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Hydrogeochemistry of Ground water around Municipal Solid Waste Dumping Site in Hyderabad City, India.

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ABSTRACT

The huge amount of solid waste generation has posed a serious threat to the environment. Owing to infiltration of rainwater, the solid waste leachate produced at the dumping site ultimately finds its way into the ground water causing contamination. The quality of ground water available near the municipal solid waste dumpsite in Autonagar, Hyderabad India has been tested for the possibility of contamination due to the leachates from dumpsite. A number of physico-chemical characteristics of ground water sample around the dumpsite were analyzed so as to ascertain the extent of ground water pollution by leachates.Anions and Cations was estimated by Ion chromatography and for metals ICP-MS was used. The results obtained from the analysis showed that the physico-chemical parameters are beyond permissible limit according to Bureau of Indian Standards.

Key words: Dumping site, leachate, Groundwater, Contamination.

INTRODUCTION

The Autonagar dumpsite is spread over an area of 47 acres and used to receive an average of 800 mt garbage per day. About 8.7 lakhs m^3 MSW has been dumped at this dumpsite, which weighs ~ 4.35 lakhs tonne. The municipal corporation of Hyderabad stopped dumping of garbage at autonagar in 2005. In 2007 a composting marketing company signed a five year contract with Hyderabad municipality for bio-mining the entire 47 acre site. Excavating the waste in vertical layers from a garbage cliff and using their own biocultures on aerobic windrows along with up to 25 % of fresh garbage.

The ground water quality is affected by the leachates from the municipal solid waste dumpsite. Leachate is the liquid produced when rain percolates through the solid waste and reacts with products of decomposition, chemicals and other materials in the solid waste. Generally leachates are acidic in nature, rich in organic acid groups, Sulphate ions and highly concentrated

common metal ions. Leachates from the solid waste sites slowly seep through the layers of soil beneath and contaminate the ground water sources. (Dictionary of environmental science).Water in soil moves from points where it has relatively high energy status to points where its energy status is lower. The first factor is the elevation position in the soil relative to the reference level. The higher an object is located above the reference level, the higher is its gravitational energy. This is true also of any given quantity of water in soil: the higher the water is located in the soil profile, the higher is its gravitational energy. Gravitational energy is expressed as the number of centimeters or inches above or below an arbitrarily chosen reference (J.Bouma)

Study Area

The location of the Dumpsite is: Lt: 17^{0}20'59.49" N; Lg: 78^{0}34'48.16" E; Elevation (ground sea level): 1688 ft.

Ground water samples were collected from the residential colonies situated around the dumpsite. Altogether fifteen samples were collected. The area of sampling, its Topographical elevation at ground sea level (source www.google.com/earth) and its distance from the dumpsite is given below: S_1 Deer Park (1735 ft, 1.7 km), S_2 Institute of Dry Land Agriculture (1677 ft, 1 km), S_3 Autonagar (1684 ft, 0.30 km), S_4 Sahara Estate (1684 ft, 1 km), S_5 Vivekananda Nagar (1729 ft, 1.66 km), S_6 Vijayasri colony (1713 ft, 1.47Km), S_7 Local Park (1698 ft, 2.08 km), S_8 Balaji Nagar (1698 ft, 2km), S_9 SPS Residency (1700 ft, 1.68km), S_{10} Raja Rajeshwary Colony (1666 ft, 2.32), S_{11}, Himapuri Colony (1660 ft., 1.3 km), S_{12} Southend Park (1652 ft, 1.2 km), S_{13} Mansoorabad (1656 ft, 2.06 km), S_{14} Tyagarayanagar (1608, 2.09km), S_{15} Bandlaguda (1596 ft, 2.10 km), S_{16} Chinna Pedda Cheruvu (1700 ft, 2.28 km).

Chemical Analysis

TDS was measured by systronics TDS meter .pH was measured using Elico digital pH meter and electrical conductivity by Elico digital conductivity meter. Sodium and Potassium were determined by using systronics flame photometer.Calcium, Magnisium, Carbonate and Bicarbonate was estimated by Titrimetric Analysis. Chlorides, Sulphates, nitrates, phosphates and fluorides were determined by using Dionex Ion-Chromatographer. Calcium and magnesium were determined by titrimetric method. Metals were analyzed by ICPMS(APHA.20th edition)

RESULTS AND DISCUSSION

The pollution level is more in those samples which are at lower topographical elevations with respect to the dumpsite and at times depend upon both elevation and distance from dumpsite

In the present study the pH values of the water samples were found to be in the range of 7.08 to 7.75. A direct relationship between pH of water and its quality is impossible to ascertain, because pH is closely associated with other aspects of water quality. The pH values of the samples were well within the permissible limits as per Bureau Indian standards (BIS) (6.5 to 8.5).

TDS ranges from 480mg/l to 1350 mg/l.The ground water samples S_2 (1000 mg/l.), S_3 (1280 mg/l.), S_4 (905 mg/l.), S_{11} (1000 mg/l.), S_{12} (1350 mg/l.), S_{13} (820 mg/l.), S_{14} (620 mg/l.), S_{15} (1200 mg/l.), are at lower elevation than the Dumpsite except S_{14} (620 mg/l). It is observed from the above TDS values of the samples that they are polluted. All the TDS values exceed the Bureau of Indian Standards. The ground water samples S_1 (700 mg/l.), S_5 (720 mg/l.), S_6 (710 mg/l.), S_9 (480 mg/l.) are at higher elevation than the dumpsite.

The ground water samples S_7 (830 mg/l) and S_{10} (1150 mg/l) showed higher values, even through they are at higher elevation with reference to dumpsite and also their distance from dumpsite is more S_7 (2.08 km) and S_{10} (2.32 km). This may be due to pond (S_{16}), Chinna-Pedda Cheruvu, which is near to the sampling sites S_7 and S_{10}. The TDS value for the pond (S_{16}) is high (1200 mg/l.) as the drainage water from various colonies are let into the pond and pollute the water. The electrical conductivity of the samples were also in accordance with the TDS values, indicating that the major cations like sodium, calcium, magnesium are present in ground water samples along with major anions like chloride, carbonate, bicarbonate and sulfate (Hach water analysis).

The major Anions Cl^-, NO_3^-, F^-, HCO_3^- and SO_4^{2-} and cations Na^+, K^+, Mg^{2+}, Ca^{2+}, which contribute to the TDS value is shown graphically in Fig-1. The graph is plotted by taking the Anions and Cations on Y-axis against the sampling topographical elevation with respect to dumpsite.

Sodium is found to be the range of 30 to 130 mg/l. The sodium concentration in all the samples is within the permissible limit (200 mg/l) as per BIS. Sodium concentration in ground water sample followed the trend of elevations i.e., for lower elevation the values of sodium are higher than those samples which are at higher elevation with respect to dumpsite.

Sodium is generally found as sodium chloride, its solubility in cold water is 357g/L and in

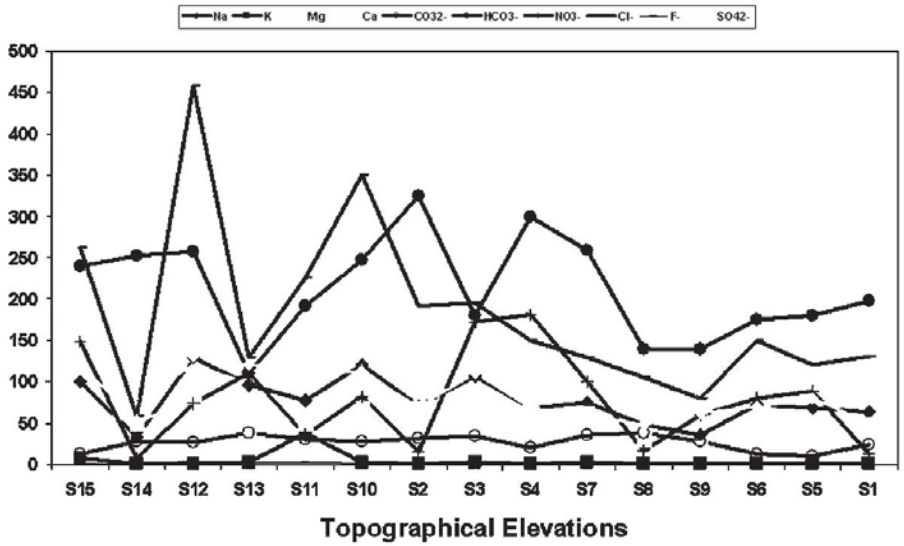

Fig. 1. Variation of Cation and Anion with respect to topographical elevations

Sample	TDS	EC	pH	Na	K	Ca	Mg	Cl	NO_3	PO_4	F	SO_4	CO_3	HCO_3	Ba	B	Si	Sr
S1	700	1.1	7.08	64	1.6	98.5	39.3	130.8	12.85	0.1912	0.5	51	24	198	0.08	0.03	0.012	0.08
S2	1000	1.6	7.64	71	1.8	152	68	191	15.25	0.128	2.01	69.7	32	325	0.13	1.47	0.032	1.63
S3	1280	1.9	7.75	106	2.0	161	65	195	173	0.05	0.8	110	34	180	0.2	0.13	0.04	1.5
S4	905	1.4	7.33	68	1.9	129	67	150	182	0.016	1.8	69.1	20.3	300	0.13	0.52	0.02	1.2
S5	720	1.1	7.30	68	1.8	95	45	120	88.2	0.00	1.0	80.2	10.2	180	0.09	0.5	0.02	0.09
S6	710	1.1	7.08	72	1.9	100	42	150	80.2	0.009	0.52	70.2	12.2	175	0.08	0.43	0.04	0.10
S7	830	1.3	7.35	75	2.4	100	62	130	100.2	0.697	1.60	60.2	35	258.9	0.09	0.38	0.02	0.23
S8	500	0.9	7.37	48	1.8	60	30	105	16.4	1.052	0.527	48	38	140	0.10	0.37	0.02	0.08
S9	480	0.9	7.08	35	0.7	78	20	80.2	60.2	0.041	0.943	62	28	140	0.12	0.30	0.02	0.05
S10	1150	2.0	7.37	120	3.0	120	68	350	82	1.066	0.785	112	28	247	0.11	1.2	0.029	1.08
S11	1000	1.7	7.80	78	38	126	50	226	36	0.006	2.1	116	30	192.3	0.107	0.89	0.033	1.07
S12	1350	2.0	7.60	130	1.8	120	82	458	73	0.009	3.3	130.4	27	258	0.10	0.9	0.032	1.08
S13	820	1.2	7.73	97	2.0	98.2	38	130	110	0.005	2.8	120.5	38	110	0.09	0.7	0.02	1.00
S14	620	1.0	7.75	33	1.2	78	50	58	8.2	0.008	1.3	53.8	28	253	0.09	0.72	0.03	0.92
S15	1200	1.8	7.38	100	8.2	190	70	263	148.2	0.007	1.2	120	12.6	240	0.12	1.2	0.04	1.4
S16	800	1.1	7.75	98	8.6	50	45	260	46	5.684	0.530	90	35	167				

*All the values are in mg/L and EC is in S/Cm

hot water it is 391g/L. Up to moderate concentrations of sodium, there is no adverse impact, but high sodium may affect the soil structure as well as permeability resulting in alkaline salts and becomes toxic to plants. Excessive intake of drinking-water containing sodium chloride concentration above 250mg/L has been reported to produce hypertension; this effect is believed to be related to the sodium ion concentration (Gigiena I sanitarija).

Potassium is found to be in the range of 0.7 to 38 mg/l. Except S_{11} (Himapuri Colony).All the samples are within the permissible limit (12mg/l). The potassium value is unexpectedly higher for S_{11} as it is at lower elevation w.r.t. Dumpsite and also very near (1.3 km) from dumpsite.

Potassium is generally found as a salt of chloride i.e. potassium chloride whose solubility in cold water is 344mg/L. Potassium is not known to have harmful or toxic effect on human beings but it helps in plant growth as an essential nutrient.

Calcium is found to be in the range of 50 to 161mg/L. The samples which are at lower elevation with respect to dumpsite showed higher values of calcium. Particularly S_2 (152 mg/l) and S_3 (161 mg/l) have the highest calcium concentration as they are very near to dumpsite beside their lower elevation with respect to dumpsite. Except S_8 all the samples is above the permissible limit (75mg/L) as per BIS. This may also be due to the fact that calcium and magnesium are present in many sedimentary rocks, and they come in contact with groundwater table (National research council Washington). There is no adverse health effect on human beings due to calcium and magnesium. In contrast, the results of a number of studies have suggested that water hardness may protect against diseases (Mackinnon AV, Taylor).

Chloride is found to be in the range of 58 to 458 mg/l. The samples S_{10} (350mg/l), S_{12} (458 mg/l) and S_{15} (263 mg/l) showed the highest value of chloride which exceeds the limit 250 mg/l as per BIS. S_{12} has the highest chloride value as it is both near and at lower elevation with respect to dumpsite. The value of chloride for S_{10} is higher even though it is far from the dumpsite (2.32 km) this may be due to the pond which is very near to it and also due to the lower topographical elevation with respect to the dumpsite. Chlorides are widely distributed in nature as salts of sodium (NaCl), Potassium (KCl) and Calcium ($CaCl_2$). Chloride level in unpolluted water is often below 10 mg/l and sometimes below 1mg/l (guidelines for drinking water. Canada). Chlorides are leached into the solid and water due to weathering of rocks. The chloride ion is highly mobile and is transported to closed basins.

Sulphate is found to be in the range of 48 to 120.5 mg/l. All the samples are within the permissible limits (150 mg/l) as per BIS. The highest value for sulphate is found in S_{12} (130.4 mg/l) and S_{13} (120.5 mg/l) as they are at lower topographical elevation with respect to dumpsite. If sulphate in water exceeds 250 mg/L, a bitter of medicinal taste may render the water unpleasant to drink and causes diarrhea and dehydration. (Dept. of Public Health and Environment, Washington County).

Fluoride is found to be in range of 0.5 to 3.3 mg/l. The samples S_2 (2.01 mg/l), S_4 (1.8 mg/l) S_7 (1.6 mg/l), S_{11} (2.1 mg/l), S_{12} (3.3 mg/l), S_{13} (2.8 mg/l) have the fluoride values exceeding beyond permissible limits of (1.2 mg/l). Except S_7 all the

The factor i is also called the dissociation factor or the Van't Hoff factor

S. No.	Sample	Osmotic Pressure (bar)	Operational Pressure (bar)
1.	S_1	0.31672	1.1877
2.	S_2	0.4680	1.7554
3.	S_3	0.51393	1.9272
4.	S_4	0.46969	1.7613
5.	S_5	0.33917	1.2719
6.	S_6	0.35415	1.3281
7.	S_7	0.40539	1.5202
8.	S_8	0.24418	0.91567
9.	S_9	0.23236	0.87135
10.	S_{10}	0.59301	2.2238
11.	S_{11}	0.45496	1.7061
12.	S_{12}	0.68453	2.5670
13.	S_{13}	0.37187	1.3945
14.	S_{14}	0.26482	0.99308
15.	S_{15}	0.58134	2.1800

samples are low lying with respect to dumpsite Fluorine does not occur in the elemental state in nature because of its reactivity; it is present in nature in the form of Sodium Fluoride.

Nitrate is found to be in the range of 8.2 to 182 mg/l. Except S_1, S_2, S_8, S_{11}, S_{14} all the samples exceeds the permissible limits (45 mg/l) as per BIS.

Phosphate is found to be in the range of 0 to 5.684 mg/l). All the groundwater samples are within the permissible limit (0.2 mg/l) as per BIS. The high value of phosphate in S16 (Pond) may be due to domestic sewage which is the only source of pollution in the pond. The samples S_7 (0.697 mg/L), S_8 (1.052mg/L) and S_{10} (1.066mg/L) have high value of phosphate as they are close to the pond.

Bicarbonates were found to be in the range of 85.4 mg/L to325 mg/L. There is no adverse effect of Bicarbonates, but the bicarbonate present in alkaline water can release F^- from CaF_2 present in the soils with the simultaneous precipitation of $CaCo_3$ due to higher rate of evapotraspiration caused by semi-arid climate. (Ref Rama Mohana Rao et.al,) Hence the association of HCo_3^- with F^- is called as alkalinity factor. This can be explained by the following reaction

$CaF_2 + 2HCo_3^- \text{ =====> } CaCo_3 + 2F^- + H_2O + Co_2$

$CaF_2 + 2NaHCo_3 \text{ =====> } CaCo_3 + 2Na^+ + 2F^- + H_2O + Co_2$

CONCLUSIONS

The Municipal dumpsite under study is surrounded by populated urban area. The ground water samples were collected from various colonies which are thickly populated. The ground water in this area can be treated by reverse osmosis process. An attempt is being made to calculate the Osmotic pressure and operational pressure for the reverse osmosis plant. The mathematical formula-(1) is used to calculate the osmotic pressure and the formula-(2) is used to calculate the operational pressure for a reverse osmosis plant (J.H.Vant hoff).

$$\pi = 1.12\ (273 + T)\ \Sigma M_j \qquad ...(1)$$

Where ΣM_j is sum of molality concentration of all constituents in a solution (Moles of solute / kg of solvent). The molality is calculated with the following formula:

Molality (m) = moles of solute / kilograms of solvent

The obtained osmotic pressure by formula-(1) is in psi (pounds per square inch)

$$1 \text{ psi} = 6.8948 \times 10^{-2} \text{ bar}$$

The formula-(2) is used to calculate the operational pressure for single membrane reverse osmosis plant.

$$\pi = i \times \phi \times c \times R \times T \qquad ...(2)$$

Where

i = number of ions produced during dissociation of solute.

ϕ = osmotic coefficient (unit less)

c = concentration of all solutes, moles / litre

R = universal gas constant, 0.083145 L.bar/ moles.k

T = absolute temperature, k.

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