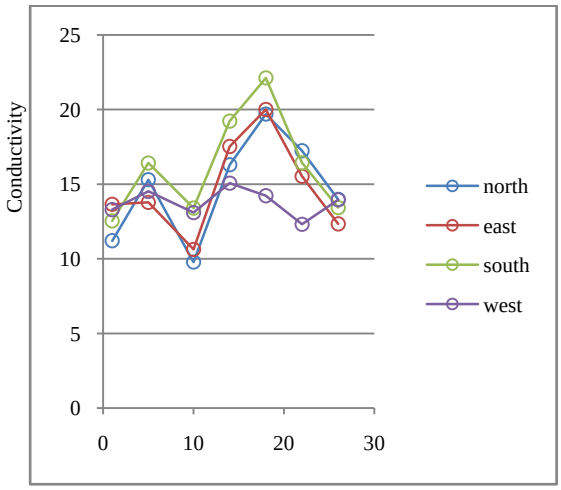


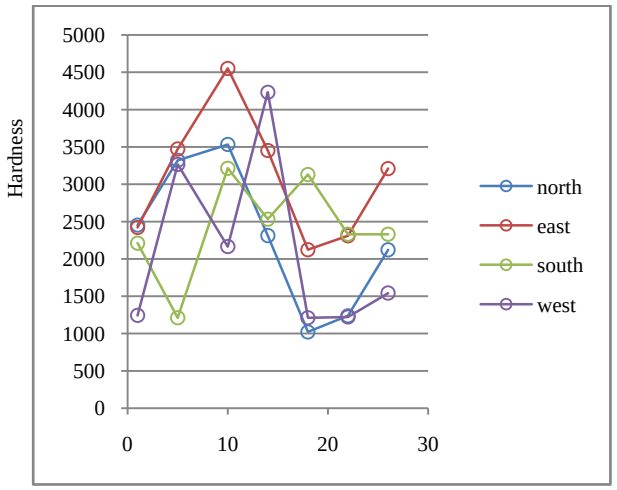












c) Comparison of Data with Who Values

Compared to WHO leachate and surface water in the present study appear to have fairly high conductivity and, to some extent, high Mn, SO_4, NO_3, and Cl contents. The limiting values of BOD and COD according to WHO are 50 and 250.However, in this study it appears large values of BOD and COD for both leachate and surrounding water. On the other hand iron content is relatively low for the surrounding water but iron content in leachate is high than that of WHO limiting value.

VI. Conclusion

The concentration of heavy metals: Cadmium, Iron are found in the leachate and surrounding surface water of Rajbandh landfill site. Total solids, Turbidity, COD and Conductivity, also were well above the permissible levels in surface water of the surrounding area. The results show that the constituent characteristics of Municipal Solid Waste is a major factor influenced on leaching solutions and heavy metal release. Although the leachate is partially treated by roughing filter, it contains huge amount of trace metals and other hazardous compounds which mix with the surrounding surface water and causing heavy pollution of the water and soil of surrounding agricultural lands. By considering all the above facts, it is necessary of designing proper treatment method for the leachate discharging from the landfill site.

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