Study of Groundwater Contamination Due to a Dump Yard: A Case Study of Vamanjoor Dump Yard, Mangalore, India

Donal Nixon D'Souza, P.S. Aditya, S. SavithaSagari, Deepanshi Jain and Dr.N. Balasubramanya

Abstract--- *Solid waste disposal is a major concern in developing countries. They are generally disposed off in dump yards where they are likely to contaminate the ground water due to leachate infiltration. The present study was conducted on the ground water, in the vicinity of Vamanjoor dump yard in Mangalore. Twenty eight ground water samples were collected and analyzed for physical and chemical parameters as per standard methods for water and waste water. The results were compared with BIS guideline values for potable water with the view to quantify the extent of ground water pollution, and its impact on health. The sampling and analysis of ground water showed contaminationdue to landfill leachate, as a result if excessive concentrations of one or more contaminants such as Iron, Nitrate, Cadmium, Total Dissolved Solids and Fluorides. The presence of these contaminants has rendered about 86% of the samples unpalatable. The variation in contamination is mapped using high resolution satellite data, with the help of GIS and Surfer mapping tools.*

Keywords--- *Expansive Soil, Fly Ash, Lime, Strength Properties*

I. INTRODUCTION

MUNCIPAL SOLID waste (MSW) disposal is a global concern, especially in developing countries across the world.Poverty, population growth and high urbanization rates combine with ineffectual and underfunded governments to prevent efficient management of wastes. Solid waste includes all the discarded solid materials from commercial, municipal, industrial, and agricultural activities.

Land filling is the most preferred method of municipal solid waste (MSW) disposal due to its cost effectiveness. However poorly designed landfills can cause serious contamination of ground water, air and soil. One of the most common reported problems are contamination of ground water due to leachate percolation.

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Leachate is produced when moisture enters the landfill, extracts the contaminants into the liquid phase and when the moisture content is sufficient high it initiates a liquid flow. This leachate contains dissolved or suspended materials associated with the waste disposed off in the landfill. The strength of leachate depends on the type of waste and the age of the landfill. In India landfills are generally called dump yards. Most cities in India have dump yards in the outskirts where municipal solid waste is disposed off in unscientific manner.

During the early stages the leachate is primarily organic in nature and stabilizes with time whereas inorganic constituents will remain long and included various heavy metals, chlorides, nitrate and sulphide.

A. Details of Study Area

Mangalore, the important port city in the western coast of India located at a distance of about 350km west of the state capital, Bangalore. Mangalore is located at 12.87^0N, 74.88^0E. It has an average elevation of 22m above mean sea level. It is administrative headquarters of DakshinKarnataka district and is the fourth largest city in the state. The local civic body is Mangalore City Corporation (MCC), which covers an area of 132.45 km^2 and a population of 4, 84,785 (2011 census).

- Topography

The topography of the city is plain up to 30 km inside the coast and changes to undulating hilly terrain sharply towards the east in Western Ghats. There are four hilly regions with natural valleys within the cities. The geology of the city is characterized by hard laterite in hilly tracks and sandy soil along the sea shore.

- Climate

Underthe Köppen climate classification, Mangalore has a tropical monsoon climate and is under the direct influence of the Arabian Sea branch of the southwest monsoon. It receives about 95 per cent of its total annual rainfall within a period of about six months from May to October, while remaining extremely dry from December to March.The annual precipitation in Mangalore is 3,479 millimetres (137 in). Humidity is approximately 75 per cent on average, and peaks during May, June and July. The maximum average humidity is 93 per cent in July and average minimum humidity is 56 per cent in January.

II. SOLID WASTE AND ITS DISPOSAL IN MANGALORE

Mangalore generates around 250 tons of solid waste every day out of which 200 tones[1] is collected and disposed into the landfill located at Vamanjoor at a distance of 15km from the city. The dumping yard has an area of 28.32 hectares which is poorly managed[2]. Vamanjoor is along the national highway (NH13) and is a home for many educational institutes. It is also a residential area and is the quarters of the officers and staff of the Mangalore regional headquarters of the employees provident fund organization.

The main waste generated is from homes, markets from agricultural products, retail and commercial markets, slaughter houses and industries. This dump yard was started in the early 80's. This dump yard has not only been a source of air pollution but also has contaminated the ground water in the vicinity. There are close to 1250 families which live within a proximity of 500m from the dump yard.

Leachate percolation has resulted in ground water turning black and smelling foul in areas like Jyothinagar and Santoshnagar, which are in the vicinity of Vamanjoor. This effect is compounded during the monsoons. Respondents in the study area reported loss of appetite, vomiting and giddiness. Local school authorities reported that school children from Vamanjoor area suffer frequently from health disorders.

Hence, the intention behind this study is to evaluate the extent of pollution in the area and identifying individual pollutant concentrations, and thereby the impact of landfill on groundwater contamination.

III. METHODS AND MATERIALS

Experiments were performed to determine the amount of pollution in groundwater. The chemical characteristics and metal traces were determined as per the standard methods for examination of water and waste water[7]. The results obtained were compared with the standards prescribed by Bureau of Indian Standards, 1991[8].

The central Ground Water Board carried out studies on ground water quality of Dakshina Kannada[12], with the study area being a part of it. The board reported that the ground water has excess concentration of Iron, resulting in non-potability.

WQI is an important parameter for demarcating groundwater quality and its suitability for drinking purposes (Tiwari and Mishra ,1985). WQI is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption. The standards for drinking purposes as recommended by BIS 10500 (1991) have been consideredfor the calculation of WQI. The WQI can be calculated using the methodsproposed by Horton[5] and modified by Tiwari and Mishra[6].

$$WQI = \text{Antilog} [\sum W^{n}_{n=1} \log_{10} q_n]$$

1. First the proportionality constant K can be calculated as $K = [1 / (\sum n_{n=1} 1 / S_n)]$
2. Now, $W_n = K / S_n$ is calculated similarly,wn is calculated for all paramters
3. Quality rating q is calculated using the formula, $q_{ni} = [(V_{actual} - V_{ideal}) / (V_{standard} - V_{ideal}) \times 100]$
   q_{ni} = quality rating of i^{th}parameter for a total of n parameters.
   V_{actual}= Value of water quality parameter obtained from laboratory analysis
   V_{ideal} for $p^H = 7$ and equivalent to zero for other parameters.
   $V_{standard}$ = B.I.S standards of parameters.
   Then take the Log of this qn
4. Finally, multiply this value by Wn, i.e (qn x Wn) Repeat this procedure for all the parameters and take the summation of all these and take the antilog of this sum, which gives the value of WQI.

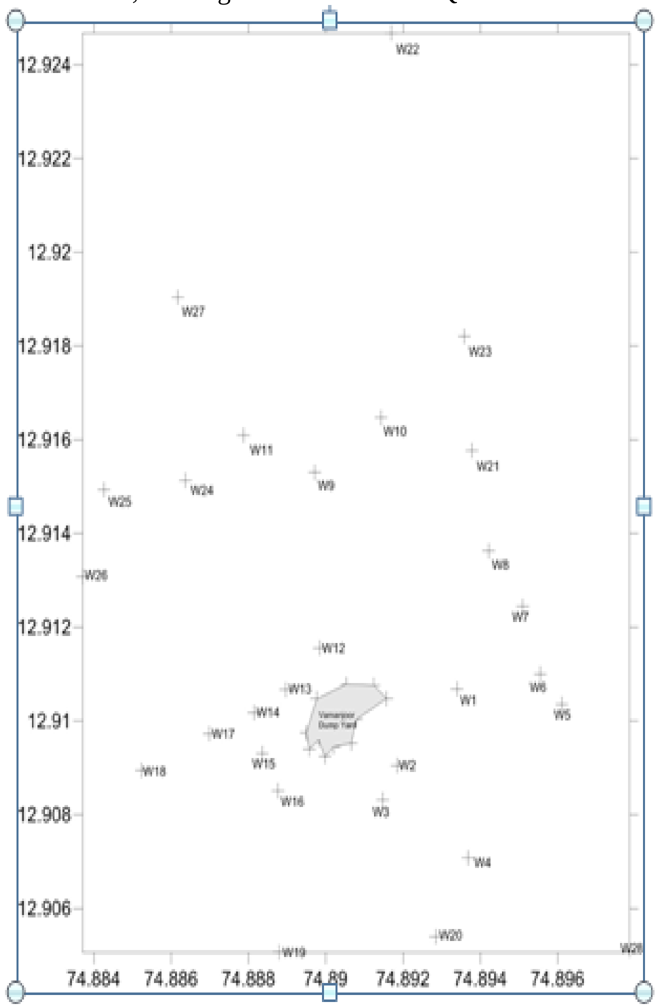


Chart 1: Location of Sample Points and Dump Yard

In the present study eight water quality parameters, namely, pH, Total hardness, nitrate, Iron, Turbidity, Fluoride, Chloride and Sulphate were considered for computing WQI.

On the basis of a number of water pollution studies, the following assumptions were made with reference to assess the extent of contamination or the quality of drinking water as shown in the Chart 1.

The assumptions were: WQI <50: fit for human consumption; WQI <80: moderately contaminated; WQI >80: excessively contaminated and WQI >100: severely contaminated[9].

IV. Results and Discussions

Twenty eight groundwater samples were drawn from the bore wells which included hand pumps and also open wells and analysed for twenty physico-chemical parameters including trace metals. The results of analysis are presented in Table 2.

Table 1 shows critical parameters exceeding the BIS permissible limits along with the permissible limits for these parameters, for the 28 samples analyzed for physico-chemical characteristics 24 were found to be non-potable as per Bureau of Indian Standards. At least one or more parameters such as Nitrate, Total Dissolved Solids, pH, Iron and Cadmium accounted for non-potability of the samples. The main contribution for rendering the water samples non-potable are iron and nitrate content.

Table 1: Critical Parameters Exceeding BIS Permissible Limits

Sl No	Parameter	BIS Permissible limit	No of samples exceeding limits.	Percentage of samples exceeding limits.
1	pH	6.5-8.5	5	17.86
2	TDS	2000	6	21.43
3	Nitrates	45	10	35.71
4	Fluoride	1.5	4	14.28
5	Iron	1	23	82.14
6	Cadmium	0.01	8	28.57

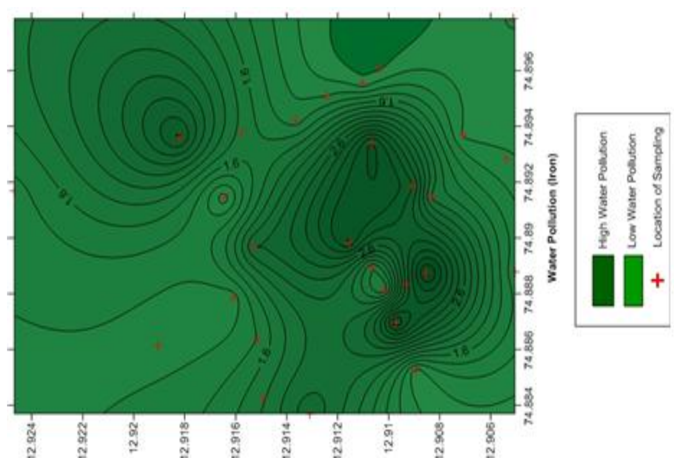
The non-potability of the samples due to Iron account for above 80% of samples. This was followed by Nitrate and Cadmium contents, which resulted in rendering 32 and 28% of the samples unsafe. 18% of non-potability of the samples was due to high pH. 21% of the samples were found to have Total Dissolved Solids greater than the permissible limits. Chart 2 shows the variation of iron content.

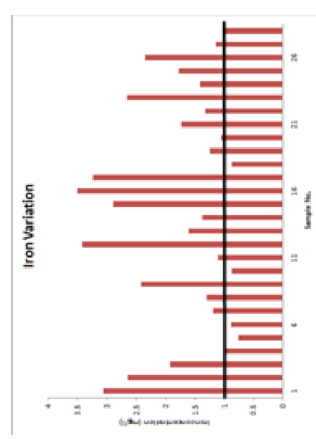
Fluorides account for 14% of the non-potability of the samples.More than 75% of the samples are found to have Iron concentrations exceeding the permissible limits. The Iron concentration in some samples is as high as 3 mg/l. The higher value is due to the natural geology of the study area, lateritic soil which contains iron and aluminum. Other causes may be due to disposal of scrap iron in the dump yard.

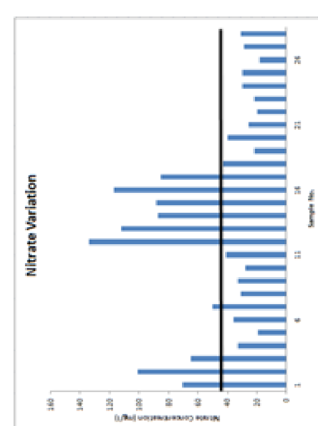
The study area has shown excessive concentrations of Nitrates, which have contributed to 35% of the samples being rendered non-potable as reported earlier. The maximum, minimum and average concentrations of Nitrates are found to be 134, 15 and 51.48 mg/l. Nitrates in several samples are very high, when compared to a BIS permissible limit of 100 mg/l. In the study area, nitrate content is contributed by the presence of waste of organic origin. Nitrate is also contributed by the presence of soak pits, due to absence of efficient drainage systems in the study area. Water with more than 100mg/l nitrate concentration is not permissible for drinking as per ISI standards and the limit is mandatory. Beyond this limit, nitrates may cause Methemoglobinemia or Blue Baby disease in infants. It may also be carcinogenic in adults. The nitrate content variation is shown in char 2.

The Fluoride values range from 0.6 to 1.69 mg/l. The high levels of fluoride, which rendered 14% of the samples unsafe, may be attributed to disposal of untreated industrial waste in the dumpyard. Fluorides in excess of 1.5mg/l may lead to a crippling disease called fluorosis, which may be in the form of dental, skeletal or non-skeletal fluorosis.

Total Dissolved Solids indicates the general nature of salinity of water. The Total Dissolved Solids concentration varies from 1050 to 3400 mg/l and account for 21% of the non-potability. Waters with high Total Dissolved Solid generally have inferior palatability and induce unfavorable physiological reactions. It can also be a possible cause of gastro-intestinal irritation. BIS prescribes a desirable Total Dissolved Solids concentration of 500 mg/l and a permissible limit of 2000mg/l. pH contributed to about 18% of the samples being rendered unfit for consumption. All samples are found to be basic in nature, with 5 samples exceeding the permissible limit of 8.5. High pH leads to bitter/soda taste and deposits. High pH may be attributed to the presence of ammonia found in the analysis.







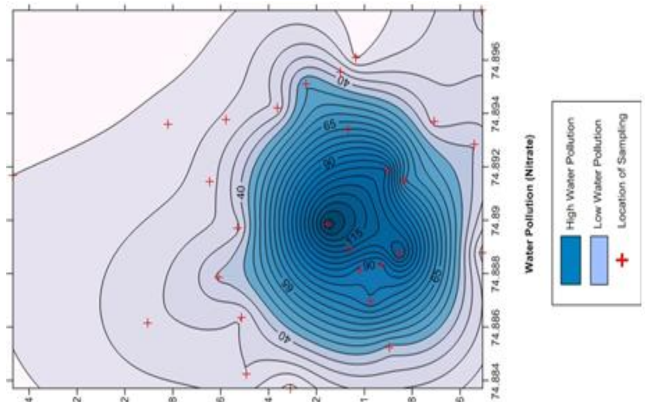


Chart 2: Water Pollution (Iron and Nitrate)

High concentrations of Cadmium were found to be present in 8 out of 28 samples. The permissible limit for Cadmium prescribed by BIS for drinking water is 0.01 mg/l. 6 samples showed alarmingly high Cadmium content of about 0.03 to 0.05 mg/l. This is probably due to the disposal of industrial and electronic waste, such as cells and batteries in the dump yard.

Concentrations of parameters like Chloride, Total hardness, Lead, Sulphate, Manganese, Zinc, Copper, Chromium etc were found to be within permissible limits.

The water quality index for all the samples ranges from 79.44 to 316.96 indicating clearly, the high overall contamination as shown in chart 3.

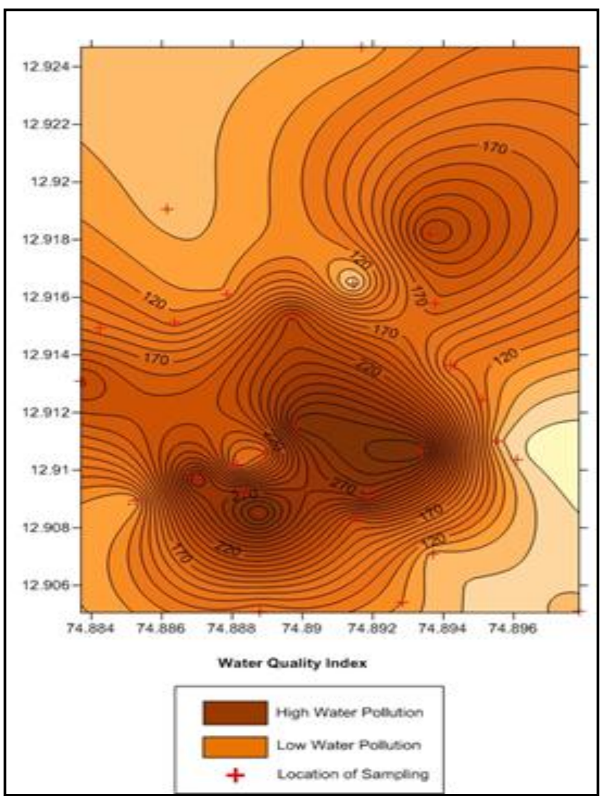


Chart 3: Water Quality Index

V. CONCLUSIONS

The analysis of ground water from the area around Vamanjoor Dump Yard, Mangalore District, Karnataka has shown contamination. Almost 86% of the samples are contaminated and are unfit for domestic use. The experiments indicate that the ground water is getting contaminated due to leachate percolation from the dump yard site. Also, the results indicate that most of the water quality parameters were beyond the permissible limits in thestudy area and its environs The Water Quality Index of the present study area had a higher WQI values upto a maximum of 316.96indicating the deteriorated water quality.This results in various health hazards due to unscientific solid waste disposal methods. The data from the social organizations and local health departments confirms the extent of contamination of ground water, resulting in various health problems faced by the residents of the study area.

Also with the passage of time water requirement is expected to increase, with additional burden being passed on to the ground water sources, compounding the problem of contamination of groundwater due to solid waste disposal. The solid waste disposal system presently being practiced is without any regard to proper care of the surrounding environment. The groundwater quality improvement can be brought about by replacement of old bore-wells, enforcement of regulations for industries regarding the disposal of effluents and other wastes and bringing about social and environmental awareness regarding recycling and sustainable methods for waste disposal.

This case study was undertaken to determine the ground water pollution levels due to leachate percolation from the dump yard. This study has shown high levels of ground water contamination. Urgent attention needs to be paid to the ground water of this region.

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Table 2: Physico-Chemical Analysis of Ground Water Sample Analysis.

Sample No	Chloride	Nitrate	Sulphate	Ammonium	Fluoride	Total Hardness	Calcium Hardness	BOD	COD	Iron	Copper	Lead	Chromium	Manganese	Zinc	Cadmium	Turbidity	Conductivity	Nickel	pH	TDS	WQI
1	610	70.4	120.3	11	1.69	41	27	3	100	3.06	0.09	0	0.01	nd	2	0.01	2	3343	0.1	8.7	1480	311.8
2	810	101	118.9	10	0.97	52	33	18	143	2.65	0.12	0	nd	0.03	3.3	0.03	8	1434	0.36	8.8	2880	268.4
3	800	65	99.3	3	1.31	60	33	5	77	1.93	0.04	nd	nd	nd	1.7	0.02	2.1	1780	0.23	7.8	1500	188.8
4	710	33	98.6	6	0.8	49	29	4	60	0.97	nd	nd	nd	nd	1	nd	0.59	1990	0.07	7.5	1140	95.23
5	520	19	77.3	8	0.89	53	34	3	40	0.76	0.04	nd	nd	nd	0.8	0.02	1.1	1190	0.09	8	1260	85.06
6	480	36	84.8	5	0.97	57	29	2	30	0.88	nd	nd	nd	nd	0.9	nd	2	1770	0.04	7.1	1470	93.65
7	210	50	116.9	nd	1.17	57	21	3	70	1.19	0.04	nd	nd	nd	0.8	nd	2	1080	nd	7.3	1470	125.4
8	380	31	33.8	3	1.29	47	27	2	59	1.3	0.09	nd	nd	nd	0.9	nd	0.8	1060	0.07	7.2	1190	129.7
9	140	33	76.2	3	1.53	37	28	7	29	2.41	nd	nd	nd	nd	0.3	nd	1.3	2343	nd	7.8	1310	224
10	240	28	46.7	1	0.71	44	30	2	34	0.87	nd	nd	nd	nd	0.2	nd	0.1	1217	0.04	7.6	1030	79.45
11	200	41	28.5	nd	0.91	39	31	nd	30	1.1	nd	nd	nd	nd	0.1	nd	2.3	1943	0.05	7.3	1540	112.5
12	1230	134	122.3	11	1.14	51	34	18	210	3.42	0.2	0	0.02	nd	6.3	0.03	8	3430	0.34	7.9	2890	297.6
13	1270	112	136.7	12	0.93	43	23	29	290	1.61	0.14	0.1	0.08	0.02	4.8	0.03	10.2	6320	0.67	8.6	3400	167.8
14	700	87	77.1	8	1.53	49	29	8	103	1.38	0.02	nd	nd	nd	2.1	0.05	4.3	1444	0.31	8.2	2010	159.5
15	840	88	80	13	1.06	55	34	10	116	2.89	0.08	0	nd	nd	2.8	0.04	8	933	0.54	8.9	2880	263.3
16	1320	117	110.4	14	0.89	47	28	34	310	3.5	0.9	0.1	0.01	nd	4.4	0.04	9.4	2710	0.43	8.6	3210	317
17	450	85	81.2	7	1.11	43	31	7	88	3.24	0.01	nd	nd	0.01	1.4	nd	1.3	4160	nd	8.1	1310	286.4
18	270	43	110.7	nd	0.9	51	33	2	33	0.87	nd	nd	nd	nd	0.7	nd	4.1	1870	nd	7.5	1970	98.32
19	260	22	21.3	nd	1.03	43	26	2	73	1.24	0.11	0	nd	0.03	0.4	0.01	0.3	1347	nd	7.7	1070	117.7
20	320	40	38.4	5	1.41	42	24	3	64	1.05	nd	nd	nd	nd	0.8	nd	0.2	1140	0.06	7.7	1050	110
21	120	26	64.3	3	1.69	49	23	nd	20	1.73	0.03	nd	nd	nd	nd	nd	2.1	1070	0.04	7.3	1500	178.6
22	210	20	33.3	nd	0.71	42	28	2	26	1.32	0.02	nd	nd	nd	0.1	nd	0.3	903	0.03	7	1070	102.7
24	120	22	39.7	3	1.12	60	34	4	44	2.66	0.07	nd	nd	0.01	0.4	nd	1	1721	nd	7.1	1240	233
23	120	30	117.4	2	0.93	43	29	3	53	1.41	0.03	nd	nd	nd	0.1	nd	0.5	1096	nd	7.2	1120	125.3
25	180	30	40.6	2	1.01	37	27	nd	77	1.77	nd	nd	nd	nd	0.1	0.01	0.5	1271	nd	7.4	1120	153.5
26	200	18	82.1	2	1.48	39	27	3	39	2.35	nd	nd	nd	nd	0.1	nd	0.8	1732	nd	7.9	1190	213.8
27	210	29	69.2	nd	0.6	41	21	2	19	1.14	0.05	nd	nd	0.01	0	nd	0.3	1104	nd	7.4	1070	96.94
28	180	51	31.4	nd	0.83	39	24	3	20	1.03	nd	nd	nd	nd	0	nd	0.2	1321	nd	7.2	1050	93.27

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