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Adsorption of heavy metals from landfill leachate: A case study of Valmiki Nagar Landfill of Nanded city, Maharashtra, India

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Abstract

Landfill leachate is one of the most contaminated waste types, which has created excessive health and environmental concerns due to the widespread use of urban landfill for final wastes disposal. Presence of heavy metals due to biological accumulation property of these materials endangered the health of living creatures especially human. The objective of the study was to assess and compare the physical chemical and heavy metals properties of leachate samples collected from the Valmiki nagar landfill of Nanded city. The leachate produced by waste disposal sites contains a large amount of substances which are likely to pollute the ground water. The different parameters were studied from the four sites viz. color, pH, EC, chlorides, alkalinity, sulphate, phosphate, magnesium, sodium, potassium, calcium exchangeable cations, fluoride, Iron, chromium, Zinc, Aluminum, Barium, Copper, nickel and cadmium. The maximum amount of Alkalinity 6500 mg/l, chloride 9286.2 mg/L, fluoride 12.223 mg/L, Sodium 1153 mg/L, zinc 32 mg/L, Aluminium 3.21 mg/L and Nickel 2.26 mg/L was found and is at alarming level.

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Introduction

Internationally, almost 70% of municipal solid waste (MSW) is disposed of to landfill (Zacarias-Farah and Geyer Allely, 2003). Solid waste disposal methods include open dump, sanitary landfill, incineration, composting, grinding and discharge to sewer, compaction, hog feeding, milling, dumping, reduction, and anaerobic digestion. Sanitary landfill is the most common MSW disposal method since it is simple disposal procedure, low cost and landscape-restoring effect on holes from mineral workings (Bashir *et al.*, 2010).

The household waste disposed in MSW landfills contains a mixture of many chemical compounds originating from the various discarded products. A number of these chemicals are released during the lifetime of the landfill and results in release of heavy metals to the environment receptors (Fetter, 2001). The contaminations of soil with heavy metals even at low concentrations are known to have potential impact on environmental quality and human health as well as imposing a long-term risk to groundwater and ecosystems (Slack *et al.*, 2005).

Groundwater contamination is a major concern in landfill operations because of pollution effects of landfill leachates and its potential health risks (Christensen *et al.*, 2001; Stollenwerk and Colman, 2003). However, the production of highly contaminated leachate is a major drawback of this method (Wiszniowski *et al.*, 2007). Leachate treatment options included off-site combined treatment at a nearby large municipal wastewater treatment plant with or without pretreatment as well as various onsite treatments (Chang and Chung, 1994). Several investigators (Rantala and Lehtonen, 1980; Henry, 1985; Robinson and Maris, 1985; Kelly, 1987; Park, 1999) have carried out researches on the combined treatment of landfill leachate with municipal wastewater.

Wastes discarded and unwanted materials, result inevitably from human activities, whether domestic or industrial. If wastes are allowed to accumulate on the ground, or if dumped indiscriminately into rivers and other bodies of water, unacceptable environmental problems would result (Eckenfelder, 2000).

Leachates consist of water which enter the landfill during rainfall or formed as a result of biological activity within the landfill. As the water percolates through the trash, it picks up contaminants (organic and inorganic chemicals, metals, biological waste products of decomposition) and is typically acidic. The function of the leachate collection system is to control the flow of leachates so that it can be properly removed from the landfill and treated.

The total amount of solid waste generated in Nanded is about 149 tons/ day, at an average of about 300 g/person/day. While there has been no initiative to establish the waste characteristics source-wise. About 73 % of waste is to be generated from domestic sources, followed by about 23 % from commercial establishments and markets and the rest of from industries.

Municipal Solid Waste is disposed in a dumping ground at Valmiki Nagar near Maltekdi in an area of 3.32 hectare. This site has been in use since around 1975.

It is needed to be assessed for its capacity to handle more dumping as well as to assess its suitability for installing scientific treatment and disposal methods. There is no treatment facility and the garbage collected from the city is merely dumped at this site (NWMC, 2006). This research includes leachate sampling and characterization and analytical determinations.

Material and methods

Study area

Nanded is located between 18°.15' and 19°.55' North latitude and 77°.7' to 78°.15' east longitudes. The district has a geographical area of 10528 Sq. Km. and is one of the fastest growing, second largest city of Marathwada region of Maharashtra state with a population of 7.3 lakh.

Fig.1. Locations of sampling stations from dumping site.

The rapid urbanization of Nanded city and its fast increasing population over the last few decades have created immense pressure on its urban services including solid waste management.

Valmikinager located at Maltekdi is one of the major landfill sites and having an area of 3.32 hectare. In order to assess the pollution level and the leaching behavior of leachate samples were collected from the study area.

Leachate sampling and characterization

Environmental contaminated sites located at Valmikinagar near MaltekdiNanded (Maharashtra) have been selected for sampling. The leachate sample was collected from the Valmikinagar Landfill site (VNLS) situated in Nanded city. VNLS is a semi-aerobic landfill site and is one of biggest site in Nanded. VNLS produces a dark black-green colored liquid that can be classified as a stable leachate. The characteristics of the leachate influent taken from site of the VNLS are listed in table1.

Sample preparation and analysis

The leachate samples were collected for their physico-chemical and heavy metals characterization in sterilized sealed pack polythene bags and it was named as Leachate Water Sample (LWS). Sodium azide (NaN_3 0.1% arbitrarily) was used to suppress the biological activity at site and samples were stored at 4°C. The leachate was spiked with heavy metals to obtain concentrations ranging from 0.1 to 50 mgL^{-1} for each heavy metal.

Laboratory studies

The pH was determined using glass electrode method with a standard calibrated pH meter. Electrical Conductivity (EC) was determined from the filtrates obtained from the suspension for pH analysis using conductivity meter. Analysis of heavy metals was carried out using spectrophotometer after wet digestion with a mixture of HCl and HNO_3. Alkalinity was determined according to standard procedure (EPA, 2001). Phosphate was analyzed calorimetrically as molybdophosphoric acid while chloride was determined using Volhard method (Volhard J. J. 1874). The physical and chemical parameters were analyzed as per standard methods of APHA (1998).

Results

Physico-chemical characteristics and Heavy Metals of the leachate depend principally upon the waste composition and water content in total waste. Table 1 shows the characterization of leachate and the range and average values for the mentioned parameters at each leachate millpond at the VNLS Nanded.

In this study total four water samples; four in pre-monsoon, four in monsoon and four in post-monsoon were analyzed. The number of physicochemical parameters like pH, EC, temperature, colour, odor, total dissolved solids, alkalinity, dissolved oxygen, chloride, salinity, total hardness, calcium hardness, magnesium hardness, sulphate, phosphate, calcium, magnesium, fluoride, iron, manganese, sodium, and potassium were performed. Heavy metal analysis for Iron, chromium, Zinc, Aluminum, Barium, Copper nickel, and cadmium was also done.

Table1. Characteristics of raw leachate value of heavy metal at VNLS site Nanded.

Sr. No.	Parameters	Sample sites				Mean ± S.D.
		LWS-1	LWS-2	LWS-3	LWS-4	
1	Colors	Yellow	Light brown	Green	Green	Green
2	pH	8.7	8.9	9.1	9.3	9 ±0.258
3	EC (μS/cm)	580	610	670	730	647.5 ± 66.520
4	Temperature	23.2	23.2	23.5	23.5	23.35 ± 0.173
5	Total Solids	4912	3244	4298	4889	4335.75 ±781.343
6	Alkalinity (mg/L)	2900	3500	6000	6500	4725 ±1789.553
7	Chloride (mg/L)	1846	5424.4	9286.2	1029.8	4396.6 ±3777.365
8	Fluoride (mg/L)	2.223	5.428	9.944	12.223	7.4545 ±4.487
9	Calcium (mg/L)	124	387	554	610	418.75 ±218.139
10	Magnesium (Mg)	104	147	221	277	187.25 ±76.908
11	Sulphate (mg/L)	630	740	1270	1290	982.5 ±346.542
12	Phosphate (mg/L)	4.8	12	67	72	38.95 ±35.457
13	Sodium (mg/L)	646.1	650.9	1127.3	1153	894.325 ±284.054
14	Potassium (mg/L)	558.7	576	747	765	661.675 ±109.393
15	Iron (mg/L)	54	94	258	670	269 ±281.526
16	Chromium (mg/L)	2.11	1.93	3.11	4.87	3.005 ±1.347
17	Zinc (mg/L)	21	27	25	32	26.25 ±4.573
18	Aluminum (mg/L)	1.5	2.12	2.96	3.21	2.4475 ±0.785
19	Barium (mg/L)	15	21	28	32	24 ±7.527
20	Nickel (mg/L)	0.47	0.75	1.80	2.26	1.32 ±0.848
21	Copper (mg/L)	10.12	11.66	12	13.74	11.88 ±1.485
22	Cadmium (mg/L)	0.71	94	1.12	1.67	24.375 ±4.418

Except electrical conductivity, temperature, colors and P^H all the parameters are expressed as mg/L^{-1}.

The pH of filtrates obtained from suspension was recorded in the range of 8.7 to 9.3 which is above the range of permissible range of 6.5 – 8.5.

The electrical conductivity noted in all sample sites was ranged from 580 to 730 μS/cm which is above the permissible limit of 250 μS/cm and the temperature remained in between 23.2 to 23.5°C.

The total dissolved solids (TDS) was found maximum 4889 ppm in LWS-4 and minimum 4912 ppm in LWS-1. Alkalinity observed minimum 2900 mg/l in LWS-1 and maximum 6500 mg/L in LWS 4. Whereas, the maximum Chloride - 9286.2 mg/L in LWS-3 and minimum- 1846 mg/L. in LWS1 was detected as compared to LWS-2 and LWS-04. Fluoride and calcium was also studied and it was found 2.223 to

12.223 mg/L; 124 to 610 mg/L respectively. The maximum amount of Magnesium and Sulphate was seen 277 mg/L and 1290mg/L in LWS-4. The phosphate content increased drastically in LWS-4 from 4.8 mg/L to 72 mg/L.

The sodium found in the range of 646.1 to 1153 mg/L and potassium 558.7 to 765 mg/L. The average sodium and potassium content were 894.325 ± 284.054 and 661.675 ± 109.393 mg/L respectively. However the Iron observed 54 to 670 mg/L which is above the suggested value – 0.3 mg/L of WHO. The mean values of chromium Zinc and Aluminum was detected 3.005± 1.347, 26.25 ± 4.573 and 2.4475 ± 0.785 respectively.

From the results depicted in the table Barium, Nickel, Copper and Cadmium was also found. It ranged from 15 to 32 mg/L Barium; 0.47 to 2.26 mg/L Nickel; 10.12 to 13.74 mg/L Copper and 0.71 to 1.67 mg/L Cadmium with their mean values of 24 ± 7.527; 1.32 ± 0.848; 11.88 ± 1.485 and 24.375 ± 4.418 respectively. In all the parameters studied, it is noted that the maximum leachates content was observed in LWS-4.

Discussion

In the present study, the data revealed that there is considerable variation in the quality of water with respect to physicochemical characteristics. This is because of continuous land filling with urban wastes. The pH varies according to the age of landfills. For new landfills, pH values are 4.5-7.5; for mature landfills pH varies from 6.6-7.5 (Tchobanoglous *et al.*, 1993) however the pH of dumpsite is ranging from 8.7 to 9.3 reveals that the soil is much contaminated. Heavy metal distribution at the investigated dump fields at Lubietova reflect the geochemical behavior of the elements, depending on their content, solubility, migration potential and sorption properties (Cataldo *et al.*, 1978). The high level of Fe (70.62 mg l-1) in the leachate sample indicates that Fe and steel scrap are also dumped in the landfill. The colour is appeared yellow to green from the samples collected and the dark brown color of the leachate is mainly attributed to the oxidation of ferrous to ferric form and the formation of ferric hydroxide colloids and complexes with fulvic/ humic substance (Chu, et. al., 1994). The presence of Zn 26.25 ± 4.573 in the leachate shows that the landfill receives waste from batteries and fluorescent lamps (Moturi *et al.*, 2004). One kind of natural zeolite called clinopteliolit in both form of unmodified (crude) and modified by hexadecyl trim ethyl ammonium- bromide surfactant (HDTMA-Br) were used for removing the lead and cadmium metals from the landfill leachates of Mehriz city, Iran(Ehsan *et al.*, 2011). We have also found the similar results recorded at Valmikinagar Nanded by Shaikh *et al.,* (2012).

Conclusion

Our result shows that the dumping site is causing the water and soil pollution due to lack of proper management system and adequate capacity for final deposition of solid waste and becoming a serious problems in urban areas. Developing countries like India have not been able to adequately address these problems due to high cost. This seems to be one of the main reasons for contaminated dumpsites are often shut down for natural recovery of the site. The present study support the allegation that shut down of dumpsites in heavily urbanized society may have been contaminated significantly due to ongoing human activities. Due to percolation of leachates viz. Chloride 9286.2 mg/L, fluoride 9.944 mg/L, Sodium 1127.3 mg/L found in LWS-3 and chromium 4.87 mg/L, Zinc 32 mg/L, Aluminum 3.21 mg/L Nickel 2.26 mg/ L in LWS-4 indicates the underground water sources become contaminated and harmful to living being. This underlines the need for appropriate authority to further monitor shut down dumpsites, alongside remediation process that may be initiated.

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