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Seasonal Variation Analysis of Leachate Contamination Potential from Landfill using Leachate Pollution Index

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Abstract: Co: ntaining hundreds of different chemicals, the characteristics of municipal landfill leachate vary greatly within an individual landfill over space and time. Also, leachate characteristics vary considerably from one landfill to another. For the proper and efficient operation of leachate treatment, evaluation of seasonal variation plays an important role. The contamination potential of leachate can be calculated in terms of LPI. The calculated LPI of Okhla Sanitary landfill was 62.32 and 44.14 in the summer and winter seasons respectively.
Keywords: Waste, Okhla Landfill, Leachate and LPI

I. INTRODUCTION

Solid waste is unwanted & discarded solid fractions, arising mainly due to human activities. Since the evolution of civilization humans have always generated solid waste. During the earlier part of civilization the nature of solid waste generated was mainly organic and was mostly scattered. With the development, Industrialization took place resulting in change in characteristics of solid waste generated as more and more inorganic waste was being generated [**9**]. The poor collection and inadequate transportation are responsible for accumulation of MSW at every nook and corner of Indian cities. During rainfall, the dumped solid wastes receive water and the by-products of its decomposition move into the water through the waste deposition. The liquid containing innumerable organic and inorganic compounds is called "Leachate". It is a highly complex mixture of soluble, insoluble, organic, inorganic, ionic, non-ionic and bacteriological constituents in an aqueous medium. Containing hundreds of different chemicals, the characteristics of municipal landfill leachate vary greatly within an individual landfill over space and time. Also, leachate characteristics vary considerably from one landfill to another [**6**]. For the proper and efficient operation of leachate treatment, evaluation of seasonal variation plays an important role [**4**]. A typical composition of leachate is shown in Table 1.

Table 1: Composition of a Typical Leachate from a Sanitary Landfill [1]

Components	Typical Value	Range
BOD5	10,000	200 - 40,000
COD	30,000	300 – 90,000
Total Organic Carbon (TOC)	6,000	1,500 – 20,000
Total Suspended Solids (TSS)	500	200 – 1,000
Specific conductivity	6,000	3,000 – 9,000
Nitrate	25	5 - 40
Total Phosphorus	30	1 – 70
Alkalinity as CaCO3	3,000	1,000 – 10,000
Total Hardness as CaCO3	3,500	300 – 10,000
Calcium	1,000	200 – 3,000
Magnesium	250	50 – 1,500
Potassium	300	200 – 2,000
Sodium	500	200 – 2,000
Sulfate	300	100 – 1500
Chloride	2,000	100 – 3,000
Total iron	60	25 – 2,500
Zinc	50	25 - 250
Lead	2	0.2 - 10
PH	6.0	4.2 – 7.8

Note: All value in mg/l except PH without unit and specific conductivity in MHO/cm

Leachate from a landfill varies widely in composition depending on the age of the landfill and the type of waste that it contains. Areas near landfills have a greater possibility of groundwater contamination because of the potential pollution source of leachate originating from the nearby site. Delhi does not have any engineered disposal site for disposal of MSW. This is resulting in Contamination of ground water due to Leachate generating at the dumping site, foul smell emanating to nearby areas & aesthetically unpleasant scene for the people living in the neighborhood & also for the passer-by. Present study deals with seasonal variation analysis of leachate contamination potential using leachate pollution index.

II. CONCEPT OF LEACHATE POLLUTION INDEX (LPI) [7]

The LPI represents the level of leachate contamination potential of a given landfill. It is a single number ranging from 5 to 100 that expresses the overall leachate contamination potential of a landfill based on several leachate pollution parameters at a given time. It is an increasing scale index, wherein a higher value indicates a poor environmental condition.

A. Variable Selection

Eighteen leachate pollutant variables were selected for inclusion in LPI. They are pH, Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD5), Chemical Oxygen Demand (COD), Total Kjeldahl Nitrogen (TKN), Ammonia Nitrogen, Total Iron, Copper, Nickel, Zinc, Lead, Chromium, Mercury, Arsenic, Phenolic Compounds, Chlorides, Cyanide and Total Coliform Bacteria.

B. Variable Weights

The weights for these eighteen parameters were calculated based on the significance levels of the individual pollutants. The weight factor indicates the importance of each pollutant variable to the overall leachate pollution. For example, the weight factor for chromium is 0.064, and so it is most important variable than the other pollutant variables, while total iron with a weight factor of 0.045 is least important variable as compared to other pollutant variables included in LPI. The weights for other pollutant variables are TDS: 0.050; BOD_5: 0.061; COD: 0.062; TKN: 0.053; Ammonia Nitrogen: 0.051; Copper: 0.050; Nickel: 0.052; Zinc: 0.056; Lead: 0.063; Mercury: 0.062; Arsenic: 0.061; Phenolic Compounds: 0.057; Chlorides: 0.049; Cyanides: 0.058 and Total Coliform Bacteria: 0.052. The sum of the weights of all the eighteen parameters is one.

C. Variable Curves

The averaged sub index curves for each parameter were drawn to establish a relation between the leachate pollution and strength or concentration of the parameter. The averaged sub index curves are the curves that represent the relation between leachate pollution and the strength or concentration of the parameter (Fig 1).

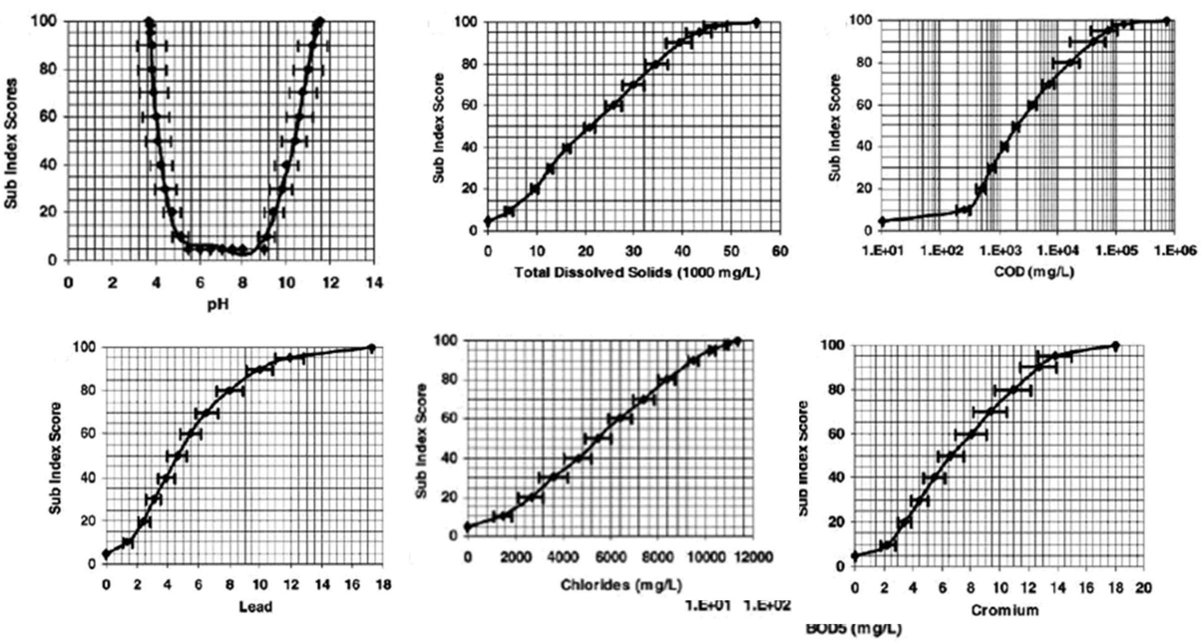

Fig 1: Sub index curves for selected parameters

D. Variable Aggregation

The weighted sum linear aggregation function was used to sum up the behavior of all the leachate pollutant variables. The Leachate Pollution Index can be calculated using the equation:

$$LPI = \sum_{i=1}^{n} w_i p_i \qquad \text{..... (1)}$$

where LPI = the weighted additive leachate pollution index,
w_i = the weight for the i^{th} pollutant variable,
p_i = the sub index value of the i^{th} leachate pollutant variable,
n = number of leachate pollutant variables used in calculating LPI

$$\sum_{i=1}^{n} w_i = 1$$

However, when the data for all the leachate pollutant variables included in LPI is not available, the LPI can be calculated using the data set of the available leachate pollutants. In that case, the LPI can be calculated by the equation:

$$LPI = \frac{\sum_{i=1}^{m} w_i p_i}{\sum w_i} \qquad \text{..... (2)}$$

where m is the number of leachate pollutant parameters for which data is available, but in that case, $m < 18$ and $w_i < 1$.

III. MATERIAL AND METHODS

A. Okhla Sanitary landfill (SLF)

The area of the National Capital Territory (NCT) of Delhi is located in northern India between the latitudes of 28°24’17” and 28°53’00” North and longitudes of 76°50’24” and 77°20’37” East with area of 1484.46 sqkm. (0.4 percent of total geographical area of India). The Union Territory Delhi is encircled by Utter Pradesh in the East, Haryana on the North, West and South. Okhla landfill site is located at Okhla Ph-I, which is about 2 km from National Highway-2 on South East end of the city, Established in 1994. The area of the landfill is 56 acres. Site serves for dumping of solid waste generated from South Delhi and Central Delhi. The SLF receives around 2000 MT of Solid Waste daily. There is no arrangement for leachate collection and treatment. Leachate is being disposed into existing sewer through open drains. The solid waste received at site is leveled and compacted with the help of hydraulic bulldozers. Average Typical Composition of Solid Waste of Okhla Landfill is given in Table 2.

Table 2: Average Typical Composition of Solid Waste of Okhla Landfill [2]

Composition of Waste	Average %by mass of weight	Category of waste
Food wastes	25.506	Biodegradable
Paper	9.544	Biodegradable
Plastic	7.294	Non-Biodegradable
Garden Trimmining	11.794	Biodegradable
Wood	0.925	Biodegradable
Rubber	0.644	Biodegradable
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
Other misc.	17.96	Non-Biodegradable
Total	100.00	

B. *Procedure to Calculate LPI*

The stepwise procedure to calculate LPI is given below:

1) Step 1 Collection of pollutant parameter data

Table 3: Leachate parameters from Okhla Solid Waste landfill site in summer and winter [4]

Parameter	Summer	Winter
pH	8.1	7.9
TDS (mg/L)	29580	34800
BOD5 (mg/L)	2250	1950
COD (mg/L)	13500	11250
Pb (mg/L)	9.5	3.8
Cr (mg/L)	11.9	4.5
Chlorides (mg/L)	4950	2850

2) Step 2 Calculating Sub-index Values

To calculate the LPI, one first computes the ‘p' value or sub-index value of the parameters from the sub-index curves based on the concentration of the leachate pollutants obtained during the tests. The ‘p’ values are obtained by locating the concentration of the leachate pollutant on the horizontal axis of the sub index curve for that pollutant and noting the leachate pollution sub-index value where it intersects the curve.

3) Step 3 Aggregation of Sub-index Values

The ‘p’ values obtained were multiplied with the respective weights assigned to each parameter. The equation (1) is used to calculate LPI if the concentrations of all the eighteen variables included in LPI are known. Otherwise, equation (2) is used when data for some of the pollutants is not available. It has been observed that LPI values can be calculated with marginal error using equation (2), when the data for some of the pollutants is not available. In the present study, out of 18, 7 significant parameters were covered, so equation (2) is used.

IV. RESULTS AND DISCUSSION

The contamination potential of leachate can be calculated in terms of LPI. The calculated LPI of Okhla Sanitary landfill was 62.32 and 44.14 in the summer and winter seasons respectively, as given in Table 4. The LPI value at was higher than its standard value of 7.4 which is the permissible limit for the leachate disposal set by the Municipal Solid Waste Management and Handling Rules, Government of India **[8].** The LPI for the two seasons was calculated to determine the seasonal variation in the pollution. The LPI values computed in this study were significantly higher than those reported for other metropolitan cities in India. The LPI value of Pune metropolitan landfill site was 24.67 in pre-monsoon and 19.04 in post-monsoon [**5**]. The calculated LPI of Njelianparamba dumping sites were 28.81 and 25.09 in the pre-and post-monsoon seasons respectively [**3**].

Table 4: Calculation of LPI

Sr. No.	Pollutant	Pollutant weight wi	Summer	Winter	Summer sub index pi	Winter sub index pi	Summer wi*pi	Winter wi*pi
1	pH	0.055	8.1	7.9	2.5	2.4	0.1375	0.132
2	TDS	0.05	29580	34800	70	82.5	3.5	4.125
3	BOD5	0.061	2250	1950	47.6	47.5	2.9036	2.8975
4	COD	0.062	13500	11250	90	82.5	5.58	5.115
5	Lead	0.063	9.5	3.8	87.5	40	5.5125	2.52
6	Cr	0.064	11.9	4.5	85	30	5.44	1.92
7	Chlorides	0.048	4950	2850	42.5	22.5	2.04	1.08
	Total	0.403					25.1136	17.7895

LPI_{summer} = 63.32 and LPI_{winter} = 44.14

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V. CONCLUSIONS

The presence of chlorides, BOD and COD indicates that leachate has significant impact on groundwater quality near the area of landfill sites. LPI reflects the composite influence of the significant pollutant variables on leachate pollution. In the present case study, the LPI value of 62.32 and 44.14 indicates that the Leachate generated from this landfill is highly contaminated and proper treatment will have to be ensured before discharging the leachate. The higher value of Leachate Pollution Index indicates that the dumping site leachate had not been stabilized. The most important aspect for the treatment of landfill leachate is controlling its concentration which varies with respect to different seasons so that the proper management of landfills is ensured. The LPI can be a very useful tool to monitor the leachate trends over the lifetime of landfill site, and thus can help to take necessary decisions. At a particular time LPI is an easy and meaningful method for assessing the leachate contamination potential. It can serve as an important information tool for the policy makers and public.

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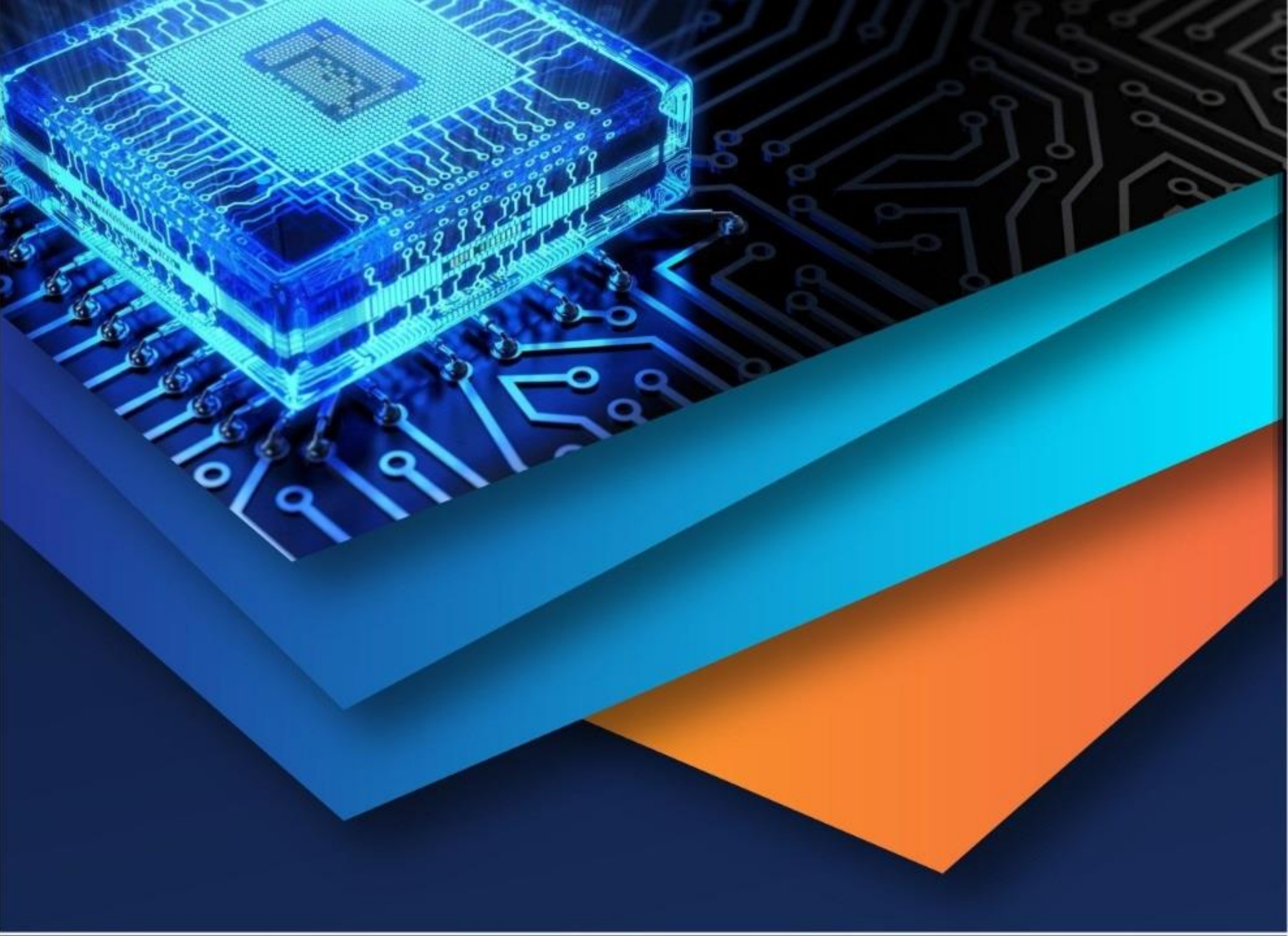

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