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Environmental assessment of solid waste dump site

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Authors Info

G. Manjula*[1], V. Rajagopalan[2] and N.T. Nayahi[2]

[1]Department of Civil Engineering, SVS College of Engineering, Coimbatore - 642 109, India

[2]Department of Civil Engineering, Anna University BIT campus, Tiruchirappalli - 620 024, India

*Corresponding Author Email : gmanjula.svs@gmail.com

Edited by

Professor M. Seenuvasan

Reviewed by

Dr. T. Anitha
Dr. S. Subhagar

Abstract

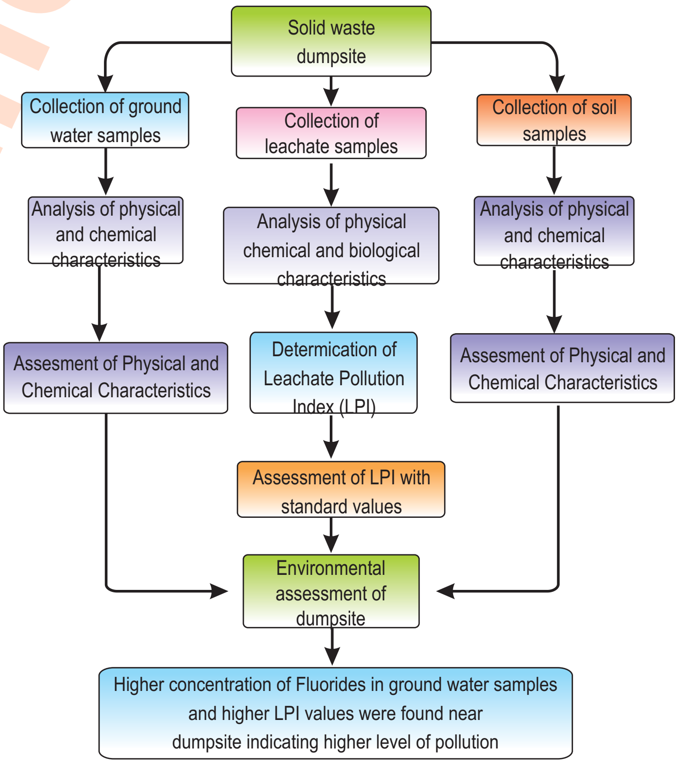
Aim: Rapid population growth, urban sprawl and industrial development has led to increased disposal of Municipal Solid Waste. Proper segregation and disposal is required for effective management of waste. The solid waste dump site causes a major impact to the environment and to the living beings if not properly managed. Hence, this study was carried out to assess municipal solid waste dump site at Vellalore, Coimbatore.

Methodology: Soil and leachate samples were collected from the dump site and analyzed for various chemical and biological parameters. The groundwater samples were collected from nearby localities and analyzed. The Leachate Pollution Index (LPI) was calculated by Delphi technique and compared with standard LPI.

Results: The results indicate that the soil and groundwater samples are highly polluted and the LPI index from the leachate collection tanks 1 and 2 of the sanitary landfill located in the integrated solid waste management plant, Vellalore, Coimbatore were much higher than the LPI standard value.

Interpretation: Proper treatment of leachate is required before it is discharged into the environment. Soil and ground water pollution is to be minimized by scientific treatment of waste.

Key words: Environmental Assessment, Ground Water, Leachate Pollution Index, Solid waste



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Introduction

India is undergoing rapid growth in population and industrialization which has led to physical, climatic, geographical, ecological, environmental and social changes. India's population has increased to 1.324 billion in 2016, compared to 1.144 billion in 2005. This shows that increased population growth is the major reason behind the increased quantity of municipal solid waste in India. India generates approximately 133,760 tonnes of MSW per day, of which approximately 68% of the wastes are collected and approximately 28% of it are treated (CPCB 2004; Shedkar 1999). In India, the MSW generation *per head* varies approximately from 0.17 kg per capita per day in small towns to 0.62 kg per capita per day (Kumar *et al.,* 2009).

India's per capita waste generation is high and there is no proper segregation and treatment of these waste (Narayan, 2008). The wastes collected are dumped into empty piece of land or in rivers or surface water sources. The wastes dumped may also include municipal solid wastes sometimes biological, electronic and hazardous wastes. After some years, the land will be completely filled with piles of solid wastes, which may reach to a several meters of height. When the land is completely occupied by the wastes, a new piece of land will be identified in a different location of the city (Kaushal *et al*., 2012).

Dumping of waste is carried out as an unorganized sector in many places (Rana *et al*., 2014). Therefore, we have to switch on to more sustainable Solid Waste Management (SWM), and this requires new waste management systems, facilities, and fund. Present SWM systems are incapable and inefficient to manage the high quantity of wastes, which cause an impact on living beings, environment and economy (Uma *et al.,* 2016). The allocated small budget will cause the municipalities to use lesser resources to deal with the larger quantity of wastes collected every day and which results in dumping of wastes without any treatment. The next major problem is the inefficiency in segregation and collection of wastes from the source. Currently, the efficiency of segregation and collection of wastes are too low. On one side, the municipalities can be blamed for not having well equipped, efficient and large systems to collect and manage the wastes. But on the other side, we the public are to be blamed for producing a large quantity of waste (Biswas *et al*., 2010). The objective of this study was to evaluate the environmental impact on soil and ground water due to dumping of municipal solid waste at Vellalore, Coimbatore.

Materials and Methods

Study area : Vellalore is a panchayat town in Coimbatore district, Tamil Nadu. It is 13 km east of the main city Coimbatore, situated on the southern banks of River Noyyal.

The entire solid wastes of Coimbatore city is open dumped since the 1980's in the Vellalore dump yard which occupy an area of 650 acres. The wastes generated within the Coimbatore Corporation limits are moved straight to Vellalore. Approximately, 8 lakh metric tons of wastes has been accumulated in the yard over the years. The major problem is that the wastes include both biodegradable as well as non-biodegradable wastes. This makes it difficult for further management. Due to the practical difficulties of segregating and composting the wastes, the wastes are simply dumped which forms bigger garbage mountains.

Sampling of groundwater, soil and leachate: The groundwater samples were collected from forur locations in all the four directions around the dump site. The sampling locations are near the main gate, opposite, left and right to the dump yard were at the distances of 500, 700, 420 and 200 m, respectively from the major landfill site of dumpyard. The borewell depth varie between 220-550 m. The soil samples were collected from the surface of the dump site. The leachate samples were collected from the leachate storage tank from the dumping site.

Physico-chemical analyses of groundwater, soil and leachate: Physico-chemical parameters were analyzed following the APHA (2005) guidelines for examination of water and waste water to evaluate the characteristics of groundwater, soil and leachate samples. (Salami *et al.* 2014) (Syeda *et al.* 2014; Oyedele *et al*. 2008) (Krishna *et al*. 2016; Al Wabel *et al*, 2011).

Biological analysis of leachate : Biological parameters such as Total Viable Coliform, Total Coliform, Total *Streptococci* and *Pseudomonas* sp. were analyzed in collected leachate samples.

Leachate Pollution Index : The LPI formulation includes testing of leachate pollutants, calculating the sub-index values and aggregation of sub-index values. Leachate parameters were selected for determining LPI value. The Leachate Pollution Index was calculated by the following equation :

$$LPI = \sum_{i=1}^{n} w_i p_i \quad (1)$$

Where, LPI is the weighted additive leachate pollution index; w_i is the weight of i^{th} pollutant variable; p_i is the sub-index value of i^{th} leachate pollutant variable; n is the number of leachate pollutant variables used in calculating LPI.

If the data for all the leachate parameters were not available, then the LPI was calculated by the following equation :

$$LPI = \frac{\sum_{i=1}^{n} w_i p_i}{w_i} \quad (2)$$

Where, m is the number of leachate pollutant variables for which data was available, but in that case, $m < 18$ and $\Sigma_i < 1$; The values for w_i and p_i were calculated by the weighted pollutant variable table and standard sub-index value graphs (Kumar and Alappat, 2005).

Table 1: Physico-chemical characteristics of groundwater samples

Sample\ Parameter	1	2	3	4	SD	Sample\ Parameter	1	2	3	4	SD
pH	7.3	7.4	7.5	7.6	0.13	P (mg l^{-1})	0.942	1.012	0.615	0.721	0.19
Temperature (°C)	25	24	24	24	0.5	Fl (mg l^{-1})	2.2	2.3	2.23	1.84	0.21
Odour	Nil	Nil	Nil	Nil	-	SO_4^{2-} (mg l^{-1})	119	164	105	187	38.3
EC (µS cm^{-1})	1850	1650	1480	1100	318	NO_3^- (mg l^{-1})	53	20	49	64	18.8
Cl^- (mg l^{-1})	60	50	55	100	22.9	Mn (mg l^{-1})	0.042	0.071	0.094	0.106	0.03
Hardness (mg l^{-1})	175	125	175	210	35	Cr (mg l^{-1})	0.005	0.01	0.008	0.004	0
Caz (mg l^{-1})	50.9	22.04	36.07	12.02	16.9	Cd (mg l^{-1})	ND	ND	0.001	0.005	-
Mgz (mg l^{-1})	12.12	16.99	20.62	43.7	14	Pb (mg l^{-1})	ND	ND	ND	0.002	-
Alkalinity (mg l^{-1})	250	195	125	90	71.5	Na (mg l^{-1})	0.059	0.012	0.086	0.063	0.03
TDS (mg l^{-1})	515	630	686	532	81.2	K (mg l^{-1})	0.125	0.041	0.216	0.478	0.19
TSS (mg l^{-1})	510	575	640	474	73.3	Cu (mg l^{-1})	0.064	0.035	0.482	0.824	0.38
DO (mg l^{-1})	0.972	1.022	0.923	1.046	0.05	Fe (mg l^{-1})	0.072	0.094	0.27	0.46	0.18
BOD (mg l^{-1})	1.6	4.8	1	3.73	1.78	Zn (mg l^{-1})	0.837	1.23	0.713	2.49	0.81
COD (mg l^{-1})	12.18	4.06	32.48	56.84	23.6						

Table 2 : Physico-chemical characteristics of soil samples

Sample\ Parameter	1	2	3	4	SD	Sample\ Parameter	1	2	3	4	SD
pH	5.7	4.6	8.2	6.3	1.51	Cr (mg l^{-1})	0.134	0.082	0.493	0.365	0.19
Temperature (°C)	22	21	21	23	0.96	Cd (mg l^{-1})	ND	ND	0.004	ND	-
EC (µS cm^{-1})	480	230	250	900	311	Pb (mg l^{-1})	0.043	0.027	0.022	0.038	0.01
Ca^+ (mg l^{-1})	86.4	93.8	127.9	115.7	19.2	Na (mg l^{-1})	34.1	15.8	33.7	24.6	8.69
Mg^+ (mg l^{-1})	52.8	46.1	72.7	91.3	20.5	K (mg l^{-1})	6.42	5.12	5.94	5.38	0.58
Organic matter (mg l^{-1})	61.42	20.7	68.86	18.24	26.6	Cu (mg l^{-1})	ND	ND	2.83	1.44	0.98
P (mg l^{-1})	2.647	2.019	3.175	1.426	0.76	Fe (mg l^{-1})	48.6	37.2	39.5	55.4	8.41
Fl (mg l^{-1})	23.70	17.46	22.87	20.08	2.84	Zn (mg l^{-1})	16.4	16.7	14.9	15.3	0.86
Mn (mg l^{-1})	5.461	ND	5.735	5.912	0.23						

Table 3: Physico-chemical and biological characteristics of leachate samples

Sample\Parameter	1	2	SD	Sample\Parameter	1	2	SD
pH	8.2	7.6	0.42	Fl (mg l^{-1})	23.74	22.75	0.7
Temperature (°C)	29	29	0	SO_4^{2-} (mg l^{-1})	75.1	60.8	10.11
Odour (Threshold number)	42	37	3.54	NO_3^- (mg l^{-1})	10.7	29.4	13.22
Colour	Dark Black	Dark Brown		Mn (mg l^{-1})	1.25	0.92	0.233
EC (µg cm^{-1})	14690	19740	3571	Cr (mg l^{-1})	0.012	0.045	0.023
Cl^{-1} (mg l^{-1})	789.7	1689.4	636	Cd (mg l^{-1})	0.063	0.102	0.028
Total hardness (mg l^{-1})	3050	2950	70.7	Pb (mg l^{-1})	0.895	1.541	0.457
Ca^+ (mg l^{-1})	460.8	701.3	170	Na (mg l^{-1})	942	1064	86.27
Mg^+ (mg l^{-1})	461.1	291.0	120	K (mg l^{-1})	1810	3648	1300
Alkalinity (mg l^{-1})	765	1225	325	Cu (mg l^{-1})	0.129	0.173	0.031
TDS (mg l^{-1})	15120	26485	8036	Fe (mg l^{-1})	14.8	10.6	2.97
TSS (mg l^{-1})	6195	2995	2263	Zn (mg l^{-1})	5.2	8.7	2.475
DO (mg l^{-1})	8.37	5.29	2.18	TVC (CFU ml^{-1})	44X10^3	78X10^3	24042
BOD (mg l^{-1})	119.7	200.9	57.4	TC (CFU ml^{-1})	12.4X10^2	16.6X10^2	297
COD (mg l^{-1})	43.07	17.07	18.4	TS (CFU ml^{-1})	2.3X10^2	3.4X10^2	77.78
P (mg l^{-1})	6.76	7.82	0.75	PC (CFU ml^{-1})	6.5X10^2	10.1X10^2	254.6

Table 4: Leachate Pollution Index

Leachate Pollutant Variable (mg l^{-1})	Variable weight w_i	LPI of Leachate Tank 1			LPI of Leachate Tank 2			LPI of Leachate disposal standards		
		Pollutant Conc. C_i	Sub index value p_i	w_i-p_i	Pollutant Conc. C_i	Sub index value p_i	w_i-p_i	Leachate disposal standards C_s	Sub index value p_i	w_i-p_s
Chromium	0.064	0.012	5	0.32	0.012	5	0.32	2.0	9	0.58
Lead	0.063	0.895	6.2	0.39	0.895	8.7	0.54	0.1	5	0.32
COD	0.062	43.07	6.8	0.42	43.07	4.9	0.30	250	10	0.62
Mercury	0.062	-	-	-	-	-	-	0.01	10	0.37
BOD	0.061	119.7	10	0.61	200.9	15.2	0.92	30	6	0.37
Arsenic	0.061	-	-	-	-	-	-	0.2	5	0.31
Cyanide	0.058	-	-	-	-	-	-	0.2	6	0.35
Phenol	0.057	-	-	-	-	-	-	1.0	5	0.29
Zinc	0.056	5.2	6.4	0.35	8.7	7	0.39	5.0	6	0.34
pH	0.055	8.2	4.3	0.23	7.6	3.4	0.19	5.5-9.0	5	0.28
TKN	0.053	-	-	-	-	-	-	100	6	0.32
Nickel	0.052	-	-	-	-	-	-	3.0	10	0.52
TCB	0.052	1240	72	3.74	1660	75	3.9	No std	-	-
NH_4-N	0.051	-	-	-	-	-	-	50	7	0.36
TDS	0.02	15120	52.1	2.60	26485	65.8	3.29	2100	7	0.35
Copper	0.05	0.129	5.1	0.25	0.173	5.4	0.27	3.0	18	0.90
Chlorides	0.049	789.7	8.7	0.41	1689.4	11.4	0.54	1000	8	0.39
Iron	0.045	14.8	5	0.22	10.6	5	0.22	No std	-	-
LPI Value				**15.82**			**18.03**			**7.378**

Results and Discussion

Table 1 shows the physic-chemical characteristics of groundwater samples collected near the dumping site. The pH values of all the samples were within the acceptable limit of 6.5 to 8.5 for drinking water. The results indicate that all the ground water samples near the dumpsite were slightly alkaline in nature. The chlorides and total hardness values are also well within the BIS acceptable limits of 250 mg l^{-1} and 350 mg l^{-1}, respectively (IS 10500:2012). The calcium level was below the BIS acceptable limit of 75 mg l^{-1} for drinking water whereas magnesium level at location 4 slightly exceeded the BIS acceptable limit of 30 mg l^{-1}. The total dissolved solids at all the locations exceeded. The concentration of sulphates was also within the 200 mg l^{-1} for drinking water and BIS acceptable limit of 250 mg l^{-1}. The concentration of nitrates was below the acceptable limit of 45 mg l^{-1} at location 2. The concentration of heavy metals was also within permissible limits at all the locations. The results show that most of the parameters were within the permissible limit according to BIS (IS 10500:2012). However, the fluoride content was found to be much higher than the World Health Organization limit of 0.5 mg l^{-1} at all the locations. Increase in fluoride levels may result in dental mottling and adverse effects on bone. Deflouridation treatment methods are required to treat the ground water in all the locations.

Table 2 shows the physico-chemical characteristics of soil samples collected from the dumping site. Accumulation of salts can result in saline, saline-sodic and sodic soils (Uma *et al.,* 2016). These soil conditions have distinct characteristics which can be observed by visual inspection. The soil should be non-sodic structure to be of good quality. Municipal Solid Waste is considered as one of the principal sources of heavy metals in soil (Oyedele *et al*., 2008). The salt intrusion in soils may be attributed to leaching of pollutants from dumping site. Hence, it is necessary to study the soil characteristics in terms of pH, EC, OM, Ca^{2+}, Mg^{2+}, Na^{+} , K^{+} and heavy metals. The soil quality parameters at four locations are presented in Table 3. The soil pH is an important parameter as it directly affects the availability of nutrients to the root zone of plants. A pH range of 6.5 to 7.5 is suitable for plant growth (Raman *et al*. 2009). The pH values at location 1 and 2 are found to be unsuitable for plant growth. The soil at locations 1 and 2 were classified as acidic whereas soil at locations 3 and 4 were normal soil (Uma *et al*., 2016). High electrical conductivity values are critical for germination (Krishna *et al*. 2016) and growth of salt sensitive crops (Deshmukh, 2012). Soil quality at location 4 was found to be toxic for germination. Sodium is found to affect the availability of crop water and cause adverse changes to the soil structure (Jaboobi *et al*., 2014). High sodium values of more than 1 ms/cm are present in location 1 and 3. High Calcium levels were detected at locations 3 and 4. Calcium is considered as an essential macro element for plant growth. It is toxic to plants only in high doses (Uma *et al.*, 2016).

Heavy metals were also detected in soil samples near the dump site indicating presence of hazardous wastes (Salami *et al.*, 2014; Syeda *et al.,* 2014). Table 3 shows the physico-chemical and biological characteristics of leachate samples collected from dumping site. The results show that both the leachate samples were highly polluted. If it is let out without any treatment it can cause serious impact on the environment (Al-Wabel *et al.*, 2011). Leachates have tendency to percolate into groundwater affecting both ground water as well as soil.

Leachate Pollution Index : LPI was calculated for Leachate from leachate collection tanks 1 and 2 of the sanitary landfill. The LPI values determined from 1 and 2 are compared with LPI standard for disposal proposed under Municipal Solid Waste (Management and Handling) Rules (2000) (Agbozu *et al.,* 2015; Barjinder *et al.,* 2014). The calculated LPI values L1 and L2 are 15.82 and 18.03 and the standard LPI value was 7.378. The LPI values of L1 and L2 were higher than the standard LPI. The leachate requires more treatment before final disposal to reduce LPI values. The leachate characteristics show that it is highly polluted as indicated in Table 4. and it should be treated in order to reduce the risk to the environment as well as to living beings.

The study concludes that the solid waste dump site has a major impact on nearby soil and groundwater. The characteristic study of groundwater, soil and leachate shows that there is an impact on groundwater and soil, but the study of shows the highest contamination. Proper treatment of leachate is to be carried out before it is discharged into the environment.

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