A CASE STUDY ON CHARACTERISTICS OF SOLID WASTE & LEACHATE TREATMENT OF OKHLA LANDFILL-NEW DELHI

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Abstract

Delhi is the most densely populated and urbanized city of India. The annual growth rate in population during the last decade was almost double the national average. Delhi is also a commercial hub, providing employment opportunities and accelerating the pace of urbanization, resulting in a corresponding increase in municipal solid waste (MSW) generation. Presently Delhi generating about 6500 tonnes/day of MSW out of which only 70-75% wastes are able to collect by the MSW management authority and rest amount of wastes are not possible to collect for the habit of people to thrown the wastes in empty places. At present three main landfill sites of Delhi are Bhalaswa at north Delhi, Ghazipur at east Delhi, and Okhla at south Delhi. But not a single landfill are sanitary landfill rather wastes are dumping crudely as a heap of wastes in open landfill. As a result the leachate generated due to percolation of rain water and squeezing of wastes itself posing a great threat in the surrounding soil structure of the landfill. Around the periphery of landfill, soils gets highly contaminated and toxic and degraded it's essential nutrients [4,6]. In this paper a case study on characteristics of solid wastes of Okhla landfill and performance of it's leachate treatment is carried out for future planning and proper management of soil structure around the periphery of landfill site.

Keywords: *BOD, COD, E-coli, leachate, solid waste, TDS, etc*

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1. INTRODUCTION

Solid wastes are generated due to human as well as industrial activities and discarded directly or indirectly after it's full utilisation. Any wastes other than human excreta, urine & waste water is called solid wastes. The process of collection, transportation, treatment, and disposal can be grouped under solid waste management. Most of the landfill are being used only for ultimate disposal of municipal waste without any environmental protection [1,3]. When moisture exceeds the field capacity of the waste matrix as a result of percolation of rain water it squeezing the waste itself and form leachate. It contains a wide variety of hazardous chemicals and when transmitted around it's soil structure it degrades the quality of original soil [2]. To minimize these problems a composting plant is working in Okhla landfill and now it is the biggest solid waste management plant working in Delhi. After collection of total wastes, all the inorganic materials are discarded to landfill directly and only the biodegradable wastes are shifted to composting plant for generation of electricity. The waste is burnt sequence wise and an ash is collected to dump at landfill. Out of total quantity of wastes, only 20% of it are possible to transfer to composting plant daily. Thus major quantity of wastes is ultimately dumping into the landfill crudely. But Okhla landfill is not a sanitary landfill rather 100% crude dumping type landfill. Thus leachate produced from the wastes percolate towards downward direction as well as moves towards horizontally too openly.

Fig 1: Open leachate movement around the periphery of Okhla landfill

At present there is no facility available to MSW management authority of Delhi to give proper protection of leachate flow or have any technology for it's treatment before coming in touch with open soil. Thus to protect the soil from anticipated toxicity of leachate, a vigorous case study on the characteristics of solid wastes and it's leachate is very essential. In this paper, light is beamed on the severity of degradation of the existing soil structure around the periphery of Okhla landfill site and analyze the performance of leachate treatment by different technological options [5].

2. METHODOLOGY

The proposed methodology includes two main phases, one is the analysis of solid wastes characteristics and second is leachate characteristics with it's treatment by physico-chemical process. In below both phases of study are briefly discussed for better understanding the present scenario of soil degradation of Okhla landfill.

2.1 Analysis of Solid Waste Characteristics

A solid waste samples represent the average quality of waste with average amount of it's different constituents of the waste collected from all sources under it's jurisdiction. To collect all these wastes from different locations, nos. of vehicles are working daily under Delhi MSW management authority. In this phase of case study approximate 30-40 kg of waste is collected from a vehicle of each location as a source of waste sample of that locality of Delhi and then mixed all the samples thoroughly. For simplicity in assessment the average percentages of each component of wastes, 100 kg of mixed wastes are taken for segregation. All segregated components are then measured individually by ordinary owing machine available in the local market and all the data are noted for further course of analysis.

Fig-2: Segregation of solid wastes collected from different vehicles

2.2 Analysis and Treatment of Leachate

In the second phase, characteristics of leachate and it's treatment are studied considering two environmental conditions i.e without rainfall condition and with rainfall condition. In both cases of conditions two different samples are collected, one is directly from landfill site and another s is generated in the laboratory.

2.2.1 Sample Collection from Landfill Site

At present there is no systematic mechanism available for leachate collection in Okhla landfill rather it is coming drop by drop from bottom of the heap. For the sample of without rainfall condition, initially ten samples are collected separately from ten different locations around the periphery of landfill by a 2" PVC pipe channel and then mixed all these samples into a big jar. For the case of with rainfall condition, sample is collected from the landfill just after the day of heavy rainfall in the landfill site.

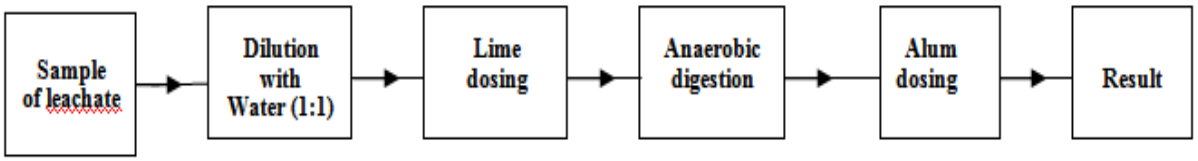
Fig-3 : Process of leachate collection

2.2.2 Sample Generated in the Laboratory

From the mixed wastes as discussed in section-2.1, roughly 100 kg of solid wastes is collected for generation of leachate samples in the laboratory. Out of this 100 kg, 50% of solid wastes are kept in a closed container for formation of leachate by anaerobic decomposition and rest 50% of wastes are kept in an open container with a provision of artificial rainfall from top and lower portion is for storage of leachate.

2.2.3 Leachate Treatment

In this section the leachate treatment has been studied by two different methods, one is physico-chemical treatment using lime & alum and second is physico-chemical with anaerobic biological treatment. In biological treatment samples are dilute by water in1:1 ratio before adding of chemicals. Dosing applied in physico-chemical treatment are 100mg/l, 150mg/l, 200mg/l, 250mg/l, and 300mg/l followed by 1-minute rapid mixing and 5-minutes slow mixing time with detention period of 2-hours for each. In physico-chemical with anaerobic biological treatment, dosing are applied same with same rapid mixing and slow mixing time but detention time are kept as 5-days instead of 2hrs. The flow diagram of physico-chemical with anaerobic biological treatment is shown below:



For the simplicity in laboratory experiments, following parameters are considered for all leachate samples: pH , BOD_3 ($27\ ^0C$), COD, TKN, TS, SS, DS, E Coli.

3. CASE STUDY

Okhla landfill is purely a open and crude dumping landfill and has no barricade around it's periphery to protect the leachates movement. Thus collection of leachate sample is not a great problem from the bottom of it's heap. The first phase of the case study is conducted continuously for eight days. Every day, about 30-40 kg of wastes are collected from different 15 vehicles as a source of wastes of 15 different locations of New Delhi. There after 100 kg of mixed wastes from these 15 samples are taken into consideration for analysis daily. All these analysis data are tabulated in table-1 for further calculation of average typical composition of solid waste of landfill in table-2. A graphical analysis (Graph-1) is also presented to compare the variation of each component of wastes of Okhla landfill.

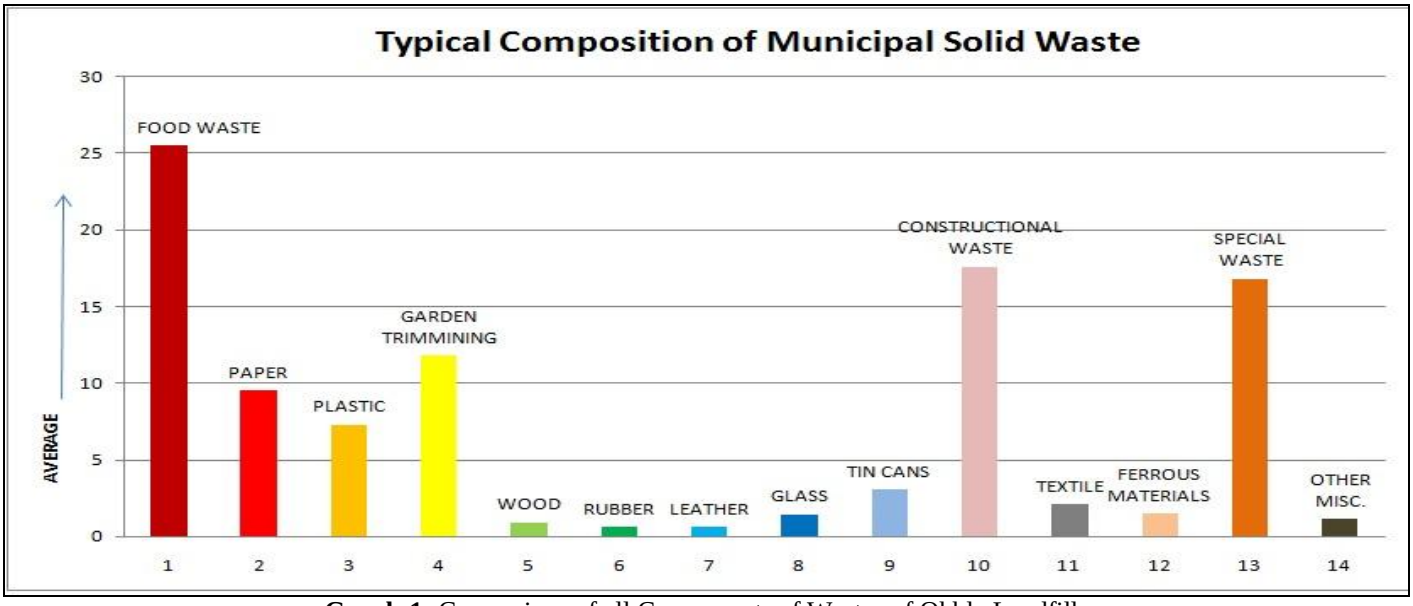
Table-1: Analysis the Composition of Solid Wastes of Okhla landfill

Composition of waste	**% by mass of weight**								
	On 10.09.14	**On 12.09.14**	**On 19.09.14**	**On 24.09.14**	**On 29.09.14**	**On 02.10.14**	**On 04.10.14**	**On 12.10.14**	**Average**
Food waste	35.30	27.60	38.15	12.50	19.75	25.25	28.65	16.85	**25.506**
Paper	12.35	11.20	8.40	10.50	6.85	7.45	9.25	10.35	9.544
Plastic	7.00	10.00	6.25	8.55	11.25	5.50	6.25	3.55	7.294
Garden wastes	9.50	7.20	11.50	9.00	15.15	10.50	12.40	19.10	11.794
Wood	1.20	0.60	2.10	0.50	0.35	1.25	0.75	0.65	0.925
Rubber	0.25	0.10	1.40	0.60	0.15	1.35	0.15	1.15	0.644
Leather	0.25	0.15	0.50	0.55	1.35	0.65	0.85	0.60	0.613
Glass	0.50	0.65	2.25	1.45	0.55	0.85	3.25	2.10	1.450
Tin cans	3.45	2.20	1.50	6.25	2.30	4.50	1.75	2.50	3.056
Demolition wastes	11.70	24.30	6.10	16.30	23.40	27.45	15.50	16.00	**17.594**
Textile	2.00	1.90	0.75	2.80	1.75	1.20	5.35	1.40	2.144
Ferrous materials	1.20	2.00	0.50	1.50	2.80	0.65	1.30	1.90	1.481
Special waste*	14.50	11.70	19.50	28.75	12.45	13.25	10.90	23.35	**16.800**
Other misc.	0.80	0.40	1.10	0.75	1.90	0.15	3.65	0.50	1.16
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100.00**

* Wastes from street sweeping, road side litters, catch basin debris, dead animals etc.

Table-2: Average Typical Composition of Solid Waste of Okhla Landfill

Composition of Waste	**Average % by mass of weight**		
Food wastes	**25.506**	Biodegradable	
Paper	9.544	Biodegradable	
Plastic	7.294	Non-Biodegradable	**Total Biodegradable Wastes = 58.464 %**
Garden Trimmining	11.794	Biodegradable	
Wood	0.925	Biodegradable	
Rubber	0.644	Biodegradable	**Total Non-Biodegradable Wastes = 41.536 %**
Leather	0.613	Biodegradable	
Glass	1.450	Non-Biodegradable	
Tin cans	3.056	Non-Biodegradable	
Demolition wastes	**17.594**	Non-Biodegradable	
Textile	2.144	Biodegradable	
Ferrous materials	1.481	Non-Biodegradable	
Special waste*	**16.800**	Non-Biodegradable	
Other misc.	1.16	Non-Biodegradable	
Total	**100.00**		



Graph-1: Comparison of all Components of Wastes of Okhla Landfill

The second phase is studied for the analysis leachate characteristics and it's treatment for the following four catagories of samples:

- Leachate sample directly from the landfill site without rainfall condition
- Leachate sample collected directly from the landfill site with rainfall condition
- Leachate sample generated in laboratory without rainfall condition
- Leachate sample generated in laboratory with rainfall condition

To generate the leachate sample in laboratory with rainfall condition, the artificial rainfall are maintained as under:

Date	Rainfall in mm/hr.
12-10.2014	35
28-10-2014	20
02-11-2014	10
14-11-2014	12
22-11-2014	8

Now the job is to do the laboratory test results of all category of leachate samples along with it's treatment followed by two different technology.

In the first case of job, all laboratory test results of leachate samples collected directly from landfill site (without rainfall condition) are tabulated below :

Table-3: Characteristics of raw leachate

Parameters	Value
pH	7.47 mg/l
BOD_3 (27 ^{0}C)	6500 mg/l
COD	17300 mg/l
$\frac{BOD_3}{COD}$ ratio = 0.375	
TKN	180 mg/l
TS	19220 mg/l
SS	57 mg/l
DS	19,163 mg/l
Total Coliform (E-coli)	3.6 x 10^5 / 100 ml

Table-4: COD-Removal after Alum Treatment

Alum – dosing mg/l	pH	COD mg/l	% removal
100	7.41	16,200	6.36
200	7.38	15,500	10.40
250	7.35	15100	12.72
300	7.33	14600	15.61
350	7.31	13800	20.23

Table-5: COD-Removal after Lime Treatment

Lime – dosing mg/l	pH	COD mg/l	% removal
100	7.47	16900	2.31
200	7.58	16300	5.78
250	7.66	15800	8.67
300	7.79	15200	12.14
350	7.83	14800	14.45

Table-6: COD-Removal after Lime - Alum Treatment

Lime – dosing mg/l	Alum – dosing mg/l	pH	COD mg/l	% removal
100	100	7.43	15,100	12.72
200	200	7.49	14,700	15.03
250	250	7.52	13900	19.65
300	300	7.56	13200	23.70
350	350	7.58	12800	26.01

Table-7: COD-Removal after Lime - Alum with Biological Treatment

Lime – dosing mg/l	Alum – dosing mg/l	pH	COD mg/l	% removal
100	100	7.43	12,300	28.90
200	200	7.49	11,900	31.21
250	250	7.52	11400	34.10
300	300	7.56	10800	37.57
350	350	7.58	10600	38.73

As a second case of job, laboratory test result of leachate sample generated in laboratory (without rainfall condition) is tabulated below:

Table-8 : Characteristics for raw leachates

Parameters	Value
pH	8.30 mg/l
BOD_3 (27 ^{0}C)	1135 mg/l
COD	4432 mg/l
$\frac{BOD_3}{COD}$ ratio = 0.256	
TKN	26 mg/l
TS	2535 mg/l
SS	72 mg/l
DS	2463 mg/l
E-coli	3.6 x 10^5 / 100 ml

In the third case of job, all laboratory test results of leachate samples collected directly from landfill site (with rainfall condition) are tabulated below :

Table-9: Characteristics for raw leachates

Parameters	Value
pH	7.48 mg/l
BOD_3 (27 ^{0}C)	62 mg/l
COD	320 mg/l
$\frac{BOD_3}{COD}$ ratio = 0.193	
TKN	11.3 mg/l
TS	6021 mg/l
SS	895 mg/l
DS	5126 mg/l
E-coli	3.6 x 10^5 / 100 ml

Table-10: COD – removal after Alum Treatment

Alum – dosing mg/l	pH	COD mg/l	% removal
100	7.44	275	14.06
150	7.33	240	25.00
175	7.25	180	43.75
200	7.09	115	64.06

Table-11: COD – removal after Lime Treatment

Lime – dosing mg/l	pH	COD mg/l	% removal
100	7.61	305	4.68
150	7.69	292	8.75
175	7.76	287	10.31
200	7.88	282	11.88

Table-12: COD – removal after Lime – Alum Treatment

Lime – dosing mg/l	Alum – dosing mg/l	pH	COD mg/l	% removal
100	100	7.55	245	23.43
150	150	7.57	220	31.25
175	175	7.68	160	50.00
200	200	7.74	93	70.94

Table-13: COD-Removal after Lime - Alum with Biological Treatment

Lime – dosing mg/l	Alum – dosing mg/l	pH	COD mg/l	% removal
100	100	7.53	227	29.06
150	150	7.55	196	38.75
175	175	7.61	132	58.75
200	200	7.69	51	84.06

Last data is for the sample generated in laboratory (with rainfall condition) given below :

Table-14: Characteristics for raw leachates

Parameters	Value
pH	7.31 mg/l
BOD_3 (27 ^{0}C)	56 mg/l
COD	218 mg/l
$\frac{BOD_3}{COD}$ ratio = 0.193	
TKN	9.5 mg/l
TS	5238 mg/l
SS	998 mg/l
DS	4240 mg/l
E-coli	3.6 x 10^5 / 100 ml

4. DISCUSSION ON EXPERIMENTAL RESULTS

The percentage wise components of solid waste of Okha landfill varied widely from one to one and 'Food Wastes' only itself contributes highest 25.506% of the total wastes of the landfill. The components 'Demolition wastes' & 'Special waste' are 17.594% and 16.80% respectively and stood the next to food wastes accordingly. The minimum % claimed by 'Leather' and 'Rubber' components that are '0.613%' and '0.644%' respectively. But the Ferrous materials, glass, tin, paper, plastic are not found in large quantity may be the reason for the segregation of all these items from the source of generation initially.

The colour of leachate for all samples are almost same and looks blackish. Study reveals that BOD, COD, TS, TSS and TDS concentrations are always high in leachate without rainfall condition. But rainfall dilutes the concentrations of all above contaminations and transferred to soil structure of landfill. Only the pH values are increases after rainfall in the leachate. Pertaining to the microbiological characteristics of leachate it may be noted that in all types of leachate, coliform organism counts are above 3.6×10^5/100ml. This may have a serious implication when leachate finds it's way into a nearby water body or spot sources. In analysis on the performances of leachate treatment, the anaerobic biological treatment shows best result in respect of all types of physico-chemical treatments and only in physico-chemical treatment, better performance shows by alum than lime.

5. CONCLUSION

The characteristics of solid wastes generated in the different places of Delhi are very typical and it's compositions varied widely by weight from each other. From study it reveals that total decomposable wastes are approximately 58.464% where as non-decomposable i.e inorganic wastes are 41.536 % that posses a great threat to Okhla landfill for shortage of land area in future. The production of inorganic wastes should be minimize at the source of generation and is better to reuse in any constructional project. The contamination of leachate after rainfall becomes very low except coliform count. This lighted a clear indication of pollution of landfill due to non available of barricade that needs protection for the existing vital environment soil, air, water and biota.

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