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CHARACTERISATION OF LEACHATE IN SOLID WASTE LANDFILL SITE: A CASE STUDY OF S. BINGIPUR IN BANGALORE

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Abstract: Living standards in developing urban areas can be improved by using proper solid waste management techniques. This helps in maintaining better health and sanitation standards. Sanitary land filling is the best method for achieving the same. The only drawback of having landfills is leachate and landfill gases that are produced. These byproducts if not controlled effectively is harmful to the health and environment. Bengaluru city has identified many disposal sites for the scientific disposal of municipal solid waste generated in its jurisdiction. This paper reviews the Characterization of Lechate, age of leachate and the nature of municipal solid waste present in one of the Solid Waste Landfill sites at S. Bingipur in Bengaluru urban district. The leachate present at the study site was characterized by collecting two leachate samples (one from the leachate outlet of underground pipe network, other in the landfill area due to rains). The study reveals that the leachate has excess of organic compounds and very low heavy metal concentrations, which indicates it was domestic in nature. The age of landfill was found to be 5-10 years.
Keywords: Municipal Solid Waste; Leachate; Landfill; Infiltration

1. INTRODUCTION

Wastes are generated by human activities on a daily basis. This waste poses risk to the environment and public health, if it it is not managed effectively. Hence these wastes are to be properly collected, treated/ recycled for protecting environment. This entire procedure is defined by the term "Solid Waste Management"(SWM).

Sanitary land filling is one of the most common and important method of disposal of solid waste. Landfill sites are basically low lying areas where the refuse is carried and dumped. Land filling is an engineered process that is planned and operated in an environmentally sound manner. Decomposition of solid waste takes place in these landfills. The bye-products of decomposition are leachate and gases like methane, carbon-dia-oxide etc. The leachate under gravity can infiltrate through the soil strata and this poses the risk of polluting the ground water. Methane gas is explosive in nature and CO_2 is readily soluble in water [2]. Thus it is of extreme importance to control the movement of these gases as well.

Leachate is a viscous black liquid formed due to water percolating through solid waste and has extracted dissolved and suspended materials [5]. The water is from external sources such as surface drainage, rainfall, ground water and water from underground springs and liquid produced from decomposition of solid waste. Due to exothermal processes inside the landfill, the temperature of the leachate is usually higher than typical groundwater in the area [6]. Landfill leachate is usually quite turbid, has a very strong odour and a brownish black colour. This leachate percolating through the soil strata contaminates the ground water and the water bodies surrounding the landfill site causing a potential risk to public health and the environment [4]. Untreated leachate is a hazard to the environment if it is allowed to enter water body [3].

Hence this study is aimed at evaluating the extent of effect of leachate on the water bodies in and around the landfill site S.Bingipura to fulfill the following objectives:

- Characterize the leachate present at site
- Determine BOD5/COD ratio and hence determine the age of landfill.
- Determine the nature of municipal waste present at site.

2. MATERIALS AND METHODS

Samples of leachate were collected from the landfill site to determine the quality of the leachate. The site has neither any bottom liner nor any leachate treatment system. The leachate is however collected by means of proper collection system. About 2 liters of each samples was collected in clean sterilized polythene bottles and they are analyzed for their physical and chemical composition in Environmental Engineering Laboratory [1].

Table-1. Details of Leach ate Sampling locations

Location	Code	Latitude	Longitude
S Bingipur	LT1	77^{0}37'43.57" E	12^{0}50'6.71" N
	LP1	77^{0}37'30.41" E	12^{0}50'5.63" N

Figure 1. Satellite image of landfill site S.Bingipura

Various physio-chemical parameters viz Color, pH, Conductivity, Total dissolved solids(TDS), Suspended solids(SS), Total solids(TS), Total hardness(TH), Calcium hardness, Magnesium hardness, Total alkalinity, Acidity, Chlorides(Cl), Fluorides(F), Sodium (Na^{2+}),Potassium (K^{+}), Amonia, Iron(Fe), Dissolved oxygen(DO), Biological oxygen demand(BOD), Dissolved oxygen(DO), Chemical oxygen demand(COD), Lead(Pb), Nickel(Ni), Cadmium(Cd), Manganese(Mn), and Zinc(Zn) were analyzed to approximate the pollution potential of the leachate is being discharged by the land fill site. Table 2 shows the methods adopted for the various parameters of leachate analysis.

3.RESULTS AND DISCUSSIONS

On testing of leachate sample, it was found that there is a high concentration of organic and inorganic constituents. Also the heavy metal concentration was in traces. It indicates that the waste is domestic in nature. The leachate being highly contaminated requires proper treatment before being disposed of into any inland surface waters, public sewers or disposed of on land. Table 3 shows the results of the leachate analysis.

Table-2. The Methods of Leachate Analysis

Sl.No	Parameter	Unit	Method adopted
1	Color	Hazens	Tintometer
2	Turbidity	NTU	Nephleometer
3	pH value	-	Digital pH meter
4	Conductivity	µS/cm	Conductivity meter
5	Total dissolved Solids	mg/l	Filter paper method
6	Suspended solids	mg/l	Filter paper method
7	Total solids	mg/l	Oven drying method
8	Total Hardness as CaCO3	mg/l	EDTA method
9	Calcium Hardness as CaCO3	mg/l	EDTA method
10	Magnesium Hardness as MgCO3	mg/l	EDTA method
11	Total Alkalinity as CaCO3	mg/l	Titration
12	Acidity	mg/l	Titration
13	Chlorides as Cl-	mg/l	Aginometric Titration
14	Sulphates as SO42-	mg/l	Flame Photometer
15	Nitrates as NO3-	mg/l	Titration
16	Fluorides as F-	mg/l	Ion Analyzer
17	Sodium	mg/l	Flame Photometer
18	Potassium	mg/l	Flame Photometer
19	Ammonia	mg/l	Titration
20	Iron as Fe	mg/l	Spectro-photometer
21	DO	mg/l	Winkler's method
22	BOD	mg/l	Dilution method
23	COD	mg/l	Autoclave method
24	Lead	mg/l	Absorption Spectro-photometer
25	Nickel	mg/l	Absorption Spectro-photometer
26	Cadmium	mg/l	Absorption Spectro-photometer
27	Manganese	mg/l	Absorption Spectro-photometer
28	Zinc	mg/l	Absorption Spectro-photometer

— Colour

The colour of the leachate samples was dark black. Also there was a foul odour associated with the leachate, which is mainly because of the presence of organic acids, which comes from the high concentration of organic matter when decomposed. The colour varies from 9 to 54 Hazens. Higher concentration of colour indicates the presence of high organic substances.

— Turbidity

Turbidity values of the leachate samples were 423 NTU and 63 NTU respectively. The leachate lake has higher turbidity due to its age and stabilization of leachate. These values are considerably higher than the standard limits.

— pH

pH values of the leachate samples were 9.56 and 8.42 respectively. Higher pH signifies that the leachate is more stabilized than that of a young leachate. Leachates are generally found to have pH ranging between 4.5 and 9. According to Chian and DeWalle, pH of leachate increases with time due to decrease in the concentration of partially ionized free volatile solids. An increase in pH suggests that a steady state has been reached between acid producing process and acid consuming process at the landfill.

— Conductivity

Conductivity values of the leachate samples were 22460 µS/cm and 11100 µS/cm respectively. This is generally influenced by the total amount of dissolved organic and inorganic materials present in the solution, and is used to demonstrate the salinity and mineral content of leachate. Total mineral content further reflects the strength and overall pollution of the leachate. The salt content in the leachate is due to the presence of potassium, sodium, chloride, nitrate, sulphate and ammonia salts. The leachate sample seems to have high value as a consequence of degradation of organic matter.

— Total Dissolved Solids, Suspended Solids and Total Solids

TS and SS values of leachate samples were 15330mg/l & 7390 mg/l; and 750 mg/l &180 mg/l respectively. TDS values of leachate samples were 14580 mg/l and 7150 mg/l respectively. TDS comprises mainly of inorganic salts and dissolved organics. These values are considerably higher than the standard limits.

— Total Hardness, Calcium Hardness and Magnesium Hardness

Total hardness, Calcium hardness and Magnesium hardness values of leachate samples were 1781 mg/l & 921.26 mg/l; 1200 mg/l & 550 mg/l; and 581.66 mg/l & 370.83 mg/l respectively. These values are considerably higher than the standard limits.

Table 3. Results of Leachate Characterization

Sl No	Parameter	Unit	LT1	LT2	Standards (Mode of disposal)*[7]		
					Inland surface waters	Public Sewers	Land Disposal
1	Colour	Hazens	54.00	9.00	-	-	-
2	Turbidity	NTU	423.00	63.00	5	10	10
3	pH value	-	9.56	8.42	5.5-9.0	5.5-9.0	5.5-9.0
4	Conductivity	µS/cm	22460.00	11110.00	-	-	-
5	Total dissolved Solids	mg/l	14580.00	7150.00	2100	2100	2100
6	Suspended solids	mg/l	750.00	180.00	100	600	200
7	Total solids	mg/l	15330.00	7390.00	-	-	-
8	Total Hardness as CaCO3	mg/l	1781.00	921.26	300	-	-
9	Calcium Hardness as CaCO3	mg/l	1200.00	550.00	-	-	-
10	Magnesium Hardness as MgCO3	mg/l	581.66	370.83	-	-	-
11	Total Alkalinity as CaCO3	mg/l	6053.00	2697.00	-	-	-
12	Acidity	mg/l	BDL	BDL	-	-	-
13	Chlorides as Cl-	mg/l	3826.00	2100.00	1000	1000	600
14	Sulphates as SO_4^{2-}	mg/l	940.00	426.10	-	-	-
15	Nitrates as NO_3-	mg/l	123.00	59.23	-	-	-
16	Fluorides as F^-	mg/l	2.12	1.23	-	-	-
17	Sodium	mg/l	3875.00	1942.00	-	-	-
18	Potassium	mg/l	156.00	54.00	-	-	-
19	Ammonia	mg/l	72.14	5.24	-	-	-
20	Iron as Fe	mg/l	1.45	0.89	-	-	-
21	DO	mg/l	ND	ND	-	-	-
22	BOD	mg/l	1242.00	150.00	30	350	100
23	COD	mg/l	6923.00	723.14	250	-	-
24	Lead	mg/l	0.03	0.02	-	-	-
25	Nickel	mg/l	0.01	0.01	-	-	-
26	Cadmium	mg/l	0.01	0.01	-	-	-
27	Manganese	mg/l	0.43	0.3	-	-	-
28	Zinc	mg/l	1.20	0.8	-	-	-

Abbervations used: LT1 is the Leachate Lake Sample; LP1 is the Leachate Pond Sample; BDL- Below Detective Level; ND-Not Detected

— Alkalinity and acidity

Alkalinity values of leachate samples were 6053 mg/l and 2697 mg/l respectively. A high alkalinity suggests that the leachate is in steady state. Acidity values of leachate samples were found to be below detection limit, which again implies that the leachate sample is achieving its steady state.

— Chlorides

The chloride values of the leachate samples were 3826 mg/l and 2100 mg/l respectively. These are higher than the standard limits. According to Deng and Englehardt (2007), the concentration of chlorides may range between 200 to 3000 mg/l for a 1-2 year old landfill and the concentration decreases to 100 to 400 for a landfill greater than 5-10 years old.

— Sulphates

Sulphate values of the leachate samples were 940 mg/l and 426.1 mg/l respectively. The sulphate content of leachate mainly depends on the decomposition of organic matter present in the solid wastes. It is expected to decrease with refuse age. This decrease is caused by the reduction of sulphate to sulphide coincident with the initiation of anaerobic conditions in the landfill. Thus, the sulphate concentration in leachate can also be used as an indicator of waste stabilization within landfill.

— Nitrates

The nitrate values for leachate samples were 123 mg/l and 59.223 mg/l respectively. The measured nitrate values were considerably higher than the standard limit. Microbial decomposition of organic carbon influences on many processes of the nitrogen cycle. With time, nitrogen concentration decreased due to microbial utilization of nitrate compounds and denitrifying as ammonia gas. Nitrates are the primary contaminant that leaches into groundwater.

— Fluorides

The fluoride values for leachate samples were 2.12 mg/l and 1.23 mg/l respectively.

— Sodium

The sodium values for leachate samples were 3875 mg/l and 1942 mg/l respectively.

— Potassium

The potassium values for leachate samples were 156 mg/l and 54 mg/l respectively.

— Ammonia

The ammonia values for leachate samples were 72.14 mg/l and 5.24 mg/l respectively.

— DO, BOD and COD

The DO values for leachate samples not detectible.

BOD is the measure of biodegradable organic mass of leachate and that indicates the maturity of the landfill which typically decreases with time. In this study, the BOD values for leachate samples were 1242 mg/l and 150 mg/l respectively. A new landfill has a BOD value of 2000 to 30,000 mg/l; whereas for a matured landfill its value varies between 100 to 200 mg/l.

COD represents the amount of oxygen required to completely oxidize the organic waste constituents chemically to inorganic end products. The COD values for leachate samples were 6923 mg/l and 723.14 mg/l respectively.

Organics in leachate are characterized by different levels of biodegradability. In this study, the BOD5/COD ratios for the collected leachate samples were 0.179 and 0.217 respectively. Generally, the BOD5/COD ratio describes the degree of biodegradation and gives information on the age of a landfill. The low BOD5/COD ratio shows the high concentration of non-biodegradable organic compounds and thus the difficulty to be biologically degraded.

— Heavy Metals

Table.4 Characteristics of Leachate at different ages of landfill [8]

Parameter	Young	Intermediate	Old
Age (years)	<5	5-10	>10
Ph	6.5	6.5-7.5	>7.5
COD (mg/l)	>10000	4000 - 10000	<4000
BOD5/COD	>0.3	0.1-0.3	<0.1
Heavy metals	Low- Medium	Low	Low

Heavy metals viz Iron, Lead, Nickel, Cadmium, Manganese and Zinc values for leachate at landfilling sites were in trace amount as the waste is domestic in nature. In general, the concentration of heavy metals in landfill leachate is fairly low. Concentration of heavy metals in a landfill is generally higher at earlier stages because of higher metal solubility as a result of low pH caused by production of organic acids. As a result of decreased pH at later stages, a decrease in metal solubility occurs resulting in rapid decrease in concentration of heavy metals except lead because lead is known to produce very heavy complex with humic acids.

4.CONCLUSSION

The following conclusions has been drawn based on the results obtained in the present study.

— Leachate sample of S.Bingipura landfill has shown high concentration of organic and inorganic constituents. The concentration heavy metals was in trace, which indicates that the waste dumped is predominantly municipal waste. The traces present may be due to solid wastes like batteries, consumer electronics, light bulbs, etc. The measured leachate samples would need an appropriate treatment strategy to reduce the pollutants to a satisfactory level prior to discharge into receiving system.

— The age of the landfill has a significant effect on leachate composition. In older landfills, the biodegradable fraction of organic pollutants in the leachate decreases as an outcome of the anaerobic decomposition occurring in the landfill. The leachate analysis indicates that the landfill is 5-10 years old (Intermediate aged landfill).

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