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Assessment of Arsenic and Physicochemical Properties of Soil Around Municipal Waste Dumpsite at Rohtak, Haryana, India

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ABSTRACT

In most of developing countries, open dumpsites are frequently opted as the best choice to get rid of waste, but this type of practice has severe threats to the environment. This may be considered as one of the factors in contamination of soil and groundwater. The study examined the arsenic and physicochemical properties of soil around a municipal waste dumpsite in Rohtak city, Haryana. For Rohtak city, leachate secretion and generation of various gases at landfill site may be a factor in contamination of soil around the dumpsite. 13 samples of soil were collected from the surrounding area of dumpsite within 2 km area. Soil samples were tested for various parameters like pH, EC, moisture content, bulk density, water holding capacity, organic matter, chloride and arsenic. The pH values of the various samples of different locations ranged from 7.14 to 8.34, EC ranged from 1034-9536 add µS/cm with a mean value of 3484 µS/cm, organic matter of the soil samples of present study ranged from 1.26 to 3.16%. Water holding capacity of soil samples ranged from 51.02% to 59.14%, moisture content was found from 3.12 to 13.86%, bulk density was found from 1.28-1.89 g/cm^3. Range of chloride content was 358-4165 mg/kg with mean value 1679 mg/kg. Higher level of arsenic contamination is found in the surrounding soil samples, ranged from 410 ppb to 840 ppb with mean value of 618 ppb which may be due to leachate secretion at dumpsite area that make soil unsuitable for agricultural purposes.

Keywords: Arsenic, Municipal solid waste, Municipal landfill, Organic matter, Fluorescence spectoscopy.

INTRODUCTION

Disposal of waste is one of the most significant issues the world is currently facing. Abandoned materials from commercial, industrial, agricultural, manufacturing, and community operations are referred to as solid waste[1]. Open dumpsites are still the most popular way to dispose of municipal solid waste, even in developing or low-income nations, despite the availability of other disposal options[2]. This is due to the fact that, in comparison to other disposal techniques like recycling, incineration, composting, and sanitary landfills, the operation of open dumpsites is comparatively inexpensive, convenient, and entails low technological obstacles[3]. 40 percent of the waste produced worldwide is thought to end up in open dumpsites, which serve about four billion people[4]. Physical, biological (fermentative) and chemical processes are all applied to wastes on the dumpsite[5,6]. There are no appropriately designed leachate confinement or treatment facilities at many municipal waste dumpsite. Therefore, there's a chance that leachates containing hazardous metals will seep from the landfill, cover the whole surface of the soil, and finally make their way into groundwater and surface water bodies. Human, animal, and ecological health are at risk due to uncontrolled and unplanned open waste dumping, which is a significant source of contamination of groundwater, the air, and soil[7]. As a result, there are significant dangers to both human health and environmental quality. A variety of health risks can arise from an open dump, including the inhalation of poisonous fumes, the consumption of toxins both directly and indirectly, and skin contact with polluted soil and water[8]. Numerous investigations have demonstrated a notable level of heavy metal pollution in the surrounding soil due to leachate migration from waste disposal sites[9,10]. Contamination of arsenic is also reported in a study conducted on soil around a municipal waste dumpsite[11]. Since arsenic contamination is earlier reported in the Rohtak district and assessment of arsenic around the Rohtak municipal waste dumpsite is not reported in any study. The present study was designed for the assessment of arsenic and physicochemical characteristics of soil around the open dumpsite of Rohtak city, Haryana.

MATERIALS AND METHOD

Details of study area, sampling locations and various methods adopted for physicochemical and arsenic analysis are described in following subsections. Statistical analysis like min, max, mean and pearson corelation matrix was also applied to the recorded data.

Study area

The study was conducted in the year 2024 (February 2024 to May 2024) at the Rohtak municipal waste dumpsite, situated in the village Sunariyan kalan and Jalalpur in Rohtak. Area of the dumpsite is approximately 35.4 Acre[12]. Fig. 1 shows the process of waste segregation at study area.

Fig. 1. Waste segregation at municipal waste dumpsite, Rohtak

Soil sample collection

Before collection of samples upper layer of soil was made garbage free.[13] Samples of soil were collected at the depth of 15 cm from different locations surrounding waste dumpsite within area of 2 km. Polythene bags with ziplocks were used for sampling and lebelled with paper tags. GPS locations of samples are shown in Table 1.

Table 1: Sample numbers with respective locations

Sample No	Latitude	Longitude
1	28.8617647 N	76.5818737 E
2	28.8798820 N	76.5531195 E
3	28.8778191 N	76.5392495 E
4	28.8798784 N	76.5531223 E
5	28.8873132 N	76.5518937 E
6	28.8765732 N	76.5410559 E
7	28.8798123 N	76.5531196 E
8	28.8798823 N	76.5531196 E
9	28.8582101 N	76.5396108 E
10	28.8721515 N	76.5291332 E
11	28.8570736 N	76.542501 E
12	28.8869566 N	76.5522086 E
13	28.8750789 N	76.5439461 E

Physicochemical analysis

After collection of soil samples, samples were air dried, crushed and sieved through 2mm size sieve and are then subjected to various physical and chemical analysis. For pH and EC in soil, soil to water ratio of 1:2.5 immersion solution was prepared and values were recorded using digital pH Meter (LMPH-10) and conductivity Meter (LMCM-20) respectively. For moisture content, soil samples were initially weighed (initial wet weight) and then placed in a hot air oven (Model AI-7781) and were dried at a temperature of 60^{O}C-70^{O}C for about 24 hours. The samples were then weighed again (final dry weight) and moisture content of soil was calculated using (equation 1)[13].

$$\text{Moisture content (\%)} = \frac{\text{initial wet weight(g)} - \text{final dry weight(g)}}{\text{wet weight(g)}} \times 100 \quad (1)$$

Bulk density of soil was calculated by dividing the weight of oven-dried soil by the volume of the soil core at the respective depth (equation 2)[14].

$$\text{Bulk density}\,(g/cm^3) = \frac{\text{Weight of ovendried soil(g)}}{\text{Volume of soil core}(cm^3)} \quad (3)$$

Volume of soil core =3.14.r^2.h (where, r = inside radius and h = height of cylinder in cm)

Total organic carbon was determined by Walkey and Black Rapid titration method[15]. Organic matter was determined by using equation 3.

$$\text{Organic matter(\%)}=\text{Total organic carbon(\%)}\times 1.72 \quad (3)$$

Soil texture and water holding capacity of soil was determined as per Adamu & Aliyu[16]. Chloride content is estimated by titration against $AgNO_3$ solution[17].

Arsenic analysis

5 gram of soil sample was predigested using 10 ml concentrated nitric acid and 3 ml hydrogen peroxide, also 5 ml of pyrocatechol containing Trilon B solution was also added to it to remove interferences. Arsenic was then analyzed by fluorimetric method using Fluorat 02 analyzer using equation 4.

$$\text{Mass concentration of arsenic}(\mu g/g)=\frac{\text{Measured mass of arsenic in sample}(\mu g)}{\text{Weight of soil}(g)} \quad (4)$$

RESULT AND DISCUSSION

Results of arsenic and physicochemical characteristics of soil around Rohtak municipal waste dumpsite are shown below in Table 2. Soil pH shows the indication of most chemical, physical and biological processes within the soil[18]. From Table 2, the range of pH of the various samples of different locations was found from 7.14 to 8.34. This indicates neutral to slightly alkaline nature of soils around dumpsite. This data is also supported by the other previously conducted studies on dumpsites by Uba *et al.,*[19] and Obasi *et al.,*[20]. These reports were concluded in a way that mostly documented pH values of soil around dumpsite are basic in nature due to the presence of liming materials and alkali-earth metals in abundant amount and there may be high activity of soil microorganisms over dumped waste. EC ranged from 1034-9536 µS/cm with a mean value of 3484 µS/cm. If the organic carbon content of soil is below 0.5%, that soil is considered as carbon deficient and if the carbon content is above 0.75%, the soil is considered very rich in carbon[21,22]. Organic matter of the soil samples of present study ranged from 1.26 to 3.16% with a mean value of 2.33%, shows the presence of sufficient amount of organic carbon and organic matter. Water holding capacity of soil samples ranged from 51.02% to 59.14% with a mean value of 55.64%. Moisture content was found from 3.12 to 13.86% with mean value of 7.9%. Values of bulk density were found from 1.28-1.89 g/cm^3 with mean value of 1.58 g/cm^3. Chloride content 358-4165 mg/kg with a mean value of 1679 mg/kg. Monitoring and testing of chloride content is required to prevent the salinity problem. Arsenic content in soil samples ranged from 410 to 840 ppb with a mean value of 618 ppb, which is below the permissible limit of 20 ppm for agricultural soil provided by the Agency for Toxic Substances and Disease Registry (ASTDR)[23] and European Community[24]. Higher concentration of arsenic around dumpsite may be due to discarded obsolete products such as electronics like circuit boards, treated woods and textile products etc. Pearson correlation matrix among conducted parameters is described in Table 3. Among various parameters, arsenic shows stronger negative correlation with pH of soil.

Table 2: Results and statistics of conducted soil parameters

Sample No	pH	EC(µS/cm)	Moisture content(%)	Organic matter(%)	Water holding capacity(%)	Bulk density (g/cm^3)	Chloride (mg/kg)	Arsenic content (ppb)
1	8.34	2454	3.12	3.16	59.14	1.77	986	490
2	7.76	8614	4.08	1.36	52.41	1.54	2246	570
3	7.68	9536	10.33	1.98	55.89	1.66	1196	600
4	7.14	1496	7.27	2.75	56.23	1.43	2956	770
5	7.49	2821	11.34	1.26	51.02	1.51	358	830
6	7.50	4125	11.12	2.08	55.67	1.62	2125	490
7	8.14	2145	3.34	2.74	56.99	1.89	412	410
8	7.82	2896	13.86	1.72	52.54	1.31	498	580
9	7.70	4257	8.88	2.98	57.36	1.56	1026	610
10	7.24	2899	5.04	2.50	56.87	1.54	768	730
11	7.78	1145	6.76	2.88	57.07	1.28	1996	410
12	7.91	1870	4.45	1.81	53.36	1.68	4165	710
13	7.86	1034	13.23	3.08	58.89	1.82	3098	840
Min	7.14	1034	3.12	1.26	51.02	1.28	358	410
Max	8.34	9536	13.86	3.16	59.14	1.89	4165	840
Mean	7.72	3484	7.90	2.33	55.64	1.58	1679	618

Table 3: Pearson correlation among chemical parameters. pH = soil reaction, EC = electrical conductivity, OM = Organic matter, Cl = chloride, As = arsenic

	pH	EC	OM	Cl	As
pH	1				
EC	-0.06209	1			
OM	0.230408	-0.48457	1		
Cl	-0.0915	-0.16895	0.047317	1	
As	-0.51049	-0.1528	-0.19458	0.290899	1

CONCLUSION

Results of analysis of physicochemical properties of soil around Rohtak municipal waste dumpsite revealed that pH values were ranged from 7.14 to 8.34, which is the optimal range for microbial activities and nutrient uptake. The higher amount of organic carbon and organic matter have significantimpact on bulk density and water holding capacity of soil. Assessed samples of soil revealed the presence of arsenic ranged from 410 ppb to 840 ppb. Results of present study reveals that soil around the dumpsite is contaminated with arsenic due to leaching process, though this lies within the permissible limit of 20 ppm for agricultural purposes. This draws the attentions towards the awareness and regular monitoring to ensure the waste segregation before dumping.

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Conflicts of interest

No such conflicts exist.

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