GROUND WATER QUALITY OF SHELGI NALA BASIN, SOLAPUR, MAHARASHTRA

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Abstract

In this present work various physico-chemical parameters were analyzed to determine the characteristics of groundwater quality in Shelgi nala basin, Solapur. Water samples were collected from 48 locations from bore wells and dug wells for the purpose of assessment of quality of groundwater during the year 2009. The locations from which the water samples were collected are extensively used for drinking and agricultural purpose. It has been proved from the present investigation that values of few parameters fall out of the permissible limit with reference to WHO standard values. Hence, suggested to take proper care to improve groundwater quality of the Shelgi nala basin.

Keywords*: Groundwater quality, Physico-chemical Characteristics, Shelgi nala basin.*

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1. INTRODUCTION

Groundwater is one amongst the states most important resources. It provide drinking water to urban and rural community, supports irrigation and industry, sustain the flow of stream and rivers and maintain wetland ecosystem. Groundwater is considered as the ideal source of water for mitigating domestic industrial and agricultural requirement due to its longer residence time in the subsurface. It is less susceptible to pollution than surface water and also soils and rocks through which groundwater flows screen out most of the contamination. Groundwater plays an important role on the earth, therefore its use and protection is fundamental importance to human life and economic activity.

The present study was carried out with the objective of identifying the suitability of ground water for domestic and agricultural purpose in Shelgi nala basin of Solapur, Maharashtra. This study is essential as groundwater is extensively used for domestic and agricultural purpose in this area.

2. STUDY AREA

The study area is part of Bhima basin situated 4 km from Solapur city, Maharashtra. In forms parts of Survey of India topographic sheets 47 O/ 14, 47 O/ 13, 56 C/1 and 56 C/2. The area is bound by north latitudes 17^{o}41’ and 17^{o}47’ and east longitudes 75^{o}15’ and 75^{o}57’ covering an area of about 183 km^2.

The annual rainfall is about 669mm which is mainly received during the monsoon months of July to September. The topography of this region is slopping towards south west and area is divided into various geomorphic units such as highly dissected plateau, moderately dissected plateau, undissected plateau and valley fill deposits. Groundwater occurrences in the area is controlled by the weathered and fractured part of the basaltic rock formation. The thickness of soil zone varies from 1m. to 60m. Groundwater is the main source for water for irrigation and domestic purpose in the study area and the agricultural activities mainly depends on pumping groundwater from dug wells and bore wells. The depth of open wells in this area ranges from 10m. to 33m. The entire region is affected due to water scarcity and pollution of groundwater is the main problems of this area (CGWB/,2000).

2.1 Geology of the Study Area

The area of investigation forms parts of the famous Deccan Traps, which occur in all the districts of the State of Maharashtra, except Nagpur, Bhandara, Gondia and Gadchiroli. The Deccan Traps is world famous as continental tholeiite province occurring in western and central parts of India.

The lava assemblage in Solapur district belongs to Sahyadri Group and consists of Indrayani, Karla, Diveghat, Purandargarh and Mahabaleshwar formations. Each of these formation have “AA” and “Pahoehoe” lava flows and may consist of simple and compound flows and of the formation has more than couple of flow units(Table 1) .

The flow units can be distinguished from one another on the basis of lithological character such as vesicularity, amygdaloidal, zeolites and compactness of the basalts. The top of the flow has been demarcated by vesicularity, flow breccias or red bole layer. The flow units have been laterally traced and correlated with the observations in the dug wells which are unlined. The lower most flow and the top most flow units are partial. This is because the base of the lower flow is not noticed and the top of the uppermost flow is not exposed in this region. Only the central flow is noticed to have completely developed and exposed in the study area. The red bole at the base and top of the central flow separates the flow units.

The flows in this region are of simple and are of “AA” type, as evidenced by the presence of fragmentary top, near absence of pipe amygdales and vesicularity restricted only to the upper top surface of flow. These vesicles are generally noticed to be filled with secondary minerals.

Lithology of Shelgi nala

Table 1: Lithological sequence and description in Shelgi nala basin

Altitude (M)at the base of flow	Flow (No.)	Avg. thickness of flow	Flow description
483	3 (partial)	20	Massive, compact and hard basalt with few joints and fractures.
457	2 (complete)	27	Vesicular amygdaloidal basalt with red boles, massive, compact and hard basalt with few fractures.
454	1 (partial)	3	Massive, compact and hard basalt with few joints, soil and alluvium in valley.

3. MATERIAL AND METHOD

Groundwater samples collected from the open wells were stored in air-tight polythene bottles of one liter after thoroughly cleaning and rinsing with the well water which has to be sampled. The sampling and analytical techniques were in corroboration with standard methods proposed by GSI 1983 manual and (APHA1994) (table no. 2) respectively, fig 1.represents the location of sampled wells on various geomorphic units. The parameters estimated are pH, conductivity, chloride, total hardness, carbonate, bicarbonate, nitrate, sulphate, calcium, magnesium, sodium, potassium, total dissolved solids and alkalinity. Samples from the representative open wells were collected during pre-monsoon 2009 period.

Hydrochemistry is essential to decipher the origin and chemical composition of groundwater and its relationship with soil and rock composition. Graphical representation of hydrochemistry has been attempted by many scientists in understanding quality of water, its causes and quantity of water plays a vital role in safeguarding man, animal and plant kingdom.

Table 2: Illustrates comprehensive scheme of analytical methods adopted for the groundwater samples from Shelgi Nala basin

Sr. No.	Parameter	Method of Analysis	Reference
1	P^H	P^H Meter	De A K (2007)
2	Electrical conductivity	Conductivity meter	GSI (1983)
3	Alkalinity	Titration	GSI (1983)
4	Total Hardness	Titration	APHA (1994)
5	Chloride	Titration	De A K (2007)
6	Nitrate	Spectrophotometry	APHA (1994)
7	Carbonate	Titration	GSI (1983)
8	Bicarbonate	Titration	GSI (1983)
9	Sulphate	Spectrophotometry	APHA (1994)
10	Total Dissolved Solid	Evaporation	GSI (1983)
11	Calcium	Titration	GSI (1983)
12	Magnesium	Titration	GSI (1983)
13	Sodium	Flame Photometer	APHA (1994)
14	Potassium	Flame Photometer	APHA (1994)

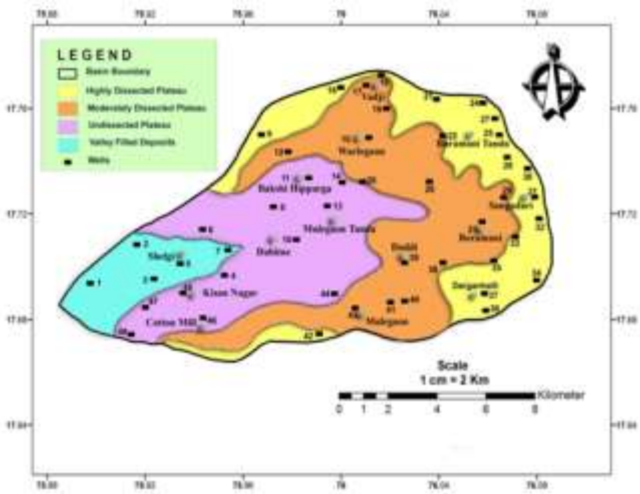

Fig 1: Illustrates 48 well locations on various geomorphic unit in Shelgi nala basin

3.1 Quality of Water for Domestic and Irrigation Purpose

The quality of the groundwater for the domestic use should be free from bacteria, odour and colour and for irrigation use it depends on sodium, calcium and magnesium percentage In the present study quality of water can be judged with the help of Gibbs diagram, USSL classification, Piper trilinear diagram, for pre-monsoon 2008, post-monsoon 2008 and pre-monsoon 2009 periods.

4. GIBB'S DIAGRAM

Geochemical ratios are widely applied to establish the facts about the chemical similarities among the waters, which are used for deciding the origin of water chemistry (Subba Rao et al 2007). One such ratio is of Na^+: $Na^+ + Ca^{2+}$ Vs TDS which has been suggested by Gibbs (1970) in order to recognize the influence of factors such as atmospheric precipitation (rainfall), rock and evaporation that govern the chemistry of groundwater in the area of investigation. Further ,the plot of anion ratio Cl-:Cl+ HCO3 vs TDS also shows a trend remarkable similar to that for cations, which supports the above factor of dominance, its application for the groundwater samples from Shelgi nala basin is illustrated in figure 2.1 for Na:Na+Ca vs TDS and figure 2 for Cl- :CL+ HCO3 vs TDS indicate rock dominance as a control for ground water chemistry. At this juncture it is not out of the way to state the presence of embryonic soil profile such as entisols and inceptisols in Shelgi nala basin which are causative factor of rock dominance for groundwater chemistry in the region.

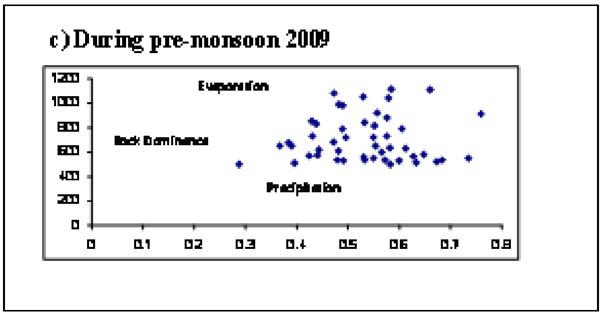

Fig 2: Plot of TDS vs (Na+K) /(Na+K+Ca) for groundwater from Shelgi nala baisn

5. USSL CLASSIFICATION

The US salinity laboratory in 1954 proposed a number of characteristics that determine water quality (USDA Handbook 60) and modified the earlier classification given by Wilcox (1948) based on EC and soluble sodium percentage (SSP). Richards (1954) proposed a diagram for classification of irrigation water based upon the electric conductivity and SAR values. The four salinity and four sodium hazard classes are derived from the diagram . A number of categories are identified in terms of salinity hazard as low, medium, high and very high and also in terms of Sodium Hazards as low, medium, high and very high. The diagram generated for the Shelgi nala basins groundwater samples are shown in figure indicates that the quality class falls under C_2 S_1 and C_3 S_1 categories. Thus the groundwater from Shelgi nala basin is considered as good for irrigation

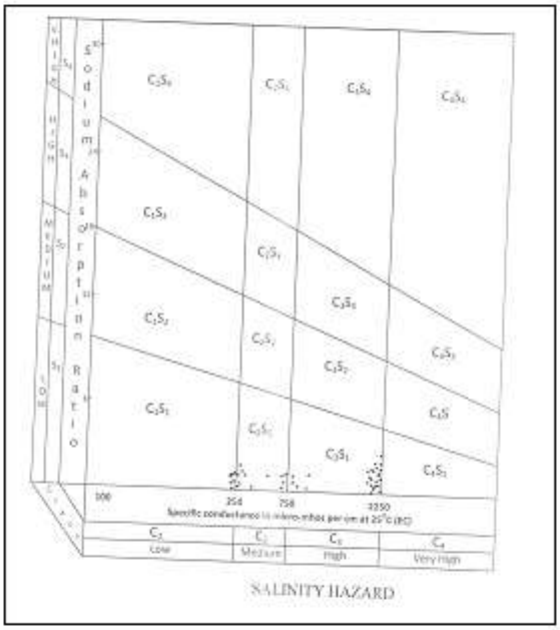

Fig 2.1: U.S Salinity diagram for classification of ground water for irrigation purpose from shelgi nala basin during Pre – monson 2009.

5.1 Piper Diagram

The major ion composition of groundwater is used to classify groundwater into various types based on the dominant cations and anions. For instance, if calcium and bicarbonate are the dominant cation and anion, then the groundwater would be a Ca-HCO_3 type. The composition of the dominant ions can be displayed graphically by many methods Hem (1987), with one of the most useful and powerful presentations being the trilinear or Piper (1944) diagram. It is possible to classification of hydro-geochemical facies using the tri-linear diagram. Interpretation for hydro-geochemical facies using trilinear diagram as a tool in understanding the flow pattern. On this diagram the relative concentrations as the major ions in percent me/l are plotted on cation and anion triangles, and then the locations are projected to a point on a quadrilateral representing both cations and anions. White et al (1963) provided an extensive compilation of groundwater analyzed from a wide variety of aquifer host rocks. Karanth (1987) identified water facies under different geological environment and lucidly illustrated its applications. Pawar et al (1982, 1984) have identified the hydro-chemical facies from Deccan basaltic terrain from Pune in Maharashtra. Origin of chemical histories of groundwater masses was successfully illustrated by Shrinivasa Moorthy et al (2007).

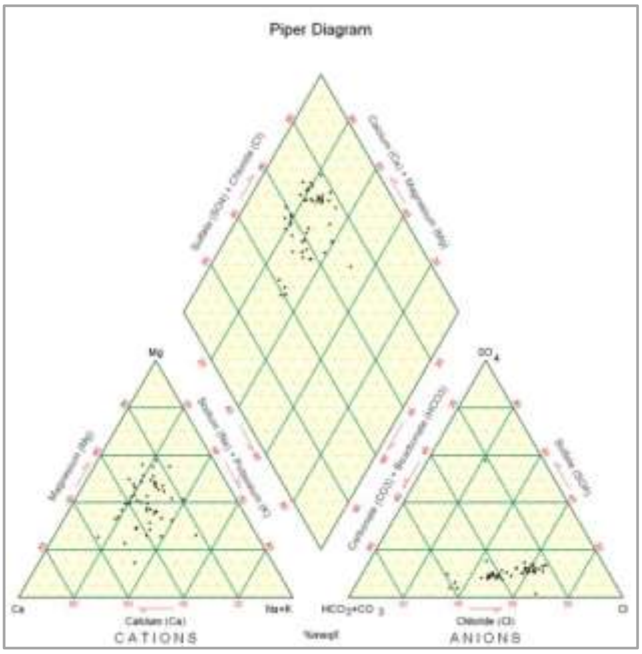

Fig 3: Illustrates trilinear diagram (Piper) of the groundwater samples from Shelgi nala basin during Pre-monsoon 2009.

Distribution of groundwater samples in different subdivisions of the diamond shaped field of the Piper diagram reveals the analogies and dissimilarities, the different types of waters are distinguished and are given in table no 3 for the groundwater chemistry from Shelgi nala basin. The Piper diagrams for pre-monsoon 2009 is illustrated in figure 3.

The entire Shelgi nala basin samples are devoid of primary alkalinity. During the pre-monsoon 2009 season the trend of alkaline earths (Ca + Mg) exceeding alkali (Na + K) in 97.91% of the groundwater samples and 2.08 % samples shows alkali (Na + K) exceeding alkaline earth (Ca + Mg) are maintained compared to the previous season. 14.58 % samples are characterized by secondary salinity, 8.33 % shows carbonate hardness (secondary alkalinity) and 75 % of the groundwater samples fall in none of the cations and anions exceeds 50 % class. Like the previous seasons the entire basin is devoid of primary alkalinity and only 2.08 % samples shows primary salinity in the pre-monsoon 2009. What is significant in the Piper diagrams for the season is a systematic decrease in the sample percentage of the field of non-carbonate hardness – secondary salinity for the season pre-monsoon 2009. Additionally, the percentage of samples falling in the field of none of the cation-anion exceeds 50% tends to appreciably increase in the season. Its value is 75%. All the said aspects appear to be largely due to non-lithogenic activities.

Table 3: Quality of irrigation water in Shelgi nala basin

Subdivisions	Description of sub-divisions in diamond shaped fields	% of sample
No. in the diamond shaped fields		Pre-monsoon 2009
1	Alkaline earths (Ca + Mg) exceeds alkalies (Na + K)	97.91
2	Alkalies exceeds alkaline earths	2.08
3	Weak acids (CO3 + HCO3) exceeds strong acids (SO4+Cl+F)	8.33
4	Strong acids exceeds weak acids	71.66
5	Carbonates hardness (secondary alkalinity) exceeds 50 % i.e. chemical properties of the ground water are dominated by alkaline earths and weak acids	8.33
6	Non-Carbonate hardness (secondary salinity) exceeds 50 % chemical alkalies and weak acids dominate prospecting of the ground water	14.58
7	Non-carbonate alkali (primary salinity) exceeds 50 % chemical alkalies and weak acids dominate prospecting of the ground	2.08
8	Carbonate alkali (primary alkalinity) exceeds 50 % i.e. chemical properties are dominated by alkalies and weak acids	Nil
9	None of the cations-anion exceeds 50 %	75.00

6. RESULT AND CONCLUSION

Water is essential for survival and has no substitute. Water quality has become a cause of concern as fresh water resources are stretched thin. Demographic growth has led to the problems of water poverty and war for water.

In the present investigation an attempt has been made to study the distribution of various hydrogeochemical parameters from the representative open wells during pre-monsoon 2009. The hydrogeochemical parameters estimated are pH, EC, Alkalinity, TH, Cl, NO_3, CO_3, HCO_3, SO_4, TDS, Ca, Mg, Mn and K using standard methods of analysis. Hydrogeochemical data was analyzed to understand the relationship of groundwater chemistry to soil and rock composition and further to decipher its quality to safeguard the human health. For most of the parameters it has been observed that their value exceeds WHO (2004) and ISI (1983) tolerance limit.

Gibbs ratio Na+ : Na+ + Ca2+ Vs. TDS plot suggest the rock dominance that govern the chemistry of ground water. Further, this aspect is in corroborates with entisols and inceptisols as indicated in soil geochemistry. The alkaline earth (Ca + Mg) exceeds alkalies (Na + K), weak acids (CO_3 + HCO_3), carbonate hardness exceeds 50 % (dominated by Alkaline earth). There is reduction of percentage of non-carbonate hardness (secondary salinity) exceeds 50 % chemical alkalies. Primary salinity is low (< 2.5 %) and high % of none of the cation – anion exceed 50 %. This is due to rock dominance and a fact true for entisols and inceptisols Plotting SAR values with electrical conductance of groundwater for the three seasons indicate that the groundwater belongs to C_2S_1 and C_3S_1 categories that happen to be good category for irrigation purpose. To a large extend the groundwater chemistry is controlled by lithogenic interaction of water with soil and rock with which it is in contact. Geochemical ratios are widely applied to establish the facts about chemical similarities among the waters, which are used for deciphering the origin of water chemistry. The ratios of Na^+: Na^+ + Ca^{2+} vs. TDS and Cl^- : Cl^- + HCO^{-3} vs. TDS show the dominance of rock water interaction in Shelgi nala basin. The basin has weathered and fractured basalts and embryonic soils such as entisols and inceptisols the hydro-geochemistry is thus dominated by lithogenic interaction with water.

The USSL classification indicates C_2S_1 and C_3S_1 categorize that indicate ground water is good for irrigation Major ion composition of groundwater is used to classify groundwater into various types based on the basis of dominant cation and anions. This is possible on tri-linear Piper (1944) diagram. Plotting the Shelgi nala groundwater chemistry data for the three seasons it is distinctly noticed of a few trends. There is similarity in trend of the percentage of samples showing alkaline earths' exceeding alkalies and strong acids exceeds weak acids for the season pre-monsoon 2009. Likewise, the percentage of samples showing weak acids exceeds strong acids and non-carbonate hardness (secondary salinity) exceeds 50 % chemical alkalis' for the said season. There is an increase in percentage of samples showing none of the cations-anions exceed 50 % for the season pre-monsoon 2009.

Hydrogeology of the unconfined conditions in Shelgi nala basin is controlled by joint, fractures and weathered basalt.87 % of 669 mm rainfall occurs in the basin just in 25 days. This gives little time for infiltration through shallow soils and massive basalts to reach for aquifer recharge.

Thus to improve groundwater quality for drinking purpose, pumping for irrigation has to be done first followed by use for potability. Rehabilitation of the groundwater from Shelgi nala has to be made to improve water quality. This can be attained by reducing the run-off and increasing the infiltration. The same can help in diluting the poor groundwater quality. Infiltration can be increased by gully and nala bunding and check dams. The rainwater harvesting structure can be built to increase groundwater recharge.

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