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Influence of municipal solid waste dumpsite on some physicochemical parameters of ground water

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Abstract

The rapid increase in the population, urbanization, industrialization and changes in consumerism pattern have given birth to several environmental problems that mainly include air, land and water pollution. The current study focuses on the effect of uncontrolled dumping of municipal solid waste on ground water. The physicochemical properties of water like temperature, pH, electrical conductivity, total dissolved solids, alkalinity, chloride, total hardness (TH), calcium hardness, magnesium hardness, acidity, phosphate, fluoride, dissolved oxygen (DO), chemical oxygen demand (COD), sodium and potassium were analysed. It was found that the values for EC, TDS, calcium hardness, magnesium hardness, sodium and potassium were beyond the permissible limit prescribed by WHO (2004) and BIS 10500 (2012).

Keywords: Municipal solid waste, dumpsite, physicochemical parameters, ground water, pollution.

Introduction

As per the Municipal Solid Waste (Management and Handling) Rules, 2000[1] Municipal Solid Waste comprises of commercial and residential wastes produced in a municipal or notified area in either solid or semi-solid form excluding industrial hazardous wastes but including treated bio-medical wastes. Municipal solid waste is of major concern due to its large amount that is generated every month from urban areas. The annual waste generation increases in proportion to the rise in population and urbanization[2]. The composition of waste depends upon several factors like location, lifestyle, food habits, cultural traditions, climate and economy of a nation[3,4]. Further, the amount of municipal waste produced from urban areas is a function of human development index which in turn rests upon the life expectancy, gross domestic product and education indices[5].

According to the report of Central Pollution Control Board, 2015 the estimated waste generation in the country is 1,43,449 metric tons/day and out of which 32,871metric tons/day is reported to be processed. Improper management of municipal solid waste has got serious effect on the quality of water, soil, plants and the life of people. In most of the developing nations the municipal solid waste is usually dumped on open grounds. The open dumps are the most common and easiest way of disposing off the solid waste and in majority of cases they are located wherever land is available, without any concern about the safety issues, health hazard and aesthetic degradation. The heterogenous nature of the waste makes the situation worse since in majority of cases the waste is unsegregated. Such reckless dumping of solid waste on land leads to surface and ground water pollution. It also affects the soil quality disturbing the soil microflora and microfauna. The dumping site at Mathuradaspura of Jaipur is one such example. The present study thus focuses on the effect of dumping of municipal solid waste in Mathura daspura dump site.

Study area: Rajasthan state is situated between 23º3' and 30º12' N latitude and 69º30' and 78º17' E longitude. It spreads over an area of 132,140 square miles (342,239 square kilometers). The capital city is Jaipur which has a humid subtropical climate. Jaipur city covers an area of 11117.8 sq.km. The city receives over 650 millimeters (or 26 inches) of rainfall annually but most rains occur during the rainy season i.e., between June and September. Temperatures remain fairly high all the year round. The average daily temperature during the summer months of April to early July is around 30°C (86°F). The population of Jaipur was 66,26,178 [6] and about 1000-1100 MT of waste is generated here every day. Mathuradaspura village which lies in the north east part of the Jaipur about 20 km away from the main city, situated in Jamwa Ramgarh Tehsil of Jaipur. The area adjoining the village is used as open dumping ground for non-segregated municipal solid waste. About 800 tons of municipal solid waste is dumped here every day.

Methodology

Ground water sampling: Water samples were collected from the study area at pre-monsoon, monsoon and post-monsoon season. The ground water samples were collected from tube-wells and hand pumps situated at varying distances and having varying depths in clean, sterilized, plastic containers of 4L capacity. The water was allowed to flow for few minutes prior to collection in the sampling containers in order to discard the water retained in the borewell pipes. The samples were carried to the laboratory for further analysis.

Analysis of the samples: The ground water samples were analyzed for temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), alkalinity, chloride, total hardness (TH), calcium hardness, magnesium hardness, acidity, phosphate, fluoride, dissolved oxygen (DO), chemical oxygen demand (COD), sodium and potassium. The temperature was measured at the site with the help of a mercury thermometer. pH was measured using pH meter (Labman, LMPH-10), EC was measured using EC meter (Labman, LMCM-20), and TDS was measured with the help of water analyzing kit (161E). The alkalinity was assessed by titrating the samples with 0.02N H_2SO_4 using phenolphthalein and methyl orange as indicators. Total Hardness was estimated by titrating the samples with EDTA (Ethylene-diamine-tetra acetic acid) with eriochrome black T as indicator. Calcium hardness was estimated by titration with EDTA using murexide as indicator. Acidity was estimated by titrating the samples with 0.02N NaOH, using phenolphthalein and methyl orange as indicators. Inorganic phosphate was determined by Stannous chloride colorimetric method using spectrophotometer (Thermoscientific Evolution 201). Fluoride was estimates in samples using fluoride ion meter (Hanna, HI253). Dissolved oxygen was estimated by azide modification of Wrinkle method. For DO analysis, the BOD bottles were filled with samples and DO of samples was fixed at the site using manganous sulphate and alkali iodide azide reagent further analysis was done after bringing the samples to laboratory. COD estimation was done by digesting the samples in COD digester block followed by titration. Sodium and potassium were analyzed using flame photometer.

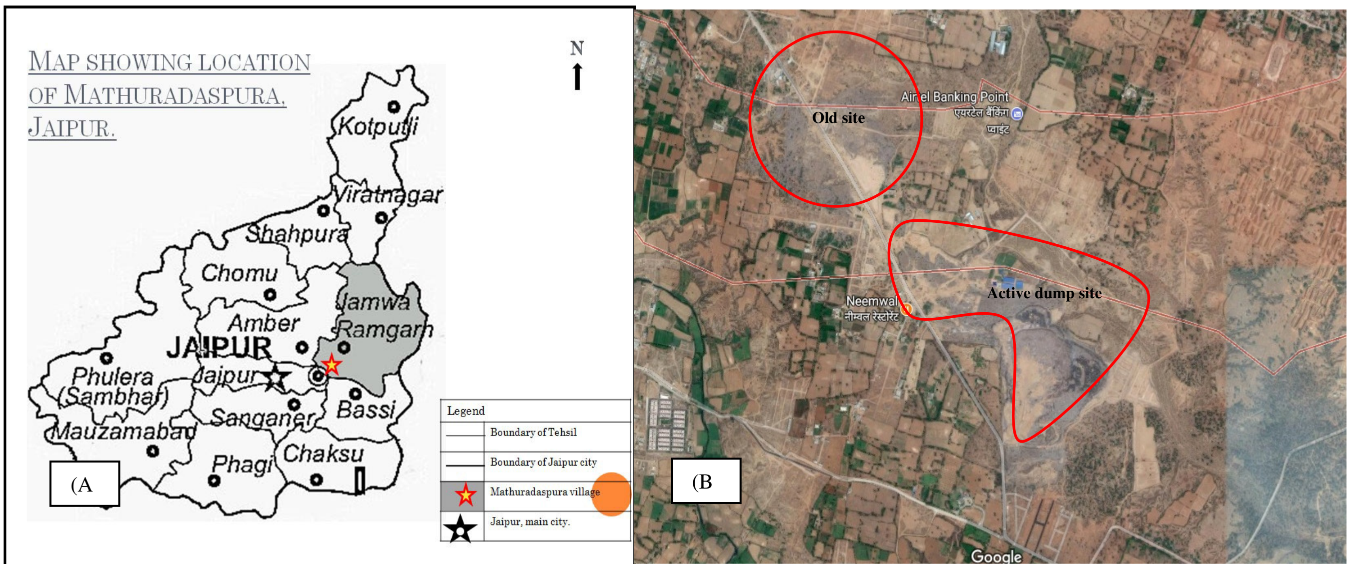
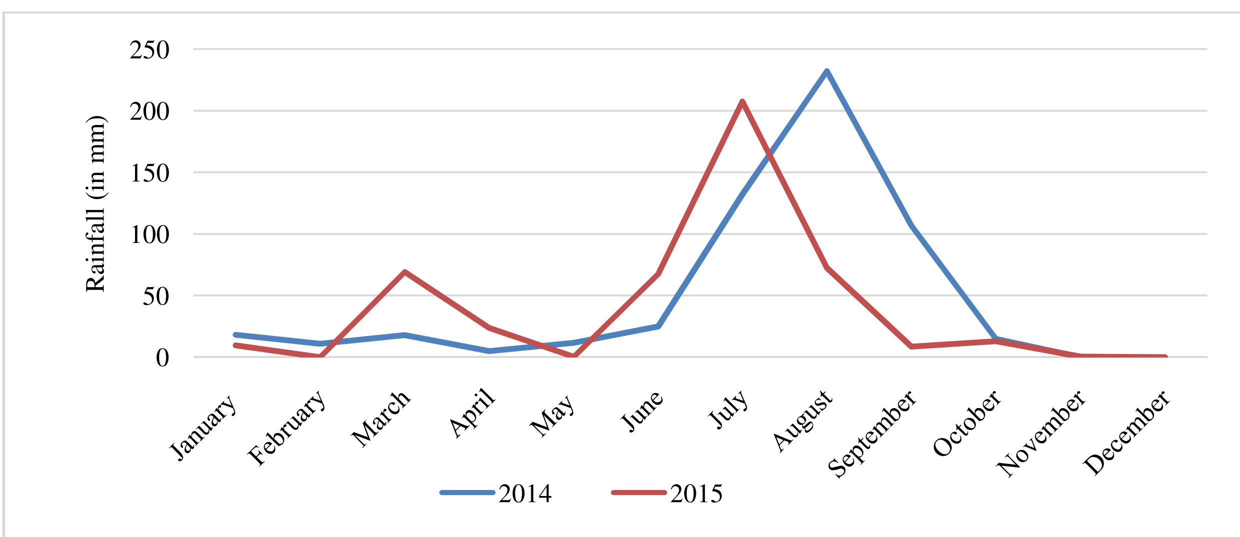


Figure-1: (A) Location of Mathuradaspura dumpsite, Jaipur city. (B) Satellite view of Municipal Solid Waste Dumpsite.



Source: Indian Meteorological Department

Figure-2: Monthly rainfall in millimeters in Jaipur District for two consecutive years.

Result and discussion

The quality of the ground water is greatly influenced by the leachate migration around a waste dumpsite. It has been well reported in several studies that the amount and quality of leachate produced in any landfill or a waste dump is greatly influenced by the local climatic conditions of the landfill or the dumpsite, along with the type of solid waste and the water content of the landfill site[7]. The result of physicochemical analysis of the ground water samples collected from around the Mathuradaspura municipal solid waste dumpsite is depicted in Tables-1 and 2.

Average temperature of 29.919 ºC was observed in the current site. Temperature may give an indication of high microbial activity in water which in turn is due to the presence of organic impurities. The average temperature in both the years of analysis was highest in the summer season. A higher temperature range of 28.7-32.1°C had been reported in other study[8]. The pH was alkaline to slightly alkaline in all the sites. In both the years of analysis the pH was found to be maximum in the rainy season followed by summer season and then winter season. The pH values reduced in the rainy and winter season but still were in the alkaline range. Similar results were obtained by other researchers[9,10]. The alkaline nature of ground water might be due to the leachate migration from waste dump and the methanogenic stage of waste degradation which produces methane and CO_2. The electrical Conductivity (EC) of the ground water samples was found to be high during the summer season in the first year of analysis and in the winter season during the second year of analysis. This may be attributed to heavy rainfall that occurred during the monsoon season of 2015 (Figure-2). The maximum rainfall data of the last two years is shown in the Figure-2, which shows highest rain fall in the August 2014. High water percolation leads to more migration of leachate in the ground water samples and also elevation in the ground water level, thus affecting the water quality both in terms of EC and TDS, during the post monsoon season. Warm climatic conditions have a complex influence of on landfill performance and there is usually a rapid increase in leachate production after precipitation[11]. High EC value is an indicator of dissolved inorganic ions in the groundwater which enter and accumulate due to leachate migration[12]. A wide-ranging electrical conductivity values may also be due to evaporation of groundwater prior to/during recharge, this might be the reason for high EC values during first season of analysis. Total Dissolved Solids (TDS) also followed a similar pattern as it was obtained in case of EC. High TDS value leads to objectionable taste, odor and color in water. High TDS values in ground water around the dump sites were also reported by other studies conducted on the ground water resources around waste dumpsite[9,13].

Chloride was also found to be more in summer season (June 2014) in the first year of analysis but in the second year it was found to be high during the winter season (2015). A surplus amount of chloride in water samples is generally considered as an indicator of organic pollution acting as a tracer for groundwater contamination[14]. Large number of other studies also reported high chloride content in ground water around the dumps sites[13,15-19]. Generally, groundwater has a greater hardness than surface water[20]. The hardness in the current study was found to be higher than the BIS standards (2012)[21]. The current study showed that there was a decrease in the TH content in the monsoon season as also shown by other study reported for ground water around the dempsite[22]. This may be attributed to the dilution of leachate percolating down. Hardness in ground water may also be because of dissolution of polyvalent metallic ions from surrounding sedimentary rocks, seepage, and run off from precipitation[23]. Excess concentrations of free carbon dioxide caused dissolution of carbonate compounds from soil and rock formations. The hardness of water is a derivative of the solution of carbon-di-oxide, released by bacterial action in the soil, in percolating rain water[24]. Both calcium and magnesium hardness were much higher than the BIS standards. This is in accordance with the results obtained in other studies in ground water of dumpsite[17]. Mg content higher than calcium was also reported in studies conducted in Tamil Nadu (India) and Nigeria[18,25] in ground water of waste dumping sites. The alkalinity of the ground water samples was highest in the post monsoon season in both the years of analysis. Alkalinity may be due to the presence of carbonate, bicarbonate and hydroxide compounds of calcium, sodium and potassium. Greater rock water interaction during post-monsoon season could also be a contributor of high levels of HCO−. This has also been reported in a study conducted in Pune (India)[26]. A study showed decline in the DO values in the rainy season as compared to the values obtained in dry season[27]. Similar trend was observed in the current study. DO content was more than 1 mg/L in all the sites in all the seasons as also reported in a study conducted at Dump Sites in Makurdi, Nigeria[28].

The COD values are indicators of the organic and reducing inorganic matter in the water[29]. Higher COD values were obtained in the summer season as compared to rainy and winter season. Similar findings were obtained by[9]. Phosphate content in the ground water samples was high in the pre-monsoon in both the years. There was increase in the phosphate content of ground water in the second year of analysis. the phosphate content was well below the standard given by WHO (2006). There are several sources of phosphates for example, sewage industrial wastes, fertilizers, domestic wastes, detergents, etc. Higher sodium and potassium concentration was observed during the pre-monsoon and as compared to post-monsoon in the groundwater which indicates possible anthropogenic input through dumpsite leachate similar results were obtained by other researchers also[9,26,30]. Sodium concentration exceeded the WHO limits (table 3) in all the three seasons. Fluoride content in the dumpsite was well below the maximum permissible limit (MPL) given by the WHO (2004)[31]. The values of standard deviation clearly indicate that several parameters vary over a very wide range, this may be due to the varying distance of sampling site from the dumpsite, variable type of waste dumped in the dumpsite, varying depths of the water sampling wells and also the hydrogeology of the region.

Conclusion

The dumping of municipal solid waste on land without proper lining or leachate collection system may be a potential source of ground water pollution. Unsegregated waste contains several components that alter the ground water quality through leachate migration. Water parameters like hardness, chloride, TDS and sodium exceeded the standards set for drinking water and may lead to several health problems in the population that consume them. Hence, from the above study it is concluded that the dumping of un segregated waste on land may pose severe deleterious effects on the quality of the soil and the under-ground water. The separation of waste is must before dumping on land. The role of temperature, rainfall and waste characteristics must be taken into consideration before designing a landfill site. The quality of the ground water in such areas depend on the climatological and hydrogeological conditions. Hence, it is highly recommended that regular, monitoring of the ground water resources in and around a dumpsite must be carried out. Strict waste segregation schemes should be adopted. Properly engineered landfill must be used for the dumping of municipal solid waste which would restrict the entry of leachate and pollutants to the ground, that would reduce the pollution on the soil and consequently on the ground water resources.

Table-1: Physico-chemical parameters of ground water samples collected from Mathuradaspura dumpsite in the first year of analysis.

Parameters	First year of analysis (2014)		
	January 2014	June 2014	August 2014
Temperature (ºC)	27.6±0.328	28.26±0.596	27.605±0.339
pH	7.549±0.264	7.696±0.315	7.956±0.245
EC (mS/cm)	1.547±0.266	1.603±0.309	1.486±0.288
TDS (mg/L)	1039±0.174	1061±0.182	990±0.172
Chloride (mg/L)	472.609±273.118	480.825±282.036	467.832±289.834
Total Hardness(mg/L)	456.05±234.962	456.842±255.670	414.157±250.399
Ca^{+2} (mg/Las $CaCO_3$)	226.258±109.980	180.695±100.442	177.008±97.411
Mg^{+2} (mg/Las $CaCO_3$)	229.53±137.522	276.147±168.534	237.15±158.280
Alkalinity (mg/L as $CaCO_3$)	116.379±27.380	108.724±26.333	104.105±27.764
Acidity (mg/L)	69.158±30.986	68±31.524	65.579±33.116
DO (mg/L)	6.185±0.320	4.571±0.829	3.863±0.658
COD (mg/L)	39.126±18.206	40.734±20.979	38.137±20.952
Phosphate (mg/L)	0.164±0.090	0.292±0.179	0.184±0.117
Sodium (mg/L)	332.432±129.861	345.574±134.543	308.484±142.446
Potassium (mg/L)	46.222±21.299	48.836±20.937	43.923±19.60
Fluoride (mg/L)	0.121±0.106	0.084±0.052	0.209±0.242

Mean±Standard deviation (n=19)

Table-2: Physico-chemical parameters of ground water samples collected from Mathuradaspura dumpsite, in the second year of analysis.

Parameters	Second year of analysis (2015)		
	January 2015	June 2015	August 2015
Temperature (ºC)	27.8±0.445	28.184±0.519	28.068±0.497
pH	7.425±0.326	7.713±0.279	7.736±0.194
EC (mS/cm)	1.924±0.830	1.624±0.296	1.457±0.248
TDS (mg/L)	1490±0.737	1055±0.199	1108±0.216
Chloride (mg/L)	484.413±254.257	459.227±261.762	390.286±208.557
Total Hardness(mg/L)	356.053±164.084	461.105±244.385	322.631±124.358
Ca^{+2} (mg/Las $CaCO_3$)	179.547±108.817	198.097±87.402	141.513±61.435
Mg^{+2} (mg/Las $CaCO_3$)	178.108±91.646	267.205±160.282	179.118±80.446
Alkalinity (mg/L as $CaCO_3$)	442.790±136.831	108.942±28.436	302.894±220.529
Acidity(mg/L)	103.789±61.441	68.789±28.430	93.568±98.453
DO (mg/L)	2.795±0.521	4.374±0.828	3.753±0.489
COD (mg/L)	36.105±14.590	43±19.258	38.474±19.222
Phosphate (mg/L)	0.263±0.161	0.398±0.362	0.268±0.189
Sodium (mg/L)	281.789±101.308	343.437±131.372	294.295±114.679
Potassium (mg/L)	44.516±19.001	54.094±23.161	48.095±20.418
Fluoride (mg/L)	0.102±0.051	0.114±0.051	0.105±0.051

Mean±Standard deviation (n=19).

Table-3: Comparison of the ground water samples with the prescribed limits.

Parameters	Unit	Average values of the Mathuradaspura dumpsite for two years	WHO (2004) Permissible Limit	IS 10500 (2012) Desirable limit
Temperature	(ºC)	27.919	-	-
pH	-	7.679	8.5	6.5-8.5
EC	(mS/cm)	1.607	1.0 (mS/cm)	-
TDS	(mg/L)	1124	500	500
Chloride	(mg/L)	459.198	2050	250
Total Hardness	(mg/L)	411.139	-	300
Ca^{+2} Hardness	(mg/Las $CaCO_3$)	183.853	75	75
Mg^{+2} Hardness	(mg/Las $CaCO_3$)	227.876	30	30
Alkalinity	(mg/Las $CaCO_3$)	197.306	-	200
Acidity	(mg/L)	78.147	-	-
DO	(mg/L)	4.257	-	-
COD	(mg/L)	39.263	-	-
Phosphate	(mg/L)	0.262	10	-
Sodium	(mg/L)	317.668	200	-
Potassium	(mg/L)	47.614	-	-
Fluoride	(mg/L)	0.123	-	1.0

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