

Review Paper on Assessment of Groundwater Quality in Open Landfill

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Abstract— Groundwater is one the important source of fresh water available on earth. It is the one which helps in meeting the water needs for various activities. This groundwater cannot be used for general purposes without assessing the quality of water. Physical, chemical and biological characteristics of water should be within the permissible limits. But water quality in most of the areas around the open dump yards are not within the permissible limits due to leachate percolation. This study is to get a detailed idea on the quality of groundwater when waste are dumped in open areas without any Engineered methods. It is found that most of the area around the open landfill contains contaminated groundwater due to open dumping of waste. When the waste contains heavy metals like Zinc (Zn) and Lead (Pb), it is evident that the waste contains batteries, Lead based paints, Fluorescent lamps. This heavy metals, when present beyond the permissible limits of Bureau of Indian Standards (BIS), causes serious health issues when it is consumed unceasingly. If leachate contains Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), presence of organic matter in the groundwater is confirmed. Analysis of water quality using statistical analysis, indicates that most of the characteristics which are highly correlated are highly responsible for contamination of groundwater. Based on the parameters which are beyond the permissible limits, the types of waste deposited in that landfill can be identified. Hence suitable appropriate preventive measures can be carried out.

Keywords— *Groundwater quality, Leachate characteristics, municipal solid waste, factor analysis, statistical analysis, sample collection.*

I. INTRODUCTION

Earth is covered by 71% of water, in which around 96.5% ocean water, 0.9% saline water and only about 2.5% of fresh water, represented in figure-1. In that, 68% of fresh water available as icecaps and glaciers and 30% groundwater. This shows that, most of our water needs is satisfied by groundwater. So, groundwater plays a vital role in human life for various factors. When the dumped waste receives rainfall, the decomposed waste by-products mixes with water. This liquid, which contains innumerable amount of organic and inorganic matter is called as leachate. Leachate percolates through the soil particles and reaches the groundwater, which leads to the contamination of water, as represented in figure-2.

Hence, water quality is to be assessed in and around the areas of landfill. Municipal waste majorly contains organic and bio-degradable waste from residential, commercial, institutional areas. This municipal solid waste are dumped in open landfills without any precautions for a long period of time and leads to the formation of leachate. This leachate

consists pathogenic elements which pollutes the groundwater quality. When this polluted groundwater is consumed by living species like humans, animals, plants, it creates harmful effects on them.

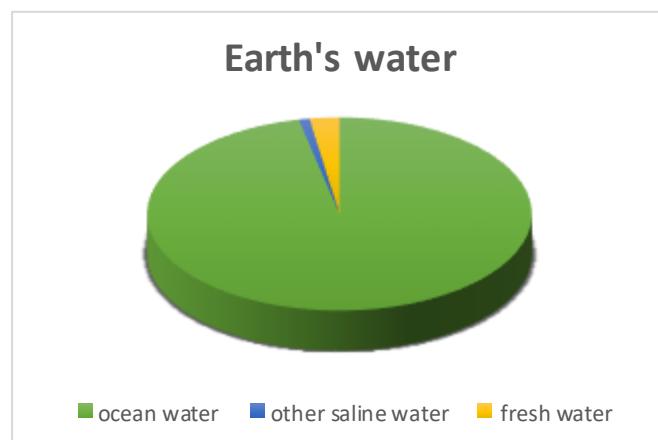


Fig. 1. Earth's water

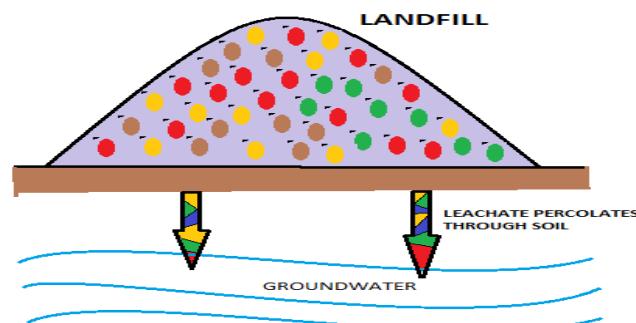


Fig. 2. Open dump impact over groundwater

II. LITERATURE SURVEY

Studies have been done on various literatures and impact on groundwater quality due to dumping of waste in open landfills without proper precautions over it. The study have been done for various places within INDIA. Due to dumping of waste, quality of water is assessed whether it is within the permissible limits, in and around the dump yard area.

A. Vellore Dump Yard, Coimbatore ^[1]

Coimbatore is a major city in Tamilnadu, which is located near Nilgiri hills (Ooty). Vellore is a town in Coimbatore which is located at 13km east of Coimbatore district situated on the southern bank of Noyyal River. For more number of years, both the sewage and solid waste created in the Coimbatore district is dumped here. Due to practical difficulties on the segregation and composting of waste it leads to the formation of Waste Mountain. Here, they have tested the groundwater quality and compared with the Water Quality Index (WQI). The samples are collected around 1km radius at the intervals of <200m, 200m to 400m, 400m to 600m, 600m to 800m, 800 to 1000m.

Leachate characteristics is found to be blackish with filthy smell and also pH is 7.83. Total hardness, turbidity, total dissolved solids, chlorides and fluorides are not within the permissible limits, but pH, conductivity, dissolved oxygen, alkalinity are within limits. From the survey they also found that this intake of water creates health issues like fever, dysentery, eye irritation, skin allergy, tooth decay, gastro intestinal problem etc. The WQI is greater than 100 which denotes that groundwater within the 1km radius from the dump yard is unfit for drinking.

B. Salem Dump Yard ^[2]

Salem is one of the city in Tamilnadu, which is also known as mango city or steel city. In Salem municipal waste are dumped in Kithchipalayam, Dalmia board, Chettichavadi. They assessed the water quality for all three dump yards. Samples are collected in clean bottles around 10km from the dump yard area. The results were obtained for parameters like Chloride (Cl), Total Hardness (TH), Fluoride (F), pH, Dissolved oxygen (DO). Test results are given below in the table-1,

TABLE – 1: Salem Dump Yard Parameter

Para-meter	Cl	TH	F	pH	DO
	<250 mg/l	300 to 600mg/l	<1.5 mg/l	6.5 to 8.5	4 to 8mg/l
Kithchipalayam	Not within limit	Not within limit	Not within limit	Within limit	Not within limit
Dalmia Board	Within limit	Within limit	Within limit	Within limit	Not within limit
Chettichavadi	Within limit	Not within limit	Not within limit	Within limit	Not within limit

They also found that during rainy season, people are suffering from environmental hazards like land fires, bad odour, eye irritation, respiratory problems, etc. Even 10years old Chettichavadi dump yard of Salem contributing more fluoride accumulation in ground water compared to other sites.

If this process continues without any Engineered methods severe impact over the groundwater will be created.

C. Erode Dump yard ^[3]

Erode district which is located on the western bank of Cauvery. It is characterized by scanty rainfall and a dry climate. Three landfills are already closed which is filled completely. In present three yard are working in Vendipalayam, Semur and Vairapalayam dump site but none of the yards were lined which will result in groundwater contamination. Quantity of waste generated are provided in the table-2 which is shown below,

TABLE 2: Erode dump yard waste produced on average

Yard	Waste produced on average in Tonnes/day
Vendipalayam	45
Semur	15 to 20
Vairapalayam	20

They made 43 observation wells for collecting groundwater samples and there is no proper lining for collecting leachate samples so it is collected randomly. Some of the tests like conductivity, pH, salinity etc., are tested in the field itself. The leachate samples contains Zn, Pb which indicates the presence of batteries, lead based paints and fluorescent lamps. This leachate also contains high level of BOD and COD, Which indicates that the sample has organic matter. It also contains Fe which shows it as heavy metals in the samples. They observed that the areas near the Vendipalayam dump yard has chloride and sodium more than the permissible limits. They tested for heavy metals concentration for Cu (copper), Fe (Iron) and Zn. But only Fe concentration exceeds the permissible limits. Some of the compounds like electrical conductivity, chloride, sodium, sulphate, etc., are in higher concentration which makes the water unfit for drinking in all the three yards. However, when we move away from the yard, concentrations of the compounds reduces and it makes the water fit for drinking.

D. Bingipur dump yard, Bangalore ^[4]

They have assessed the impact on both groundwater and soil, by dumping of waste without proper lining and engineering measures. Bangalore is understood as Silicon Valley of India. It's situated on the south eastern a part of Karnataka. In Bangalore city, waste are collected and deposited within the Bingipur dump yard which is unlined landfill. They collected the samples within 5km and it's tested for various parameters. They found that a number of the characteristics are within the permissible limits and a few of them aren't up to the desirable limit. The samples which are obtained from the downstream side is contaminated more compared to the upstream. The iron content of the sample ranges between 0.07 mg/l to 0.15 mg/l which falls below the desirable limit. But pH of the sample falls within the limit. The conductivity of the sample is so high, which indicates that the water sample is contaminated.

E. Gazipur dump yard, Delhi ^[5]

Delhi is the capital of India, which is located on the banks of Yamuna River. The waste collected in Delhi is transported and dumped in the Gazipur dumping yard. This yard started in the year 1984 and it is still in use. On average 2200 metric ton/day of waste is dumped at the site. The waste dumped here includes kitchen waste, paper, plastic, cardboard, cloths, construction and demolition waste, poultry waste, fish market waste, dairy farm waste and non – infectious hospital waste. The dump is unlined and waste for about 12 to 20m height is dumped. 16 samples were collected around the Gazipur dump yard. They collected the samples in clean water bottles and maintained in 4°C until it is tested. They found that groundwater gets contaminated through the leaching action. Some parameters like TDS (Total Dissolved Solids), alkalinity, chloride, sulphate, nitrate, calcium, magnesium, sodium, potassium alkalinity, total hardness, and total dissolved solids are not within the permissible limit in some of the sites.

F. Kodungaiyur dump yard, Chennai ^[6]

Chennai is the capital of Tamilnadu. The waste generated from the city is dumped in Perungudi in south and Kodungaiyur in the north. Due to increase in population, urbanization, change in lifestyle, consumption pattern, there is no proper waste management in the Chennai city. Sewage from the Kodungaiyur sewage treatment plant are also discharged into the dumpsite. This yard is covered by water course in all directions. They collected the samples in the clean water bottles, which are cleaned with 1% nitric acid and it is analyzed. 17 samples were collected in the post-monsoon season. The conductivity and TDS of the sample is very high and it indicates the presence of inorganic matter. Leachate contains high level of BOD and COD, which indicates the presence of organic matter. The groundwater sample contains maximum value of 2225 mg/l, which is more than the permissible limit in some of the sample sites. Total hardness and magnesium are high in almost all the samples, which results in scale formation. Heavy metals like Cu, Fe and Zn are also tested. In which Zn and Cu are within the permissible limits but Fe exits the permissible limit of 0.3mg/l.

G. Pirana site, western India ^[7]

Ahmadabad being one of the important city in India. It has large number of chemical and textile industry. But this city has only one dump site in Pirana which is working for more than 20yrs. The waste generated is around 1100 mg/l to 1200 mg/l, in which 95% of waste is dumped in Pirana site. The waste of about 1000 mg/l per day is dumped in this site. They collected 11 groundwater samples and 1 leachate sample. Sample were collected in the clean water bottle, these bottles are soaked in 1:1 HNO₃ (Nitric acid) after washing with detergents. Then again they washed the bottles with the distilled water.

Samples are stored in 4°C. This leachate and groundwater samples collected are tested. There are four methods finding the impact of leachate and they opted for “statistical, correlation, factor and cluster analysis”. The analysis results are provided in the below table – 3,

TABLE - 3: Method used for finding the impact of leachate from landfill

Analysis Method	Result obtained
Statistical analysis	It provides the results in form of range, mean and standard deviation of concentration of parameters. This shows the results EC and TDS are very high. And leachate contains heavy metals in the order of Fe>Mn(Manganese)>Zn>Cu>Pb>Cr(Chromium)>Ni(Nickel)>Cd(Cadmium).
Correlation analysis	Here they used Pearson correlation. It is the bivariate method, was applied to describe the degree of relationship between two parameter. High correlation value denotes a good relationship. Good correlation is obtained for EC with TDS, NO ₃ (Nitrate) and SO ₄ (Sulphate). Most of the important correlated pairs are obtained due to human activities.
Factor analysis	In this large number of variables are converted to few factors. In this five significant factors are used. In that five factors, factor 1 group of variables like EC (Electrical conductivity), TDS, NO ₃ , Cl and SO ₄ are largely influenced in the contamination.
Cluster analysis	Method of grouping parameters of same kind into respective categories. In this Euclidean distance methods for finding distance. The distance between samples indicates the similarity and dissimilarity between parameters. They found that samples in group 1 influence more contamination than group 2 samples.

These techniques are handy and helps in preliminary determination on impact of landfill. These analysis technique are cost effective. Almost factor and cluster analysis holds good for analyzing the impact compared to statistical and correlation method. With the help of these analysis, assessment of groundwater quality is made.

H. Jawaharnagar Dump Yard, Hyderabad ^[8]

Jawaharnagar municipal dump site located in the Greater Hyderabad Municipal Corporation, Hyderabad. The city produces of 5454 metric tons every day, which is dumped in the site. Total 12 samples were collected using Garmin GPS (Garmin Global Positioning System). From the test, they found the percentage of sample exceeding the limits, which is provided in the table- 4.

TABLE – 4 : Percentage of Samples Exceeding The Permissible Limit

Parameter	% of samples exceeding limits
Ca ²⁺	83.33
Mg ²⁺	75
Cl ⁻	76
TDS	100
Total hardness	50
NO ₃	58.33
Fluoride	66.66

There is also a presence of heavy metals, which is due to anthropogenic activities of various sources like incineration plants, industrial effluent plant, and traffic activities. Most of the parameters are not within the limits but heavy metals concentration are within the permissible limits.

I. Bhalswa landfill yard, Delhi^[9]

The study area is located in the western part of Delhi which is one of the most urbanized areas in Delhi. Samples are collected for 2 years for an approximate distance of 28km² from the landfill area. Collected samples are tested for various characteristics such as pH, TDS, EC, Mg, Na (Sodium), etc. and also for heavy metals like zinc, copper, lead, cadmium. They used multivariate statistical analysis like factor and correlation analysis for assessment of groundwater quality.

From the correlation analysis, it is found that most of the variables which are highly correlated, are obtained in the groundwater due to anthropogenic activities. For example, iron is highly correlated with Cl (0.61) and Zn (0.68), which indicates leaching of steel and alloys from anthropogenic sources.

From the factor analysis, they used principal component factor analysis in which various variables are grouped into factors. Number of factors required depends on the Eigen value of the variables. F1 from factor 2 and Ni from factor 4, shows that these two variables are not natural one and occurred due to anthropogenic activities. This site also shows the presence of heavy metals in the water, which is beyond the limit. From the research they studied that, this site is affected more due to dumping of waste and need to change the disposal site or to change the site into Engineered landfill for future dumping.

III. CONCLUSION

Groundwater is one of the important source of fresh water for Humans. When the waste are dumped as such without any proper Engineered lining, it leads to the contamination of the groundwater due to the leaching process. From the study of above literatures, it is evident that groundwater quality gets affected by open landfills. So, proper steps have to be taken to avoid this contamination and to make sustainable groundwater. Some of the remediation to avoid this impact over groundwater are,

- 1) Use 3R (Reduce, Reuse and Recycle) formula, in order to reduce the waste generation.
- 2) Segregation of waste at the point of generation will be effective in reducing the waste and helps in waste management.
- 3) Using Engineered landfills, will avoid the contamination of groundwater, soil and air.
- 4) Proper awareness should be created regarding the waste disposal and its impact over groundwater, which is harmful to living beings and non-living beings.
- 5) Treating leachate with suitable methods like biological methods, anaerobic lagoons, activated sludge process, nanoparticles and adsorption methods can reduce the hazards.

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