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Impact of Municipal Solid Waste on Subsurface Water Quality near the Landfill Site

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Abstract

Groundwater samples were collected in and around the Khermai Road landfill to study the possible impacts of MSW (Municipal Solid Waste) on the groundwater resources in that area. The objective of the study is to assess the subsurface water pollution due to landfill at residential area nearer to landfill site, Satna city. The quality of the subsurface water is assessed in terms of physical & chemical parameters. The concentrations of various parameters like pH, Temperature, Electrical Conductivity (EC), Turbidity, Total Dissolved Solids (TDS), Total Hardness(TA), Calcium, Magnesium, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Chloride, Fluoride, Nitrate, nitrite, sulfate including heavy metals (Pb, Zn, Ni, Cu) present in the subsurface water samples are measured. The results show that concentration of some of the parameters like Total Dissolved Solid (TDS), Total Hardness (TH), Calcium and Magnesium concentration are found above the stipulated limits of Indian Standards for drinking water (BIS- 10500:1991) and WHO. The study has revealed that at present the MSW has minimal impact on the subsurface water quality in and around the dumping area.

Keywords: *Municipal Solid Waste, groundwater, heavy metals, landfill, leachate, pollution*

1. Introduction

MSW disposal is a problem of global concern, especially in developing countries across the world where poverty, population growth and ever increasing urbanization rates combined with paucity of funds and poor planning and management of the government-departments [1-2]. Land filling is the simplest, cheapest and the most cost effective method of disposing of solid waste in both developed and developing nations of the world [3]. The rampant and rapid growth of population is contributing towards quantity, quality and variety of MSW at their worst as far as environmental and land pollution are concerned. Collection, transportation and handling of the waste must also be dealt properly with, as the same creates variety of problems, many of which are related to human health and environment [4-5].

Groundwater is that portion of subsurface water which occupies the part of the ground that is fully saturated and flows into a storage area under pressure greater than atmospheric pressure. Groundwater occurs in geological formations known as aquifer. [6]

Landfills are considered as one of the major threats to the groundwater [7-8]. The scale of this threat depends on the concentration and toxicity of contaminants in leachate, type and permeability of geologic strata, depth of water table and the direction of groundwater flow [9]. Water through rainfall is mixed with the water already present in the solid waste piles which causes the leachate to leave the dumping ground as infiltration in lateral or vertical directions to find its way into the ground water thereby causing the contamination [10-11]. Municipal landfill leachate is highly concentrated complex effluent which contains dissolved organic matters; inorganic compounds such as ammonium, calcium, magnesium, sodium, potassium, iron, sulphates, chlorides and heavy metals such as cadmium, chromium, copper, lead, zinc, nickel; and xenobiotic organic substances [12-13].

It is therefore necessary to check the quality of ground water at regular time intervals to study the danger of its possible contamination which may cause water-borne diseases to human population. The determination of physical & chemical parameters of water samples which also dictate various other life processes should be taken as an environmentally viable study [14-15].

The present study involves the analysis of water quality in terms of various parameters of ground water around the Khermai Road MSW dumpsite area close to Trimurti Narsing Home in Satna city, M.P. The aim of the study is to understand how the water gets polluted due to the dumping of MSW in and around the select area.

2. Materials and Methods

Description of study area

Satna city is located on 24 ^{0} 34' N latitude and 80^{0} 55' E longitude at an altitude of 315 m above mean sea level. The place is renowned for Dolomite mines and Limestone. The leachate is observed to be generated due to the dumping of waste which mixes to a 'Nala' and the same water contaminated with leachate is being used for an agricultural watering.

The landfill is surrounded by some small ice factories, two nursing homes, a motor park, four to five automobile repair workshops and road network act as the sources of waste and pollution discharge in addition to the transported waste discharge into the landfill. The wastes deposited in the landfill are predominately solid wastes from domestic sources including market wastes. The samples for this study were taken from 8 sampling points across the landfill.

Field Sampling and Laboratory Analysis

In an effort to investigate the extent of groundwater contamination, eight sampling points designated as BW1 to BW8 were selected between 20 and 100 m down-gradient of the landfill site. Field sampling was done at the end of September, 2013. Water samples were collected in 1litre plastic containers and prior to collection all the bottles were washed with nonionic detergent and rinsed with de-ionized water prior to usage. Before the final water sampling was done, the bottles were rinsed three times with well water at the point of collection. Each bottle was labeled according to sampling location while all the samples were preserved at 4ºC and transported to the laboratory.

Physico-Chemical Analysis

All the samples were analyzed for the following parameters: pH, Temperature, Electrical Conductivity (EC), Turbidity, Total Dissolved Solid (TDS), Total Alkalinity(TA), Total Hardness (TH), Chloride, Ca hardness, Mg hardness, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Fluoride, Nitrate, Nitrite, Sulfate. The physicochemical analysis of water samples were carried out in accordance to standard analytical methods (APHA). pH determination was carried out by digital pH meter (HACK make), turbidity by using Nephelometric turbidity meter. The heavy metals were analyzed by using Atomic Absorption Spectrophotometer (Varian make).

3. Results and Discussion

The results of physic-chemical analysis of the subsurface water samples are shown in Table -1.

The pH of all the bore-well water samples was about neutral, the range being 7.2 to 7.8. The temperature of bore-well water samples varies from 24.5^{0}C to 25.8^{0}C.

Table-1 Physio-chemical parameters of ground water samples in and around the Municipal solid waste dumping site

S. No.	Parameters	BW1	BW2	BW3	BW4	BW5	BW6	BW7	BW8
1	pH	7.2	7.2	7.3	7.2	7.6	7.4	7.3	7.8
2	Temperature (^{0}C)	24.8	25.0	25.3	25.6	25.5	25.8	24.5	25.3
3	Electrical Conductivity (µS/cm)	728	717	620	616	556	580	550	472
4	Turbidity (NTU)	1.5	1.2	1.3	0.6	0.5	0.6	0.8	0.5
5	TDS (ml/l)	760	720	615	603	665	587	668	654
6	Total Alkalinity (mg/l)	164	112	98	95	86	95	105	110
7	Total Hardness (mg/l)	560	567	412	439	482	397	506	443
8	Calcium Hardness (mg/l)	268	246	205	118	172	165	121	129
9	Magnesium Hardness (mg/l)	128	120	112	97	79	74	96	105
10	Dissolved Oxygen (mg/l)	5.1	5.3	5.2	5.8	5.6	5.6	5.4	5.4
11	COD (mg/l)	3.8	3.2	3.6	2.8	2.9	3.2	2.4	2.8
12	Chlorides(mg/l)	245	192	202	147	132	143	138	133
13	Fluoride (mg/l)	0.8	0.5	0.6	0.5	0.4	0.3	0.1	0.2
14	Nitrate (mg/l))	2.6	3.4	2.8	3.0	3.2	2.2	1.0	1.5
15	Nitrite (mg/l)	0.15	ND	0.01	ND	0.02	0.03	ND	ND
16	Sulfates (mg/l)	64.0	51.5	54.3	88.2	45.8	38.7	55.6	39.8
17	Iron as Fe (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND
18	Lead as Pb (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND
19	Zinc as Zn (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND
20	Nickel as Ni (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND
21	Copper as Cu (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND

* BW- Bore-well, ND – Not Detectable

The EC of bore-well water samples varies from 472 µS/cm to 728 µS/cm. It is a valuable indicator of the amount of material dissolved in the water. The high value of EC can be related to the effect of the leachate seepage towards the bore-wells. According to Langenger (1990), the importance of the electrical conductivity is its measure of salinity, which greatly affects the taste and thus has a significant impact on potability of water.

Turbidity of all the bore-well-waters ranges from 0.5 to 1.5 NTU, the values are under the limits of BIS.

Total Dissolved Solid (TDS) indicates the general nature of water quality or salinity. The range of TDS at bore-well varies from 587 mg/l - 760 mg/l. The TDS concentration was found to be above the permissible limit may be due to the leaching of various pollutants into the ground water. The ground water pollution from refuge in the vicinity of the dumping sites is detectable through increased TDS concentration of water [19]. High concentration of TDS decreases the palatability and may cause gastro-intestinal irritation in human and may also have laxative effect particularly upon transits [24].

The concentration of Total Alkalinity (TA) as $CaCO_3$ in bore-well water ranges from 87 to 164 mg/l which are under the limits of BIS.

The total hardness (TH) of water samples varies from 397 mg/l to 567 mg/l, the desirable limit for hardness of water is 300 mg/l. The water in all bore-wells is very hard.

Calcium hardness in ground water samples ranged from 118 mg/l to 268 mg/l. The desirable limit for calcium is 75 mg/l, the concentration of calcium in all water samples is very high. Calcium often comes from carbonate based minerals, such as calcite and dolomite. The excess of calcium causes concretions in the body such as kidney and bladder stones and irritation in urinary passages.

Magnesium hardness in the bore-well water samples varies from 74 mg/l to 128 mg/l, the desirable for magnesium is 30 mg/l., the concentration of magnesium in all water samples is very high. Magnesium salts are cathartic and diuretic and high concentration may cause laxative effect, while deficiency may cause structural and functional changes. It is essential as an activator of many enzyme systems [24].

Dissolved Oxygen (DO) is one of the most important measures of water quality. It is found in the ground water samples ranges from 5.1 mg/l to 5.8 mg/l.

The COD level in the bore-well water samples ranges from 2.4 mg/l to 3.8 mg/l, the COD is a measure of oxygen equivalent to the organic and non-organic matter content of water susceptible to the oxidation by a strong chemical oxidant and thus is an index of organic pollution [2].

The concentration of Chloride in the water samples ranged between 132 mg/l to 205 mg/l. which are under the limits of BIS. An excess of Chloride in water is usually taken as an index of pollution and considered as a tracer for ground water contamination [23].The Chloride content of ground water is likely to originate from pollution sources such as domestic effluents, fertilizers, septic tank and from the natural sources such as rainfall and the dissolution of fluid inclusion. Increase in chloride level is injurious to the people suffering from diseases of heart or kidney [24].

The concentration of Fluoride in the bore-well water samples ranged from 0.1mg/l to 0.8 mg/l. Fluoride at low concentration in drinking water has been considered beneficial but high concentration may cause dental fluorosis (tooth mottling) and more seriously skeletal fluorosis [25].

The concentration of nitrate in bore-well water samples ranges from 1.0 mg/l to 3.4 mg/l, the values are under the limits of BIS. The concentration of nitrite in water samples ranges from ND to 0.15 mg/l.

The concentration of Sulphate in bore-well water samples ranged from 38.7 mg/l to 88.2 mg/l, values are under the limits of BIS.

The bore-well water samples were analyzed for heavy metals such as Lead, Zinc, Nickel and Copper, which are characterized as undesirable metals in drinking water. The concentration of these metals was found to be below the detection limit in ground water samples. This indicates that these metals are possibly absorbed by the soil strata or by the organic matter in soil.

4. Conclusion

From the present study of the assessment of subsurface water in and around MSW dumping site, it is found that some of the parameters like Total Dissolved Solid (TDS), Total Hardness (TH), Calcium and Magnesium concentration are above the limits of Indian Standard for drinking water (BIS-10500:1991) and WHO. The higher concentration of TDS shows the penetration of landfill leachate has occurred to the subsurface water and polluted the water. While total hardness (TH) and Calcium and Magnesium hardness is due to the soil of that area because the place is renowned for Dolomite mines and Limestone. Hence we can conclude that at present the MSW has minimal impact on the subsurface water quality. Although the water quality is just good but it needs to be maintained from being polluted due to MSW landfill sites for the future. The emphasis should be given to improve the waste management practices and construct properly engineered landfill sites to curtail the ground water pollution.

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