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Assessment of ground water contamination in soil due to leachate migration from an open dumping site of Dharapuram Municipality, Tamilnadu, India

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ABSTRACT

The ground water pollution was studied in the soil samples collected around the municipal solid waste (MSW) open dumpsite, Dharapuram, Tirupur District, Tamilnadu to understand the heavy leachate migration from an open dumping site. The dump site receives approximately 33 to 40 tonnes of municipal solid waste per day. Ground water samples were collected in and around the solid waste dumping yard and analyzed for their physico- chemical characteristics to ascertain the extent of groundwater pollution through leachate migration. The data discussed in this study shows that sampling stations S4 and S5 were highly polluted due to the migration of leachate into ground water. Currently, the well and bore well were not used by the concern land owner. Indiscriminate dumping of municipal solid waste without proper solid waste management practices should be stopped or some remedial measures were required to be adopted to prevent contamination.

Keywords: leachate, ground water, heavy metals, dumpsite, samples

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INTRODUCTION

The management of MSW is going through a critical phase, due to the unavailability of suitable facilities to treat and dispose of the larger amounts of MSW generated daily in metropolitan cities [1]. Improper MSWM activities can deteriorate our living environments and eventually threaten the public health. An indiscriminate dumping of wastes, on one hand, can contaminate the soils as well as the surface and ground waters. The solid wastes can clog the drain systems, which in turn creates stagnant water for insect breeding or causes flooding during the rainy seasons. Ground water plays a vital role in meeting the water requirements of people. The rapid industrialization and urbanization makes the groundwater susceptible to pollution. Ground water which was once considered to be very pure is now getting deteriorated due to increased human activities. The main problem arises from the fact that the aquifer is used as a ground water resource as well as a waste disposal medium. Landfills have been identified as one of the major threats to groundwater resources [2] not only in India but throughout the world. This leachate accumulates at the bottom of the landfill and percolates through the soil and reaches the groundwater. Areas near landfills have a greater possibility of ground water contamination because of the potential pollution source of leachate originating from the nearby dumping site. Such contamination of groundwater results in a substantial risk to local groundwater resource user and to the natural environment. The impact of landfill leachate on the surface and groundwater has given rise to a number of studies in recent years and gained major importance due to drastic increase in population [3].

Thus, generation of solid waste in urban areas is an obvious result of human activities. Natural growth of population, classifications of habitation and migration trends are common in urban populations. Urbanization is now becoming a global phenomenon, but its ramifications are more pronounced in developing countries. This urbanization, economic growth, and improved living standards in cities led to an increase in quantity and complexity of generated waste. This increase induces unhygienic conditions on the surface and also affects both the surface and underground quality of water to an alarming extent [4].

At present there is no data available on ground water quality of Dharapuram Municipality, Tirupur District, Tamilnadu, India. Hence, Dharapuram Municipality from Tirupur district, Tamilnadu has selected as case study region for this paper. Due to the dumping of the around 33 MT/day of municipal solid waste in open landfill area, it generates leachate and it will pollute the ground water quality. So the quality of ground water was analyzed in and around the Dharapuram dump yard region and ensure the ground water quality.

MATERIALS AND METHODS

Ten ground water samples from well and bore well were collected during the month of May and December, 2013 at various places around the Dharapuram dumping site within a radius of 25m to 200m. The water samples were collected in one litre container after thorough washing and rinsed with sample water. The samples were numbered and stored in laboratories for further analysis. The samples were collected at different directions and it covers all the direction of the dump site and one bore water sample was collected within the dump site area. The sampling locations of the ground water were shown in Table1.

Table 1 Ground water sampling locations

Bottle No.	Location	Well/ Borewell
S1	North East	Well
S2	North	Borewell
S3	East	well
S4	South	Borewell
S5	South West	Borewell
S6	North West	well
S7	West	well
S8	South East	well
S9	Dump Site area	Bore
S10	East	Well

The collected water samples were analyzed the physico-chemical parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Turbidity, Total Hardness, Calcium, Magnesium, Total Alkalinity, Nitrate, Nitrite, Chloride, Sulphate, Sodium, Potassium, Iron, Copper, Zinc, lead, Nickel, Cadmium, Chromium, Silicates, COD and BOD based on the standard procedure APHA 2012.

RESULTS AND DISCUSSION

To assess the state of the quality of ground water in the vicinity of landfill site, water samples from the existing water sources in and around the Dharapuram disposal site at varying distances from the boundary of the disposal site were collected and analyzed for physico-chemical characteristics during Summer (May) and Winter (December) seasons of the experimental study period and the results of which are shown in Table 2 and 3 respectively.

The water samples were collected from the nine places around the dumpsite and one sample from the inside dump yard area. The samples were collected both wells and bore wells in and around the dump yard for both seasons. The field testing kit was taken to the sampling sites and the important Insitu parameters such as temperature, electrical conductivity (EC), pH and dissolved oxygen (DO) were tested at the site itself. Then samples were stored in laboratory for further studies.

3.1 pH

The pH of the water samples were ranged between 7.3 to 8.2 pH at May month and 7.2 to 8.4 pH at December Month. The pH values of the samples were in the alkaline range both during summer and winter seasons. The pH values were within the prescribed limit of drinking water quality standards. While comparing the both seasons, there was a slight increase in the pH during the winter season, it may be due to the sampling after the rainy season may leads to the dissolution of ions from the leachate in to ground water. It was observed that the samples S4 and S5 were collected at south and southwest direction of the dump yard shows higher alkaline value than the other samples.

3.2 Electrical conductivity

The EC values varied from 5260 to 7248 µs/cm in the samples analyzed during summer season and from 4965 to 7500 µs/cm during winter season. Electrical conductivity gives an idea about the concentration of ions in solution that determines the quality of water for drinking and irrigation purposes. The sample S4 shows higher EC value at both seasons. It was noticed that groundwater samples collected at S4 station contain more soluble salts.

3.3 Total Dissolved Solids

The BIS and WHO standard fixed for the TDS in the ground water is 500 mg/l. But unfortunately, the values observed during the May and December month were high for all the stations except a few. The TDS was ranged between 2365 to 6700 and 2100 to 6800 mg/l for May and December months respectively. The EC values have linear relationship with the TDS values. The sample S4 has high TDS among all the samples.

As per both the standards, water containing more than 500 mg/l of TDS is not considered to be desirable for drinking water supplies. High TDS value in water samples may be due to leaching from the waste into the ground water. To ascertain the suitability of groundwater for any purposes, it is essential to classify the groundwater depending upon their hydrochemical properties based on their TDS values [5]. The high concentrations of dissolved solids in the groundwater may decrease the palatability and may cause gastro-intestinal irritation in human and laxative effect particularly upon transits [6].

Table 2: Ground Water Quality Analysis at May Month of the year 2013

Parameter	BIS Standards	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	6.50 to 8.50	7.7	7.7	8.2	7.4	8.1	7.9	7.6	7.8	7.3	8
Electrical Conductivity (µs/cm)	-	7248	6800	7041	9250	5700	5260	6700	6900	5820	6950
Total Dissolved Solids (mg/l)	500	4600	3986	4241	6700	2965	2365	3962	4154	3028	4165
Turbidity(NTU)	5	1	3	1	8	7	2	4	2	3	6
Total Hardness (mg/l)	300	1600	1000	700	2000	200	400	1000	900	700	800
Calcium (mg/l)	75	278	296	353	454	231	234	298	234	293	393
Magnesium (mg/l)	30	140	171	154	372	511	298	175	187	140	213
Total Alkalinity (mg/l)	200	400	542	854	345	365	456	323	435	234	302
Nitrate (mg/l)	45	2.23	4.78	5.30	6.98	5.35	4.19	3.05	3.94	5.45	3.47
Nitrite (mg/l)	-	0.14	0.18	0.23	0.34	0.36	0.18	0.16	0.15	0.19	0.21
Chlorides (mg/l)	250	1744	1599	1657	2616	872	262	1686	1773	1279	1744
Sulphate (mg/l)	200	245	202	189	321	231	78	98	172	187	201
Sodium (mg/l)	150	298	301	294	585	389	384	352	302	325	382
Potassium (mg/l)	-	23	23	22	34	24	21	23	26	23	20
Iron (mg/l)	0.3	0.42	0.34	1.3	1.1	0.34	0.3	0.7	0.3	0.45	0.3
Copper (mg/l)	0.05	0.0025	0.0015	0.005	0.01	0.007	0.04	0.005	0.004	0.01	0.005
Zinc (mg/l)	5	0.0013	0.0015	0.097	0.002	0.093	0.04	0.093	0.083	0.064	0.064
Lead (mg/l)	0.05	0.0027	0.008	0.023	0.009	0.043	0.003	0.043	0.0064	0.004	0.03
Nickel (mg/l)	0.02	0.01	0.006	0.006	0.03	0.003	0.01	0.003	0.009	0.008	0.01
Cadmium (mg/l)	0.1	0.003	0.008	0.004	0.08	0.006	0.008	0.007	0.009	0.007	0.006
Chromium (mg/l)	0.05	0.02	0.01	0.01	0.03	0.04	0.02	0.02	0.01	0.03	0.02
Silicates (as SiO_2)(mg/l)	0.4 to 25	7.63	6.6	10.1	10.1	5.7	6.78	3.45	2.73	5.34	6.24
COD(mg/l)	5	4	3	3	6	3	3	4	5	4	2
BOD(mg/l)	-	1.5	1	1.1	1.6	1.1	1.2	1.1	1.3	1.2	1.3

3.4 Turbidity

The turbidity was due to the colloidal fine dispersion of suspended solids. Some microorganism might also contribute the turbidity. The Turbidity in the Ground water was ranged from 1 to 8 NTU and 2 to 8 NTU for May and December months respectively. The values shown in the Table 2 and 3 indicated that some bore well and open well water samples had turbidity value present in the range of maximum permissible limit, but some of the samples S4, S5 and S10 at May month and S4, S5, S7 and S9 had high turbidity at December month.

3.5 Total hardness:

In ground water, hardness is primarily due to presence of carbonates, bicarbonates, sulphates and chlorides of calcium and magnesium. If the hardness is less than 50 mg/l the water will be soft. If the hardness is from 50 to 100 mg/l, the water will be moderate soft. If the hardness is from 101 to 200 mg/l and more than 200 mg/l, the water will be slightly hard and quite hard, respectively. The total hardness values were ranged between 400 to 2000 mg/l at May month and 300 to 1800 mg/l at December month. Again the study confirmed the excess quantity of hardness creating cations and anions were present in and around the water samples.

Table 3: Ground Water Quality Analysis at December Month of the year 2013

Parameter	BIS Standards	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	6.50 to 8.50	7.2	7.8	7.2	8.3	8.4	7.6	7.3	7.2	7.9	7.9
Electrical Conductivity (µs/cm)	-	7450	7500	7100	9200	6250	4965	7100	6850	6100	6500
Total Dissolved Solids (mg/l)	500	4600	4650	4200	6800	3500	2100	4325	4200	3300	3900
Turbidity(NTU)	5	2	5	3	6	8	4	6	3	6	4
Total Hardness (mg/l)	300	1500	1200	700	1800	700	300	1200	900	600	800
Calcium (mg/l)	75	298	342	376	487	276	212	232	265	275	352
Magnesium (mg/l)	30	127	162	125	325	356	302	162	172	162	201
Total Alkalinity (mg/l)	200	500	672	763	847	564	345	463	543	429	453
Nitrate (mg/l)	45	3.78	4.82	5.63	7.89	6.78	5	3.092	4.922	5.67	8.83
Nitrite (mg/l)	-	0.23	0.15	0.16	0.43	0.13	0.16	0.14	0.16	0.12	0.23
Chlorides (mg/l)	250	1672	1672	1635	2613	814	293	1721	1672	1365	1625
Sulphate (mg/l)	200	212	232	243	353	254	87	76	143	102	154
Sodium (mg/l)	150	234	254	254	432	343	253	321	276	254	273
Potassium (mg/l)	-	22	23	21	32	21	23	21	24	23	21
Iron (mg/l)	0.3	0.3	0.2	1	0.9	0.3	0.3	0.4	1.3	0.53	0.3
Copper (mg/l)	0.05	0.0035	0.001	0.03	0.04	0.002	0.07	0.05	0.04	0.081	0.005
Zinc (mg/l)	5	0.0013	0.0015	0.097	0.026	0.053	0.03	0.033	0.093	0.029	0.063
Lead (mg/l)	0.05	0.037	0.048	0.03	0.007	0.053	0.063	0.033	0.064	0.093	0.03
Nickel (mg/l)	0.02	0.01	0.006	0.006	0.023	0.003	0.002	0.002	0.009	0.008	0.002
Cadmium (mg/l)	0.1	0.003	0.008	0.003	0.007	0.005	0.008	0.006	0.007	0.007	0.004
Chromium (mg/l)	0.05	0.02	0.01	0.01	0.03	0.04	0.04	0.03	0.01	0.03	0.01
Silicates (as SiO_2)(mg/l)	0.4 to 25	6.7	6.5	10.5	10.4	7.8	5.6	4.5	6.4	3.5	8.4
COD(mg/l)	5	3	5	3	7	6	4	2	4	4	2
BOD(mg/l)	-	1.2	1.3	1.1	1.5	1.2	1.1	1.2	1.3	1	1.2

It was indicated that S4 have more total hardness at May and December months and it was followed by the samples S1, S2, S7 and S10. The author also was observed the same results in their research [7]. The high hardness content in the ground water provides the salty taste and the water would not suitable for drinking purpose, agriculture activity and other domestic activities. Hardness also contributes to inefficient and costly operation of water using appliances.

3.6 Calcium

The high concentration of Calcium was observed at all samples (S1 to S10) for the both seasons. The Ca concentration was ranged between 231 to 454 mg/l for May month and 212 to 487 mg/l for December month. The values of calcium measured for all the samples during summer and winter exceeded the drinking water limit (75 mg/l) recommended by Indian and International standards. Calcium is the third most abundant metal in the earth's crust. Excess of ca ions causes concretions in the kidney and causes irritation and pain in the urinary passages.

3.7 Magnesium

The IS standards prescribed the limit for the presence of magnesium in water is 30 mg/l. But the water samples collected over the Dharapuram dump yard crosses the limit and the values were given in the Table 2 and 3. The concentration of magnesium ranged between 140 to 372 mg/l at summer and 125 to 356 mg/l at winter. The excess concentration of the magnesium may be due to the percolation of leachate into the ground water. High concentration of Mg can cause laxative effect in human being.

1.8 Total Alkalinity

The combination of carbonate and bicarbonate present in the water sample provides the total alkalinity. Carbonate concentration was not present in the water sample. So the bicarbonate concentration was providing the complete contribution for total alkalinity. Samples containing only bicarbonate alkalinity have a pH of 8.3 or less. In this case bicarbonate alkalinity is equal to the total alkalinity. Alkalinity which was found greater than hardness could be due to the presence of basic salts of sodium and potassium, in addition to calcium and magnesium. The IS standard prescribe the limit for total alkalinity is 200 mg/l. But the concentration of alkalinity in samples S1 to S10 were crossed the maximum permissible limit. The presence of calcareous materials together with CO_2 generation in landfill is the cause of increased carbonate and bicarbonate concentrations.

3.9 Nitrate and Nitrite

The concentration of Nitrate concentration in the ground water samples were recorded as 2.23 to 5.45 mg/l at May month and 3.09 to 8.83 mg/l at December month. The prescribed limit for the nitrate concentration is 45 mg/l. The distribution of nitrate in the ground water in the study area suggests that the human waste source of nitrate enters the aquifers, and possibly in the Dharapuram dump yard, both liquid and solid wastes, are sources for the nitrate concentration increase in the study area. Groundwater nitrate contamination may be due to wastewater discharge, effluent from on-site sanitation, leachate from solid waste dump sites, and reuse of wastewater for irrigation [8]. High nitrate concentration in groundwater causes methamoglobinemia or blue baby disease in infants, alimentary canal, respiratory and nervous system disorders [9]. The concentration of nitrite in the water samples was present less than 0.5 mg/l for both the seasons.

3.10 Chloride and Sulphate

The concentration of Chloride was ranged between 262 to 2616 mg/l for May month and 293 to 2613 mg/l for December month. The maximum permissible limit for the chloride in water is 250 mg/l. For the both seasons the values were exceeded the limit prescribed by IS standard. Chloride occurs naturally in all types of water. Also it was observed that, the sources of chloride ions are related to ionic exchange between the rocks and percolated water while recharging the ground water. The most important source of Chlorides in the waters is discharge of domestic sewage. Man and other animals excrete very high quantities of chloride together with Nitrogenous compounds. Chlorides in water samples when exceeds the recommended limit of drinking water (IS standard-250 mg/l and WHO standard-200 mg/l), imparts salty taste and this can cause laxative effect. Increase in Cl level is injurious to people suffering from heart and kidney diseases [6]. It was illustrated that chloride in reasonable concentration is not harmful, but it causes corrosion in concentrations above 250 mg /l, while about 400 mg /l it causes a salty taste in water [10].

Sulphate is a naturally occurring ion in almost all types of water bodies. The natural sources of sulfate in ground waters include sulfide minerals weathering and gypsum and/or anhydrite [11]. Sulphate concentration varied from 78 to 321 mg/l and 86 to 353 mg/l for May and December months respectively. It was observed that samples S4 and S5 have more amounts of sulphate concentrations than the other places. Some samples were under the permissible limit. Sulfate may cause gastro intestinal irritation at higher concentrations, particularly when Mg^{2+} and Na^+ are also present in drinking water.

3.11 Sodium and Potassium

Sodium concentration was varied from 294 to 585 mg/l for summer season and 234 to 432 mg/l for winter season. All the samples collected were exceeded the maximum permissible limit prescribed by IS standards. Furthermore, potassium varied from 20 to 34 mg/l and 21 to 24 mg/l for May and December months. The minimum concentration of potassium was present in the ground water. The main groundwater potassium sources may include rain water, weathering of potash silicate minerals and application of potash fertilizer [12].

3.12 COD and BOD

The concentration of COD varied from 26 to 168 mg/l in summer season and 27 to 134 mg/l in winter season. BOD concentration ranged from 2 to 17 mg/l in both summer and winter season. The sample S4 shows high BOD and COD values. High COD value in ground shows the presence of oxidizable organic materials that had leached from domestic refuse in the landfill site [13]. The leachate generated at the landfill site carries considerable amount of organic matter, percolated through the soil and entered into ground water showing increase in BOD value. Ground waters free of dissolved oxygen tend to dissolve iron and manganese from the geological strata of the aquifer material and also ground waters with depleted oxygen promote the conversion of sulphate to H_2S which is highly obnoxious. High COD and BOD concentration in ground water samples indicate the presence of organic contaminants in the water.

3.13 Heavy Metals

Heavy metals contamination in groundwater has received great attention due to their toxicity and accumulative behavior. . These metals are introduced into the environment through weathering of rock minerals and by anthropogenic activities. The metal ion concentrations in groundwater collected during month of May and December are presented in Table 2 and 3. The toxic effects of these elements and the extent of their ground water contamination are discussed below. The concentrations of Cu, Zn, Pb, Ni, Cd and Cr in ground water collected around the dump yard were very low than the permissible limit. Except Fe and Si, it shows the slight increase in the concentration than the permissible limit. High iron concentrations generally cause a bitter and astringent taste. It also clogs and pits pipes, discolors clothes and plumbing fixtures and causes scaling which encrusts pipes [12]. The high iron concentration is possibly due to rusty pumps and reduced condition in the aquifer. For the both seasons, the samples S4 and S5 show the higher concentration of Fe and Si metals. Water samples from the existing water sources collected and analyzed for physico-chemical and biological characteristics during May and December months of the study period showed significant increase in almost all the water quality parameters except a few parameters. Also the concentration of the heavy metals was very less in all the samples except Fe and Si. The above results showed that majorly the samples S4 and S5 were represent the higher concentration of physico chemical parameters than the other samples. The samples S4 and S5 were collected near the dump yard and currently the ground water was not utilized by the owner of the bore wells, it was confirmed by visiting the respective sampling location and after had interview with the owners. The study concluded that water quality was deteriorated in and around the disposal facility and the existing dumpsite was the only and major source of contamination.

CONCLUSION

The ground water samples analysis reports for May and December month concluded that significant increase in almost all the water quality parameters except a few parameters. Also the concentration of the heavy metals was very less in all the samples except Fe and Si. The above results showed that majorly the samples S4 and S5 were represent the higher concentration of physico chemical parameters than the other samples. Currently, the S4 and S5 bore wells were not utilized for domestic purposes. However, these pollutant species continuously migrate and percolate through the soil strata in different layers and after certain period of time might contaminate the entire groundwater system if no action is taken to prevent this phenomenon. This will serve several objectives, such as; reducing the amount of waste produced and dumping in the landfill and consequently reduces their negatively environmental impacts. The most new technology that may be applied in this respect, using such wastes as a source of raw materials for industrial purposes or to be a source for energy production, or as a conditioner used for the improvement of soil or conversion of organic waste in to manure and applied for agricultural activities.

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