International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

IMPACT OF LEACHATE ON GROUNDWATER AROUND VELLAKAL DUMPING SITE , MADURAI , TAMILNADU

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Abstract - *In most cities, the solid waste is dumped in open dumps without proper lining which affects the environmental media such as air, water and land. So, the present study was focused on the impact of leachate percolation on ground water quality. Leachate and ground water samples were collected from Vellakal Dump site and the surrounding areas. The leachate and ground water samples were tested for various physiochemical parameters and heavy metals. The heavy metals tested in the groundwater shows Fe and Pb in places nearer to dumpsite. The result of the test and interpolated maps of parameters shows that there is a high concentration of TDS, Total hardness,Ca^{2+} ,Mg^{2+} ,Cl^{-} present in all collected ground water samples. And the western side of dumping site is highly affected by leachate intrusion. This indicates that the groundwater is affected by leachate percolation and further the groundwater is undesirable for domestic water supply and other uses.The results shows that there is a need of landfill liner in the Vellakal dumping site.*

Keywords: *Vellakal Dumping site , Leachate, Ground Water, Water quality, BIS ,WHO*

1. INTRODUCTION

Madurai is the second largest city in Tamilnadu and also considered as the cultural capital of Tamilnadu. The city is located at 9.58º N latitude and 78.1º E longitudes. The city is a lotus shaped city with the world famous Sri Meenakshi Amman Temple as epicenter. Now after India's independence, Madurai is one of the major districts of Tamilnadu state. Later on Madurai District was bifurcated into three districts namely Madurai, Dindigul and Theni Districts.. The Madurai Corporation area is divided into 4 zones, which in turn is divided into 72 wards for functional convenience by Madurai Corporation. Madurai Corporation is disposing the MSW of 450t daily in the dump yard at Vellakal near Avaniapuram, 10 km away from the center of the city. Vellakal near Avaniapuram which is having a total area of 385 acres. he site is non-engineered low lying open dump, looks like a huge heap of waste up to a height of 20 m. Trucks from different parts of the city collect and bring waste to this site and dump the waste in irregular fashion, when the waste is dumped on ground the leachate produced may contaminate groundwater.

2. STUDY AREA

The present study was conducted three areas around Vellakal municipal dumping site at Madurai.

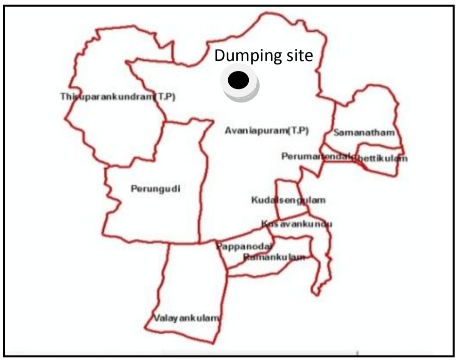


Figure1. Study area map

Avaniapuram is a municipality in Madurai district on the state of Tamil Nadu, India. As of 2011, the town had a population of 8635. According to 2011 census, Avaniapuram had a population of 8635 with a sex-ratio of 979 females for every 1,000 males, much above the national average of 929. A total of 9,568 were under the age of six, constituting 4,830 males and 4,738 females. Tirupparankunram is a suburb Madurai district in Tamil Nadu, India. As of 2011, the town had a population of 48,810. According to 2011 census, Tirupparankundram had a population of 48,810.The town had a total of 12934 households. There were a total of 18,480 workers, comprising 109 cultivators, 386 main agricultural labourers, 516 in house hold industries, 15,926 other workers, 1,543 marginal workers, 47 marginal cultivators, 69 marginal agricultural labourers, 228 marginal workers in household industries and 1,199 other marginal workers. Perungudi is a large village located in Madurai South Taluka of Madurai district, Tamil Nadu with total 2397 families residing. The Perungudi village has population of 9081.

3. COLLECTION OF SAMPLES

The Bore water or well water was purged either through pumping or bailing in wells with or without pumps respectively and samples were collected from the Bore wells in clean polyethylene bottles. The samples were collected separately for physico-chemical and heavy metal analysis. The physical and chemical parameters considered for the study include Total Dissolved Solids (TDS) and Electrical Conductivity (EC),Turbidity (NTU). The chemical parameters include pH ,Sodium (Na_{+}), Potassium (K_{+}), Calcium (Ca^{2}_{+}) and Magnesium (Mg^{2}_{+}), Chloride (Cl), Sulphate (SO^{2}_{4}), Ammonia (NH_3), Nitrate (NO_3^-), Nitrite(NO_2^-), Total

Alkalinity (TA),Phosphate (PO_3),Fluoride (F^-).The heavy metals considered for the study include lead (Pb) and Iron (Fe) .The analyses were based on the standard methods prescribed by the American Public Health Association (APHA 2005).

Table -1: Details of sampling sites

S.No	**Lat(N)**	**Lon(E)**
GW1	9^{0}51'23.6''	78^{0}5'26.97''
GW2	9^{0}52'24.55''	78^{0}5'57.86''
GW3	9^{0}52'27.19''	78^{0}5'59.23''
GW4	9^{0}52'25.15''	78^{0}6'11.41''
GW5	9^{0}52'18.62''	78^{0}5'48.27''
GW6	9^{0}52'33.23''	78^{0}4'57.74''
GW7	9^{0}52'33.6''	78^{0}5'11.41''
GW8	9^{0}52'22.65''	78^{0}5'8.32''
GW9	9^{0}52'1.23''	78^{0}5'13.79''
GW 10	9^{0}52'47.05''	78^{0}5'22.9''
GW11	9^{0}52'51.77''	78^{0}4'39.05''
GW12	9^{0}52'51.77''	78^{0}5'49.87''
GW13	9^{0}52'57.84''	78^{0}6'29.15''
GW14	9^{0}52'48.13''	78^{0}6'40.59''

4. GRAPHICAL REPRESENTATION OF PHYSICHO-CHEMICAL DATA

A graphical representation of the physical and chemical quality groundwater is clearer to visualize than presenting them in the form of the tables. This data aids qualitative comparison and interpretation of groundwater quality. The GIS is one of the most useful graphical representations in groundwater quality studies. It is also very useful in bringing out the chemical relationships in groundwater in more definite terms than with the other possible plotting methods.

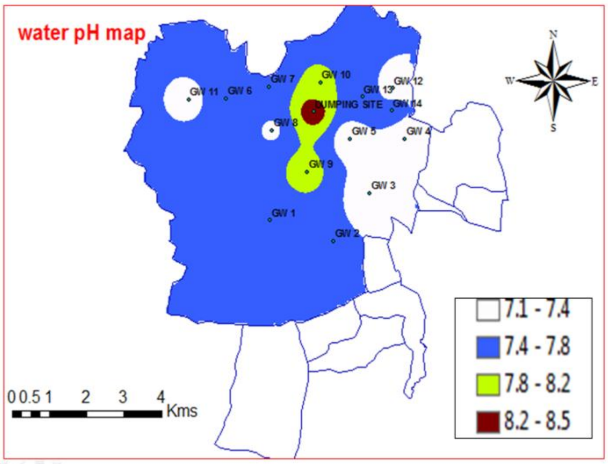
5. RESULTS AND DISCUSSION

5.1 PHYSICAL-CHEMICAL PARAMETERS

5.1.1 PH

In the present study, pH values for all the samples were well within the allowable range (7.1 - 8.1). pH is one of the most commonly analyzed parameters in soil and water testing. It represents the acidic or alkaline potential of a solution and is measured on a scale of 1-14.

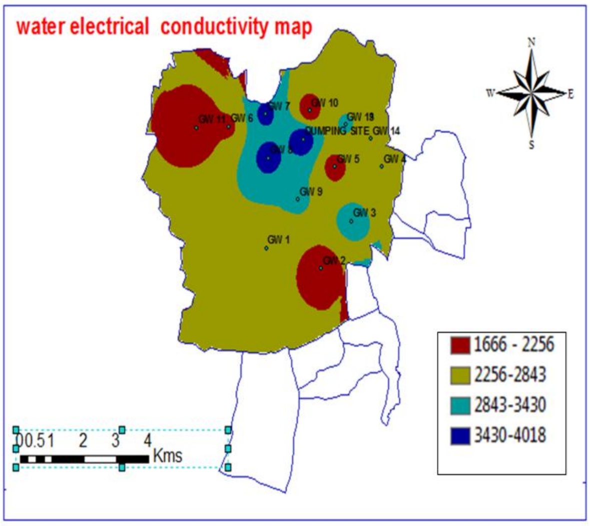
Figure 2. Interpolated map of pH



5.1.1.2 Electrical conductivity

Electrical Conductivity ranged from 1669-3745 µs/cm. EC values exceed 2000 µs/cm, water produce laxative effects to the consumers (World Health Organization, 2004).

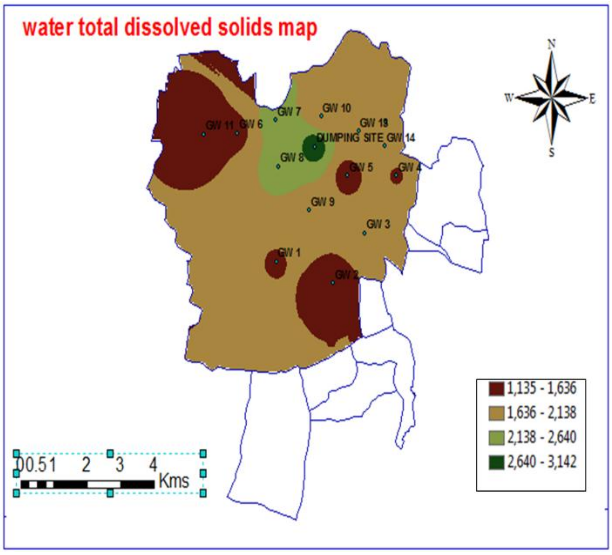
Figure 3. Interpolated map of Electrical conductivity



5.1.1.3 Total Dissolved Solids

The Total Dissolved Solids concentrations are higher than the desirable level of 500 mg/L in the all samples. The high Total Dissolved Solids in the close vicinity of the dumpsite indicates the effect of leachate in the groundwater .Total Dissolved Solids observed in the GW7,GW8 located along the western direction of dumpsite show higher concentrations ranging from 2446 mg/L to 2463mg/L which is in agreement with the groundwater flow direction. The high concentration of Total Dissolved Solids decreases the palatability and may cause gastrointestinal irritation in humans and may cause laxative effects (World Health Organization 2004).More concentration of Total Dissolves Solids, observed shows the intrusion of leachate in groundwater.

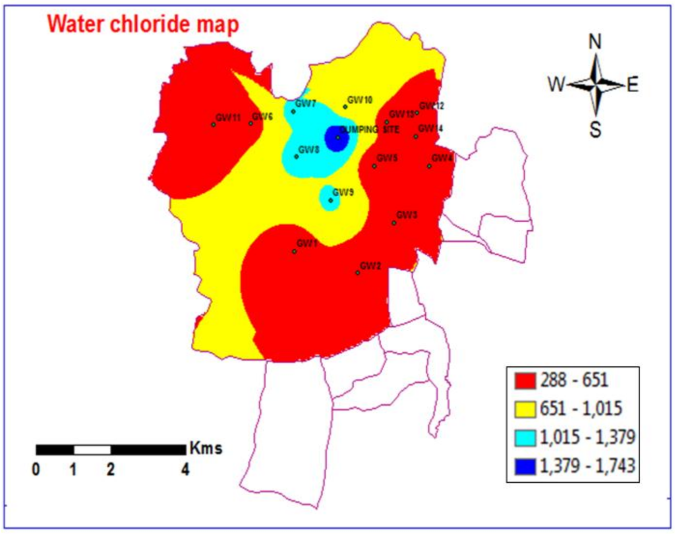
Figure 4. Interpolated map of Total Dissolved Solids



5.1.1.4 Chloride

Chloride varied from 280 to 1080 mg/L. All of the samples had higher chloride concentration than the desirable level of 250 mg/L as stipulated by BIS. Increase in Cl^- level is injurious to people suffering from diseases of heart or kidney (WHO 2004). An excess of chloride in water is usually taken as an index of organic pollution and is considered as tracer for groundwater contamination. If there is excess of chloride content in the water it is salty and it is not used for drinking purposes in the study area all sampling locations have excess of chloride content when comparing with (BIS 2012) and WHO(2004) acceptable limit.

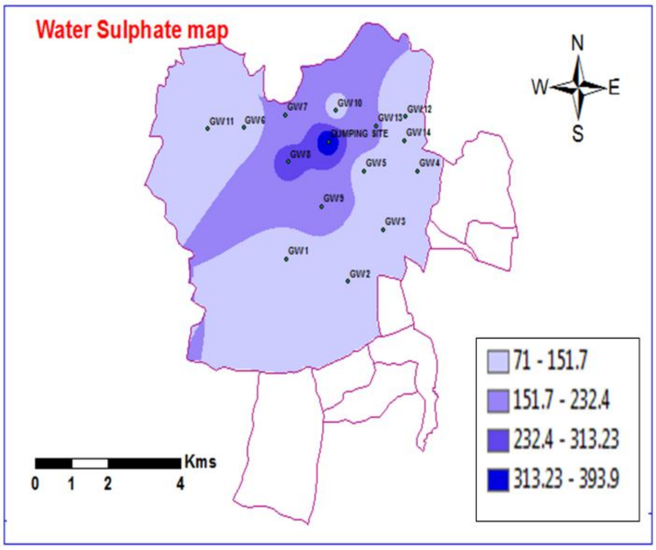
Figure 5. Interpolated map of Chloride



5.1.1.5 Sulphate

Sulphate in most of the samples were found to be lower than the permissible level of 200 mg/L. Sampling location GW8 only exceeds the permissible limit of WHO(2004) and BIS (2012). So according to WHO(2004) excess of sulphate gives laxative effect.

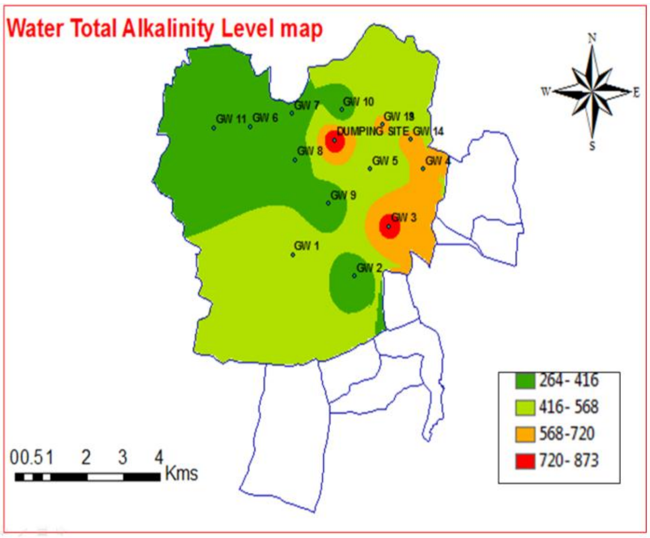
Figure6. Interpolated map of Sulphate



5.1.1.6 Total Alkalinity

The analysis shows that alkalinity is caused only by bicarbonates, as carbonate values in all the samples were found to be nil. This is in line with the fact that the pH of the water is greater than 6.0 but less than 8.4 , total alkalinity is mainly due to bicarbonates ,but if pH exceeds 8.4, bicarbonate begins to convert into carbonate ion.

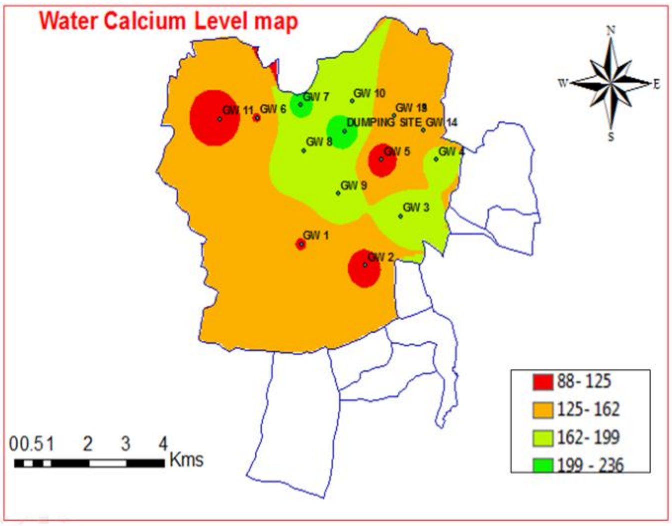
Figure 7. Interpolated map of Total Alkalinity



5.1.1.7 Calcium

Calcium was found to be higher than the desirable limit of 75 mg/L The calcium favoured the abundance of pathogenic bacteria, which leads to harmful diseases.

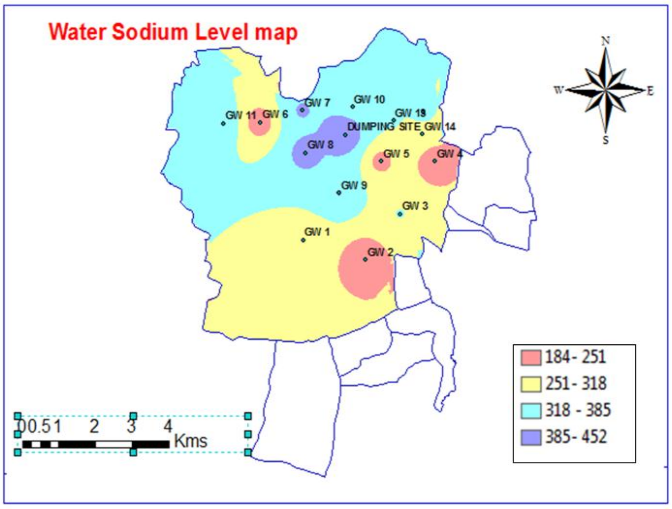
Figure 7. Interpolated map of Calcium



5.1.1.8 Sodium

Higher sodium concentration of 184 to 410 mg/L in the groundwater indicates possible anthropogenic input via dumpsite leachate.It can be concluded from the results that the groundwater possess high values of TDS, anions and cations which makes the water non-potable. The consumption of this contaminated water will definitely increase the health hazards to the people residing in the vicinity of the dumpsite.

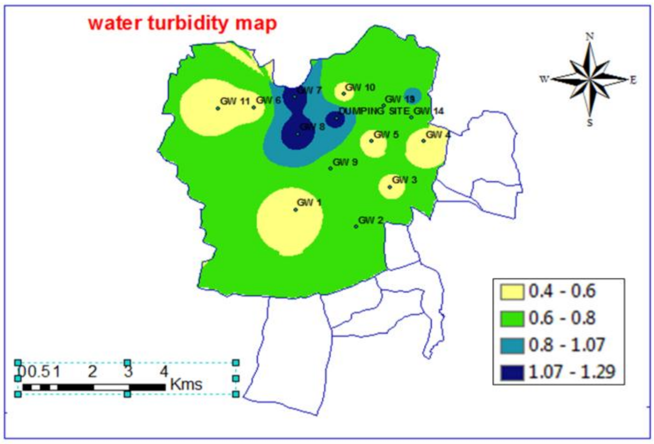
Figure 9. Interpolated map of Sodium



5.1.1.9 Turbidity

Turbidity pertains to water cloudiness or the level of pellucidity. High turbidity reflects an abundance of impurities, which may be due to silt, plant fibers, microorganisms, wood ash, sawdust, or chemicals. Ideally, turbidity must less than 1NTU because higher values indicate health risks due to bacterial contamination. High turbidity values are obtained around the dumping site area, where the value ranges maximum of 1.3 NTU in sampling location GW8. GW7,GW8 are the samples which have more turbidity than BIS(2012) and WHO (2004).

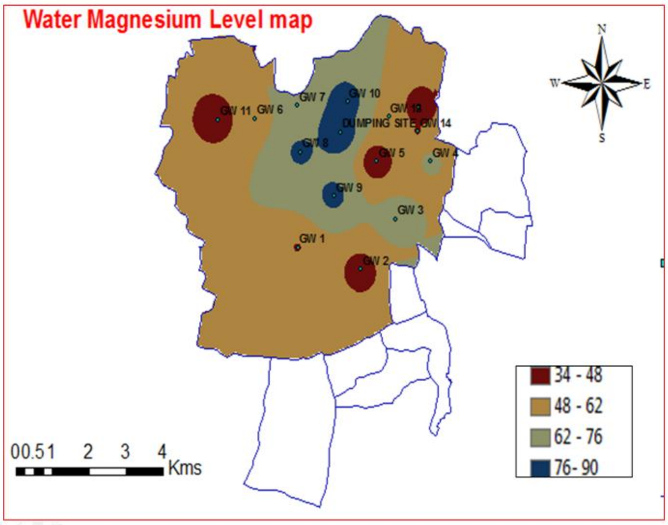
Figure 10. Interpolated map of Turbidity



5.1.1.10 Magnesium

All sampling locations had greater magnesium values than permissible limit (30 mg/l) of BIS(2012). And samplesGW3,GW4,GW6,GW7,GW8,GW9,GW10, GW13 were greater than WHO(2004). So th excess of magnesium leads to the scale formation.

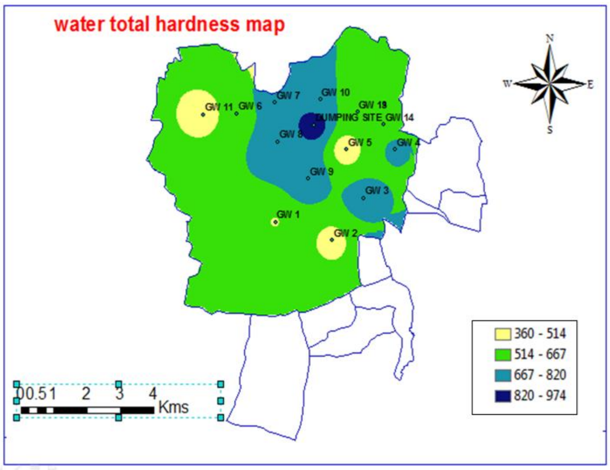
Figure 11. Interpolated map of Magnesium



5.1.1.11 Total hardness

The total hardness of groundwater samples were found in the range of 360 up to 784 mg/l which is further compared with the standard value ranged 300 mg/l. Water hardness is usually due to multivalent ions ,which comes from minerals dissolved in the water. However there is an inverse relationship between water hardness and cardiovascular disease. All the sampling locations excceding the hardness limit given by Bureau of Indian Standards (2012) and World Health Organization (2004).

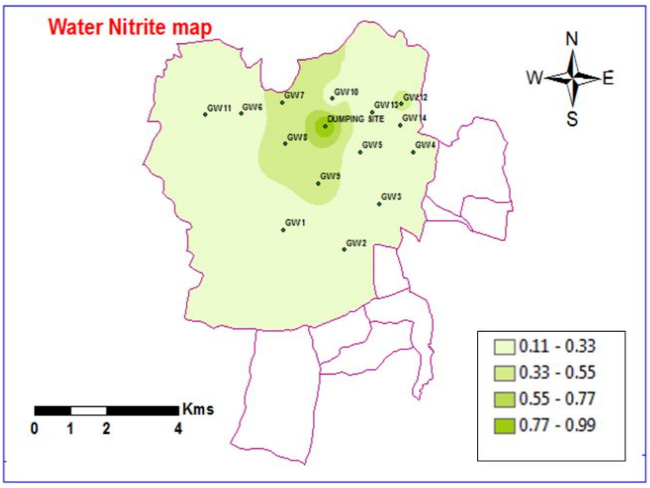
Figure 12. Interpolated map of Total Hardness



5.1.1.12 Nitrite

Nitrite was recorded in the range of 0.12 mg/l -0.42 mg/l and it was found within the desirable limit (45 mg/l) of BIS at all the sampling sites . Highest value of nitrite (0.42 mg/l) was found at the sampling site GW 8 while, GW 2 has the second higher value (0.40 mg/l). Bureau of Indian Standards (BIS, 2012) and WHO (2004) has not prescribed any norms for Nitrite in drinking water as Nitrite is not considered as harmful constituent in drinking water.

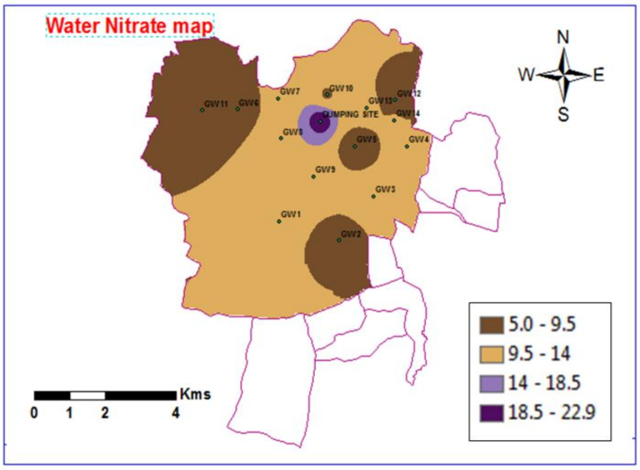
Figure 13. Interpolated map of Nitrite



5.1.1.13 Nitrate

High concentration of nitrate causes Methemoglobinia in infants. Nitrate was recorded in the range of 5 mg/l - 13 mg/l and it was found within the desirable limit (45 mg/l) of BIS at all the sampling sites. Highest value of nitrate (13 mg/l) was found at the sampling site GW 8 while, the minimum value of nitrate (5 mg/l) was found at the sampling site GW5. So the test shows that nitrate was within the permissible limit specified by Bureau of Indian Standards (2012) and World Health Organization (2004).

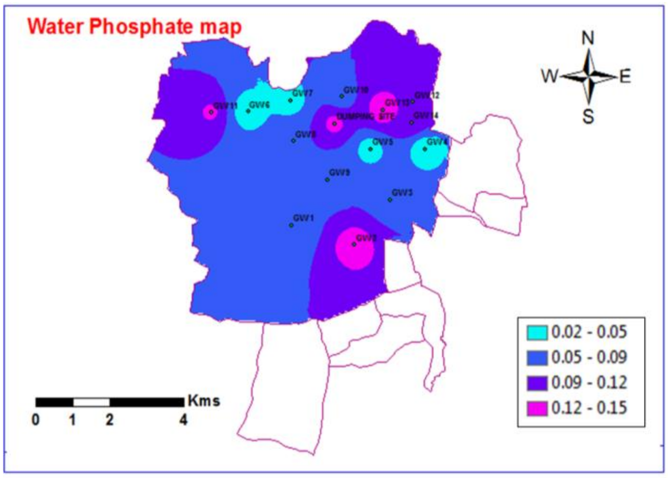
Figure 14. Interpolated map of Total Hardness



5.1.1.14 Phosphate

Bureau of Indian Standards (BIS, 2012) has not prescribed any norms for phosphate in drinking water as phosphate is not considered as harmful constituent in drinking water. However, its presence accelerates the growth of algae.. Highest value of phosphate (1.04 mg/l) was found at the sampling site GW14 while, the minimum value of phosphate (0.02 mg/l) was found at the sampling site GW4 .

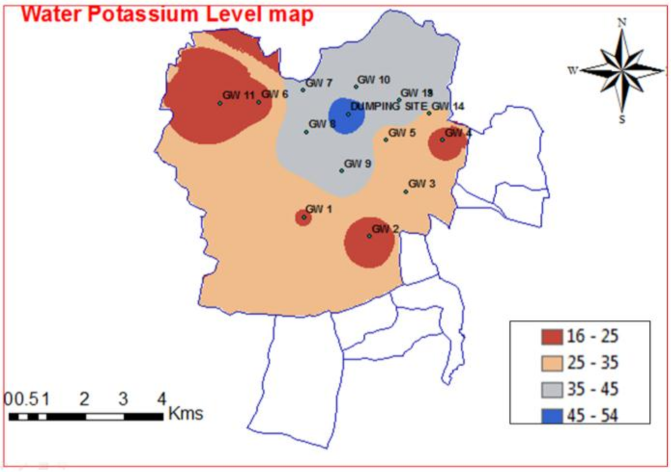
Figure 15. Interpolated map of Phosphate



5.1.1.15 Potassium

BIS also has not recommended any norm for potassium. Excessive intake of potassium may have laxative effect. As per the study, potassium concentrations in samples were found in the range of 16mg/l (minimum) - 44 mg/l (maximum). Highest value of potassium (54 mg/l) was found at the sampling site GW 8 while, the minimum value of potassium (16mg/l) was found at the sampling site GW11 . As per the study conducted by Sabahi *et al.* (2009), potassium was found in low concentrations in natural waters since rocks that contain potassium are relatively resistance to weathering.

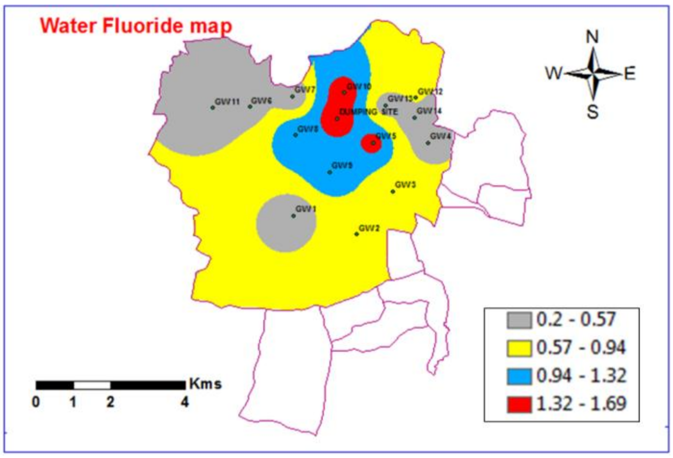
Figure 16. Interpolated map of Total Hardness



5.1.1.16 Fluoride

The concentration of fluoride in the studied water samples ranged from 0.01 to 1.8 mg/l. The concentration of fluoride at high concentration nearer to dumpsite may causes dental fluorosis and more seriously skeletal fluorosis.

Figure 17. Interpolated map of Total Hardness



5.2 Heavy Metal Analysis

The heavy metal analysis found in the groundwater are:

5.2.1 Lead

The lead is present in the GW7,GW 8 which is nearer to dumpsite. Lead is commonly used in automobile fuels, paint and plumbing. Lead is toxic for drinking water. So the results show that western side was affected by lead.

5.2.2 Iron

Iron ranges from 0.05 to 1.1 mg/L. Most of the samples were below or nearer to the desirable level (0.3 mg/L) as specified by BIS. The concentration of iron may increase under favourable conditions close to a landfill and may lead to serious toxic risk.

Table 2. Interpolation of analysed results with BIS limit

Parameters	Unit	BIS Acceptable limit	GW Samples exceeding limit
pH		6.5-8.5	-
Turbidity	NTU	1	GW7,GW8
TDS	mg/l	500	ALL SAMPLES
TH	mg/l	200	ALL SAMPLES
Fe	mg/l	1	GW4,GW8,GW14
T Alk	mg/l	200	ALL SAMPLES
Ca^{2+}	mg/l	75	ALL SAMPLES
Mg^{2+}	mg/l	30	ALL SAMPLES
Cl	mg/l	250	ALL SAMPLES
NO_3	mg/l	45	-
NH_3	mg/l	0.5	-
SO_4^{2}	mg/l	200	GW8
F	mg/l	1.5	GW2,GW5,GW8, GW9,GW10

Table 3. Interpolation of analysed results with WHO limit

Parameters	Units	WHO permissible limit	GW Samples exceeding limit
pH	-	7-8.5	-
EC	µmhos /cm	2000	GW1,GW3,GW4,GW6,GW7, GW8,GW9,GW12,GW13,GW14
TH	mg/l	500	GW1,GW3,GW4,GW6,GW7,GW9 ,GW10,GW12,GW13,GW14
Na^{+}	mg/l	200	GW1,GW3,GW5,GW6,GW7, GW8,GW10,GW12, GW13,GW14
Ca^{2+}	mg/l	75	ALL SAMPLES
Mg^{2+}	mg/l	50	GW3,GW4,GW6,GW7,GW8, GW9,GW10,GW13
Cl	mg/l	200	ALL SAMPLES
NO_3	mg/l	45	-
SO_4^{2}	mg/l	200	GW8
F	mg/l	1.5	GW2,GW5GW10

Also Leachate (LC) sample was tested for physico-chemical analysis and the results obtained are listed in the table 4.In this study both the leachate and samples were tested and analysed.The groundwater samples were interpolated with acceptable limit of Bureau of Indian Standards (2012) and World Health Organization (2004).

Table 4. Physicochemical parameters of ground water samples (borewell water) and leachate around Vellakal Dumping sites.

Parameters	Units	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	GW10	GW11	GW12	GW13	GW14	LC
pH	-	7.6	7.5	7.2	7.1	7.1	7.6	7.5	7.4	8.1	7.9	7.4	7.2	7.8	7.7	8.6
Turbidity	NTU	0.4	0.7	0.6	0.5	0.5	0.5	1.2	1.3	0.8	0.5	0.5	0.9	0.8	0.7	1.2
EC	μmho s/cm	2345	1756	3102	2345	1888	2136	3597	3745	2912	1745	1669	2753	2904	2805	4021
TDS	mg/l	1595	1194	2109	1595	1284	1452	2446	2463	1968	1637	1135	1889	1974	1907	3145
TH	mg/l	510	460	770	710	360	540	780	793	784	674	436	555	590	530	975
Fe	mg/l	0.05	0.05	0.24	0.40	0.05	0.06	0.06	1.1	0.08	0.06	0.06	0.07	0.05	0.70	1.4
T.Alk	mg/l	556	320	780	584	448	264	276	312	283	304	380	474	588	612	874
Na^+	mg/l	260	190	320	184	224	208	390	410	387	372	164	330	330	320	453
K^-	mg/l	25	20	28	18	32	20	40	44	43	41	16	42	40	35	55
Ca^{2+}	mg/l	124	112	192	176	88	124	212	187	191	174	106	136	140	132	237
Mg^{2+}	mg/l	48	43	70	65	34	55	72	79	81	83	41	40	58	48	91
Cl^-	mg/l	410	395	525	390	320	525	1050	1112	1080	901	288	580	565	530	1745
NO_2^-	mg/l	0.12	0.12	0.14	0.12	0.2	0.12	0.40	0.42	0.42	0.28	0.17	0.40	0.12	0.14	1.0
NO_3^-	mg/l	10	7	12	11	5	6	10	13	12	9	6	6	11	10	23
NH_3^-	mg/l	0.19	0.21	0.16	0.18	0.19	0.16	0.19	0.19	0.21	0.31	0.19	0.25	0.22	0.16	0.44
SO_4^{2-}	mg/l	118	71	124	129	118	106	153	272	161	121	106	111	153	147	394
F^-	mg/l	0.2	1.8	0.6	0.4	1.5	0.4	0.2	1.3	1.2	1.6	0.2	0.6	0.4	0.2	1.7
PO_4	mg/l	0.06	0.15	0.07	0.02	0.03	0.03	0.03	0.09	0.07	0.07	0.13	0.12	0.16	0.12	0.14
Lead	P/A	A	A	A	A	A	A	P	P	A	A	A	A	A	A	P

6. CONCLUSION

It was concluded that the surrounding area of Vellakal dumping site is affected by intrusion of leachate. The concentration of various physico-chemical parameters like electrical conductivity, total dissolved solids (TDS), alkalinity, total hardness, calcium, magnesium, chloride were recorded higher in all the sampling sites. Especially GW7 and GW8 sampling sites have high concentrations in most of the parameters. Thus, there is a need of landfill liner in the Vellakal dumping site to prevent ground water contamination and the regular monitoring of the ground water and adjoining areas especially western side of landfill dumping site is required.

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