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STUDY ON GROUND WATER QUALITY IN AND AROUND PERUNGUDI SOLID WASTE DUMPING SITE IN CHENNAI

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ABSTRACT

In developing country like India landfills are situated near to cities, releasing harmful contaminants which percolate to the groundwater. This results in contamination of the ground water. Municipal wastes and hazardous wastes are the main cause of polluting the ground water. The Chennai Corporation has two major dumping sites namely Perungudi and Kodungayaiyur located south and north of Chennai. These open dumpsites are smelly and surface water percolating through the trash can dissolve or release harmful chemicals, among these chemicals, heavy metals causes environmental problem. Heavy metals when gets dissolved in ground water which then consumed by humans leads to health issues, Hence the presence of bore wells and tube wells near the dumpsite threatens the life of people living near that area. In this study an attempt was made to know the concentration of heavy metals in ground water around the Perungudi dumpsite. For this study 10 number of ground water samples were collected and preserved by adding of 2-3 drops of nitric acid. The samples were subjected to analysis of pH, TDS, hardness, COD and four trace metals Cr, Cu, Cd and Fe by using inductively coupled plasma mass spectrometry (ICP-MS). It was observed that the health of the people residing near the dumpsite was affected due to consumption of this water. It is concluded that the ground water is contaminated and cannot be used for drinking water as well as domestic purpose.

Keywords: Solid waste, Ground water, Heavy metals, Leachate.

INTRODUCTION

The relationship of man with environment is necessarily symbiotic and hence the equilibrium between the two must be maintained in all aspects. During the last few decades, man's relationship with environment has drastically changed due to industrialization. Large quantities of solid wastes are being disposed off on land, being an effective medium for disposal of solid wastes. The quantity of municipal and industrial waste generated by the society is constantly increasing. The growth of Municipal Solid Waste (MSW) generation in India has outpaced the population growth in recent years. Improper dumping and management of solid waste cause hazards to the ground water and inhabitants. The average solid waste generated in the Chennai City, India is around 3500 Metric Tonne (MT) per day. Perungudi near Chennai is one such open dump site with a capacity of 1600 MT per day. This disposal causes threat to the ground water in and around the dumpsite. Hence an attempt is made to analyse the amount by which the groundwater is contaminated in recent years. The contamination from an unplanned solid waste disposal system becomes a threat to the environment. The presence of bore well at the landfill sites to draw ground water threatens to contaminate the ground water[1,2]. The landfill site nearer to Perungudi are open dumpsites, because the open dumpsites are low operating costs and lack of expertise and equipment provided no systems for leachate collections. Open dumps are unsightly, unsanitary, and generally smelly. They attract scavenging animals, rats, insects, pigs and other pests. Surface water percolating through the trash can dissolve out or leach harmful chemicals that are then carried away from the dumpsites in surface or subsurface runoff. Among these chemicals heavy metals are particularly insidious and lead to the phenomenon of bioaccumulation and bio magnifications.

Study Area

Chennai lies on the southeast coast of India and is the capital of Tamil Nadu. The population of the city is 37.19 million (2011 census), which makes it the fourth largest city. At present, Chennai has two open dumpsites, Perungudi in the south and Kodungaiyur in the north[3-7]. These Dumpsites are placed on marshy land, which is used to be Aquifers and bird sanctuaries. Perungudi is used for dumping the waste collected from south since 1987. The total area of the site is about 800 acres in which about 350 acres have been used so far for dumping. Perungudi dumping ground lies at 12.057'13.5" N and 80.014'05.8" E. The existing dump site at Perungudi is located approximately 1.2 km south of the city centre. Velachery marsh lies immediately north to the site. The site is non-engineered low lying open dump, looks like a huge heap of waste. There are four villages which are situated near the Perungudi dump yard. Oggium, Thuraipakkam, Mettukuppam, Oggium Pettai and Mootaikaranchavadi have been affected due to groundwater contamination[3-5]. The recent survey stated that on an average of 19% of the people depends on groundwater for drinking in four villages. The Figure 1 shows the Perungudi area. The lower economic group and the people living for 3 or 4 decades were depend on the groundwater for drinking whereas the middle income groups were partly depend on public water supply and partly on private water supply. The higher income groups and the recent settlers were totally depends on private water supply.

EXPERIMENTAL

The Figure-1 shows the methodology adopted for this study. Whereas, Figure-2 shows the location of the Perungudi landfill site (Fig.-2), where the study was conducted.

Survey of the Landfill Site → Collection of Water and Leachate Samples → Analysis of Physical and Chemical Properties → Results and Discussion

Fig.-1: Flow of Methodology

Fig.-2: Map showing Perungudi area

Sample Sites

For the initial study the leachate sample was collected for the landfill site. The leachate was collected from the water logged areas near the dumping ground. The moisture content coming out of the waste gets accumulated near a low land area. Sampling site shown in Figure-3 and Figure-4

Fig.-3: Perungudi landfill site

Fig.-4: Map showing Perungudi landfill site.

Leachate Collection

The plastic bottle was cleaned and dried under sun for the collection of the sample. Proper precautions to be taken while collecting the leachate sample from the dump yard (using gloves while collecting the sample). The leachate sample was collected from the water logged area of the dump yard. The collected sample is brought to the laboratory to test the parameters of the collected leachate sample.

Instrumental Analysis

The following instruments were used for analysis of the leachate sample.

Atomic Absorption Spectrometer (AAS)

It is a spectroanalytical procedure for the quantitative determination of chemical elements using the absorption of optical radiation (light) by free atoms in the gaseous state. AAS can be used to determine over 70 different elements in solution or directly in solid samples. The technique makes use of absorption

spectrometry to assess the concentration of an analyte in a sample. It requires standards with known analyte content to establish the relation between the measured absorbance and the analyte concentration. The electrons of the atoms in the atomizer can be promoted to higher orbitals (excited state) for a short period of time (nanoseconds) by absorbing a defined quantity of energy (radiation of a given wavelength).

Inductive Coupled Plasma Mass Spectrometer (ICPMS)

The instrument used was a Perkin-Elmer Sciex Elan 5000 ICP-mass spectrometer (Perkin-Elmer, U¨berlingen, Germany) equipped with quartz torch, nickel sampler and skimmer cones, a peristaltic pump (maintaining a 1 ml min-1 sample uptake rate), a cross-flow type pneumatic nebulizer and a double pass Scott-type spray chamber. ICP-MS is said to be the most useful techniques for the determination of trace metals up to parts per billion levels.

Groundwater Sample Collection from Perungudi Area

The plastic bottles was cleaned and dried under sun for the collection of the sample. Proper precautions to be taken while collecting the water sample from the nearby dumpsite area. The water sample was collected from hand pumps, bore well and tap water from the residential area located near to the dumpsite.

While collecting the water sample the coordinates were noted for plotting the ARCGIS map[7]. The Table-1 shows the coordinates from where the samples were collected. The collected samples was taken to the laboratory for testing the parameters[8-10].

Table-1: Co-ordinates of the ground water sample collected.

S. No.	Sample No.	Source	Latitude	Longitude
1.	Sample no.1	Tube well	12.9536392	80.23882455
2.	Sample no. 2	Bore well	12.9536174	80.23811
3.	Sample no. 3	Tube well	12.95163111	80.23818713
4.	Sample no. 4	Tube well	12.9522119	80.23818713
5.	Sample no. 5	Tube well	12.9625	80.24020522
6.	Sample no. 6	Tap water	12.96723	80.2355
7.	Sample no. 7	Tube well	12.967000	80.23311533
8.	Sample no. 8	Tube well	12.9805	82.4736
9.	Sample no. 9	Tube well	12.9512	80.2344
10.	Sample no.10	Tap water	12.9573	80.1761
11.	Sample no. 11	Tube well	12.966429	80.2423881
12.	Sample no. 12	Tube well	12.9524292	80.2391567
13.	Background water	Tube well	13.0054976	80.212171

From each sample location three 250 ml of sample was collected known as triple system collection. The collected sample was tested for pH, conductivity, TDS, COD, hardness and heavy metals like cadmium, chromium, copper and Iron. The heavy metals were determined using ICPMS instrument. Along with the Perungudi area, water sample was collected from Guindy area which was considered as the background water[11,12].

RESULTS AND DISCUSSION

The physical and chemical properties of the leachate are tested in the laboratory. The results are tabulated below in Table-2.

Source: Permissible limit according to the 'Standards for treated leachate from land disposal', Ministry of Environment and Forest, Schedule IV rule 6(1).

The standard pH of the leachate varies between 5.5 and 8.5. The obtained sample lies within the range. Similarly the colour, appearance and odour is as per the standard values. The other parameters such like

COD, TSS and BOD are more than the permissible limit. Hence the obtained leachate sample lies beyond the permissible limit. The desirable limit of Total Dissolved Solids 500 mg/L. TDS is generally considered not as a primary pollutant, but it is rather used as an indication of aesthetic characteristics of drinking water.

Table-2: Results of the leachate test

S. No.	Description	Units	Results	Permissible Limit
1.	Appearance	----	Turbid	Turbid
2.	Colour	---	Brownish	Blackish
3.	Odour	---	Foul smell	Foul smell
4.	Turbidity	NTU	3.4	–
5.	Total Suspended Solids	mg/L	300	0–200
6.	Total Dissolved Solids	mg/L	1010	0–2100
7.	Electrical Conductivity	Micro mho/cm	12.4	–
8.	pH	-----	7.58	5.5–8.5
9.	COD	mg/L	1556	–
10.	BOD	mg/L	410	0–350
11.	Chromium	mg/L	0.16	< 2.0
12.	Copper	mg/L	0.08	< 3.0
13.	Total Hardness as CaCo3	mg/L	1600	400–2000

Ground Water Analysis

The chemical characteristics of ground water samples taken in 10 locations were analysed and the results are shown in Table-3. The major parameters like pH, TDS, Hardness, Cd, Cr, Cu, and Iron were analysed.[13,14]

Table-3: Chemical characteristics of Ground water samples

Sample No	pH	TDS	Hardness	Cadmium	Chromium	Copper	Iron
1	6.2	128	653	0.008	0.48	0.09	0.52
2	6.4	256	689	0.015	0.42	0.35	0.41
3	6.6	358	654	0.013	0.35	0.21	0.39
4	6.5	456	789	0.012	0.08	0.08	0.25
5	6.5	486	526	0.018	0.21	0.19	0.19
6	7.2	652	423	0.02	0.07	0.17	0.18
7	7.4	752	586	0.019	0.09	0.2	0.35
8	6.9	613	598	0.009	0.06	0.09	0.26
9	7.4	585	1013	0.008	0.15	0.08	0.19
10	7.1	423	1052	0.009	0.09	0.07	0.09

The Table 4 shows the permissible limit of various parameters as per IS: 10500 standards.

Table-4: Standards of Drinking Water (IS: 10500) [2]

S. No.	Parameters	Units	Permissible Limit
1.	pH	–	6.5–8.5
2.	Total Dissolved Solids	mg/L	500

3.	Hardness	mg/L	300
4.	Cadmium	mg/L	0.01
5.	Chromium	mg/L	0.05
6.	Copper	mg/L	0.05
7.	Iron	mg/L	0.3

Heavy metal pollution is a serious threat to the environment. Metals that are deposited in the aquatic environment may accumulate in the food chain and cause ecological damage and affect human health.

Heavy Metals

Cadmium

The permissible limit for cadmium is 0.01 mg/l. Beyond this the water becomes toxic. Sample S2, S3, S4, S5, S6 and S7 are beyond the limits.

Chromium

The permissible limit for chromium is 0.05 mg/L. All the water samples are beyond the permissible limits. Hence the Cr content is more in all most all the surrounding places.

Copper

The desirable limit for copper is 0.05 mg/L. The undesirable effect beyond the desirable limit is astringent taste, discoloration and corrosion of pipes, fittings and utensils will be caused. The present water sample are having copper value ranging from 0.07 mg/L to 0.35 mg/L. Hence the water samples are contaminated due to copper and not suitable for drinking[2].

Iron

The permissible limit for iron is 0.3 mg/L. Sample S1, S2 S3 and S7 are beyond the permissible limit. Industrial discharge, domestic sewage, non-point source runoff and atmospheric precipitation are the main source of toxic heavy metals that enters aquatic systems. Many metals are essential for living organisms but some of them are highly toxic or become toxic at high concentration. Transition metals like Fe, Cu which are essential but harmful at high concentrations.

Background Water

Along with the perungudi ground water analysis, a water sample was collected from Guindy near to Guindy railway station. The parameters were tested which is tabulated in Table 5**.** The background study was important to get a conclusion as the ground water near the dumpsite is contaminated due to penetration of leachate to the water table. According to the results obtained the heavy metal content is minute, below the permissible limit[2].

Table-5: Analysis results of background water sample

S. No.	Parameters	Units	Value Obtained	Permissible Limit	Interface
1	pH	–	7.32	6.5–8.5	Within the limit
2	Conductivity	µS/cm	35.5	10	Above the limit
3	Hardness	mg/L	380	300	Above the limit
4	TDS	mg/L	22.4	500	Within the limit
5	Chromium	mg/L	0.01	0.05	Within the limit
6	Cadmium	mg/L	BDL	0.01	Within the limit
7	Copper	mg/L	0.01	0.05	Within the limit
8	Iron	mg/L	0.01	0.3	Within the limit

Environmental Problems due to Dumpsite

Other than the surface and groundwater pollution, the dumpsite can cause air pollution. The decay of organic waste is associated with emissions of methane and hydrogen sulphide. The existing dumpsite is subjected to a significant number of fires initiated by rag pickers on site as means of liberating and recovering metals and non-combustible materials from the waste. The quality analysis clearly shows that four villages of Oggium Thuraipakkam panchayat union namely Oggium Thuraipakkam, Mettukuppam, Oggium Pettai and Mootaikaranchavadi have been affected due to groundwater contamination. The analysis shows that on an average of 19% of the people depends on groundwater for drinking in four villages. About 19% were depends on public water supply and remaining 62% depends on private water supply.

CONCLUSION

The concentration of the heavy metals Cr, Cd, Cu and Iron in the ground water samples are beyond the permissible limit. But the survey shows that the leachate sample is percolating from the landfill site to the ground water and it also affects the other subsurface water sources. Due to the penetration of the leachate produced from the landfill site, contaminates the existing landfill site. The findings indicate the contamination is severe in localities around the dumpsite. The long term exposure of excessive amount of copper and cadmium causes kidney damage and lung cancer. Chromium is also said to cause cancer if exposed for long time.

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