Assessment of Impact on Sub-Surface Water Quality at Landfill Site at Kathonda, Jabalpur

Prashant Gupta[1] Asso. Prof. R.K. Bhatia[2]
[1]ME Student [2]Associate. Professor
[1,2]Department of Civil (Environmental) Engineering
[1,2]Jabalpur Engineering College, Jabalpur, MP, India

Abstract— Due to rapid urbanization and uncontrolled growth rate of population, municipal solid waste Management (MSWM) has become acute in India Solid Waste Management may be defined as the discipline associated with the control of generation, collection, storage, transfer and transport, processing and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics and other environmental considerations. 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. . For calculating the WQI, the following 9 parameters have been considered: pH, electrical conductivity, dissolved oxygen, Total dissolved solids, Alkalinity. 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 physicochemical analysis. 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.

Key words: Sub-Surface Water Quality, WQI

I. INTRODUCTION

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. 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.

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 in 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.).

II. 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)

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

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 anuual precipitation is nearly 55 inches (1386 mm).

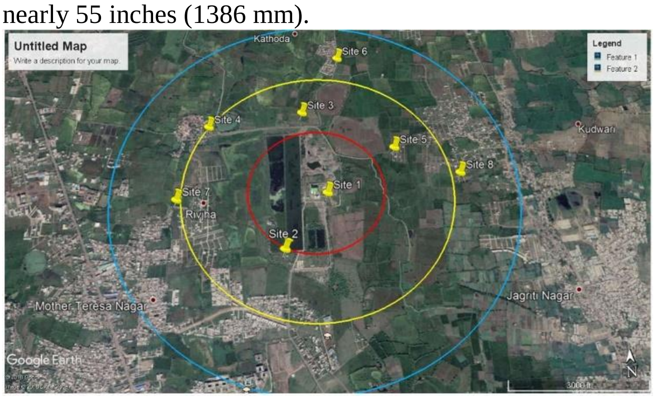

Fig. 2: Showing Sampling Points

III. MATERIALS AND METHODS

Groundwater samples were collected from 8 locations during post-winter period. Each of the groundwater samples were collected on 2 lit standard sample jar & analyzed for 9 parameters such as pH, electrical conductivity, Total Dissolved Solids, total hardness, nitrate, fluoride, calcium, alkalinity and Dissolved Oxygen using standard procedures. Fig 2 showing different points of collection around the plant and land fill site.

A. 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 (wi) according to its relative importance in the overall quality of water for drinking purposes (Table 1). 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 (Wi) is computed from the following equation

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

Where, Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters. Third step involves assignment of a quality rating scale (Qi) 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 Qi denotes the quality rating, Ci denotes the concentration of each chemical parameter in each water sample in mg/L, and Si 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). Therefore, the quality rating for pH is calculated from the following equation:

$$Q_{pH} = 100(V_{pH} - 7.0)/(8.5 - 7.0) \quad .$$

Where VpH=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

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

Where VDO=observed value of dissolved oxygen. For computing the WQI, the SI is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation

$$SI_i = W_i \, . \, Q_i \, . \; WQI = \sum SI$$

SIi is the sub-index of ith parameter; Qi is the rating based on concentration of ith parameter and n is the number of parameters. The computed WQI values are classified into five types, "excellent water" to "water unsuitable for drinking".

IV. RESULTS & DISCUSSION

The various physico-chemical parameters of different sources are analyzed according to SFRI lab manual Water quality Test. Table 3 below gives the observed values (Vi) of the (09) selected physicochemical parameters of water samples at various places surrounding WTE plant, standard drinking water according to IS 10500 – 2012 and WHO, unit weights (Wi),water quality (Qi) and WiQi. 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 - 1500 µS/cm during postmonsoon. 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).

Chemical parameters	Indian Standards	Weight (w_i)	Relative weight (W_i)
pH	6.5 – 8.5	4	0.12500
Total hardness(TH)	300 – 600	2	0.06250
Electrical Conductivity(EC)	1400	4	0.12500
Calcium	75 – 200	2	0.06250
Flouride	1 – 1.5	4	0.12500
Nitrate	45 – 100	5	0.15625
Dissolved Oxygen(DO)	5*	5	0.15625
Total Dissolved Solids(TDS)	500 – 2000	4	0.12500
Alkalinity	200 – 600	2	0.06250
		$\sum w_i$ =32	$\sum W_i$ = 1.0000

Table 1. Relative weight of chemical parameters

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

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

Sn	Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8
1	pH	6.96	7.07	7.12	6.85	7.22	7.31	7.3	7.2
2	Total Hardness, mg/l	279	343	360	270	320	312	312	380
3	Electrical onductivity, µs/c	708	726	624	1492	822	678	822	705
4	Calcium , mg/l	145	211	215	142	193	183	183	227
5	Flouride , mg/l	0.38	1.83	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	5.63	6.98	7.07	6.33	7.6	6.35	6.27	5.87
8	Total dissolved solids , mg/l	357	458	316	1000	413	340	442	337
9	Alkalinity , mg/l	344	340	285	345	280	255	240	225
	WQI	62.88	89.38	68.03	102.07	67.22	68.05	67.55	72.69

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

V. CONCLUSION

The WQI for 8 samples ranges from 62.88 to 102.07. 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 chlorides 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 northwest side of the landfill site. Land filling is 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 atleast groundwater.

REFERENCES

[1] CPCB, Guide Manual of water Quality Analysis. C. R. RAMAKRISHNAIAH, C. SADASHIVAIAH and G. RANGANNA," Assessment of Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State, India", E-Journal of Chemistry http://www.e-journals.net 2009, 6(2), 523-530.

[2] Horton, R. K. 1965. "An index number system for rating water quality," J. Water Pollut. Control Fed., vol. 37, no. 3, pp. 300–306.

[3] Indian Standard, Drinking Water- specification (Second revision of IS 10500: 2012) B U R E A U O F I N D I A N S T A N D A R D S manak bhavan, 9 bahadur shah zafar marg new delhi 110002.

[4] Izabela A. Talalaj1 and Pawel Biedka1. 2016. "Use of the landfill water pollution index (LWPI) for groundwater quality assessment near the landfill sites" Environ Science Pollution Res., 23:24601–24613, DOI 10.1007/s11356016-7622-0.

[5] Jabalpur City Development Plan Jawaharlal Nehru National Urban Renewal Mission, Municipal Corporation Jabalpur.

[6] Jabalpur Municipal corporation, report related to "WTE under project UDAY". Mausmi choudhray et al "WQI to monitor water quality for irrigation and potable use", Directorate of water management.

[7] Samiksha Jain and Prof. R.K. Bhatia "Impact of landfill leachate on groundwater quality- A case study on central India", International journal of Advanced and Innovative Research (2278-7844).

[8] State Forest Research Institute Jabalpur, MP, India. WHO, 1993. Guidelines for drinking water quality, Second Edition, Geneva.