



RESEARCH ARTICLE

ASSESSMENT OF IMPACT ON SUB-SURFACE WATER QUALITY AT LANDFILL SITE: A CASE STUDY WTE PLANT KATHONDA

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ABSTRACT

Due to rapid urbanization and uncontrolled growth rate of population, municipal solid waste Management (MSWM) has become acute in India. MSWM, though an essential service, is given low priority. Although presently many cities in India taking a step forward and adopting new technologies like Thermal treatment which reduces the load on landfill site and increase the life span of it. Reduction in landfill site is also reduces the contamination of ground water due to landfill leachates. Hence the present work is aimed at assessing the sub surface water quality index (WQI) for the groundwater of surrounding areas of landfill site & WTE plant kathonda Jabalpur. This has been determined by collecting groundwater samples and subjecting the samples to a comprehensive physicochemical analysis. For calculating the WQI, the following 9 parameters have been considered: pH, electrical conductivity, dissolved oxygen, Total dissolved solids, Alkalinity. Hence this paper presents the comparative study of the results of ground water pollution due to individual solid waste landfill site and landfill site along with Waste to energy plant.

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INTRODUCTION

Groundwater is used for domestic and industrial water supply and irrigation all over the world. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization. Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions. Along with all this, nowadays increasing landfill also equally responsible for polluting ground water. Despite different possibilities of municipal waste treatment, including recycling, composting and incineration, municipal landfills are still a common way of waste disposal in many regions of the world. This paper is an attempt to show whether landfill cause more groundwater pollution or not as the study area is now facilitated with Waste to energy plant which reduces the load of landfill site. Water Quality index is one of the most effective, simple and easily understandable tools to assess water quality for its suitability for various purposes (Gopal Krishan *et al.*). Water Quality Index (WQI) were formulated in many countries based on their National standards. Horton, 1965 proposed the first WQI to be used as a tool for assessing the overall quality of water Cude 2001, improves the

understanding of water quality issues by integrating complex data and generating a score that assess the appropriateness of the quality of water for a variety of uses. Sargaonkar and Deshpande, 2003 defined quality in terms of its physical, chemical and biological parameters and developed an overall index of pollution for surface water based on a general classification scheme in Indian context. Boyacioglu, 2007 developed the Universal Water Quality Index (UWQI) to provide a simpler method for describing the quality of the surface water used for drinking water supply (Mausumi Raychaudhuri *et al.*).

Study Area: This study was conducted in the Jabalpur Municipal area, one of the oldest municipalities in Madhya Pradesh, India. Geographical spread of JMC is 215 sq.km with 1,267,567 populations as per census 2011 and generating 450TPD MSW. Jabalpur municipalities cover 53 sq km and have 79 wards and the plant having Area of 4 hac. (JMC report under project UDAY). The study was conducted in July to December 2017 with the average temperature ranging from 29°C to 14°C. Summer is followed by the southwest monsoon, which lasts until early October and produces 35 inches (898 mm) of rain from July to September. Average annual precipitation is nearly 55 inches (1386 mm).

MATERIAS AND METHODS

Groundwater samples were collected from 8 locations during post-monsoon period (nov-dec 2017).

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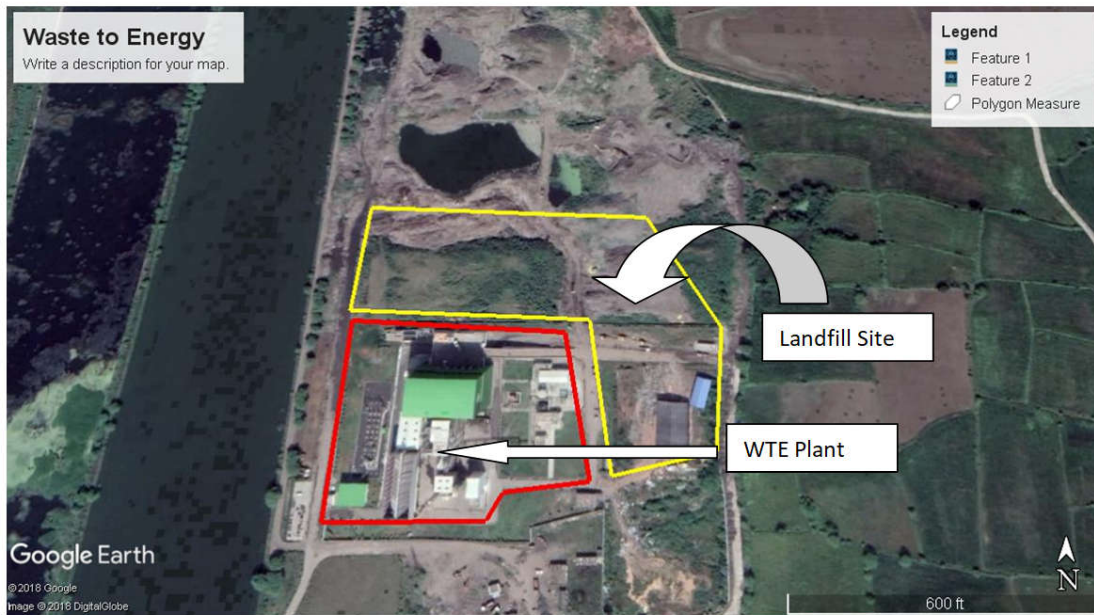


Figure 1 Satellite Image of Waste to energy plant and landfill site situated at Kathonda, Jabalpur Madhya Pradesh, India

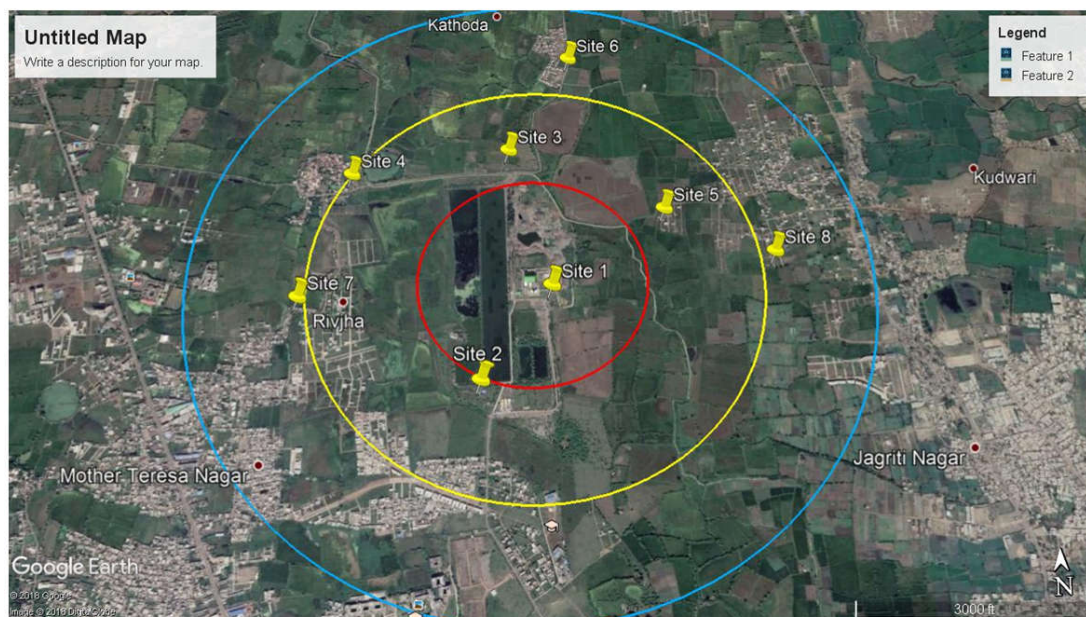


Figure 2. Satellite image showing points of sampling

Each of the groundwater samples were collected on 2 lit standard sample jar & analyzed for 10 parameters such as pH, electrical conductivity, Total Dissolved Solids, total hardness, chloride, nitrate, fluoride, calcium, alkalinity and Dissolved Oxygen using standard procedures. Fig 2 showing different points of collection around the plant and land fill site.

Calculation for Water quality Index

The calculations of WQI are done as per weighted arithmetic water quality index which was originally proposed by Horton (1965) and developed by Brown *et al* (1972) (Horton) (Brown *et al.*). IS 10500 and WHO standards of drinking water were used for WQI calculations. Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality parameters.

This method has been widely used by the (Izabela *et al.*, 2016). For computing WQI three steps are followed. In the first step, each of the 9 parameters has been assigned a weight (w_i) according to its relative importance in the overall quality of water for drinking purposes (Table 3). The maximum weight of 5 has been assigned to the parameter nitrate due to its major importance in water quality assessment. Calcium which is given the minimum weight of 2 as alkalinity may not be harmful. Other In the second step, the relative weight (W_i) is computed from the following equation

$$W_i = \frac{w_i}{\sum_{i=1}^n w_i}$$

Where, W_i is the relative weight, w_i is the weight of each parameter and n is the number of parameters. Third step involves assignment of a quality rating scale (Q_i) for each

parameter by dividing its concentration in each water sample by its respective standard according to the guidelines laid down in the BIS followed by multiplication with 100:

$$Q_i = \frac{C_i}{S_i} \times 100.$$

Where Q_i denotes the quality rating, C_i denotes the concentration of each chemical parameter in each water sample in mg/L, and S_i is the Indian drinking water or irrigation water standard for each chemical parameter in mg/L according to the guidelines of the BIS 10500, 1991 or WHO. The above formula is valid only for parameters having ideal value zero (0 mg/l). Hence for pH, the ideal value is 7.0 (pure water) and a permissible value is 8.5 (for polluted water).

chemical parameter, which is then used to determine the WQI as per the following equation

$$SI_i = W_i \cdot Q_i \cdot WQI = \sum SI$$

SI_i is the sub-index of i^{th} parameter; Q_i is the rating based on concentration of i^{th} parameter and n is the number of parameters. The computed WQI values are classified into five types, "excellent water" to "water, unsuitable for drinking".

RESULTS AND DISCUSSION

The various physico-chemical parameters of different sources are analyzed according to SFRI lab manual Water quality Test.

Table 1. Relative weight of chemical parameters

Chemical parameters	Indian Standards	Weight (w_i) [#]	Relative weight (W_i)
pH	6.5 – 8.5	4	0.114286
Total hardness(TH)	300 – 600	2	0.057143
Electrical Conductivity(EC)	1400*	4	0.114286
Calcium	75 – 200	2	0.057143
Flouride	1 – 1.5	4	0.114286
Nitrate	45 – 100	5	0.142857
Dissolved Oxygen(DO)	5*	5	0.142857
Total Dissolved Solids(TDS)	500 – 2000	4	0.114286
Alkalinity	200 – 600	2	0.057143
		$\sum w_i = 32$	$\sum W_i = 1.0000$

[#] C. R. RAMAKRISHNALAH et al.

Ground water quality variation

Table 2. Classification of groundwater quality based on Water Quality Index

WQI	STATUS	GRADING
<50	Excellent water quality	A
50-100	Good water quality	B
101-200	Poor water quality	C
201-300	Very poor water quality	D
>300	Unsuitable for Drinking	E

(ref. Mausumi Raychaudhuri et al)

Table 3. Calculation of Water quality Index based on following parameters

Sno.	Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
1	pH	6.97	7.06	7.11	6.87	7.2	7.3	7.25	7.18
2	Total Hardness, mg/l	278	342	360	270	320	312	312	380
3	Electrical conductivity, $\mu\text{S}/\text{c}$	708	726	624	1940	822	678	822	705
4	Calcium, mg/l	144	207	215	142	193	183	183	227
5	Flouride, mg/l	0.38	1.84	0.42	1.17	0.37	0.51	0.25	0.6
6	Nitrate, mg/l	0	0.7	5	25	0.6	4	2.1	2.1
7	Dissolved Oxygen, mg/l	5.65	6.99	7.07	6.33	7.6	6.35	6.27	5.87
8	Total dissolved solids, mg/l	356	455	316	1000	413	340	442	337
9	Alkalinity, mg/l	345	340	285	345	280	255	240	225
	WQI	57.06	85.8	70.16	102.22	71.76	66.84	66.32	68.71

Therefore, the quality rating for pH is calculated from the following equation:

$$Q_{pH} = 100[(V_{pH} - 7.0)/(8.5 - 7.0)].$$

Where V_{pH} =observed value of pH

For dissolved oxygen, the ideal value is 14.6 mg/l and the standard permissible value for drinking water is 5 mg/l. Therefore, its quality rating is calculated from the following equation

$$Q_{DO} = 100[(V_{DO} - 14.6)/(5.0 - 14.6)].$$

Where V_{DO} =observed value of dissolved oxygen. For computing the WQI, the SI is first determined for each

Table 3 below gives the observed values (V_i) of the (09) selected physicochemical parameters of water samples (collected in month of Nov 2017) at various places surrounding WTE plant, standard drinking water according to IS 10500 – 2012 and WHO, unit weights (W_i), water quality (Q_i) and $W_i Q_i$. Electrical conductivity of water is a direct function of its total dissolved salts. Hence it is an index to represent the total concentration of soluble salts in water. In our study area, the electrical conductivity of the ground water samples varied between 650 - 2000 $\mu\text{S}/\text{cm}$ during post-monsoon. The permissible total dissolved salts for drinking water is 500 mg/L. In the absence of potable water source the permissible limit is upto 2000 mg/L. It is found from the analysis, all the well water samples TDS is within the

maximum limit of 2000 mg/L in pre-monsoon period. The range of TDS levels in the study area is 70-1500 mg/L. Total 8 samples in premonsoon period show TDS value beyond the desirable limit of 500 mg/L. The highest concentration of total dissolved solids was found to be 1000mg/L due to dense residential area and due to intensive irrigation in that area. High values of TDS in groundwater are generally not harmful to human beings but high concentration of these may affect persons, who are suffering from kidney and heart diseases. Water containing high solids may cause laxative or constipation effects. All the parameters of the selected sites are within standard limit except of sample 4 which is an agricultural land. The value of calcium is little more than standard value (75 mg/l) but not exceeding the permissible limit (200 mg/l). Only two samples exceeding the permissible limit (Sample 3 & 4 having 215mg/l & 227 mg/l respectively).

Conclusion

The WQI for 8 samples ranges from 57.06 to 102.00. Almost ninety nine percent of the samples are under 100, the normal limit for drinking water. Only 1 sample has exceed the desirable limit. The high value of WQI at this stations has been found to be mainly from the higher values of, nitrate, total dissolved solids, hardness, fluorides, bicarbonate, chloride and manganese in the groundwater. About 99% of water samples are good in quality only few remain unsafe. In this part, the groundwater quality may improve with the reduction of landfill load on the site due to working of waste to energy plant. The only sample which exceed the WQI value of 100 has poor quality is because of pesticides used in the agriculture land. As the sample 4 is ground water of an agricultural farm in north-west side of the landfill site. Earlier the same study was done and through those samples the WQI of the area was found to be very poor (samiksha jain *et al.*) which shows that with the execution of the plant the contamination of the ground water reduced and the quality was improved. Land filling is also hazardous during the monsoon period as it create nuisance to surroundings and leachates responsible for contamination of pollutants into groundwater. Hence we can conclude that Waste to energy process for Municipal solid waste is more sustainable and pollution free for at least groundwater.

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