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Identification of corrosivity ratio in the groundwater chemistry: A case study from Vaippar River Basin, Tamil Nadu

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ABSTRACT

An attempt has been made to detect corrosivity ratio of groundwaters in the Vaippar River Basin by interpretation of fifty water samples during pre and post monsoon periods and it could be observed that the corrosivity ratio are found be more than fifty percentage in both seasons. In this study reveals that during the premonsoon period corrosivity ratio ranges from 0.06 -17.53 whereas post monsoon periods minimum are found to be 0.11 and maximum are exists 9.99. In this context, a study has been conducted to analyses various factors to involved abnormal ratio of corrosive tendencies. Further, the geological significance with reference to corrosivity ratio, geochemical characteristics of groundwater samples has also been interpreted.

KEYWORDS

Corrosivity Ratio;
Ground Water Chemistry;
Vaippar River Basin;
Tamil Nadu.

INTRODUCTION

Groundwater is one of the most important natural resources required for human consumption, domestic purposes, irrigation and urbanization etc., As groundwater is adjoining to the tank and rage, maize are grown in rain fed areas, most of the areas are found to be cotton, cucumber, coconut, groundnut, chillies and commercial crops in the basin. Surface water supply from small, medium and large scale tanks occur in the study area. Majority of the crops pattern depend upon the surface water during the monsoon periods and groundwater to be utilized in non monsoon periods. The largest available sources of water, it has become crucial quality than quantity. The demand for groundwater increasing day by day in the Vaippar River basin owing to rapid growth of population, expansion of agricultural activities and increasing trend of industrialization. In these

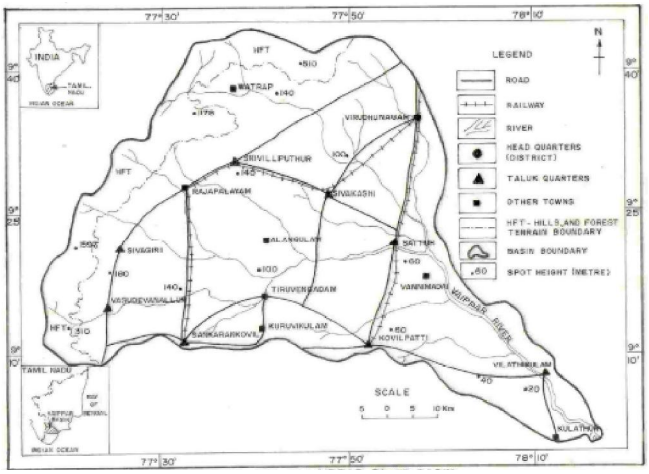

Figure 1 : Location map of Vaippar River Basin

river basin lying between longitudes 77°23' 25"to 78°17'02" E and latitudes 9°0' 05" to 9° 44' 56" N. The areal extent about 4406 Sq.Km and covered by part of three districts namely Tirunelveli, Viruthunagar and Tuticorin and majority of this area is covered by Virudhunagar district (Figure 1).

GEOLOGY, PHYSIOGRAPHY AND HYDROGEOLOGY

Geologically, the basin occupied by Archaean rocks consisting of charnockite, hornblende biotite gneisses with minor isolated pockets of pyroxene granulites, quartzite's, granites, calc-granulites, ultramafic rocks, crystalline limestones, sandstone and kankar. Alluviums of recent to sub recent age group of formations are found along the river courses and coastal alluviums are existing in the coastal belt are shown in the Figure 2 and Geological map prepared from Geological and Mineral map of Tamilnadu and Pondicherry (GSI, 1995) and stratigraphic successions are shown in the TABLE 1.

TABLE 1 : Regional stratigraphic succession of Vaippar River Basin (after public works department, ground water division, 2004)

Era	Periods	Age	Lithology
	Quaternary	Recent	- Soils, Coastal sands,
			- Kankar, Alluvium
Cenozoic			- Limestone
		Pleistocene	- Calcareous Sandstone
			- Laterites
	Tertiary	Middle Mio-Pliocene	- Shell Limestones
			- Cuddalore Sandstone
Unconformity			
Archaean	Khondalite		- Granites
Formation	Group		- Peninsular Gneisses
			- Garnetiferous Sillimanite Gneisses
			- Garnetiferous Biotite Gneisses
			- Garnetiferous Sillimanite Graphite Gneisses
	Charnockite Group		
			- Charnockites
			- Calc- Granulites
			- Pyroxene Granulites
			- Quartzites

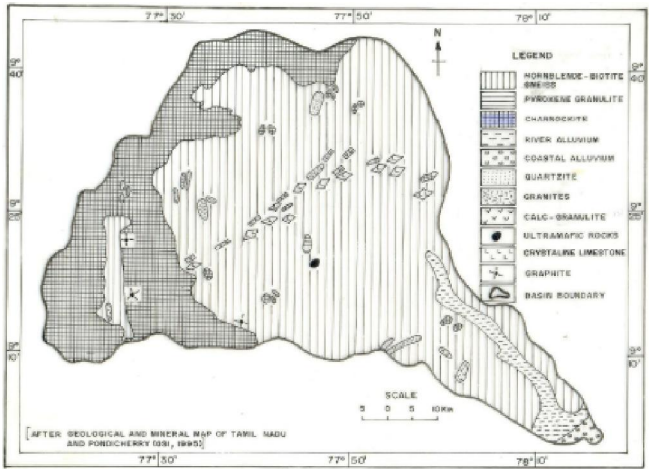

Figure 2 : Geological map of Vaippar River Basin

Physiographically in the study area is classified into three categories such as highly elevated hills (1597-180 m AMSL), gently sloping area (180-20 m AMSL) and coastal plain (less than 20 m AMSL). Vaippar river is starting from Western Ghats towards the south eastern parts (Bay of Bengal) along with number of major tributaries like Nichabandhi, Deviar, Arjuna Nadhi, Senkottai and Kayalkudiyar. The drainages are found in the basin dendritic and sub dendritic pattern. Most of the soils are found to be black cottons, red, clay loamy soils, river alluvium, coastal alluvium and coastal sands etc.,.

Groundwater occurs under water table conditions in the form of fissures, fractures, faults, joints, and lineaments in the hard rock areas whereas semi confined nature are found to be sedimentary formations. The depth of the water table various from 1.5 to 10 m and 2.5 to 13.5m below ground level in the post and pre-monsoon periods respectively.

The water supply system of Vaippar River Basin area commissioned in 1969 by the Tamil Nadu Water Supply and Drainage Board (TWAD), In addition to that Central Ground Water Board (CGWB), Public Works Department,Ground Water Division (PWD,GWD) are the main source of supply to the consumers. At present the development i.e., planning, design and construction different types wells in the form open wells, dug wells, dug cum bore wells and shaloow circular wells, Tube wells etc., by the Tamil Nadu Water Supply Drainage Board (TWAD). Through State Water Supply department is more contribution than the Central Ground Water Board (CGWB) and no of bore wells,

open wells lifts groundwater and pumps it to the consumers.

MATERIALS AND METHODS

The important geochemistry of 50 observation wells of groundwater has been collected from Public Work Department, Ground Water Division (GWD), Tamil Nadu. Corrosivity Ratio (CR) is defined as the corrosive tendency of groundwater due to the proportional occurrence of alkaline earths and saline salts along with sulphates in groundwater. Corrosion causes significant loses in the hydraulic capacity of pipes and pipe fittings. Corrosion is mainly an electrolytic process which series of damages and gradually destroys and corrodes away a metal surface. The range of corrosion continuous relative type chemical equilibrium reaction as well as upon specific physical influence such as temperature, pressure and velocity of flow[2]. In addition to that lack of carbonate minerals intensity concentration of chlorides and sulphate minerals which causes also increase of corrosion rate[7].

The corrosivity ratio first suggested by Ryzner[9] and number of researchers have been applied corrosivity formula in the Sabarmathi River basin by Badrinath et al.[3], Raman[7], Balasubramanian[4], Rengarajan, Balasubramanian[8], Sankar[10], Sharma and Jayashree[13] have been successfully worked the corrosive tendencies of groundwater in the various parts of country.

The Corrosivity Ratio expressed as

$$\frac{(C1/35.5) + 2(SO_4/96)}{2((HCO_3 + CO_3)/100)}$$

where all the ion concentration is expressed in ppm.

The rate intensities of corrosivity ratio of groundwater derived from the study area has been calculated above mentioned formula. It denotes susceptibility of groundwater to corrosion and is expressed as ratio of alkaline earth to saline salts in groundwater. The effects of corrosion are losses in hydraulic capacity of pipes.

Gibbs[5] have been studied some of the mechanism controlling the chemistry of groundwater ratio of CAI-I-(Na + K) / (Na +K+ Ca) and CAI-II-Cl / (HCO3 + Cl) have been plotted visa verse Total Dissolved Solids.

RESULTS AND DISCUSSIONS

The Corrosivity ratios are shown in the Figures (3&4) for the pre and post monsoon respectively. During pre monsoon periods number of water samples location are found to be more than two are shown in the TABLE 1. It could be seen from the table maximum corrosive tendancy are found in the location of Vilathikulam (17.53) and Pillaipatti Malai(13.3), in the post and pre monsoon respectively. While low corrosivity ratio is observed Kallikachalapuram (0.05) and Karisalkulam (0.16) in both seasons respectively. Out of fifty water samples tenty six percent of the post monsoon water samples have corrosive ratio (CR) more than one (safe zone), while fifty four percentage

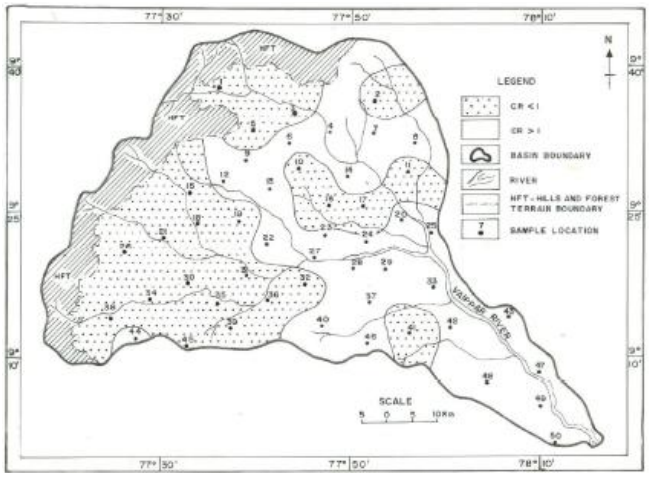

Figure 3 : Corrosivity ratio of Vaippar River Basin

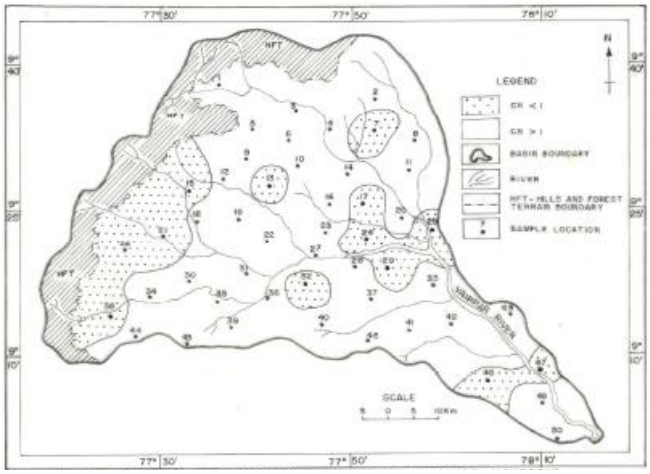

Figure 4 : Corrosivity ratio of Vaippar River Basin (Post – Monsoon)

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TABLE 2 : Seasonal variations of the corrosivity ratio in the Vaippar River Basin, Tamil Nadu

Sr. No	Name the Village	Corrosivity Ratio		Ranges of Difference	Ranges (safe& Unsafe)		Existing –(ppm)
		Pre-monsoon	Post-monsoon		Pre-monsoon	Post-monsoon	
1.	Kodikulam	0.64	1.12	-0.48	-0.36	0.12	
2.	Sengundrapuram	0.50	2.06	-1.56	-0.50	1.06	
3.	Nathampatti	0.88	1.03	-0.15	-0.22	0.03	
4.	Reddiapatti	3.88	1.39	2.49	2.88	0.39	
5.	Pillaiyarnatham	0.60	2.22	-1.62	-0.40	1.22	
6.	Kuppampatti	2.83	1.98	0.85	1.83	0.98	
7.	Amathur	6.62	0.69	5.93	5.62	-0.31	
8.	Sulakkarai	4.74	3.79	0.95	3.74	2.79	
9.	Srivilliputhur	2.21	3.25	-1.04	1.21	2.25	
10.	Naduvappatti	0.96	1.58	-0.62	-0.04	0.58	
11.	Ettunaikanpatti	0.48	4.92	-4.44	-0.52	3.92	
12.	Mamsapuram	1.98	1.41	0.57	0.98	0.41	
13.	Nagapalaiyam	2.78	0.48	2.3	1.78	-0.52	
14.	Pillaipattimalai	4.16	13.03	-8.87	3.16	12.03	
15.	V. Venganullur	0.82	0.11	0.71	-0.18	-0.89	
16.	Sitturajapuram	0.74	9.99	-9.25	-0.26	8.99	
17.	Anuppankulam	0.60	0.40	0.20	-0.40	-0.60	
18.	Muddukudi	0.63	2.37	-1.74	-0.37	1.37	
19.	Karisalkulam	0.16	3.19	-3.03	-0.84	2.19	
20.	Veppilaipatti	2.71	1.63	1.08	1.71	0.63	
21.	Panjampatti	0.23	0.55	-0.32	-0.77	-0.45	
22.	Alankulam	5.44	4.45	0.99	4.44	3.45	
23.	Gananjampatti	5.26	1.22	4.04	4.26	0.22	
24.	Subramaniapuram	2.34	0.53	1.81	1.34	-0.47	
25.	Chokkalingapuram	1.20	0.93	0.27	0.20	-0.07	
26.	Sivagiri	0.65	0.79	-0.14	-0.35	-0.21	
27.	Vembakkottai	1.34	1.13	0.21	0.34	0.13	
28.	Achankulam	15.52	6.63	8.89	14.52	5.63	
29.	N.Mettupatti	1.69	0.69	1	0.69	-0.31	
30.	Paruvakkudi	0.69	5.58	-4.89	-0.31	4.58	
31	Koiloor	0.23	1.10	-0.87	-0.77	0.10	
32.	Meenakshipuram	0.35	0.61	-0.26	-0.65	-0.39	
33.	Aiyampatti	5.48	5.19	0.29	4.48	4.19	
34.	Panaiyur	0.48	2.32	1.84	-0.52	1.32	
35.	Suppalapuram	0.85	1.58	-0.73	-0.15	0.58	
36.	Thiruvengadam	0.49	1.46	-0.97	-0.51	0.46	
37.	Nainapuram	1.56	5.29	-3.73	0.56	4.29	
38.	Vasudevanullur	0.80	0.45	0.35	-0.20	-0.55	
39.	Sevalkulam	0.60	2.77	-2.17	-0.40	1.77	
40.	Ilaiyarasanendal	7.66	2.17	-2.17	-0.40	1.77	
41.	Kadalai	0.34	7.07	-6.73	-0.66	6.07	
42.	Virappatti	1.35	2.78	-1.43	0.35	1.78	
43.	Nagalapuram	2.13	3.05	-0.92	1.13	2.05	
44.	Mullikulam	1.96	1.97	-0.01	0.96	0.97	
45.	Sankarankovil	0.88	5.98	-5.1	-0.12	4.98	
46.	Kovilpatti	3.77	4.02	-0.25	2.77	3.02	
47.	Vilathikulam	17.53	0.31	17.22	16.53	-0.69	
48.	Kaluhachalapuram	2.80	0.05	2.75	1.80	-0.95	
49.	Marthandanpatti	10.52	4.23	6.29	9.52	3.23	
50.	Kulathur	2.60	6.07	-3.47	1.60	5.07	

pre-monsoon samples have (CR) more than one (unsafe zone). Most of the area are found be in the unsafe zone, excepting southwestern parts and a few isolated patches in the safe zone in both seasons. In the area where groundwater has CR values> 1 Polyvinyl Chloride (PVC) pipes should be used. It could be seen from the table corrosive tendency steadily increasing during the post monsoon period due to increasing of carbonates, bicarbonates, chloride and sulphates very high loading carbonate and bicarbonate sources from soils. In additions to that very high loading carbonates and bicarbonates sources from soil associated with potassium rich materials of the host rock and influence of carbon dioxide[6]. The post monsoon period, groundwater aquifer system characterized, during passage of water it will be carries salts solutions from rock and soils. The corrosive tendency are maximum in the black cotton soil, granites, gneissic rock formation, kankar and limestone areas due to highly weathered nature and easily dissolved during passage of groundwater movements because of less resistance capability.

Figures 5&6 show the Gibb's plots of groundwater chemistry. In general it classifies three divisions like evaporation, precipitation and rock water dominance. Out of this maximum water samples falls under the rock water dominance of minimum are observed evaporation dominance. More than 90% of water samples under rock water interaction because of aquifer stayed quit lot of times[6]. A few samples could be found precipitation and evaporation on both seasons respectively.

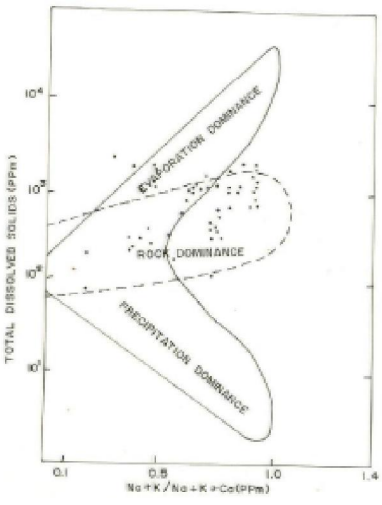

Figure 5 : Mechanism controlling the chemistry of Vaippar River Basin in Pre-monsoon (Gibb's Plots for cations)

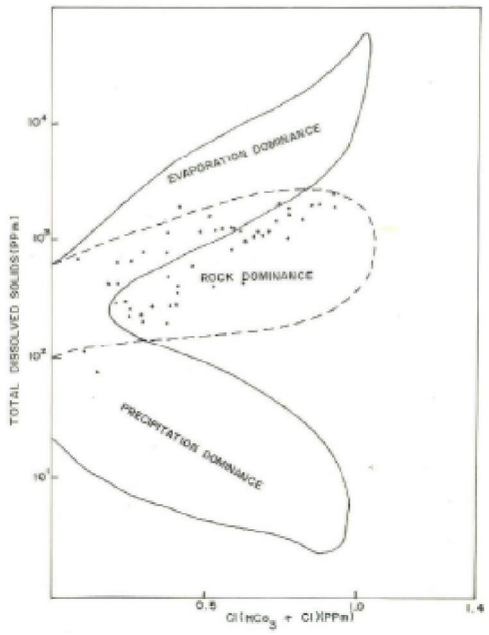

Figure 6 : Mechanism controlling the chemistry of Vaippar River Basin in Pre-monsoon (Gibb's Plots for anions)

CONCLUSIONS

The chemical characteristics of groundwater particularly corrosive tendency highly influenced by chloride, sulphate, carbonate, bicarbonate sources along with kankar and black cotton soil types twenty six percent of the Post-monsoon water samples have corrosive ratio (CR) of less than on (safe zone) while fifty four percent pre-monsoon samples are more than one (unsafe zone), excepting southwestern parts and a same isolated patches in the safe zone in either seasons. In the basin where ground water sample has >1 corrosive ratio Polyvinyl chloride (PVC) pipes should be used. According to Gibbs Diagram of groundwater chemistry sample is mainly predominantly rock water interaction and hydrogeologic properties like porosity, permeability and non homogeneity of the unconfined aquifer formation. The groundwater quality of Vaippar river basin is potable and very hard nature in terms of temporary hardness. In groundwater point of view it is suitable for drinking, irrigation, agricultural and allied fields except few places. Generally, the good quality of groundwater found to be southwestern and northwestern part of the study area.

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