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Leachate Characteristics and Evaluating Leachate Contamination Potential of Landfill Sites Using Leachate Pollution Index

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Abstract **- The developing and under developing countries hazardous industrial waste is also mixed with municipal solid waste (MSW). The dumping of MSW in uncontrolled landfills can cause major impact on human health and surrounding environment. Leachate is the main culprit, causing pollution of surface water bodies and ground water. Ground water once contaminated, is very difficult task to improve. The aim of research study is to determine the leachate characteristics of Alevoor landfill near Udupi, India. The pH of samples was 8.21 and 7.77 respectively. This paper also presents the leachate contamination potential of Alevoor landfill using Rand Corporation Delphi Technique. The leachate pollution index (LPI) represents the level of contamination potential of given landfill. LPI is a single number express the overall leachate contamination potential of landfill based on several leachate pollution parameters at a given time. The LPI is also used to compare the contamination potential of different leachate sampling stations of Alevoor landfill. The LPI values of the Alevoor landfill is significantly high and proper treatment is required before the discharge of the leachate.**

Keywords: **MSW, Leachate characteristics, LPI**

I.INTRODUCTION

Leachate is slurry water from solid waste containing highly polluted suspended particle. 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. The characteristic of leachate depends on the penetration of the solid waste such as segregation of recyclable materials like plastics, paper, metals, glass, etc. Also leachate composition is influenced by many factors, types of waste deposited in landfill, composition of waste, moisture content, particle size, the degree of compaction, the hydrology of site, age of landfill, the climate, and other site conditions including liner, landfill design. The leachate produced from a landfill may enter the underlying ground water or surface water bodies and can seriously degrade the water quality. Ground water once contaminated, is difficult if not possible to improve. It has already become necessary to shutdown many drinking water wells across the world due to contamination from landfill (Masters 1998). The problem is common in under developed and developing nations, where the landfills do not have any base liners or leachate collection and treatment systems.

Kumar and Alappt (2003) have developed a technique to quantify the leachate contamination potential of different landfills on a comparative scale in terms of leachate pollution index (LPI). Leachate pollution index (LPI) has many potential applications including ranking of landfill sites, resource allocation, en-forcemeat of standards, scientific research, trend analysis, public information and scientific research.

This paper presents the leachate characteristics such as biological oxygen demand, chemical oxygen demand, suspended solids, and heavy metals, etc. And also application of LPI has been for ranking of leachates from Alevoor landfill.

Fig.1 Alevoor landfill site

Fig. 2. Sample 1

Fig. 3. Sample 2

TABLE I ALEVOOR SITE FEATURES

Features	Details
Latitude and longitude	$13^0\ 21^1\ 0^{11}$ North, $74^0\ 45^1\ 0^{11}$
Land use	Barren
Nearest highway	NH 13
Socio economic	Agriculture based
Water bodies	Small check dam within 2 Km

II. LEACHATE SAMPLING AND ANALYSIS OF VARIOUS PARAMETERS

Sample of leachate was collected from two different leachate ponds. The samples were collected in clean bottles and stored in incubator before proceeding for the analysis according to "Standard method for examination of water and wastewater" (APHA). Temperature is measured in-sit using thermometer; p^H is measured using digital pH meter in laboratory. DO of samples are calculated within two hours of samples collection using Winkler's method. BOD of samples are measured using Winkler's method after 5 days incubation at 293 K, the difference in initial and final DO gives the amount of oxygen consumed by the bacteria during the period. And also many parameters analyzed using various instruments and titration methods as show in Table 2.

TABLE II LEACHATE CHATACTERISTICS OF ALEVOOR LANDFILL

Sl.No.	Details	Titration/Instrume	Sample 1	Sample 2
1	p^H	Digital p^H meter	7.77	8.21
2	Odour	Physiological sense	Medium	Medium
3	Temperature, ^0c	Thermometer	27	27
4	Colour	Visual	Light dark	Dark
5	Turbidity, NTU	Nephelo-Turbidity meter	350	385
6	Conductivity, µS	Conductivity meter	3846	4123
7	DO, mg/L	Winkler method	1.2	1.6
8	BOD5, mg/L	Incubation followed	4800	5322
9	COD, mg/L	Reflux method	16058	18584
10	Total dissolved solids,	Conductivity meter	3117	3089
11	Total solids, mg/L	-	73.2	72
12	Filterable solids, mg/L	-	22.6	31.2
13	Sodium, mg/L	Flame photometer	3200	3850
14	Potassium, mg/L	Flame photometer	2384	3564

15	Lithium, mg/L	Flame photometer	950	1120
16	Calcium, mg/L	Flame photometer	330	280
17	Oil and Grease, mg/L	-	75	102
18	TKN, mg/L	Kjeldahl apparatus	2300	2580
19	Chlorides, mg/L	Titration	7256	6800
20	Iron, mg/L	Spectrophotometer	4.6	3.2
21	Ammonia nitrogen, g/L	Spectrophotometer	1608	1850
22	Lead, mg/L	Atomic absor	0.6	0.3
23	Zinc, mg/l	Atomic absor	1.2	0.8
24	Chromium, mg/L	Atomic absor	0.01	-
25	Arsenic, mg/L	Atomic absor	-	-
26	Mercury, mg/L	Atomic absor	0.001	0.0011

III.CALCULATING LEACHATE POLLUTION INDEX (LPI)

To comparing the leachate pollution potential of various landfills sites in geographical area 80 panelists were surveyed including scientists, consulting engineers, environmental regulatory authorities, members of international solid waste association, and academicians in environmental science throughout the world. The survey was conducted using multiple questionnaires to formulate LPI based on Rand Corporation Delphi Technique.

Panelists were also requested to rate each parameter marked 'include' according to the significance of its contribution to overall leachate pollution. The rating was to be done on a scale of 1 to 5. The value 1 was to be used for the parameter that has lowest relative 5 was to be used for the parameter that has highest relative significance. The 18 selected pollutants and the significance obtained for them are given in Table 3.

And also leachate pollution sub index score from 0 to 100 were indicated on the ordinate of each graph , while various level of strength or concentration of particular variable , up to maximum limits reported in literature, were marked along the abscissa. The panelists were requested to start the curve for each pollutant variable with a minimum value of 5 of leachate pollution even if threat is no contamination from pollutant to the overall leachate pollution. This was done to ensure that multiplicative aggregation function can be used at the later stage, if required, and the minimum value of 5 units of leachate pollution will ensure that the LPI value does not result in zero even if some of the pollutants do not show any pollution. Therefore the theoretical ranges of LPI is from 5 to 100 (Kumar and Alappat 2005).
The stepwise procedure to calculate LPI is given below.

Step 1: Testing of leachate pollutants

Analytical laboratory tests are to be performed on the leachate sample collected from the landfill to find out concentration of 18 pollutants included in LPI. It should be noted that the LPI value would be representative of the leachate data used and will provide the index value corresponding to the particular time for which data is used.

Step 2: Calculating sub- index values

To calculate the LPI, one first compute the 'p' values or sub-index values for all the 18 parameters from the sub-index curve based on the concentration of the leachate pollutants obtained during tests. The 'p' value are obtained by locating the concentration of the leachate pollutant on the horizontal axis of the sub-index curve for that pollutant and nothing the leachate pollution sub-index value where it intersect the curve.

Step 3: Aggregation of sub-index values

The 'p' values obtained above for all the parameters are multiplied with the respective weights assigned to each parameter. The equation (1) is used to calculate LPI if the concentration of all the 18 variables included in LPI are known. Otherwise, equation (2) is used. The value of LPI is obtained when the concentration of all the 18 variables included in LPI are known.

The LPI is calculated using the following equations.

$$LPI = \sum_{i=1}^{n} WiPi \quad \ldots\ldots (1)$$

Where LPI=The weighted additive leachate pollution index,
W_i= The weight for the i^{th} pollutant variable,
Pi = The sub index value of the i^{th} Leachate pollutant vairbale,
N= Number of leachate pollutant variables used in calculating LPI

$$LPI = \frac{\sum_{i=1}^{m} WiPi}{\sum_{i=1}^{m} Wi} \quad \ldots\ldots\ldots (2)$$

Where m is the number of leachate pollutant parameters for

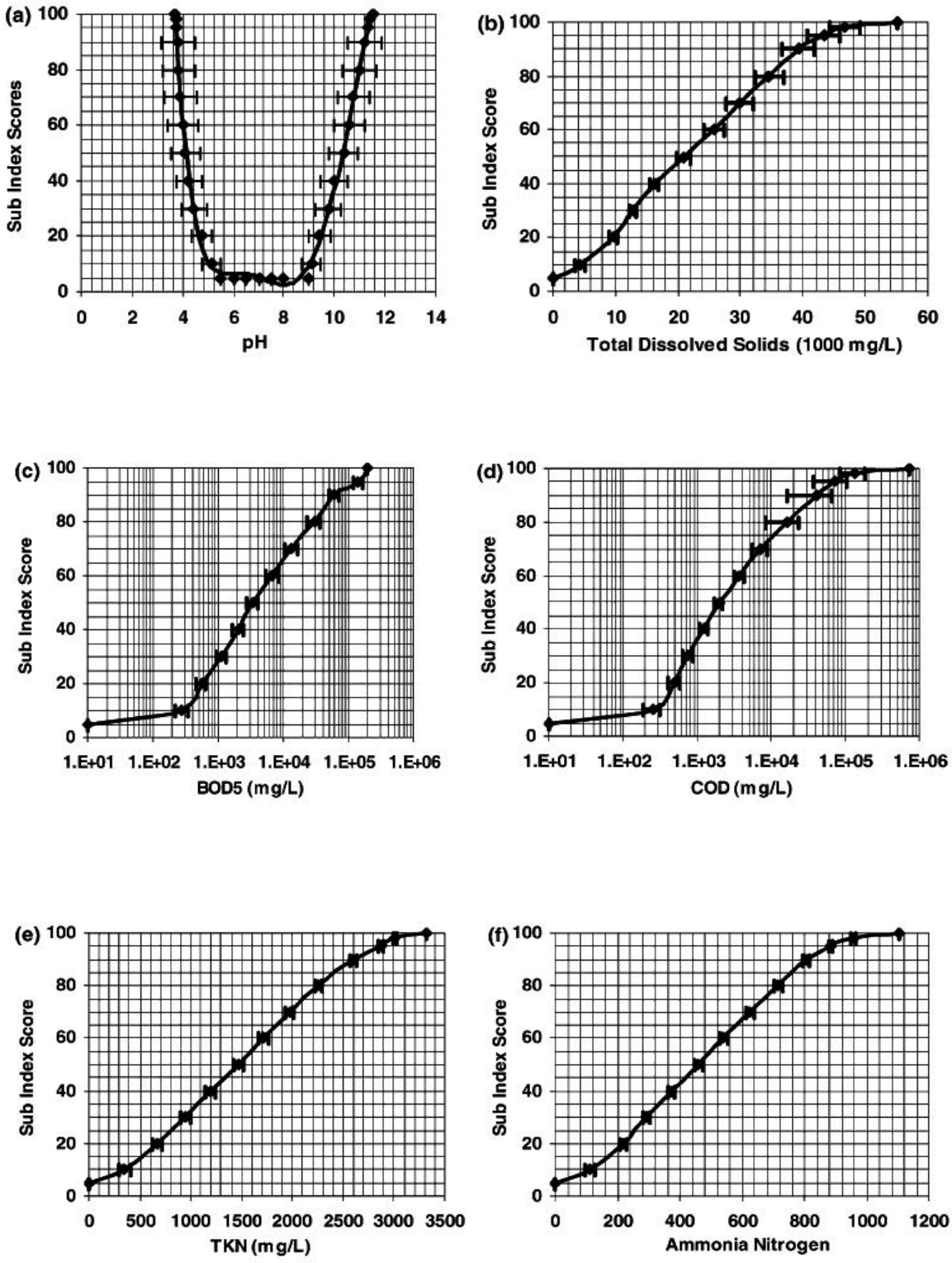
which data is available.

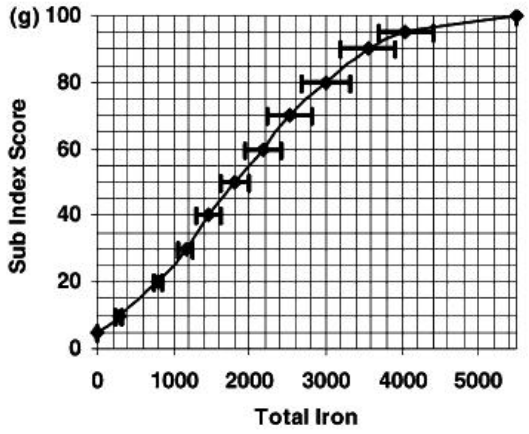
Step 4: Comaparison with standards:

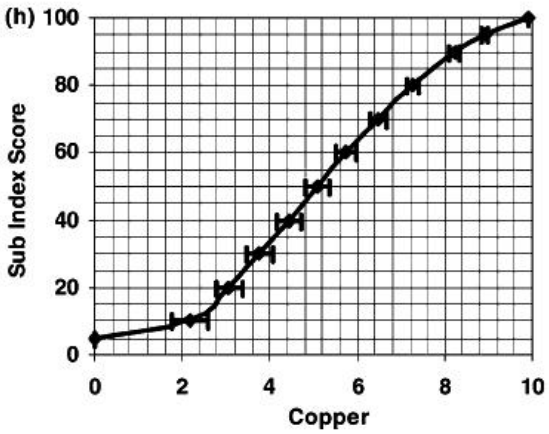
The standards for the disposal of treated leachate of treated leachate to inland surface water as per MSW management and Handling Rules, 2000 for the various parameters are presented in Table 4 and 5.

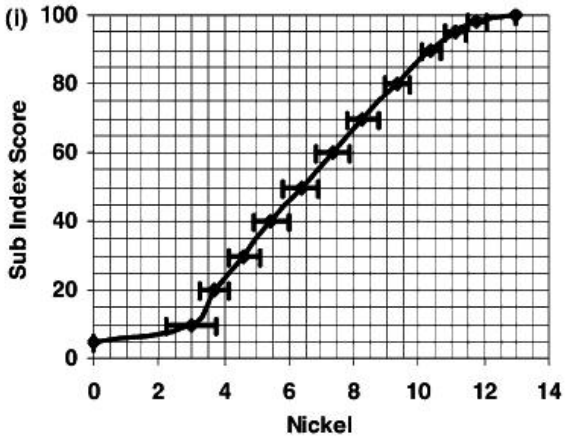
TABLE III WEIGHTS OF THE POLLUTANT PARAMETERS INCLUDED IN LEACHATE POLLUTION INDEX

Pollutant, mg/l	Significance	Weight
pH	3.509	0.055
TDS	3.196	0.050
BOD5	3.902	0.061
COD	3.963	0.062
TKN	3.367	0.053
Ammonia Nitrogen	3.25	0.051
Iron	2.83	0.044
Copper	3.17	0.050
Nickel	3.321	0.052
Zinc	3.585	0.056
Lead	4.019	0.063
Chromium	4.057	0.064
Chlorides	3.078	0.048
Mercury	3.923	0.062
Arsenic	3.885	0.061
Cyanide	3.694	0.058
Phenolic compounds	3.627	0.057
Total Coliform	3.289	0.052
Total	63.665	1.000


(a)
Sub Index Scores
pH
(b)
Sub Index Score
Total Dissolved Solids (1000 mg/L)
(c)
Sub Index Score
BOD5 (mg/L)
(d)
Sub Index Score
COD (mg/L)
(e)
Sub Index Score
TKN (mg/L)
(f)
Sub Index Score
Ammonia Nitrogen


(g)
Sub Index Score
0
20
40
60
80
100
0
1000
2000
3000
4000
5000
Total Iron


(h)
Sub Index Score
0
20
40
60
80
100
0
2
4
6
8
10
Copper


(i)
Sub Index Score
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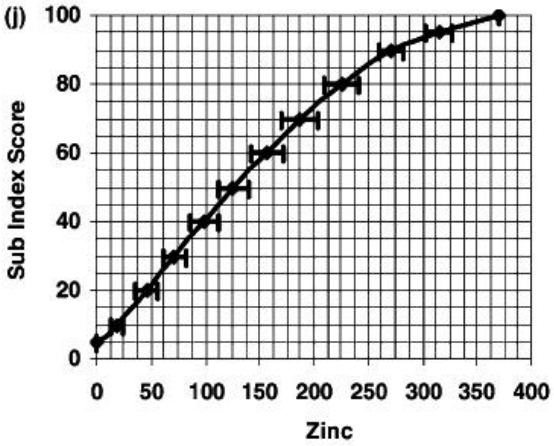
20
40
60
80
100
0
2
4
6
8
10
12
14
Nickel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Sub Index Score
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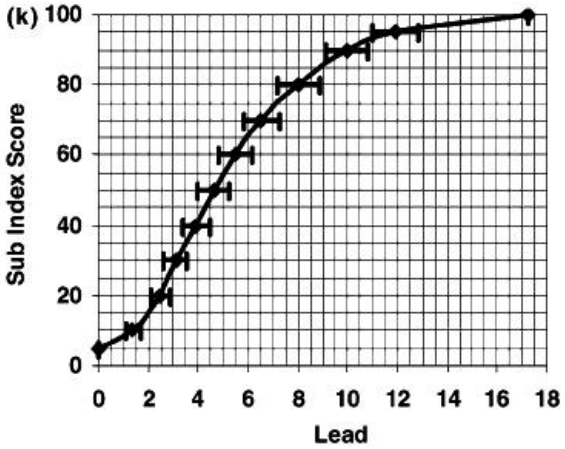
20
40
60
80
100
0
50
100
150
200
250
300
350
400
Zinc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Sub Index Score
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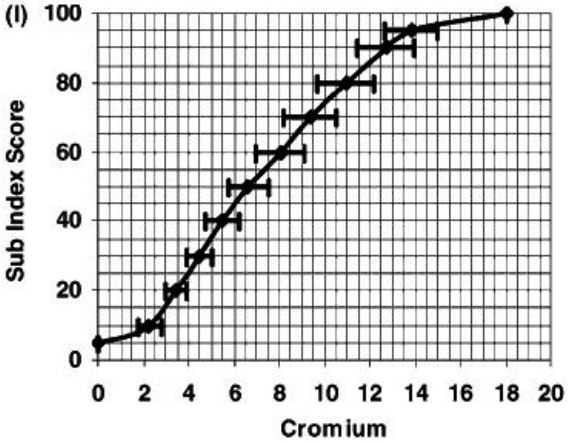
60
80
100
0
2
4
6
8
10
12
14
16
18
Lead


(l)
Sub Index Score
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20
40
60
80
100
0
2
4
6
8
10
12
14
16
18
20
Cromium

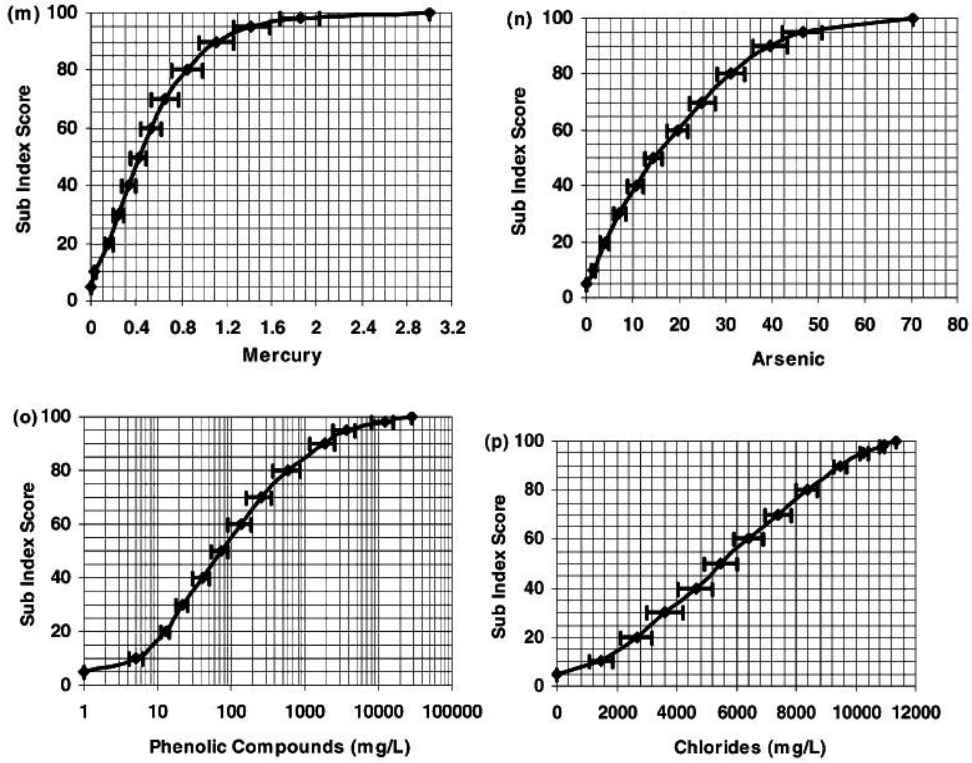

Fig 1. The average sub index curves for the leachate pollutant variables a) pH b) Total dossolved solids c) Biological oxygen demand d) Chemical oxygen demand e) TKN f) Ammonia nitrogen g) Total iron h) Copper i) Nickel j) Zinc k) Lead l) Chromium m) Mercury n) Arsenic o) Phenolic compounds P) Cholorides (Kumar and Alappat 2005).

TABLE IV LPI FOR ALEVOOR LANDFILL SAMPLE 1

Leachate Pollutant variable	Variable Weight (W_i)	Pollutant Conc.	Pollutant Sub index Value (P_i)	Overall Pollution Rating	Leachate Disposal standards
Chromium	0.064	0.01	5	0.32	2
Lead	0.063	0.6	5	0.315	0.1
COD	0.062	16058	83	5.146	250
Mercury	0.062	0.001	8	0.496	0.01
BOD_5	0.061	4800	52	3.172	30
Arsenic	0.061	-	-	-	0.2
Cyanide	0.058	-	-	-	0.2
Phenol	0.057	-	-	-	1.0
Zinc	0.056	1.2	1.1	0.0616	5.0
pH	0.055	7.77	5	0.275	5.5-9
TKN	0.053	2300	80	4.24	100
Nickel	0.052	-	-	-	3.0
TCB	0.052	-	-	-	No standard
Ammonia	0.051	1608	100	5.1	50
TDS	0.05	3177	8	0.4	2100
Copper	0.05	-	-	-	3.0
Chlorides	0.049	7256	70	3.43	1000
Iron	0.045	4.6	5	0.225	No standard
Total	0.67			23.1806	
LPI Value				34.59	

All values in mg/l, except pH and total coliform bacteria unit cfu/ml

TABLE V LPI FOR ALEVOOR LANDFILL SAMPLE 2

Leachate Pollutant variab	Variable Weight (W_i)	Pollutant Conc.	Pollutant Sub index Value (P_i)	Overall pollution Rating (W_iP_i)	Leachate Disposal standards
Chromium	0.064	0.01	5	0.32	2
Lead	0.063	0.6	5	0.315	0.1
COD	0.062	16058	85	5.27	250
Mercury	0.062	0.001	7	0.434	0.01
BOD_5	0.061	4800	56	3.416	30
Arsenic	0.061	-	-	-	0.2
Cyanide	0.058	-	-	-	0.2
Phenol	0.057	-	-	-	1.0
Zinc	0.056	1.2	1	0.056	5.0
pH	0.055	7.77	5	0.275	5.5-9
TKN	0.053	2300	81	4.293	100
Nickel	0.052	-	-	-	3
TCB	0.052	-	-	-	No standards
Ammonia	0.051	1608	100	5.1	50
TDS	0.05	3177	8	0.4	2100
Copper	0.05	-	-	-	3
Chlorides	0.049	7256	65	3.185	1000
Iron	0.045	4.6	5	0.225	No standards
Total	0.67			23.292	
LPI Value				34.76	

IV. RESULTS

The LPI values of the two landfill samples are 34.59 and 34.76 respectively. The high value of LPI demands that Leachate generated from landfill should be treated and site should be monitored on a continuous basis. The possible treatment option with high organic strength may be to use aerobic biological treatment process with extended aeration to take care of high ammonia nitrogen may be with nitrification followed by denitrification.

V.CONCLUSIONS

1. In the present cause study, the LPI values of landfill samples indicate that the leachate generated is contaminated and proper treatmrnt will have to be ensured before discharging the leachate.
2. 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.
3. At a particular time LPI is an easy and meaningful method for assessing the leachate contamination potential.
4. It can serve as an important information tool for the policy makers and public.

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