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Assessment of Water Quality from a Regional Water Body in Southern India Investigation

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Abstract
Musi River is flowing through Hyderabad which is having a population of about 6.7 million and a metropolitan population nearly of about 7.75 million, it is the fourth most populous city and sixth most populous urban area in India and its area covers nearly 2219 km2. Due to industrial and urbanization activities resulted in the contamination of the Musi River. To study the influence of contaminated river on groundwater and surface water, 20 water samples were collected from a part of the river flowing area and analyzed for major ions and trace metals. Various widely accepted methods such as Sodium Absorption Ratio (SAR), residual sodium carbonate, salinity, soluble sodium percentage, permeability index and water quality index are used to classify groundwater and surface water (stream) for drinking as well as irrigation purposes . Besides this, Piper trilinear diagram, geochemical controls using various statistical parameters, and hydro-geochemistry of groundwater and surface water samples were studied.

***Keywords-**: Musi River, groundwater and surface water, geochemical.*

INTRODUCTION

Among the dissolved constituents in groundwater, fluoride (F-) occurs as a natural secondary constituent (0.01–10 mg/l). Water rock interaction is the main source for fluoride thus-considered to be one of the major geogenic contaminants in the nature. There are several geographical belts across the world having rocks and soils with high fluoride content, and

India lies in one such belt (Mollert 1993). Besides, out of 85 million tons of fluoride deposits on the Earth's crust, about 12 million tons are found in India (Teotia and Teotia 1984).Groundwater comprises of dissolved ions exceeding the permissible limit is harmful and not suitable for domestic use and also for drinking purposes. Both the excess and low concentrations of F–cause a harm to human health i.e. low(<0.60 mg/l) F–content in drinking water causes dental caries whereas the high(>1.50mg/l)concentration results in Fluorosis (ISI,1983).The WHO's prescribed guideline value for F- is 1.5 mg/l (WHO, 2010). Considering high sodium and low calcium concentrations in drinking water in most parts of India, the Bureau of Indian Standards recommended the acceptable limit of fluoride in drinking water as 1 mg/l. However, the permitted limit is 1.5 mg/l for the water stress regions(BIS 2012).

The history of fluoridation was started at the beginning of the 20th century by American and European dentists through the observation of mysterious dental stainingand now more than 20 countries in the world are witnessing the fluorosis problem (Susheela, 1999). However, it took almost 30 years from the first observation (1901) of fluorosis to the first reported study in India by Shortt et al. (1937) in Andhra Pradesh.Later by 1950, three more states (i.e., Punjab, Tamil Nadu and Uttar Pradesh) joined in the list of endemic fluorosis. At present, 201 districts of 20 (out of 29) Indian states are reported to be affected by fluoride (Chakraborti et al. 2016) and this situation is predominantly worrisome as 85% of the drinking water supply in India is derived from groundwater sources (World Bank 2010). It projects that the skeletal and dental health of~62millionpeople including 6 million children is at risk. The positive correlation of groundwater level drop with increase in F-concentrations particularly in arid and semi-arid climates further confirms the role of water rock interactions in these regions. On the other hand, these regions evidencing the drastic decline in ground water level due to over exploitation, mainly for irrigation, resulting in virtual drying up of the shallow unconfined aquifers. To compensate the need, more and more deep bore wells were drilled to extract the groundwater from the deeper aquifers. The groundwater derived from deep aquifers showing high F-concentrations due to high rate of water rock interaction and residence time in deep aquifers(Nordstrom and Jenne 1977; Apambire et al. 1997; Genxu and Guodong 2001; EdmundsandSmedley2005).

In sedimentary terrains, porosity provides the chance of water rock interaction in contrast, the structural features (treated to be the secondary porosity) in hard rock terrains are responsible for the deeply circulation of groundwater thus, have relatively high fluoride concentrations (Kundu et al. 2001; Kim and Jeong 2005; Reddy et al. 2019). Most of the fluoride research is focused on hard rock terrains especially containing granitic-gneissic compositions. Less attempts were observed in contact zones of lithology where high density of structural features complicates the natural processes. This research was carried out to assess the quality of groundwater in both granitic and basaltic terrains (contact zone)of Jukkal and Bichukunda areas of Nizamabad District. The objectives of this paper are to (i) evaluate the geochemistry of major dissolved ions, (ii) quantify the F-concentrations in the region. Multifarious approaches are used to understand the mechanism responsible for the spatial and temporal distribution of fluoride across composed of different geological units (granitic/basaltic) and its environmental effects.

2. Materials and Methods

Study Area

Study area is located in the south-eastern corner of Telangana state between 17° 0′ 0″- 17° 30′ 0″ N and 79° 0′ 00″ - 79° 40′ 00″ E (Fig. 1) and covers an area of 1300 sq.km. The area falls under the semi-arid zone. The study area is normally hot in summer and cool in winter. The temperature gradually increases from the month of February and it reaches a maximum temperature in the month of May and gradually decreases form June to December. It is recorded that May is the hottest month with a temperature range from 40 to 46.5˚C, and it varies from 10 to 17˚C during winter. Rainfall occurs between June and October during the onset of the southwest monsoon. The humidity is very high and varies between 60 and 80 % during the monsoon period. The highest rainfall would occur during the months from June to September. The area receives an average annual rainfall of 900 mm/ year from the southwest and northeast monsoon. The highest precipitation occurs during the southwest monsoon. The intensity and amount of rainfall are unpredictable during the northeast monsoon period.

Geologically This primarily comprises of granite and granitic gneisss. These rocks are generally medium to coarse-grained. These rocks are traversed by numerous dolerite dykes and quartz veins. The granitic rocks are intensely weathered and the thickness of weathered zone ranges from 4 to 15 m. GSI (1995). Calcareous material like calcrete was observed in the weathered zone of several large diameter wells. In certain regions calcrete was also observed in ground surface and rock exposures. Occurrence of calcrete and nodular forms of calcrete was also reported from the neighbouring watershed Reddy, Nagabhushanam et al. (2010).

3. Methodology

Groundwater samples were collected from 25 locations from study area during pre-monsoon period (May-2016). The water samples were collected from different locations using the standard procedures recommended by APHA-1995 (Association) separately as filtered and acidified (pH-2) for analysis of chemical characters.

Chemical analyses are carried out for the major ion concentrations of the filtered water samples using ion Chromatography method.

Acidified samples are used for Trace metal studies using ICP-OES method in the laboratory as per the standard APHA-1995 (Association) 1 procedures. The analytical data can be used for the classification of water for utilitarian purposes and for ascertaining various factors on which the chemical characteristics of water depend.

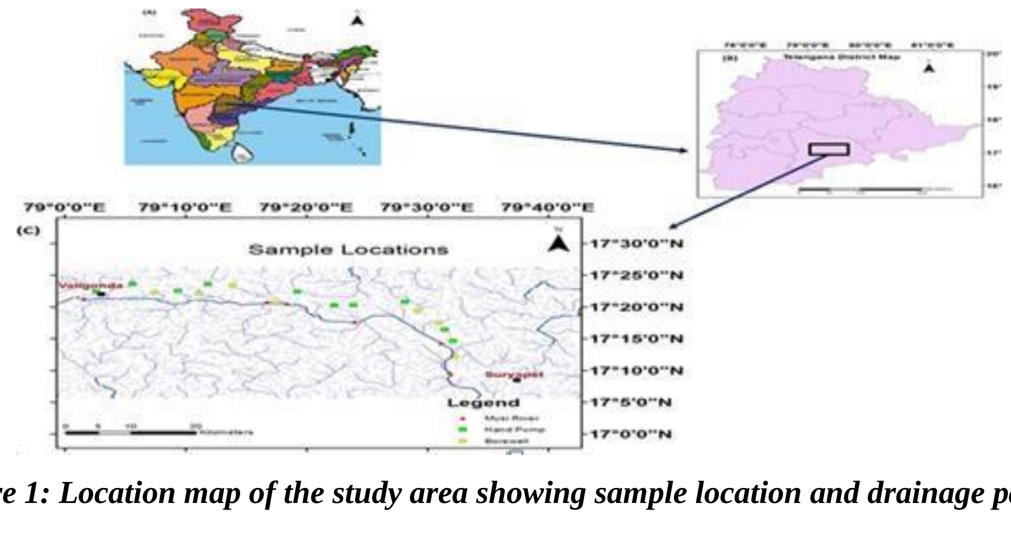

Figure 1: Location map of the study area showing sample location and drainage pattern

3. Results and Discussion

Variations in Major Ions Concentrations

Maximum and minimum concentration of major ions including fluoride present in the groundwater from the study area is presented in Table 1

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Table 1: Maximum and minimum concentration of major ions in groundwater samples

	Musi River (MR)		Bore Well (BW)		Hand Pump (HP)	
Ions	Min(mg/l)	Max(mg/l)	Min(mg/l)	Max(mg/l)	Min(mg/l)	Max(mg/l)
Na+1	206.8	557.1	83.4	471.5	35.5	1089.7
K+1	17.3	26.7	1.3	9.6	1.3	63.3
Ca+2	62.6	275	64.6	353.9	72.8	301.3
Mg+2	35.3	104.2	76	169.9	12.3	172.3
CO3−2	0	80	0	40	0	120
HCO3−1	120	400	310	380	250	630
Cl−1	246.8	515	130.3	1136	209.2	1812.8
SO4−2	75.2	117.7	55	286.1	57.5	378.6
pH	7.72	8.63	7.04	7.42	7.03	7.58
Total hardness	770	1820	514	1930	110	5020

The Piper-Hill diagram is used to infer hydro-geochemical facies. These tri-linear diagrams are useful in bringing out chemical relationships among groundwater samples in more definite terms rather than with other possible plotting methods.

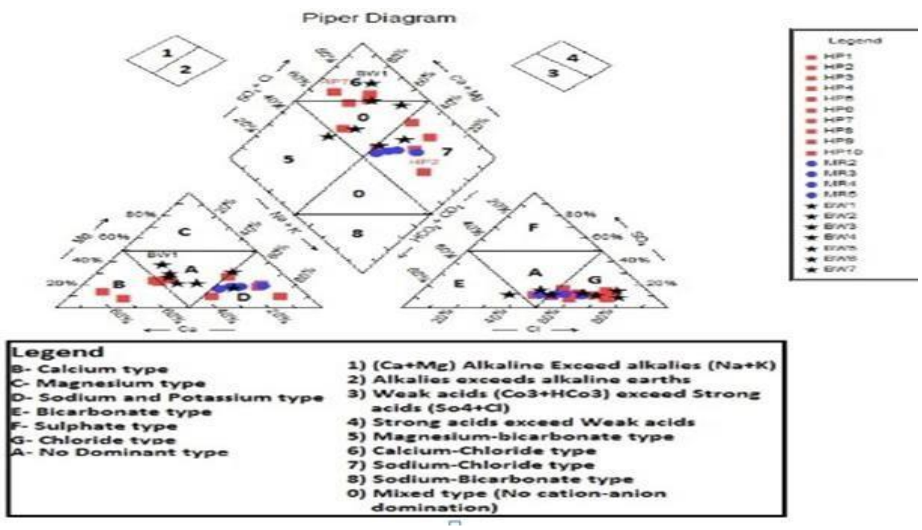

Figure 2: Characterization of groundwater on the basis of Piper tri-linear diagram

The Piper Trilinear Diagram (Piper 1953) is used to infer hydro-geochemical facies. Chemical data of representative samples from the study area are presented by plotting them on a Piper-tri-linear diagram. The plot shows that most of the groundwater samples fall in the field of Na-Cl type, Ca-Cl type and Some samples are also representing mixed Ca-Mg-Cl type of water (Fig. 2). From the plot, alkaline earths (Ca^{2+}- Mg^{2+}) and the alkalis (Na^{1+}- K^{1+}) are more or less same and strong acids (Cl^{1-}-SO_4^{2-}) exceed the weak acids (HCO_3^{-}- CO_3^{-})Eaton (1950) recommended the concentration of residual sodium carbonate to determine the suitability of water for irrigation purposes. The US Salinity Laboratory of the Department of Agriculture adopted certain techniques based on which the suitability of water for agriculture is explained. The sodium in irrigation waters is usually denoted as per cent sodium and can be determined using the following formula(Wilcox 1955).

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

Table-2: Sodium percent water class where the quantities of Ca^{2+}, Mg^{2+} Na^{+1} and K^{+1} are expressed in milliequivalents per litre (meq/l).

Sodium (%)	Water class	Samples Status
<20	Excellent	10.73 (1 sample)
20–40	Good	21.50–35.54 (8 samples)
40–60	Permissible	42.48–58.95 (10 samples)
60–80	Doubtful	61.07–79.81 (6 samples)
>80	Unsuitable	-

The classification of groundwater samples with respect to per cent sodium is shown in Table 4. It is observed that about 9 samples are excellent to good, 10 samples are in permissible limit and 6 samples fall under doubtful classes. In waters having high concentration of bicarbonate, there is tendency for calcium and magnesium to precipitate as the water in the soil becomes more concentrated. As a result, the relative proportion of sodium in the water is increased in the form of sodium carbonate. RSC is calculated using the following equation.

$$RSC=(HCO_3^{-}+CO_3^{-}) - (Ca^{2+} +Mg^{2+})$$

According to the US Department of Agriculture, water having more than 2.5 meq/l of RSC is not suitable for irrigation purposes. Groundwater of the study area is classified on the basis of RSC and the results are presented in Table 5 for both pre- and post-monsoon seasons. Based on RSC values, over 24 samples have values less than 1.25 and are safe for irrigation only 1 sample fall under doubtful class.

Table-3: Groundwater quality based on RSC (Residual sodium carbonate)

RSC (meq/l)	Remark on quality	Samples Status
<1.25	Good	-20.18 - 1.06 (24 samples)
1.25–2.5	Doubtful	4.26 (1 sample)
>2.5	Unsuitable	-

The sodium hazard has been expressed as per cent sodium of total cations. A better measure of the sodium hazard for irrigation is the SAR which is used to express reactions with the soil. SAR is computed as where all ionic concentrations are expressed in meq/l

SAR=Na/{Ca2++Mg2+}1/2

The classification of groundwater samples from the study area with respect to SAR is represented in Table-4. The SAR value of 23 samples are found to be less than 10, and are classified as excellent for irrigation and 2 samples.

Table-4: Sodium hazard classes based on USSL classification

Sodium Hazard class (Alakalinity)	SAR in Equivalents per mole	Remark on quality	Samples status
S1	10.00	Excellent	0.61-8.17 (23 samples)
S2	10 – 18	Good	14.06-14.71 (2 samples)
S3	18–26	Doubtful	
S4 and S5	>26	Unsuitable	

This area the groundwater is generally Ca-Mg-HCO3 type, which is mainly due to the geology of the area which comprises igneous rocks of crystalline nature, in which the major units are gneisses and granites. Ground water in the study area occurs under water table conditions in the weathered and fractured granite, Gneisses.

CONCLUSION

Study of the geochemical process is essential, as fluoride contamination is selective even in similar hydrogeological environments; hence, the unique characteristics of the water that are responsible for higher assimilation of fluoride need to be explored and understood. The reasons for this discreet fluoride absorption could be delineated by attempting a comprehensive study of analytic results, which may open up new ideas for understanding more clearly the water-rock interaction. The geochemistry of groundwater was evaluated in various methods like Gibbs plots, Kelley's index, chloro alkali indices (CAI) which indicate the hostrock as the main source and secondary source of dissolved solids in the groundwater.

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