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Evaluation Of Potential Level In The Municipal Solid Waste Of Dumping Yard Of Mandya By Using Leachate Pollution Index

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Abstract

Leachate is one of the most serious environmental hazards associated with landfills, especially those which are unlined and uncontrolled. Considering this, the present study investigates the leachate pollution index (LPI) of the open dumping site of the Mandya district of Karnataka using leachate characteristics from the sample collected from the open dumping site from the Mandya open dumping site. The physicochemical and heavy metals concentrations were also analyzed such as Lead (Pb), Zinc (Zn), Copper (Cu), Iron (Fe), Chromium (Cr), Nickel (Ni) and Mercury (Hg). The LPI value was calculated for the four leachate samples collected namely, L1 (28.85), L2 (28.86), L3 (28.76) and L4 (30.84) respectively. The LPI aggregate value is 29.32 which immensely exceeds the limits of the Indian standards of 7.378 for disposal. There should be immediate action for remediation plans to reduce the environmental risk and better treatment plans and incorporate a better solid waste management (SWM) system to reduce the pollution potential.

Key words: Solid waste, leachate, leachate pollution index, Mandya

1. Introduction

Solid waste can be defined as any waste that is a useless or undesirable solid material that is generated by humans and other activities which could be from many different sources such as residential, commercial, and industrial. In India, 143499 MT amount of solid waste is approximately generated on a daily basis. As per the CPCB, waste generation has increased exponentially with an increase of 0.26 to 0.85 kg per day (2) which poses a serious threat to the environment if the disposal and treatment are done improperly. The composition of the solid waste differs based on the amount of organic material, paper, plastic waste and commercial waste present in the wastes.(2).

In India, the processing of biodegradable waste occurs under ULBs with the help of solid waste processing sheds such as windrow composting sheds and vermicompost. For local ULBs, the route for management and disposal of the solid waste collected is through the method of landfilling and composting due to the higher organic content of the waste present.(2). Leachate is an emerging pollutant that contains many organic pollutants such as Ammonia content, BOD, and COD, inorganic pollutants such as Copper, Nickel, Calcium, Magnesium, Chloride, Sodium, and Potassium and heavy metals such as Chromium, Nickel, Zinc, and Copper (5). Leachate has a high pollution potential due to its high organic concentration. The composition of leachate

may differ from case to case and may also contain pathogenic microorganisms. Heavy metals may also so may be present in the leachate present which increases its pollution potential.
The leachate pollution index (LPI) is a tool utilized for quantifying the contamination potential of leachate. This tool can be utilized to develop measures to prevent any environmental pollution. LPI refers to the calculation of the sub-index values and the aggregation of these values formulation that includes testing of leachate pollutants(6). Selective parameters were selected for the calculation of the LPI value. This method of quantifying the potential of the leachate present can be extremely helpful in figuring out what remediation techniques would be adequate to combat the leachate generated to ensure safe disposal (7).

Aim and objectives of the study.
The aim of this study is to assess the physicochemical parameters and heavy metals parameters of samples collected from the open dumping site in Mandya in Karnataka. The objectives of the study are to assess the characteristics of the leachate and calculate the leachate pollution index (LPI) of the open dump yard located in Mandya and to discuss different methodologies that can be utilized for the treatment of the leachate for its proper disposal.

The objectives of the study
- To Study the physicochemical characteristics of leachate samples.
- To Study the heavy metal content of the obtained samples.
- To calculate the leachate pollution index (LPI) of the open dumpsite located in Mandya.

Review of Literature

Maged Hussieny *et al.*, (2022) conducted a study on the leachate characteristics of the MSW in the Cairo Metropolitan Area. The study analyzed the outputs from the MSW sorting and different management strategies were presented. It was analyzed that a higher percentage of organic waste is in landfills than the dump site. Mir Amir Mohammad Reshadi1 *et al.*, (2021) conducted a study on the evolving trends of landfill leachate treatment research over the last 45 years were five topics titled oxidation processes, nitrogen removal processes, constructed wetlands/coagulation, adsorption, and membrane-based processes. Suprajha *et.al* ., (2020) conducted a study on assessing the leachate pollution index (LPI) in the Big lake , Pallavaram located in Tamil Nadu .The samples were analyzed for BOD, COD, TDS, Chlorides, Zinc, Cadmium, Lead and fecal coliform. The results showcased LPI organic, LPIinorganic, LPI heavy metals are 29.044, 19.592 and 5 respectively.

Materials and Methodology

The leachate pollution potential of the leachate generated from open dumping site located in Mandya City, Karnataka. The Physico-chemical and heavy metal characteristics was analyzed for this study.

Fig 1: Map of the study region , Mandya open dumping site

Description of the Study Area:
The focus of the study is the Mandya solid waste open dumpsite. The site of Mandya landfill is located 13 kilometers away from the city center. The open dumping site has 20 vermicomposting tanks and has a bailing machine as equipment. According to the data, by 2018, the generation of waste by Mandya City is 37% of organic or wet waste, 40% of dry or recyclable waste and 23% of inert or reject waste. the generated waste majorly comes from the regular households which takes up about 59.3% of the waste generated other major sources of waste generated are educational institutions and small shops which makes up about 29% of the waste generated. Other sources of toxic and non-recyclable waste are hospitals which make up a small portion of the waste generated however they do generate a potent harmful effect on the environment if discarded without proper care (36).

Sample collection:
There were four samples obtained from the landfill dumping site. The sample collection was done in the pre-monsoon during April of 2023 with the help of a lysimeter.

Physico –chemical parameters:
The collection of samples was performed using Lysimeter and were analyzed using standard methods prescribed by APHA (2016). Parameters pertaining to physico -chemical characteristics were analyzed by following the standards methods of the leachate samples the parameters were measure of hydrogen ions (pH), Electric conductivity (EC) in $\mu s/cm$ and total solids of the samples were tested by conductivity meter method. Total dissolved solids (TDS), Temperature and Turbidity are measured with TDS meter. Total suspended solids (TSS) and Total solids (TS) were measured with the help of a hot air oven. Biological oxygen demand (BOD) by Winkler's method, Chemical oxygen demand (COD) by dichromate method. Nitrate (NO3) and sulphate Phosphate Ammonium (NH_4) by UV spectrophotometric method. Calcium (Ca^{+2}) and magnesium (Mg^{+2}) were analyzed by titrimetric method. Phenols were analyzed by gas chromatography. TKN was analyzed by the Kjeldahl method.

Analysis for heavy metals concentration

Heavy metals concentrations like Chromium (Cr), Mercury (Hg), Copper (Cu), Nickel (Ni), Zinc (Zn), Lead (Pb) and Iron (Fe) of all four leachate samples were analyzed with the help of Atomic Absorption Spectrometric Method.

Table 1: Leachate sample number with geographical coordinates

Sample Number	Location with latitude and longitude
Leachate 1 (L1)	Landfill pit (N 12◦ 29' 12.5736" E 76◦ 49' 28.9848")
Leachate 2 (L2)	Landfill pit (N 12◦ 29' 12.6672" E 76◦ 49' 6.284478")
Leachate 3 (L3)	Landfill pit (N 12◦ 29' 14.8086" E 76◦ 49' 29.2758 ")
Leachate 4 (L4)	Landfill pit (N 12◦ 29' 14.6718" E 76◦ 49' 29.37")

Results and Discussion

The study analyzed 23 parameters which include physiochemical characteristics and heavy metals were analyzed. Heavy metals concentration was analyzed with the Atomic Absorption Spectrometric method.
The results showcased those certain parameters exceeded the permissible limits.
For the physiochemical characteristics, all the leachate samples were in the acidic range. Certain parameters were found to be in higher concentrations among the samples such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonia and Phosphate. These parameters were above the permissible limits. This suggests that the higher concentration of these parameters indicates that the wastes present in the open dumping yard of Mandya have agricultural pesticides, fertilizers present in them due to which suggests a high pollution potential. Without safe disposal measures present the leachate would be harmful to the environment . Hence, it's important to carry out the proper disposal measures for the leachate generated at the dumpsite.
Heavy metal concentration of the leachate samples was analyzed and the concentrations of heavy metals such as Zinc (Zn), Copper (Cu) and Chromium (Cr) all exceeded the permissible limits of the WHO guidelines which suggest higher concentrations of pharmaceutical products present in the dumpsite. The values for the parameters studied are displayed in ***Table 3***.

Leachate Pollution Index (LPI)

The measurement of these values is done with the curves defined by Kumar and Alappat (2005). The value ranges from best to worst index measures from 5 to 100. There is an ascending order scale index, wherein greater values represent poor environmental condition (6).

$$\text{LPI} = \frac{\sum_{i=1}^{m} WiPi}{\sum_{i=1}^{m} Wi}$$

In this equation, where n is the number of pollutant variables, Wi is the weight for the pollutant variable and the sub-index score of the i^{th} pollutant variable is defined as Pi, used in calculating LPI.

Table 2: Overall results of leachate pollution index of all samples of Mandya open dumping yard.

Sample	LPI values
L1	28.85
L2	28.86
L3	28.72
L4	30.84
LPI aggregate	29.32

Table 3: Physio-chemical characterization of all the samples obtained from the open dump yard in Mandya.

PARAMETERS	Units	Sample 1	Sample 2	Sample 3	Sample 4
pH		4.2	4.3	4.5	4.3
Temperature	Celsius(◦C)	33.5	32.5	31.8	32.7
Turbidity	NTU	555	756	630	515
Electrical conductivity	$\mu s/cm$	18.5	55.2	55.6	42.6
Total dissolved solids (TDS)	Parts per million (ppm)	312	364	315	264
Total suspended solids (TSS)	mg/l	6.86	8.93	9.40	6.33
Total solids (TS)	mg/l	30	49	61	39
BOD	mg/l	2350	2150	3100	3979
COD	mg/l	1100	1167	1333	1500
Chlorine	mg/l	75.82	81.44	70.21	89.86
Phosphate	mg/l	112.79	244.04	247.26	172.83
Ammonia	mg/l	6.0	5.8	6.3	4.6
Calcium	mg/l	2980	1950	1870	2806
Magnesium	mg/l	3300	4100	2540	3201
Lead	mg/l	6.5	5.5	6.2	6.56
Copper	mg/l	2.9	0.8	1.9	2.2
Zinc	mg/l	5.6	5.8	5.1	5.2
Iron	mg/l	100	150	184	194
Mercury	mg/l	0.90	1.2	1.0	0.95
Nickel	mg/l	1.4	1.9	1.9	1.32
Chromium	mg/l	0.4	1.0	0.6	0.75
Phenols	mg/l	2.0	4.0	1.8	2.8
TKN	mg/l	102	135	74	168

Parameter	unit	L1				L2				L3				L4			
		Value	Sub index value(Pi)	weight factor(WI)	Pi*Wi	Value	Sub-index value (pi	weight factor(WI)	Pi*Wi	Value	Sub index value(pi)	weight factor(WI)	Pi*Wi	Value	Sub index value(Pi)	weight factor(WI)	Pi*Wi
Cr	mg/L	0.4	5.2	0.13	0.025	1.0	5.8	0.125	0.725	0.6	5.4	0.125	0.675	0.8	5.6	0.125	0.700
Pb	mg/L	6.5	70.0	0.12	8.610	5.5	60.0	0.123	7.380	6.2	67.0	0.123	8.241	6.6	72.0	0.123	8.856
COD	mg/L	1100	42	0.27	11.214	1167	42.5	0.267	11.348	1333	43.65	0.267	11.655	1500	45	0.267	12.015
Hg	mg/L	0.9	80.0	0.121	9.680	1.2	92.0	0.121	11.132	1.0	85.0	0.121	10.285	0.9	82.0	0.121	9.922
BOD	mg/L	2350	45.0	0.263	11.835	2150	42	0.263	10.915	3100	51	0.263	13.413	3979	57	0.263	14.991
Zn	mg/L	5.6	5.4	0.110	0.594	5.8	5.6	0.110	0.616	5.1	4.7	0.110	0.517	5.2	4.8	0.110	0.528
pH		4.2	20.0	0.214	4.280	4.3	20.2	0.214	4.323	4.5	10.0	0.214	2.140	4.3	20.2	0.214	4.323
Ni	mg/L	1.4	5.2	0.102	0.530	1.9	6.1	0.102	0.622	1.9	6.1	0.102	0.622	1.3	5.1	0.102	0.520
NH3-N	mg/L	6.0	5.4	0.198	1.069	5.8	4.8	0.198	0.950	6.3	5.7	0.198	1.129	4.6	3.8	0.198	0.752
TDS	mg/L	312	100	0.195	19.500	364	100	0.195	19.500	315	100	0.195	19.500	264	100	0.195	19.5
Cu	mg/L	2.9	22.0	0.098	2.156	0.8	7.5	0.098	0.735	1.9	9.6	0.098	0.941	2.2	10.2	0.098	1.000
Phenols	mg/l	2.0	5.5	0.246	1.353	4.0	10.0	0.246	2.460	1.8	5.2	0.246	1.279	2.8	9.2	0.246	2.263
TKN	mg/L	102	5.3	0.206	1.082	135.0	5.4	0.206	1.108	74.0	5.2	0.206	1.061	168.0	5.6	0.206	1.154
Cl	mg/L	75.8	5.2	0.187	0.963	81.4	5.4	0.187	1.000	70.2	5.025	0.187	0.940	89.9	6.2	0.187	1.159
Fe	mg/L	100	5.5	0.088	0.484	150.0	6.5	0.088	0.572	184	7.3	0.088	0.642	194.0	8.4	0.088	0.739

Table 4: Physio-chemical characterization of all the samples obtained from the open dump yard in Mandya

Summary and Conclusion

The physicochemical characteristics that were analyzed are as follows; pH, Turbidity, Biochemical oxygen demand (BOD), Temperature, Electrical conductivity, Total Dissolved Solids (TDS), Chemical oxygen demand (COD) Total solids (TS), Total suspended solids (TSS), Calcium (Ca^{2+}), magnesium (Mg^{2+}), Chloride (Cl^{-}), Nitrate, Phosphate, Ammonia, TKN and phenols. The heavy metals concentrations were also analyzed such as Mercury (Hg), Chromium (Cr), Zinc (Zn), Copper (Cu), Lead (Pb), Nickel (Ni) and Iron (Fe).
The LPI aggregate value is 29.32 which immensely exceeds the limits of the Indian standards of 7.378 for disposal. The LPI of the leachate samples collected were extremely higher than the permissible limits due to which if this leachate enters the environment due to poor infrastructure it could lead to serious health issues for the communities living nearby. There should be immediate action for remediation plans to reduce the environmental risk and better treatment plans to reduce the pollution potential. Firstly, the collection of the wastes from around the city is in an inadequate condition where there is improper management of the workers by the municipal corporation staff. The open dumpsite doesn't have a proper management system present. There are no leachate tanks present for storage of the leachate due to which the leachate seeps into the dumpsite and further leads to harmful toxicity produced at the site. The infrastructure of the dumpsite is unfit for the pollution potential that is produced from it.

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