Characterization of Leachate from Municipal Solid Waste (MSW) Landfilling Sites of Kalaburagi, Karnataka, India

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Abstract: ***The paper discusses the characteristics of leachate generated from municipal solid waste landfilling sites of Udnoor village, Kalaburagi district (Karnataka). Leachate samples were collected and analysed for various physico-chemical parameters to estimate its pollution potential. This study aims to serve as a reference for the implementation of the most suitable technique for reducing the negative environmental effects of discharge leachate. The landfilling sites of Udnoor village are engineered low lying open dumps. They have bottom liner and leachate collection system. Therefore, It has been found that leachate contains high concentrations of organic and inorganic constituents beyond the permissible limits. While, heavy metals concentration was in trace amount as the waste is domestic in nature. The data presented in this study indicated that the age of the landfill has a significant effect on leachate composition. The biodegradable fraction of organic pollutants in the leachate decreases as an outcome of the anaerobic decomposition occurring in the landfill.***

Keywords: Landfilling, Leachate, Organic and inorganic constituents, groundwater, Contamination

1. Introduction

With the rapid industrialization and population growth, the status of our environment is degrading day by day. As the limits of urbanization are extending to far flying areas in India , the problem of solid waste management is causing a great concern to our environment. MSW generation, in terms of kg/capita/day, has shown a positive correlation with economic development at world scale. Due to rapid industrial growth and migration of people from villages to cities, the urban population is increasing rapidly. Waste generation has been observed to increase annually in proportion to the rise in population and urbanization. The per capita generation of MSW has also increased tremendously with improved life style and social status of the populations in urban canters [1]. As more land is needed for the ultimate disposal of these solid wastes, issues related to disposal have become highly challenging [2]. Seeing the scenario of increase in generation, improper utilization and disposal of waste in the country, the Ministry of Environment and Forest (MOEF) has Municipal Solid Waste (Management and Handling) Rules, 2000[3], which states that Municipal Solid Waste (MSW) is commercial and residential wastes generated in a municipal or notified areas in either solid or semi-solid form, excluding industrial hazardous wastes but including treated biomedical wastes. These solid wastes are generally disposed off in a low lying area called sanitary landfill area by the municipal authorities. These rules have specified many compliance for the management of solid waste for the State Committee and Pollution Board, which includes proper segregation of solid waste into biodegradable waste, recyclable and others i.e., non-recyclable wastes are stored in coloured bins at the source of generation and properly treated, recycled and disposed to landfill areas.

The quantity of municipal solid waste in developing countries has been consistently rising over the years [4]. Today more than 45 million tonnes/year of solid waste is generated from the urban centres of India which are collected inefficiently, transported inadequately and disposed unscientifically [5]. The generation is expected to rise to 125 million tonnes/ year by the year 2025 [6]. According to Ministry of Urban Affairs, Govt. of India estimate, India is generating approximately 100,000 metric tonnes of solid waste everyday of which 90 % is dumped in the open place [7]. In Delhi, the capital of India alone, more than 6,800 tonnes of MSW is generated every day and is expected to rise to 12,750 tonnes per day by 2020 [8]. The MSW generated per day in India's other major cities are Mumbai- 6,500 tonnes, Kolkata-3,670 tonnes, Chennai-4,500 tonnes, Bangalore-3,700 tonnes, Hyderabad-4,200 tonnes, Lucknow-1,200 tonnes and Ahmedabad- 2,300 tonnes [7].

2. Materials and Methods

2.1 Study Area

Gulbarga is an historical city located in north east of Karnataka. It is the administrative capital of Gulbarga District and is located at a distance of 613 km from state's capital Bangalore. It is the head quarters of the Gulbarga district. The city is located at 17° 22' N and 76° 47' E. Gulbarga was earlier known as 'Kalburgi', which means stony land in Kannada. Gulbarga was formerly in the Hyderabad state of Nizam and became a part of Karnataka State after re-organization of states. Recorded history of this district dates back to the 6th Century A.D. The district was ruled by various dynasties of kings. In 1948 Hyderabad state became a part of Indian Union and in 1956. Gulbarga is known for its historical monuments built during bahumani kings, religious places and is more importantly as a commercial hub for the Hyderabad Karnataka region.

Gulbarga is primarily a regional market and service center for the district and also a education center and is home to the Jnana Ganga University and other education centers including Medical, Engineering, pharmacy, Dental, Law, Nursing and other Colleges. Gulbarga is served by a major rail line connecting Bangalore to Mumbai and New Delhi and has a national highway. The nearest airport is in Hyderabad. The city is at a distance 212 KM from Hyderabad, 360 KM from Hubli and 606 KM from Mumbai. The city is well connected by road and train to its neighbouring districts

India Karnataka Gulbarga Dist

Figure 3.1: Showing the Location of UDNOOR SITE

2.2 Sampling

To determine the quality of leachate, integrated samples was collected from landfill locations. Leachate sample for the study was collected from the landfilling sites of Gulbarga city as shown in figure 3.2 i.e. first land filling site is on ring Road at Udnoor Village having 28 acres of low lying land area. These sites are engineered low lying open dumps. They have bottom liner for leachate collection system. These landfilling sites were equipped with leachate collectors. Leachate samples were collected from the base of solid waste heaps where the leachate was drained out by gravity.

Leachate samples were collected in October end 2015 to July 2016 at monthly once as fresh samples from the landfilling sites located 13 km from Gulbarga city. Various physico-chemical parameters like pH, Total Solids (TS) Suspended Solids (TSS), Total Dissolved Solids (TDS), Hardness, Biological Oxygen Demand (BOD_3), Chemical Oxygen Demand (COD), Chloride (Cl^-), Nitrate (NO_3^-), Total Phosphorus (TP), Sulphate (SO_4-) and heavy metals like Iron (Fe), Lead (Pb), Copper (Cu), Nickel (Ni) were analysed by standard water and wastewater methods as shown below in table 4.

Table 4: Analytical Methods and Equipment used in the study

S .NO	Parameters	Methods	Equipment's
1	pH	Electrometric	pH Meter
2	Total Solids-TS	Gravimetric method	Oven
3	Suspended Solids-SS	Gravimetric method	Oven
4	Total Dissolved Solids-TDS	Total dissolved solids	Oven
5	Total Hardness – TH	EDTA Titrimetric method	-
6	Chloride-Cl	Argentometric Method	-
7	Chemical Oxygen Demand-COD	Open Reflux Method	Reflux Condenser
8	Biochemical Oxygen Demand-BOD3	Titrimetric Method	Incubator
9	Nitrates – NO3	Phenoldisulphonic acid method	Spectrophotometer
10	Sulphate – SO4	Turbidimetric method	Spectrophotometer
11	Phosphate-PO4	Stannous chloride method	Colorimeter
12	Iron-Fe	Phenanthroline method	Spectrophotometer
13	Lead-Pb	Dithizone method	Spectrophotometer
14	Copper-Cu	Neocuproine method	Spectrophotometer
15	Nickel-Ni	Atomic absorption spectrometric method	Spectrophotometer

3. Results and Discussion

3.1 Characteristics of Leachate at Udnoor Site Gulbarga

Leachate samples collected fromUdnoor site in Gulbarga and they are analyzed for the Following parameters and the results of the leachate sample are tabulated in the table and the diagram showing the variation of different parameters are represented in Table 5.

3.1.1 pH (Hydrogen Ion Concentration):

The determination of the pH facilitates the broad and quick evaluation of the acidic/alkaline nature of leachate. The pH in study area ranges from 6.3to 7.3 the mean value is 6.7 and the standard deviation value is 0.305 coefficient of variation value is 0.045. The bar diagram showing the variations of pH as shown in Figure 4.1.

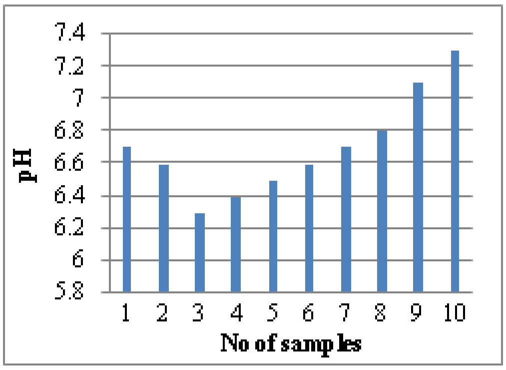

Figure 4.1: Showing variation of pH in Number of samples

3.1.2 Total Solids

Total solids values of leachate samples of the landfilling sites were varies 16640mg/l to 8490mg/l the avg value of TS is 12062.3mg/l and standard deviation value is 2419.92 Coefficient of variation is 0.2006 The bar diagram showing the variation of TS in months as shown in Figure 4.2.

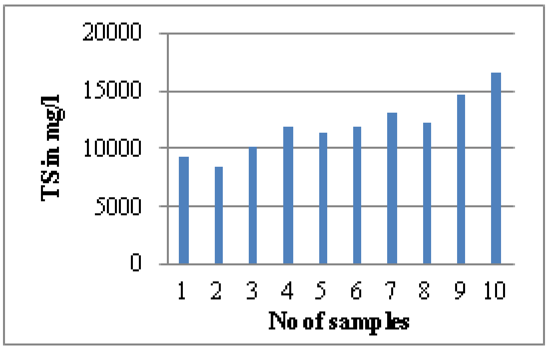

Figure 4.2: Showing variation of TS in Number of samples

3.1.3 Suspended Solids

Suspended solids values of leachate samples of the landfilling sites were varies 4290mg/l to 1990mg/l the avg value of TS is 2876.2mg/l and standard deviation value is 816.52 Coefficient of variation is 0.2838 The bar diagram showing the variation of TS in months as shown in Figure 4.3.

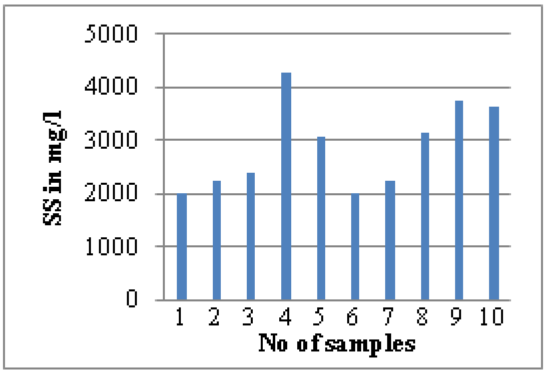

Figure 4.3: Showing variation of SS in Number of samples

3.1.4 Total Dissolved Solids

The total dissolved solids of leachate samples of the landfilling sitesvaries from a minimum value of 6050mg/L and maximum values of 13003mg/L. The mean value is 9185.2mg/L and the standard deviation is 2056.48. And the coefficient of variation value is 0.2238 the bar diagram showing the variations TDS as shown in Figure 4.4.

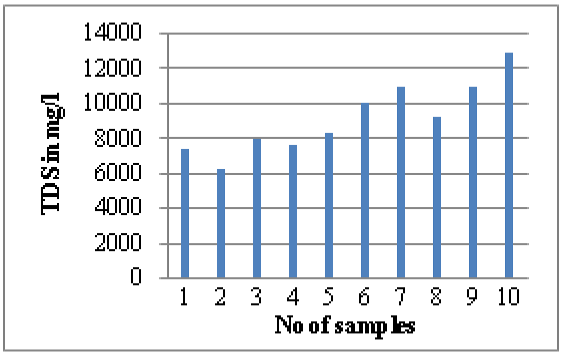

Figure 4.4: Showing variation of TDS in Number of samples

3.1.5 Total Hardness

The total hardness of leachate samples of the landfilling sites variesfrom a minimum value of 2936 mg/L and the maximum value of 4048 mg/L, the mean value being 3599 mg/L and the standard deviation is 325.11 And the coefficient of variation value is 0.0903 the bar diagram showing the concentration variations in the days is as shown in Figure 4.5.

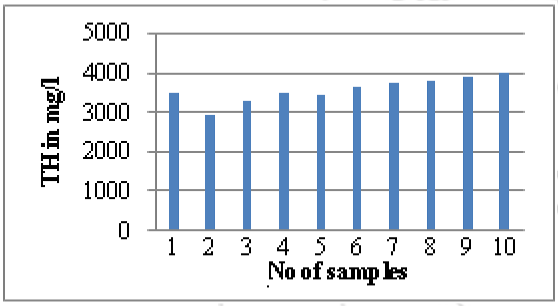

Figure 4.5: Showing variation of TH in Number of samples

3.1.6 Chloride

The Chloride concentration of leachate samples of the landfilling sites varying from a minimum value of 1613mg\L to a maximum value of 3018 mg\L, the mean value is 2430.5 mg\L and the and the standard deviation value is 411.06 And the coefficient of variation value is 0.016 and bar diagram showing the concentration variations are shown in Figure 4.6.

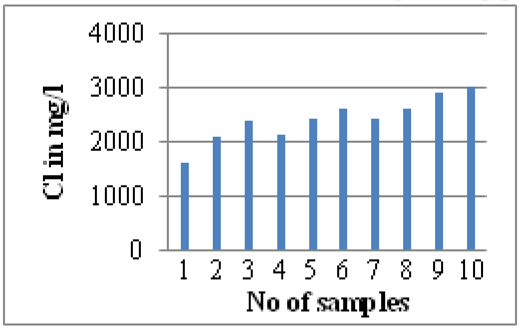

Figure 4.6: Showing variation of Cl in Number of samples

3.1.7Chemical oxygen demand

The COD values of leachate samples of the landfilling sites varies from a minimum value of 16248 mg/L and the maximum value of 25100 mg/L, the mean value being 21024 mg/L and the standard deviation is 3173.9 And the coefficient of variation value is 0.0164 the bar diagram showing the concentration variations in the days is as shown in Figure 4.7.

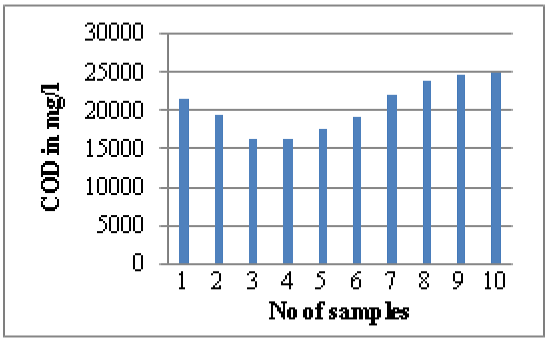

Figure 4.7: Showing variation of COD in Number of samples

3.1.8 Biochemical oxygen demand

The BOD values for 3 days of leachate samples of the landfilling sites varies from a minimum value of 9748 mg/L and the maximum value of 16566 mg/L, the mean value being 13306 mg/L and the standard deviation is 2353.2 And the coefficient of variation value is 0.1768 the bar diagram showing the variations of BOD is as shown in Figure 4.8.

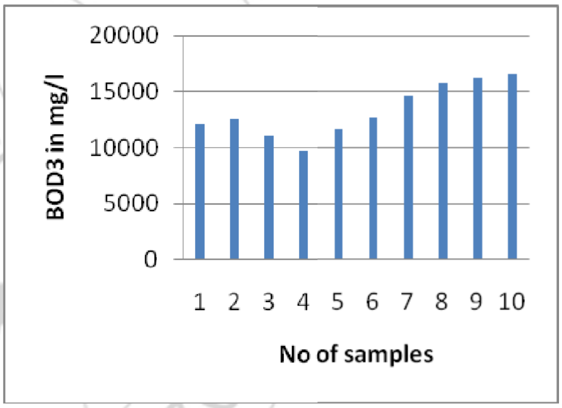

Figure 4.8: Showing variation of BOD in Number of samples

3.1.9 Nitrate

The Nitrate concentration of leachate samples of the landfilling sites varying from a minimum value of 14.2 mg\L to a maximum value of 19.4 mg\L, the mean value is 16.32 mg\L and the and the standard deviation value is 1.66 And the coefficient of variation value is 0.1019 and bar diagram showing the concentration variations are shown in Figure 4.9.

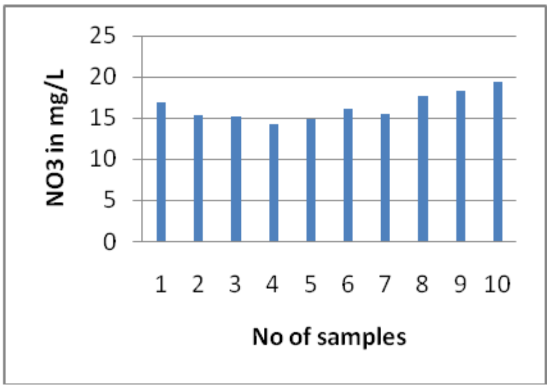

Figure 4.9: Showing variation of NO3 in Number of samples

3.1.10Sulphate

The Sulphate concentration of leachate samples of the landfilling sites varying from a minimum value of 31.01 mg\L to a maximum value of 42.1 mg\L, the mean value is 35.48mg\L and the standard deviation value is 3.243 And the coefficient of variation value is 0.094 and bar diagram showing the concentration variations are shown in Figure 4.10.

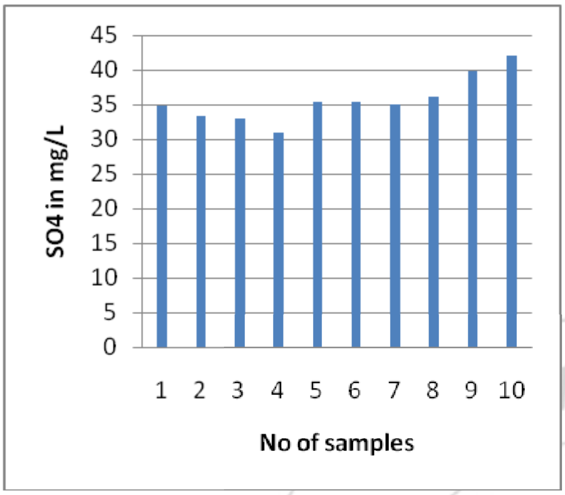

Figure 4.10: Showing variation of SO4 in Number of samples

3.1.11 Phosphate

The Phosphate values of leachate samples of the landfilling sites were varies 42.02 mg/L to 56.9 mg/L the avg value is 48.66 mg/L and standard deviation value is 4.678 Coefficient of variation is 0.096 The variations of Phosphate as shown in Figure 4.11.

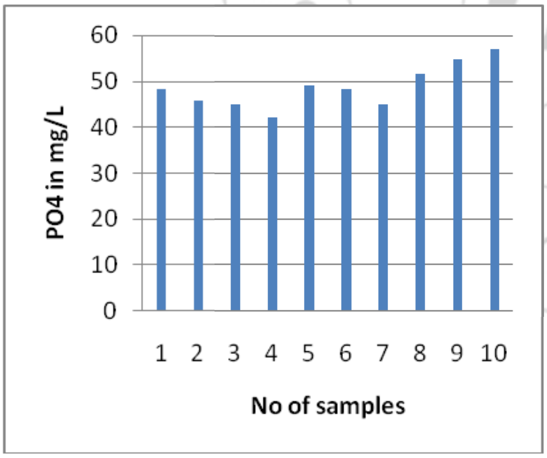

Figure 4.11: Showing variation of PO4 in Number of samples

3.1.12 Iron

The Iron concentration of leachate samples of the landfilling sites varying from a minimum value of 4.82 mg\L to a maximum value of 8.16 mg\L, the mean value is 6.36 mg\L and the and the standard deviation value is 4.678 And the coefficient of variation value is 0.096 and bar diagram showing the concentration variations are shown in Figure 4.12.

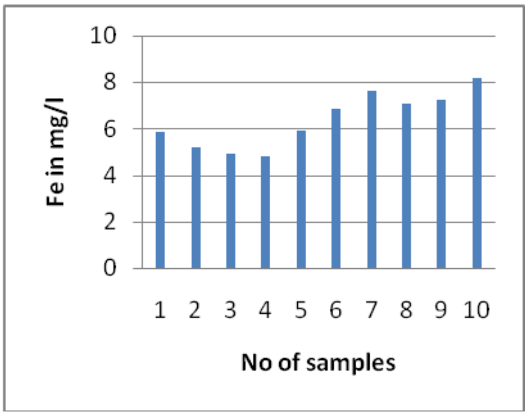

Figure 4.12: Showing variation of Fe in Number of samples

3.1.13 Lead

The Lead concentration of leachate samples of the landfilling sites varying from a minimum value of 0.08 mg\L to a maximum value of 0.24 mg\L, the mean value is 0.166 mg\L and the and the standard deviation value is 0.05 And the coefficient of variation value is 0.33 and bar diagram showing the concentration variations are shown in Figure 4.13.

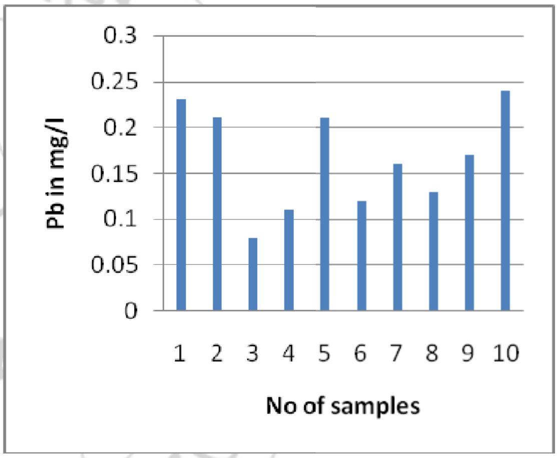

Figure 4.13: Showing variation of Pb in Number of samples

3.1.14Copper

The Copper values of leachate samples of the landfilling sites were varies 0.04 mg/L to 0.11 mg/L the avg value is 0.075 mg/L and standard deviation value is 0.022 Coefficient of variation is 0.303 The bar diagram showing the variation of Phosphate in months as shown in Figure 4.13.

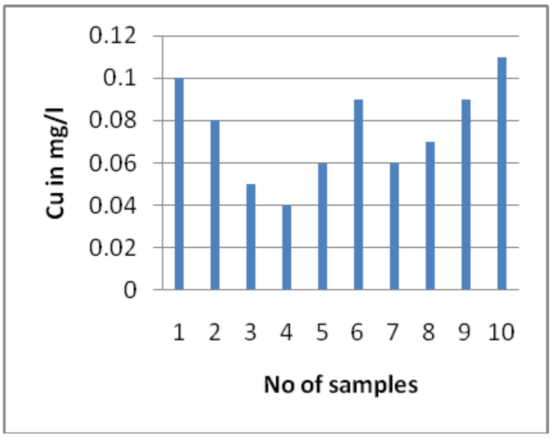

Figure 4.14: Showing variation of Cu in Number of samples

3.1.16 Nickel

The Nickel concentration of leachate samples of the landfilling sites varying from a minimum value of 0.21 mg\L to a maximum value of 0.84 mg\L, the mean value is 0.539 mg\L and the and the standard deviation value is 0.18 And the coefficient of variation value is 0.351 and bar diagram showing the variations of nickel are shown in Figure 4.15.

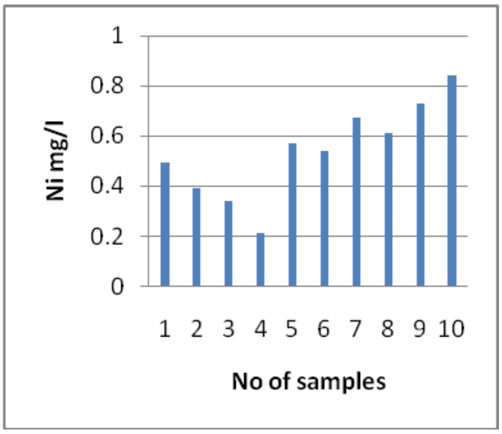

Figure 4.16: Showing variation of Ni in Number of samples

Table 5: Characteristics of Leachate From Udnoor Site

Parameters	PH	TS	SS	TDS	TH	CL	COD	BOD_3	NO_3	SO_4	PO4	Fe	Pb	Cu	Ni
1	6.7	9430	1990	7440	3498	1613	21640	12090	16.9	34.8	48.4	5.83	0.2	0.1	0.5
2	6.6	8490	2240	6250	2936	2107	19400	12610	15.3	33.4	45.7	5.17	0.2	0.1	0.4
3	6.3	10330	2390	7940	3320	2394	16300	11084	15.2	32.9	44.8	4.93	0.1	0.1	0.3
4	6.4	11940	4290	7650	3530	2140	16248	9748	14.2	31	42	4.82	0.1	0	0.2
5	6.5	11400	3060	8331	3460	2418	17600	11616	14.8	35.3	49.2	5.91	0.2	0.1	0.6
6	6.6	12030	2018	10012	3660	2626	19270	12718	16.1	35.4	48.4	6.87	0.1	0.1	0.5
7	6.7	13248	2248	11000	3770	2440	22140	14612	15.48	34.9	44.8	7.64	0.2	0.1	0.7
8	6.8	12390	3140	9250	3848	2630	23850	15741	17.62	36.2	51.5	7.08	0.1	0.1	0.6
9	7.1	14725	3749	10976	3920	2919	24660	16275	18.21	39.8	54.8	7.24	0.2	0.1	0.7
10	7.3	16640	3637	13003	4048	3018	25100	16566	19.4	42.1	56.9	8.16	0.2	0.1	0.8
sum	67	120623	28762	91852	35990	24305	206208	133060	163.2	356	487	63.7	1.7	0.8	5.4
Max	7.3	16640	4290	13003	4048	3018	25100	16566	19.4	42.1	56.9	8.16	0.2	0.1	0.8
Min	6.3	8490	1990	6250	2936	1613	16248	9748	14.2	31	42	4.82	0.1	0	0.2

3.3 Correlation Analysis of leachate at Udnoor site

In the present study area, the correlation co-efficient (r) between appropriate parameter pairs computed by taking the average values.

Correlation co-efficient (r) between any two parameters, X and Y is calculated for parameters such as pH, TS,SS,TDS, TH,Cl,COD,BOD_3, NO_3,SO_4,Fe,Pb,Cu,,Ni of the leachate.

The degree of line association between any two of the leachate parameters as measured by the simple correlation coefficient (r) is presented in Table 4.3 as 16x16 correlation matrix.

The correlation co-efficient (r) is calculated by using the formula:

The correlation co-efficient (r) is calculated by using the formula:

$$r = \frac{(\sum XY / N - X\,Y)}{6X6Y}$$

The positive correlation is found between all the parameters except suspended solids and lead, suspended solids and copper as shown in Table 6 were observed and for the same regression equations were formed and regression lines are drawn as shown in Fig. 4.17 to 4.80

Table 6: Correlation and Regression of Leachate from Udnoor Site

Parameters	PH	TS	SS	TDS	TH	CL	COD	BOD	NO3	SO4	PO4	Fe	Pb	Cu	Ni
pH	1														
TS	**0.84**	1													
SS	0.42	0.58	1												
TDS	**0.82**	**0.95**	0.286	1											
TH	**0.72**	**0.91**	0.44	**0.89**	1										
CL	**1.61**	**0.83**	0.426	**0.81**	**0.68**	1									
COD	**2.46**	0.63	0.134	**0.69**	**0.68**	0.49	1								
BOD_3	**0.91**	**0.71**	0.153	**0.77**	**0.71**	**0.7**	**0.95**	1							
NO_3	**0.85**	0.66	0.2	**0.7**	**0.71**	0.56	**0.9**	**0.86**	1						
SO_4	**0.92**	**0.79**	0.262	**0.82**	**0.73**	**0.73**	**0.84**	**0.87**	**0.91**	1					
PO_4	**0.86**	**0.68**	0.283	**0.68**	**0.67**	**0.67**	**0.8**	**0.82**	**0.92**	**0.96**	1				
Fe	**0.83**	**0.81**	0.085	**0.92**	**0.84**	**0.7**	**0.85**	**0.89**	**0.75**	**0.83**	**0.73**	1			
Pb	0.41	0.11	-0.05	0.15	0.05	-0.09	0.47	0.34	0.42	0.51	0.49	0.31	1		
Cu	0.63	0.32	-0.16	0.44	0.35	0.24	**0.72**	0.61	**0.82**	**0.76**	**0.76**	0.57	0.66	1	
Ni	**0.85**	**0.75**	0.076	**0.85**	**0.75**	**0.68**	**0.86**	**0.9**	**0.8**	**0.93**	**0.85**	**0.94**	0.5	0.65	1

4. Conclusions

1) The concentration of heavy metals is high in leachate sample and the leachate contains more contaminants than domestic waste water and thus needs efficient treatment process before disposal.
2) Leachate samples of landfilling sites were collected and analyzed for various physico-chemical parameters to estimate its pollution potential. It has been concluded that leachate samples contain high concentration of organic and inorganic constituents beyond the permissible limits.
3) 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 concentration of leachate contaminants at Udnoor site were comparative greater. Based on the characterization of landfill leachate, Udnoor village of landfilling site demonstrated low biodegradability.

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