Hydro-Chemical Analysis and Evaluation of Ground Water Quality for Drinking and Irrigation Purpose around Solid Waste Dumping Site at Uruli Devachi, Pune, Maharashtra

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Abstract— Groundwater contributes to main source of drinking water and irrigation in most of the villages in India. But many resources are polluted due to various factors and one of the main reason for pollution is solid waste dumping. The paper presents the evaluation of groundwater quality around solid waste dumping yard for drinking and irrigation at Uruli Devachi located in Pune district of Maharathtra. Water samples were collected from 7 open wells and 2 bore wells during premonsoon and post monsoon season of year 2014. The type of water that predominates in the study area is Ca-Cl type for both during pre and post-monsoon seasons. Suitability of water for drinking was checked by analysing various parameters with standard values. Also the feasibility of groundwater for agriculture was checked by finding the sodium adsorption ratio, residual sodium carbonate and sodium hazards.

Key words: Groundwater, Piper Diagram, Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Sodium Hazards

I. INTRODUCTION

Assessment of groundwater quality plays an important role in characterization of water for drinking, agricultural and industrial use. Moreover it becomes upmost if the groundwater resources are located near the solid waste dumping site. The continious migration of leachate from dumping site takes place which later on joins the groundwater. Thus groundwater gets polluted and it effects it use for drinking and irrigation purpose. Considering the individual and paired ionic concentration, certain indices are proposed to find out the alkali hazards. Piper trilinear diagram is used to infer hydro-geochemical facies. Piper diagrams show the relative concentrations of six to seven ions in solutions, in this case, the Cations Ca, Mg, and Na, K, and the anions Cl, SO_4, HCO_3, and CO_3 are shown. In most natural waters, these ions make up 95 to 100% of the ions in solution. The US salinity Laboratory of the Department of Agriculture adopted certain techniques based on which the suitability of water for agriculture if found out. It includes sodium hazards, Sodium Adsorption Ratio (SAR), Residual sodium carbonate (RSC).

II. METHODOLOGY

A. Study Area

The present study area is located in the Pune district of Maharashtra state in India. The solid waste disposal site at Puneis located at Mantarwadi at Uruli Devachi in Haveli taluka 20 km away from Pune City between latitude $18^0$28'N and longitude $73^0$57'E. About 1200-1300 metric tons of solid waste from Pune municipal area is disposed per day. During the early period, Municipal solid waste was conveniently disposed off at Mantarwadi disposal site in low lying areas with large open land space.

Fig. 1: sampling location around dumping site

B. Collection of water Sample

Sampling stations were selected randomly within 3 km radial distance from dumping site by grab sampling methods.7 samples were collected from open wells located around 699.38, 1167.53, 1161.14, 1305.07, 1236.57, 1373.73, 1589.26 meters and 2 samples were collected from bore well located at 1022.49, 949.05 meters respectively with reference to the solid waste landfill site. The sampling was carried out manually, and water samples are stored in opaque polythene container or bottles. Collected samples were analyzed within 24 hrs.

C. Selection of Water Quality parameters

The occurrence of the ion and impurities in the ground water is mainly depends upon the geologic formation at the particular area. The deccan trap basalt forms the main water bearing formation in the Pune district. The hydrogeology of the Pune district forms the basis of selection of the water quality parameters like Colour, Temperature, PH, Turbidity, Conductivity, Total Hardness, Total Alkalinity, Total Dissolved solids, Total Suspended solids, Biochemical Oxygen Demand, Chemical Oxygen Demand, Chlorides, Sulphates, Phosphates, Nitrates, Calcium, Magnesium, Sodium and Potassium. Physio-chemical method of analysis recommended by APHA is used for finding the amount of constituents present in water from open wells as well as bore wells.

D. Piper Diagram, sodium hazards, Sodium Adsorption Ratio (SAR), Residual sodium carbonate (RSC)

1) Piper Diagram:

The Piper diagram includes two trilinear diagrams, one for anions (on the lower right) and one for cations (on the lower left). For each sample, the information from each trilinear diagram is projected up into the central quadrilateral. Therefore, each sample will plot in each frame of the Piper,

once representing cations, once representing anions, and once representing the combination.

As shown in figure below the diamond shape is divided into various parts, where each part has significance.

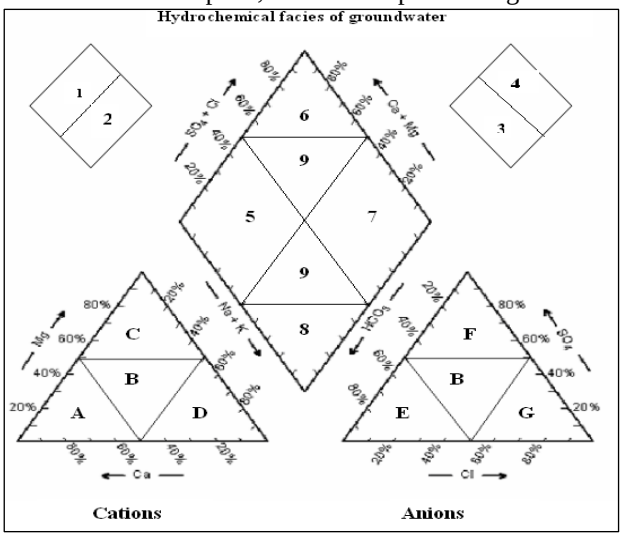

Fig. 3: Hydrochemical facies of groundwater

a) Legend

A- Calcium type, B- No Dominant type, C- Magnesium type, D- Sodium and potassium type, E- Bicarbonate type, F- Sulphate type, G- Chloride type

2) Sodium Hazards:

The sodium in irrigation waters is usually denoted as per cent sodium and the formula for calculating it is as follows-

$$\% \text{ Na} = (Na^{+}) \times 100 / (Ca^{2+} + Mg^{2+} + Na^{+1} + K^{+1})$$

Where Ca^{2+}, Mg^{2+}, Na^{+} and K+ are expressed in milli equivalents per litre.

3) Sodium Adsorption Ratio (SAR):

Sodium Adsorption Ratio (SAR) is a measure of the suitability of water for use in agricultural irrigation, as determined by the concentrations of solids dissolved in the water. In general, the higher the sodium adsorption ratio, the less suitable the water is for irrigation.

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2-}+Mg^{2+}}{2}}}$$

4) Residual sodium carbonate (RSC):

The Residual sodium carbonate (RSC) determines whether excess Ca and Mg remains in the irrigation water after reactions with the carbonate, or whether all Ca and Mg are precipitated from the irrigations water. Continoues use of waters having RSC more than 2.5 meq/l leads to salt build up which may hinder the air and water movement by clogging the soil pores and lead to degradation of the physical condition of soil.

$$RSC = (HCO^{3-} + CO_3^{2-}) - (Ca^{2+} + Mg^{2+})$$

III. Results and Discussion

Total Hardness is ranging in between 1423-3280 mg/lit(pre-monsoon) and 234-276 mg/l (post monsoon) at the study area. Evidently hardness does not pose any adverse effect, but hardness of 150-300 mg/l may cause kidney problem and inhibits the reaction in case of process industries. The high alkalinity of groundwater in certain locations in the study area may be due to the presence of bicarbonate and some salts. The alkalinity is 145-960 mg/l (pre-monsoon) and 28-96 mg/l (post-monsoon). Total Dissolved Solids concentration at the study area found out to be in the range of 360- 1323 mg/l (pre-monsoon) and 315-934 mg/l (post-monsoon).The presence of high values of Total Dissolved Solids in many locations of the study area may be due to the influence of anthropogenic sources such as domestic sewage, solid waste dumping, agricultural activities and influence of rock-water interaction.

Chloride concentration is 1890-6230 mg/l (pre-monsoon) and 260-476 mg/l (post monsoon). Chloride imparts a salty taste and some times higher consumption causes for the development of essential hypertension, risk for stroke, left ventricular hypertension, osteoporosis, renal stones and asthma in human beings. Moreover the BOD of groundwater found to be in the range of 28-58 mg/l (pre-monsoon) and 38-68 mg/l (post-monsoon), which impart odour to the water making it unpleasant for the drinking purpose. Other parameters were found in range.

The Piper Diagram is plotted for both the seasons by using Groundwater chart software.

The piper plots are as follows as follows-

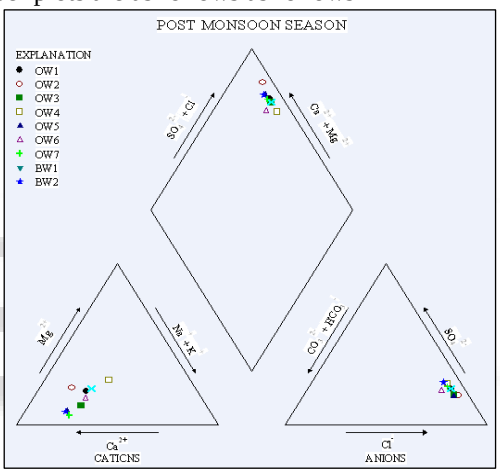

Fig. 4: Piper Diagram for Post Monsoon Season

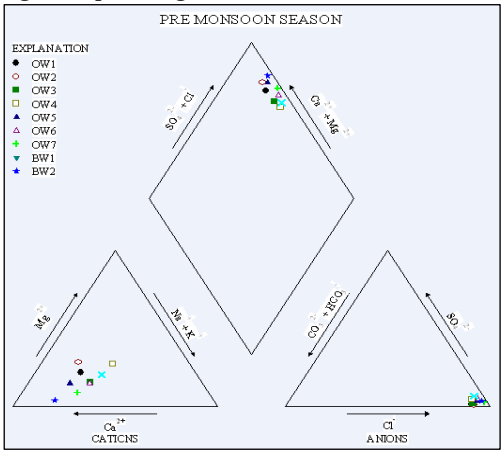

Fig. 5: Piper Diagram for Pre Monsoon Season

piper diagram plotted clearly explains the variations or domination of cation and anion concentrations during pre-monsoon and post-monsoon. Characterization of groundwater on the basis of Piper tri-linear diagram is as follows-

Sub-division	Characteristics of corresponding	Percentage of samples in this category

of the diamond	subdivisions of diamond-shaped fields	Pre Monsoon	Post Monsoon
	Alkaline earth (Ca+Mg) Exceed alkalies (Na+K)	100	100
	Alaklies exceeds alkaline earths	0	0
	Weak acids(CO_3+HCO_3) exceed Strong acids (SO_4+Cl)	0	0
	Strong acids exceeds weak acids	100	100
	Magnesium bicarbonate type	00	00
	Calcium-chloride Type	100	100
	Sodium-chloride Type	00	00
	Sodium-Bicarbonate type	00	00
	Mixed type (No cation-anion exceed 50%)	00	00

Table 1: Characterization of groundwater of Uruli Devachi, Pune on the basis of Piper Tri-linear diagram

It is clearly depicted that water type is predominantly of Ca-Cl type for both during pre and post-monsoon seasons. There was no significant change in hydro-chemical facies for both the seasons.

Sodium (%)	Water class	Pre-monsoon Samples	Post-monsoon samples
<20	Excellent	7.26-19.46 (8 samples)	6.58-16.71 (7 samples)
20-40	Good	22.39(1 sample)	20.46-22.15(2 samples)
40-60	Permissible	-	-
60-80	Doubtful	-	-
>80	Unsuitable	-	-

Table 2: Classification of groundwater based on Sodium percent

From above table it is observed that 8 (OW1, OW2, OW4, OW5 OW6, OW7, BW1, BW2) and 7 (OW2, OW4, OW5 OW6, OW7, BW1, BW2) samples are excellent during pre and post monsoon respectively and 1(OW3) and 2 (OW1, OW3) samples are good during pre and post monsoon respectively for irrigation purpose.

A. Sodium Absorption Ratio (SAR)

From the calculations for the sampling stations are checked for SAR. The results obtained are summarized in table no.3

Sodium Hazard class	SAR in Equivalents per mole	Remark on quality	Pre monsoon samples	Post monsoon samples
S1	10	Excellent	0.59-1.58(9 samples)	0.49-1.49(9 samples)
S2	10-18	Good	-	-
S3	18-26	Doubtful	-	-
S4 and S5	>26	Unsuitable	-	-

Table 3: Classification of groundwater based on Sodium Absorption Ratio

From above table it is observed that 9 (OW1, OW2, OW3, OW4, OW5 OW6, OW7, BW1, BW2) samples are excellent during pre and post monsoon respectively for irrigation purpose.

B. Residual Sodium Carbonate (RSC)

From the calculations for the sampling stations are checked for RSC. The results obtained are summarized in table no.4

RSC	Remark on quality	Pre-monsoon samples	Post-monsoon samples
<0	None	9 samples	9 samples
0-1.25	Good	-	-
1.25-2.5	Doubtful	-	-
>2.5	Unsuitable	-	-

Table 4: Classification of groundwater based on Residual Sodium Carbonate

All the values for RSC were found to be negative i.e. <0. A negative RSC indicates that more Ca and Mg are in water than Carbonates, where the excess Ca and Mg have been precipitated and excess Ca and Mg can act as counter ions to displace Na.

IV. CONCLUSION

The water was checked for drinking water standards and it can be seen that the water is not suitable for drinking purpose, as many parameters are not within permissible limit. The use of water for drinking shall be completely stopped as it may cause ill effects on human health. The Piper-trilinear approach helped to evaluate the hydro-chemical facies at the study area, which clearly revealed the water is predominantly of Ca-Cl type for both during pre and post-monsoon seasons. There was no significant change in hydro-chemical facies for both the seasons. The suitability of water for irrigation for the study area is evaluated based on SAR, %Na, RSC. Since the all groundwater sampling stations are falling in excellent and good category for SAR and % Na, it can be concluded that all the ground water sources are safe for the irrigation use, whereas RSC obtained are negative for all the stations, says that more Ca^{2+} and Mg^{2+} ions present in the samples than carbonates ions.

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