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Original Research Paper

Leachate Characterization and Assessment of Groundwater Pollution Near Municipal Solid Waste Landfill Site

Pavithra S. Reddy and N. Nandini
Department of Environmental Science, Bangalore University, Bangalore-560 056, Karnataka, India

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ABSTRACT

Municipal Solid Waste (MSW) generation, treatment and disposal are, both economic and environmental problem of concern, for the urban communities, especially in fast population exploding countries like India. The insanitary methods adopted for disposal of solid wastes are, therefore, a serious health concern. The poorly maintained landfill sites are prone to groundwater contamination because of leachate production. The leachate from the dump is allowed to stagnate in a ditch next to the dump and slowly finds its way into surface and groundwater aquifers. The present work aims to determine the effects of solid waste on groundwater quality those close to refuse dumps sited within and around Mavallipura in Bangalore city. Over the years all drinking water sources in the vicinity have been adversely affected, and the threat looms large of contaminating the groundwater, which is the major source of drinking water.

INTRODUCTION

Solid waste means unwanted materials or substances that are left or discarded after use, also included in it are by-products of process lines or materials that may be required by law to be disposed off (Okecha 2000). Solid wastes can be classified in a number of ways such as on the basis of source, environmental risks, utility and physical property. On the basis of source, which is commonly used, solid wastes are classified as: municipal solid wastes, industrial solid wastes, agricultural solid wastes, mining and mineral wastes, construction and demolition wastes, healthcare wastes, radioactive (nuclear) wastes, human and animal wastes. The generation of solid waste from household, industries, markets, abattoir and shops result in improving the standard of living of the inhabitants. The most common method of waste disposal in India is dumping on land, because it is the cheapest method of waste disposal. It, however, requires large area and proper drainage. The land disposal of municipal and industrial solid waste is potential cause of groundwater contamination. Uncontrolled dumping of waste is subjected to leaching by percolating rain water and surface water or by groundwater contact with landfill. These solid wastes can as well contaminate groundwater. The generated leachate contains high levels of BOD, COD, nitrates, chloride, alkalinity, trace elements, hazardous wastes, etc. Leaching of water from inappropriate dumping sites produce a foul smell and is a nuisance to people living in surrounding areas (Omofonmwan et al. 2009). The objective of the paper is qualitative analysis of the leachate and the groundwater in and around the land fill site of Mavallipura.

MATERIALS AND METHODS

Study area: Mavallipura landfill site is located about 20 km north of Bangalore city, 5.6 km away from the critical defence zone close to Yelahanka air force base. It is about 2.5 km away from the flow of River Arkavathi. With the tacit approval of Bhruhat Bangaluru Mahanagara Palike (BBMP), every day since May 2003, about 200 truck loads weighing about 2.5 to 3 tons of municipal solid waste each from some of the northern wards of Bangalore, are being dumped on Mavallipura landfill site. The site was handed over to Ramky Infrastructure Ltd. in 2004 for composting.

Methodology: The utility of water is limited by its quality, which may make it unsuitable for a particular purpose. Therefore, assessment of water quality is an important aspect of water evaluation and standard of living of the people. Solid waste generated leachate and groundwater samples in and around Mavallipura were collected and analysed for various physico-chemical parameters like pH, electrical conductivity (EC), total dissolved solids (TDS), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total hardness, calcium hardness, sulphates, sodium, potassium and chlorides following standards methods (APHA 2005). The results of leachate and groundwater samples were compared with standards prescribed by WHO (1997), Bureau of Indian Standards (BIS 1993) and Indian Council of Medical Research (ICMR 1975) for disposal on surface waterbodies.

RESULTS AND DISCUSSION

Physico-chemical analysis of leachate samples: Physico-chemical characteristics of the leachate depend primarily on the waste composition and water content in the waste. The characteristics of the leachate samples collected from the Mavallipura landfill site are presented in Table 1. The Indian standards for composting and treated leachate call for a complete cover of the waste storage area. If such storage area is present in an open area, then it must be provided with impermeable base with facility for collection of leachate and surface water run-off into lined drains leading to leachate treatment facility. Based on this notion, environmental analysis to determine the extent of pollution caused by untreated leachate into the groundwater was carried out. The average pH was 8.37 (standards for leachate discharge into inland surface water = 5.5-9.0). Electrical conductivity was above the limit at 7937 micromhos/cm. Total dissolved solids (TDS) was high at 4445 mg/L (permissible limit = 2100 mg/L). The relatively high values of EC and TDS indicate the presence of inorganic materials in the samples. Chemical oxygen demand (COD) on an average was more than twenty times as high at 5027 mg/L (disposal standards = 250 mg/L). Biochemical oxygen demand (BOD) was also very high at an average of 3556 mg/L (permissible limit = 30 mg/L). The presence of high values of COD and BOD indicate the organic strength. Total alkalinity was at 2505 mg/L. Total hardness of the leachate samples was above the limit at an average 905 mg/L. Calcium hardness and magnesium hardness were at an average of 732 mg/L and 172 mg/L respectively (Table 1). The average sulphate content was found to be 377 mg/L which was slightly higher than the prescribed limit of 250 mg/L. An average chloride content in the samples was higher at 309 mg/L than the prescribed limit of 250 mg/L. The nitrate content in the leachate samples was 394 mg/L. An average sodium and potassium contents in the leachate samples were in the range of 1205 mg/L and 855 mg/L respectively.

Physico-chemical analysis of groundwater samples: The underground water of the study area is used for domestic and other purposes. Table 2 shows the desirable and maximum permissible limit recommended by BIS (BIS 1993), World Health Organization (WHO 1997) and Indian Council of Medical Research (ICMR 1975). The pH of all the groundwater samples was neutral, the range being 7.4 to 7.8. The average pH of the groundwater samples was found to be 7.5. The EC is a valuable indicator of the amount of material dissolved in water. The EC in the study area was found to be high ranging between 610 and 977 µS/cm. The average EC was 811 µS/cm. These high conductivity values obtained for the underground water near the landfill are an indication of its effect on the water quality. TDS indicates the general nature of water quality or salinity. The range of TDS is between 389 mg/L and 789 mg/L with the average value of 637 mg/L. This high value of TDS may be due to the leaching of various pollutants into the groundwater. The high concentrations of TDS decrease the palatability and may cause gastro-intestinal irritation in human and may also have laxative effect particularly upon transits (WHO 1997). COD is a measure of oxygen equivalent to the organic matter content of the water susceptible to oxidation by a strong chemical oxidant and thus is an index of organic pollution. The COD level in the groundwater samples ranged from 243 mg/L to 436 mg/L with an average value of 331 mg/L indicating the presence of organic contaminants in the water and can be used as organic indicator to assess the groundwater

Table 1: Physico-chemical analysis of leachate samples.

Parameters	Standards of disposal of treated leachate (MPL by BIS and ICMR for surface water)	Sample 1	Sample 2	Sample 3	Sample 4
pH	5.5-9.0	8.4	8.6	8.2	8.3
EC	Not specified	8140	10420	7560	5630
COD	250 mg/L	2820	14420	1690	1180
BOD	30 mg/L	1566	10785	978	898
TDS	2100 mg/L	4060	7070	3910	2740
T. Alkalinity	600 mg/L	1800	4760	1670	1780
T. Hardness	600 mg/L	850	1200	760	810
Ca Hardness	500 mg/L	620	940	640	730
Mg Hardness	416 mg/L	230	260	120	80
Sodium (Na)	200 mg/L	920	2305	838	760
Potassium (K)	-	1010	1140	330	941
Sulphates	250 mg/L	350	456	358	345
Chlorides	250 mg/L	280	365	298	295
Nitrates	-	380	425	398	376

Table 2: Physico-chemical analysis of the groundwater.

Parameters	Tolerance level prescribed by BIS, ICMR and WHO	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
pH	6.5-8.5	7.6	7.8	7.6	7.5	7.4
EC	250 -750 micromhos/cm	610	977	812	872	786
COD	NIL	243	436	327	323	327
BOD	NIL	8.7	9.0	8.4	8.3	8.6
TDS	500 mg/L	389	789	606	716	685
T. Alkalinity	200 mg/L as $CaCO_3$	174	124	132	120	144
T. Hardness	300 mg/L as $CaCO_3$	283	396	314	264	278
Ca Hardness	187.5 mg/L as $CaCO_3$	68	120	93	68	75
Mg Hardness	125 mg/L as $CaCO_3$	215	276	221	196	203
Chlorides	250mg/L as Cl	98	146	125	124	131
Sulphates	250mg/L as SO_4	94	156	136	128	136
Nitrates	45mg/L as NO_3	4.2	6.5	3.8	2.4	3.1
Sodium	200 mg/L	34	49	39	32	29
Potassium	55 mg/L	1.2	1.6	1.4	1.3	1.2

Note: For EC, the standards are adopted from Manivasakam (2003)

pollution caused by landfill. Total alkalinity of the groundwater samples was within the permissible limit with the average value of 138 mg/L. The high alkalinity imparts an unpleasant taste, and may be deleterious to human health with high pH, TDS and total hardness. Multivalent cations, particularly Mg^{2+} and Ca^{2+} are often present at a significant concentration in natural waters. These ions are easily precipitated and in particular react with soap to make it difficult to remove scum. Total hardness is normally expressed as the total concentration of Ca^{2+} and Mg^{2+} in mg/L equivalent $CaCO_3$. Total hardness ranged from 264 mg/L to 396 mg/L and the average value was 307 mg/L. Calcium hardness and magnesium hardness ranged from 68 mg/L to 120 mg/L and 196 mg/L to 276 mg/L respectively. Magnesium salts are cathartic and diuretic and high concentration may cause laxative effect. Chloride content in the water samples ranged from 98 mg/L to 146 mg/L. High chloride content of groundwater is likely to originate from pollution sources such as domestic effluents, fertilizers, septic tanks and from natural sources such as rainfall and the dissolution of fluid inclusions. Increase in chloride level is injurious to people suffering from diseases of heart or kidney (WHO 1997). Sulphate in the water samples ranged from 94 mg/L to 146 mg/L. Nitrates ranged from 2 mg/L to 6 mg/L. The average value of sodium and potassium content was 37 mg/L and 1.3 mg/L respectively. The high concentration of sodium may pose a risk to persons suffering from cardiac, renal and circulatory diseases.

CONCLUSIONS

The moderately high concentration of EC, TDS, Cl^-, SO_2^{-4}, NO^{-3}, Na^+, etc. in groundwater near landfill deteriorates its quality for drinking and other domestic purposes. Further, the presence of Cl^-, NO^{-3} and COD can be used as tracer with relation to leachate percolation. From the groundwater monitoring it is clearly evident that the leachate generated from the landfill site is affecting the groundwater quality in the adjacent areas through percolation in the subsoil. As there is no natural or other possible reason for high concentration of these pollutants, it can be concluded that leachate has significant impact on groundwater quality near the area of Mavallipura landfill site. The groundwater quality improves with the increase in depth and distance of the well from the pollution source. Although, the concentrations of few contaminants do not exceed drinking water standard even then the groundwater quality represent a significant threat to public health. This will go a long way to protecting natural resources such as water that are degraded by these solid wastes. Solid waste handling, controlling and monitoring techniques in Mavallipura must be geared towards achieving quality environmental condition for man to live in.

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