CHARACTERIZATION AND ECOLOGICAL IMPACTS OF GROUNDWATER IN AROUND NOYYAL RIVER, COIMBATORE DISTRICT, TAMIL NADU, INDIA

by

Meenalakshmi DHESINI[*] and Muttharam MADHAVAN

Department of Civil Engineering, Faculty of Civil Engineering, Anna University, Chennai, India

Original scientific paper
https://doi.org/10.2298/TSCI200814211D

In this research article details the hydrogeo chemical process characterization and ecological impact of groundwater was carried out around the Noyyal river, Coimbatore region, India. In pre and post monsoon region, the surrounding shallow wells groundwaters are used for this trial experiments (50 samples) and its major cations and anions are also observed. From the analytical results it's identify that majority of ions pursue the succeeding sequence Cl > Na > Ca > Mg > HCO_3 > SO_4 during both seasons. About 6% of the groundwater samples was lying in under saline water group during both seasons. The dying industries use many chemicals throughout the dyes process, resulted in high content of Cl and sodium within the groundwater. During the post and pre monsoon, 42% and 45% of samples were affected. It revealed that the absorption of Na and Cl were surpassed the allowable percentage. About 55% of the examples fall in Na-Cl sort, which plainly demonstrates the prominent impact of enterprises profluent and geochemical measures on the nature of water. Spatial distribution indicates that all the major ions increase towards northern and central part of the region. Strong positive correlation for Cl with EC, Ca, Mg, and Na were observed during both seasons due to influence of anthropogenic impact and natural processes. The Kelly's and Magnesium Hazards about 50% of the samples exceeded above the limit indicates unsuitable for agriculture purpose during the season of pre and post monsoon. In current location, the process like silicate weathering and reverse ion exchange establishing the groundwater chemical properties. This study further reveals that in the proximity of industries the ground water possesses higher concentration of associated ions is found around the industries due to the ecological impact of effluents. Hence it is realised that to recover the groundwater quality of this region, it is essential to treat the effluent effectively.

Key words**:** *groundwater quality, hydro geochemical processes, ecological impact, noyyal river*

Introduction

The life cannot be survived without water. While surface water is the most widely used resource, groundwater is the largest available fresh water reservoir on the earth. Assessment of water surface is detectable and easily accessible. The source of groundwater is not

[*]Corresponding author, e-mail: lakshmimeena6@gmail.com

easily accessible and not evaluating directly. It accommodates various parameters like infiltration, interrelationship, utilize of land, precipitation, and run off to evaluate the sources of water surface. Dissolution and corrosion are two significant factors of groundwater, to dealing with chemical evolution. It revealed that the formations of the chemical ions are initiated in the groundwater. The rainwater leaks the gases like H_2S, NH_3, He, CH_4, and CO_2 into the unsaturated soils. Above the gases led to weaken the acidic range and raises the chemical combativeness in the groundwater [1]. The evaluation of groundwater sources is based upon the performance and quantity, which is almost equal in level. The chemical and physical property of the data increases into the groundwater is mainly contribution of dissolution or dilution of minerals from the source rock derived from the groundwater recharges, discharge, movement, and storage [2]. Chemical characteristics of the aquifer materials changes in spatially and temporally impact of groundwater quality during hydrogeochemical processes [3]. The performance of water is relates with chemical, biological and physical attributes. The water quality is a quality, where it presents in various rock terrains which may be excellent, good or poor [4, 5].

The chemical interaction of the groundwater had following categories like exchange of ions, disintegration, oxidation, reduction, precipitation, and finally filtration [6]. During the physicochemical process, the ions were exchanged between the rock soil and groundwater. The chemical and physical forces are the major reason for adsorbing the molecules and ions on the surfaces [7]. The two stages are involved in chemical weathering: in the first step, inorganic processes are initiated and compose the rotten rocks or saprolities it's known as geochemical weathering process and in the second step, decomposition was started and produces the soils in saprolitic material it's called as pedogeochemical weathering [8]. The various researchers investigated the geochemistry of groundwater and classify the hydrogeochemical to measures the hard rock area in the southern region of India. It revealed that the Cl and EC outcomes varied in huge amount due to the influence of hydrogeochemical processes. Groundwater quality based on physico-chemical parameters studied many of the researchers were carried out different parts in India [9-12]. Hydrogeochemical studies have been carried out by several workers in world and India [13]. In this study discussed about the correlation between air temperature and the qualitative characteristics of the water courses in pannonian basin.

Through several researchers studied the water performances in different river-basin, the attributes of ground water in Noyyal River Basin is not well documented. Since Noyyal river basin caters the water need covering an area of 3510 km^2 in the present study, it is propose to carry out the quality analysis for groundwater. This will facilitate to arrive at the portability of water for domestic purpose and also to identify the degree of contamination. Variation of ions and geochemical processes involved in the groundwater of Noyyal river basin located in Coimbatore, Coimbatore district, India is presented in this research article. A lot of industries were functioning in this current research region which may affect the attributes of groundwater. In addition, the various researchers examined various investigations subjected to groundwater performances in the study area. Moreover, this investigation does not analyze the hydrogeochemical processes in contamination of groundwater. For that reason, the present investigate is to measure the pollution of groundwater by hydrogeochemical actions.

Sample collection and analytical procedure

In pre and post monsoon region, the surrounding shallow wells groundwaters (50 samples) are used for this trial experiments. One litre polyethylene bottles have been used to collect the samples. A portable meter has been used to measure the content of temperature, electrical conductivity (EC) and pH in the field itself [7]. The total dissolved solids (TDS) was multiplied with EC and their calculated values are divided by 0.64. The EDTA is a titration technique, to identify the absorption (Ca, Mg, HCO_3, and Cl) in the collected trials [14]. The flame photometer (Make: Systronics UV-VIS 118) utilized to determine the potassium, sodium and sulphate content. In particle investigation, ion balance error was found to verify the significant precision value (±5%). As per the standards of American Public Health Association, the procedure has been followed to measure the ion present in groundwater. The ArcGIS 10.9 software were used to make the spatial disseminations of major ions maps based on the inverse distance weight techniques. The Rockworks 16.1 software has been used to identify the hydrogeochemical faces in the region. The factor analysis and correlation matrix of hydrochemical statistics with SPSS software (17.0)

Description of research area

In the present study investigation area is situated in the middle portion of Tamil Nadu (latitude 10° 56' 01" N – 11° 1' 10" N and longitude 76° 45' 24" E – 77° 6' 56"E) as shown in fig. 1. The paddy field was mainly covered in this research. Generally, climate condition of these regions are arid to semi-arid and the rain fall in the influence of through two seasonal monsoon such as northeast and southwest monsoon. These regions were forming in part of the Noyyal river basin, a tributary of the once relentless Cauvery river, starts from the steeply rising Vellingiri and Boluvampatti scope of slopes of Western Ghats. Noyyal River had adjoined with a cluster of small rivers and streams such as Kovai kuttaralam, Pavanasu River or Samimudi River, Periyar, and Chennapallam. It runs through the undulating plains towards east for 180 km to meet Cauvery river Via the Karur Triuppur, Erode districts.

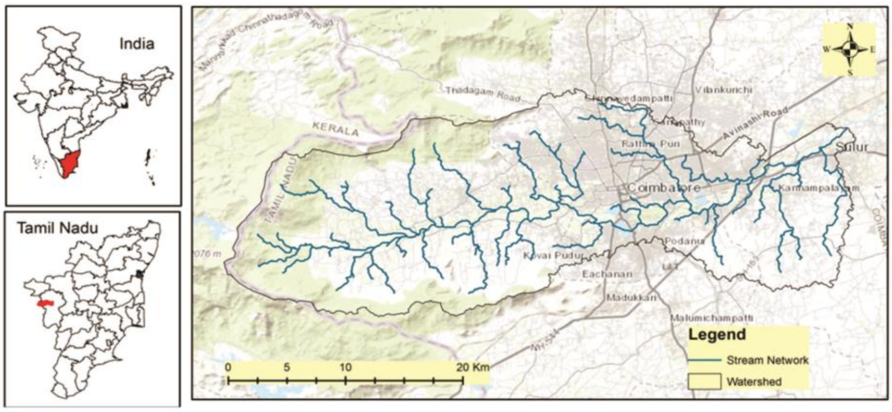


Figure 1. Study area map

This river flow covers an area around 3510 km^2 with good to moderate flow during south-west and north-east monsoon period. The average width of the basin is around 25 km. In the study area covered six different major soils such as red soil, brown soil, alluvial soil, forest soil, and black soil. Major part of the region consists of complex Granitic Gneiss formation. Kankar and jointed gneissic formations are observed below the top soil. Since of the down through, the thickness of top soil is establish to be more in the north bank of Noyyal river. Geological formation of these region associated with crystalline rocks are signified by weathered and fractured granite gneisses, charnockites and other rocks. All the selected wells located in this region falls in the charnockite formation. Normally the underground water was found in phreatic situation, the semi-confined and weathered mantle circumstances of the fractured regions. The shallow aquifers occur within the depth of 30 m. The depth of the wells ranged from 7 m to 45 m below ground level [15]. Groundwater is mainly used by domestic, agricultural and industrial area. The hazardous waste of dying units near the natural water resources would come under red category. Dyeing and bleaching effluents (semi treated or without treated) are continuously discharged in the range of 80 mld to 100 mld per day into the Noyyal river stream.

Results and discussion

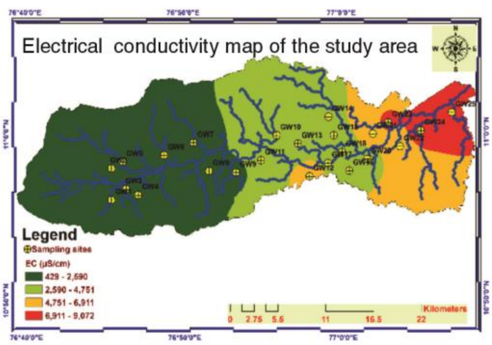
Geochemistry of groundwater

The physicochemical parameter of groundwater represented in tab. 1. It can be seen that the pH of groundwater sample in the range of 6.9 to 8.9 in pre monsoon and 6.5 to 8.6 in the in post monsoon. In the region most of the samples is controlled by alkaline in nature. The EC of groundwater samples varied between 560 μS/cm and 10632 μS/cm in pre and 429 μS/cm to 9073 μS/cm post monsoon. A suggestion was made that the groundwater can be classified into three groups founded on the EC content as: fresh water (<1500 μS/cm), brackish water (1500-3000 μS/cm), and saline water (>3000 μS/cm) [16].

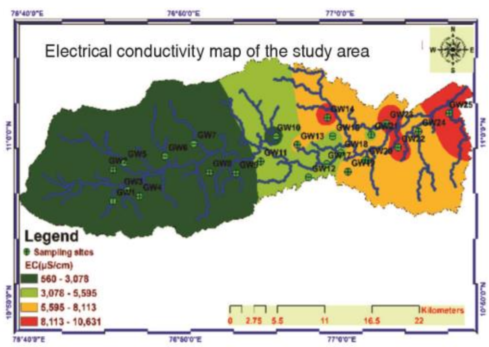
Table 1. Hydrogeochemical data (all parameters are in mg/L and EC in μS/cm)

Parameters	Pre monsoon			Post monsoon		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
pH	6.9	8.9	7.0	6.5	8.6	7.0
EC	429	9073	3898	560	10632	4614
TDS	275	5807	2495	359	6805	2953
Ca	22	290	120	16	852	266
Mg	10	265	91	21	369	104
Na	35	1395	596	46	1650	624
K	1	16	7	1	12	7
HCO_3	53	385	205	75	659	291
Cl	65	2658	1035	95	3350	1195
SO_4	25	847	369	10	1363	433

Around 60% of the samples were found under saline water group during both seasons. The TDS content reaches from 359 mg/L to 6805 mg/L in pre storm and 275 mg/L to 5807 mg/L for post storm. Spatial variety of the EC is high in the eastern and focal bit of the space, fig. 2.



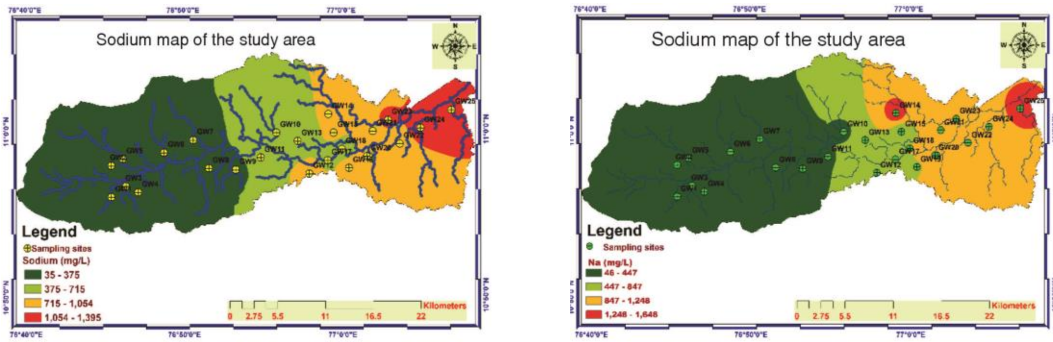
(a)



(b)

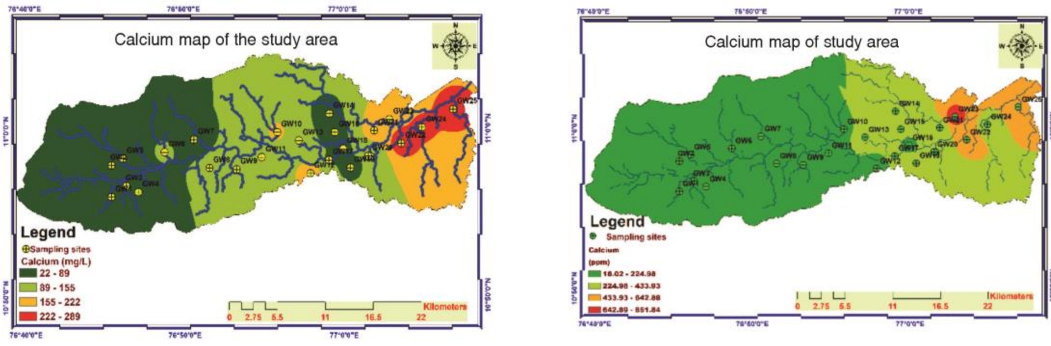
Figure 2. Spatial variation in EC concentrations of groundwater during pre and post monsoon; (a) pre monsoon and (b) post monsoon

The assimilation of sodium of groundwater varies from 46 mg/L to 1650 mg/L in pre storm and 35 mg/L to 1395 mg/L during post rainstorm in the district in the region 48% of test during pre rainstorm and 45% of test in post storm demonstrate sodium content higher than overhead worthy cut off. The content of Na^+ in spatially varied and it's moderately high in the eastern region, fig. 3. The percolation of polluted water from Noyyal River to the aquifers is found to be high in south part as compared to the north part of the region. Results clearly illustrate that the effect of monsoon is highly significant with respect to sodium ions in these water. The required limit of calcium in potable water is 75 mg/L (BIS, 1991). Generally the content of calcium increases in the water mainly contribution of many geochemical processes and dilution of different minerals like gypsum, anhydrite, dolomite, calcite and aragonite (WHO, 1996). Calcium changed between 16 mg/L and 852 mg/L during post storm, 22 mg/L and 290 mg/L in pre rainstorm. Around 65% of the samples has above the desirable limit during both seasons. The desirable limit of magnesium in potable water is 30 mg/L. The substance of magnesium present in the range of 21 mg/L to 369 mg/L in post rainstorm and 10 mg/L and 265 mg/L for the time of pre storm. The convergence of Ca increment towards eastern and focal piece of the space, fig. 4.



(a) (b)

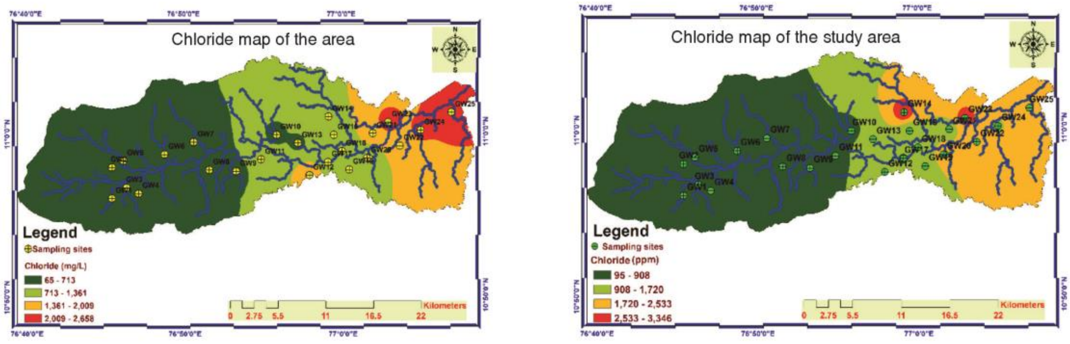
Figure 3. Spatial variation in Na concentrations of groundwater during pre and post monsoon; (a) pre monsoon and (b) post monsoon



(a) (b)

Figure 4. Spatial variation in Ca concentrations of groundwater during pre and post monsoon; (a) pre monsoon and (b) post monsoon

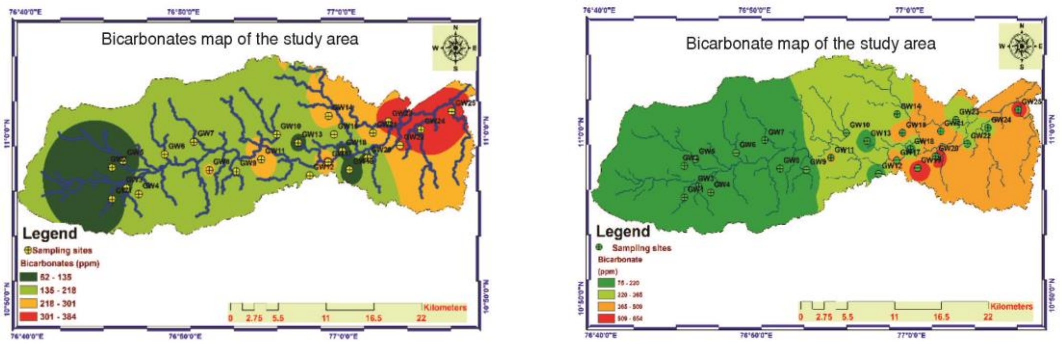
The content Mg and Ca increases in post monsoon likened to the other period. Results clearly illustrate that the effect of monsoon is highly significant with respect to Ca ions in these waters. The convergence of Cl goes from 95 mg/L to 3350 mg/L in the pre rainstorm, 65 mg/L to 2658 mg/L through post storm. The Cl content in the groundwater is more south and centre part slightly increases after monsoon, fig. 5. According to the BIS (1991) the concentration of Cl has been classified three categories based on the values such as: less than the permissible range of 250 mg/L its treated as good, 250 mg/L and 1000 mg/L treated as moderate, and above the 1000 mg/L poor quality. The Cl content of around 45% of ground water samples in pre and 42% of ground water samples during post rainstorm of the samples exceed overhead acceptable limit. Generally, the dying industries use several chemicals during the dyes processing.



(a) (b)

Figure 5. Spatial variation in Cl concentrations of groundwater during pre and post monsoon; (a) pre monsoon and (b) post monsoon

It has been observed that there was a considerable dilution with respect to this ion during the post rainstorm period. The sulphate (SO_4) substance of samples varied between 25 mg/L and 847 mg/L in pre monsoon and 10 mg/L and 1363 mg/L during post monsoon. In the study of the groundwater sample have Bicarbonate (HCO_3) content of ground water samples varied from 53 mg/L to 385 mg/L and 75 mg/L to 659 mg/L. Spatial variation HCO_3 of groundwater high in eastern and focal part of the region were observed, fig. 6.



(a) (b)

Figure 6. Spatial variation in HCO_3 concentrations of groundwater during pre and post monsoon; (a) pre monsoon and (b) post monsoon

The higher SO_4 and HCO_3 value of the groundwater samples were noticed near the dying industries and rock weathered region due to the impact of dying waste and geochemical processes.

Irrigation water quality

Sodium ratio and sodium absorption ratio

Sodium ratio (Na%), sodium absorption ratio (SAR), and magnesium hazards (MH) has apply to measure and identify the irrigation of groundwater in the region. The content of Na% can be considered based on Wilcox diagram [17]. Generally, Na absorption is significant in categorising the irrigation water. The permeability of the soil decreases due to sodium reaction in soil. These diagrams comprises of four classes such as: very good, good to permissible, permissible to doubtful, and doubtful to unsuitable. The percentage of sodium is identified by:

$$\%\text{Na} = \frac{100\text{Na}}{\text{Na} + \text{K} + \text{Ca} + \text{Mg}}$$

During the two seasons it was seen that about 55% of the groundwater tests was in the classification of (class-II) good to allowable and 35% of the examples deceiving in the class of undecided to unacceptable, fig. 7. The results of the Na% it's clearly indicates effect of polluted river stream water into the groundwater aquifers is extremely important.

The SAR is determined by the connection:

$$\text{SAR} = \frac{\text{Na}^{+}}{\frac{\left(\text{Ca}^{+} + \text{Mg}^{2+}\right)^{1/2}}{2}}$$

where concentrations are reported in meq/L (milliequivalents of solute per litre of solution).

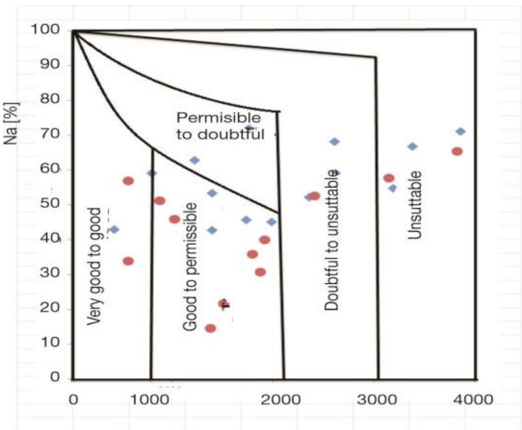


Figure 7. Wilcox Diagram among sodium percentage

The SAR can be categorised into four classes based on the parameter of SAR such as: 0-10 is excellent, 10-18 is good, 18-26 is fair, and >26 is poor. Consequences of the SAR focus goes from 1.5 to 28.9 for pre-storm and from 0.8 to 22.6 in post rainstorm. About 52% of tests fall in 0-10 (excellent) classes and 42% of the examples laying 10-18 (good) class during the two seasons. The low content of SAR values stipulating the effects of percolation is insignificant in the water bodies in this region. In the area the vast majority of the water utilized for water system design is more in sodium and low in calcium, due to the ion-exchange reaction.

Kelley's ratio and magnesium hazard

The sodium content assessed against the Mg and Ca was measured by Kelley.

Water possesses Kelley's proportion more than one is for the most part thought as unqualified for water system. During pre-storm, Kelley's proportion shifts from 0.7 to 10.1 and for post rainstorm, the qualities goes from 0.2 to 3.5 were observed in the region. According to Kelley's ratio, around 15% of the groundwater sample having less than one for good water remaining of the samples are found to be exceed the value for unsuitable category during both seasons. The Kelly's ratio is calculated by:

$$\text{Kelly's ratio} = \frac{\text{Na}^{2+}}{\text{Ca}^{2+} + \text{Mg}^{2+}}$$

The Mg proportion with over half is considered as hurtful also, inadmissible for water system. In the year 1964 Szabolcs and Darab [18] proposed magnesium hazard esteem for irrigation water system as given underneath:

$$\text{Magnesium hazard} = \frac{\text{Mg}^{2+}}{\text{Ca}^{2+} + \text{Mg}^{2+}} 100$$

In the groundwater sample of the magnesium ratio were found between 21.6 and 81.6 in pre-monsoon, 19.6 and 77.5 during post monsoon was observed in the region. About 50% and 37% of the samples exceeded above the limit it's clearly indicates not suitable for irrigation during pre monsoon and post monsoon season. The magnesium ratio was significantly increases after monsoon due to dilution of minerals and precipitation of water.

Multi objective statistical analysis

Pearson correlation coefficient method has been applied to comprehend the affiliation among the parameter and its swaying factors. A correlation matrix between the major ions obtained represent during pre monsoon and post monsoon are represented in tabs. 2 and 3. Strong positive correlation of Cl with EC, Ca, Mg. and Na during both seasons due to influence of anthropogenic and natural processes. Similarly, positive correlation was identified for sodium with EC, Ca, and Mg throughout pre monsoon and post monsoon. Moderate positive correlation for HCO_3 by means of Ca, Mg, Na, and SO_4 indicates reverse ion exchange and the silicate weathering during both periods. Positive correlation of K with Na, Cl and Ca it's clearly specifies agricultural activities. Groundwater chemistry having two components with over all difference of 72% and are addressed in tab. 4**.** Factor 1 was included particles like EC, Ca, Mg, Na, SO_4, Cl-, and HCO_3 were extracted 20% variance. Factor 1 had most of the major ions positive values which specify the anthropogenic impact and dissolution of mineral from the source rock of aquifer material and leaching of secondary salt. Factor 2 was represented by K, Na, Cl, and SO_4 with 19% of variance and positive values indicates agricultural activities during both periods.

Table 2. Correlation matrix of hydrochemical boundaries for post-storm period

	pH	**EC**	**Ca**	**Mg**	**Na**	**K**	**Cl**	**HCO_3**	**SO_4**
pH	1								
EC	0.049	1							
Ca	0.093	0.777	1						
Mg	–0.05	0.791	0.72	1					
Na	0.047	0.983	0.69	0.724	1				
K	0.198	0.497	0.338	0.357	0.569	1			
Cl	0.043	0.981	0.771	0.738	0.954	0.446	1		
HCO_3	0.077	0.637	0.646	0.691	0.569	0.354	0.62	1	
SO_4	0.042	0.812	0.508	0.642	0.834	0.394	0.707	0.295	1

Table 3. Connection framework of hydrochemical parameters for pre-storm period

	pH	**EC**	**Ca**	**Mg**	**Na**	**K**	**Cl**	**HCO_3**	**SO_4**
pH	1								
EC	–0.221	1							
Ca	–0.159	0.804	1						
Mg	–0.231	0.702	0.561	1					
Na	–0.203	0.972	0.666	0.648	1				
K	–0.372	0.489	0.392	0.513	0.448	1			
Cl	–0.189	0.965	0.779	0.56	0.937	0.39	1		
HCO_3	–0.224	0.64	0.605	0.53	0.624	0.421	0.523	1	
SO_4	–0.207	0.815	0.561	0.78	0.792	0.548	0.677	0.413	1

Table 4. Factor analysis of hydrochemical parameters of groundwater during pre and post rainstorm

Component	Premonsoon		PostMonsson	
	1	2	1	2
pH	0.079	0.927	-0.314	0.812
EC	0.983	-0.043	0.975	0.167
Ca	0.824	-0.033	0.811	0.191
Mg	0.853	-0.192	0.796	-0.109
Na	0.957	0.000	0.932	0.175
K	0.563	0.436	0.618	-0.519
Cl	0.947	-0.055	0.897	0.250
HCO_3	0.715	-0.005	0.708	-0.036
SO_4	0.790	-0.040	0.848	-0.019

Hydrogeochemical processes

Evaporation and silicate weathering

$$\frac{\mathrm{Na}+\mathrm{K}}{\mathrm{Na}+\mathrm{Ca}+\mathrm{K}} \tag{1}$$

$$\frac{\mathrm{Cl}}{\mathrm{Cl}+\mathrm{HCO_3}} \tag{2}$$

The silicate weathering, carbonate, and evaporation process was computed by the ratio diagrams like: Na/Cl *vs*. EC, Na *vs*. Cl, (Na + K) *vs*. total cations. and (Ca + Mg) *vs*. total cations. Many of the research have used this diagram to determine the three processes [19, 20]. The relationship Na/Cl^- *vs*. EC of the samples were varied between 0.6 meq/L and 2.0 meq/L during the pre rainstorm and 0.2 meq/L and 1.2 meq/L during post monsoon, respectively. These relationship shows in pre monsoon Na^+/Cl^- ratio is more or less similar increase compare with during post monsoon. In the region maximum of the samples fall in linear line, it indicates specify evaporation processes, fig. 8(a). Similar, the Na^+ *vs*. Cl^- ratio specifies maximum ground water samples were found among the evaporation of freshwater process line throughout the seasons, fig. 8(b). It was suggested that the halite mineral dissolution the concentration of Na released into the water. If the Na/Cl *vs*. Cl molar ratio was more than one indicates silicate weathering. The Na/Cl *vs*. Cl indicates around 36% in pre rainstorm and 20% during post storm of the examples lying above more prominent than one in light of the fact that the Na help because of silicate enduring cycles. Similar, the ratio Na + K with total cations show that some of the groundwater samples were found near the Na + K = 0.6 (total cations) TZ line and few of the samples shows Ca/Na exchange process during both seasons, fig. 8(c). Commonly, content of Na and K rises into the ground water because of the impact of silicate weathering and Ca/Na exchange process. High absorption Ca and Mg was occurrence into the groundwater due to the dilution of silicate minerals (hornblende, plagioclase, pyroxene, and amphibole) from the source rocks was reported. Moreover, the scatter Ca + Mg *vs*. total cations, fig. 8(d) indicate that during silicate weathering process the dissolution of silicate minerals into the groundwater throughout periods that was observed in the present area. Gibb's plot [21] can be used to categorise into three processes such as precipitation, rock-water interaction, and evaporation. Normally, during precipitation and evaporation processes high level of Na and Cl are released into the groundwater. In this investigation region, major part of the groundwater samples were tested and arranged in evaporation process region, fig. 9, during both seasons.

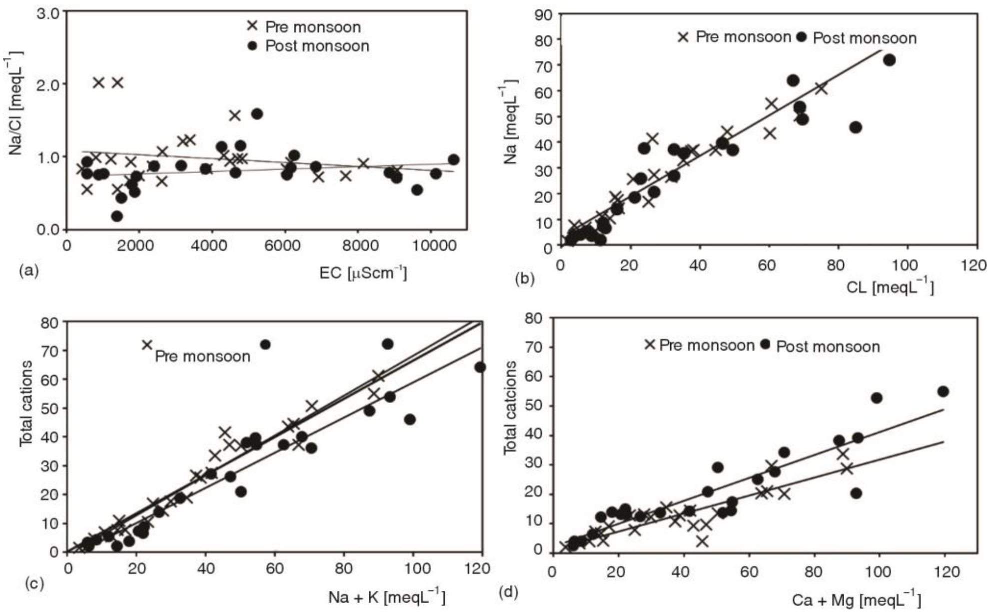


Figure 8. Cross-plots among; (a) Na^+/Cl^- *vs*. EC, (b) Na^+ *vs*. Cl^-, (c) (Na^++K^+) *vs*. TC, and (d) $(Ca^{2+}+Mg^{2+})$ *vs*. TC for silicate weathering and evaporation

Reverse ion exchange processes

A proportion plot, for example, (Ca + Mg) vs. Cl and (Ca + Mg)/HCO_3 *vs*. Cl comprises two cycles, for example, turn around particle trade and saltiness [22]. The Ca + Mg esteem into the groundwater was lying somewhere in the range of 1 mmol and 17 mmol in pre storm and 1 mmol and 28 mmol post rainstorm, fig. 10(a)**.** The ratio plot (Ca + Mg) *vs*. Cl of trend line increases the concentration of salinity rises into the groundwater due to the impact of converse particle trade. It was suggested that the dissipate plot (Ca + Mg)/HCO_3 was viewed as two cycles particle trade (>0.5) and invert particle trade (<0.5). The (Ca + Mg)/HCO_3 *vs*. Cl worth went somewhere in the range of 0.6 mmol and 4.9 mmol during pre storm and 0.5 mmol to 6.1 mmol in post rainstorm, fig. 10(b).

A large portion of the underground water tests were arranged above 0.5 qualities, which unmistakably demonstrate turn around particle trade processes, was observed in the region. Chadda [23] plot covered four hydro geo chemical cycles, for example: Field 1 Ca-

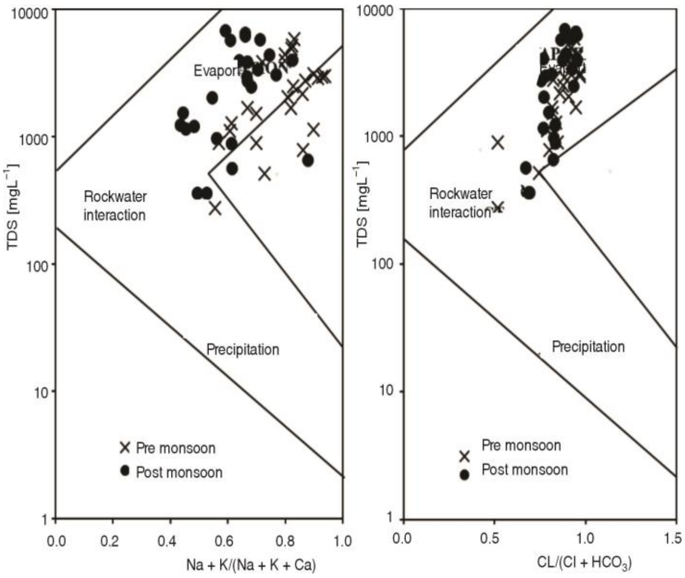


Figure 9. Gibb's plot in the study area

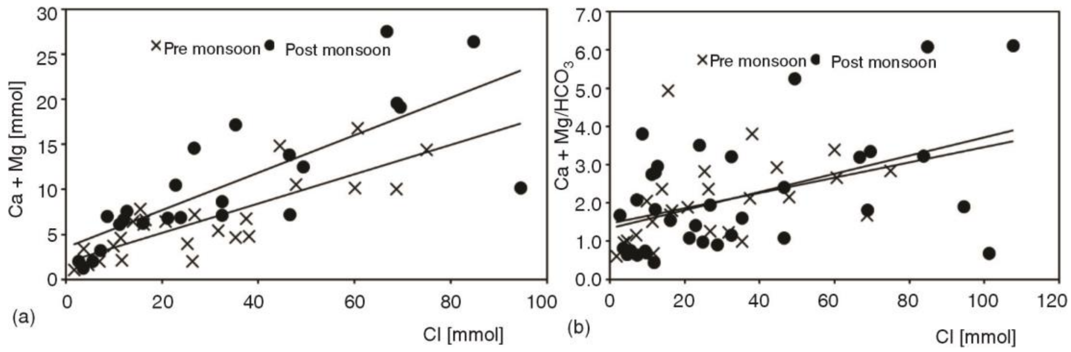


Figure 10. Cross plot among; (a) (Ca^{2+} + Mg^{2+}) *vs*. Cl^-, (b) (Ca^{2+} + Mg^{2+})/HCO_3^- *vs*. Cl^- for reverse ion exchange during pre and post monsoon

HCO_3 type, Field 2 Ca-Mg-Cl sort, Field 3 Na-Cl sort, and Field 4 Na-HCO_3 type. Many of the researcher has been used the same procedure for interpreting the groundwater geochemistry processes. These plots shows around 85.6% in pre and 75.3% during post storm of the examples was fall in Field 4 Na-HCO_3 Field 3 Na-Cl and 13.3% of pre rainstorm and 36.6% of post storm, fig. 11.

These plots it's plainly shows saline water blending in with groundwater because of anthropogenic effect and geochemical measures. The connection among (Ca + Mg) and (SO_4 + HCO_3) determines three geochemical cycles like disintegration of calcite and dolomite, reverse ion exchange process; ion exchange processes [22]. Most of the samples derived towards left side specify reverse ion exchange process and few of the ground water samples were lying (1:1) equal line impact in dissolution of dolomite and calcite minerals were observed during both seasons, fig.12.

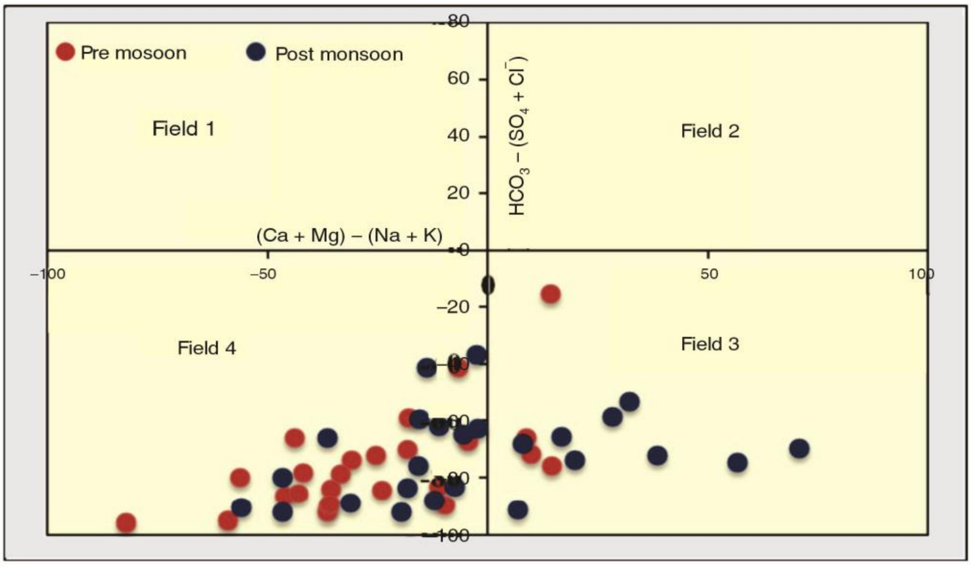


Figure 11. Chadda plot for the hydrochemical parameters in the study area

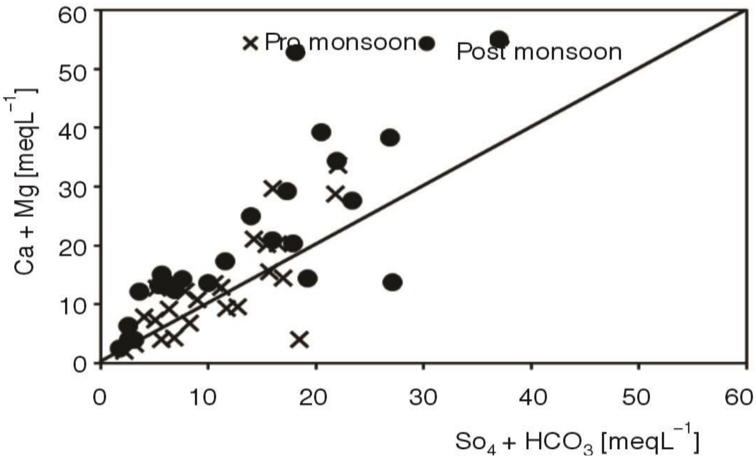


Figure 12. Bivariate plots between (Ca^{2+} + Mg^{2+}) and (HCO_3^- + SO_4^{2-})

Chloro-alkaline Indices

Schoeller proposed the concept of index of base exchange to depict the metasomatism occurring in surface/groundwater dependent on the chloro-alkaline Indices. Ordinarily Chloro-Alkaline Indices considered two cycles, for example, the CA-I and CA-II having positive qualities demonstrated particle trade and negative qualities determines turn around particle trade measures. Cation trade assumes a significant part in the science of Na and K. In the current investigation, the vast majority of the example has positive proportion of CA-I and CA-II in the water of the examination territory exhibits the likelihood of trade of Ca-Mg water by Na-K mineral. The Chloro-alkaline indices is determined depict as given beneath the condition:

$$\text{Chloro-alkaline indices}\,(\mathrm{I}) = \frac{\mathrm{Cl} - \mathrm{Na} + \mathrm{K}}{\mathrm{Cl}}$$

$$\text{Chloro-alkaline indices}\,(\mathrm{II}) = \frac{\mathrm{Na} + \mathrm{K}}{\mathrm{SO_4} + \mathrm{HCO_3} + \mathrm{CO_3} + \mathrm{NO_3}}$$

Conclusion

This research article outline spatial variation of major ions and geochemical processes around the Noyyal River located in Coimbatore, Coimbatore district, India. The TDS content reaches from 359 mg/L to 6805 mg/L in pre monsoon and 275 mg/L to 5807 mg/L for post monsoon were lying in this region. The dying industries use several chemicals during the dyes processing, resulted in maximum content of Cl and Na in the groundwater. The Cl concentration of about 42% of the samples was lying above the 1000 mg/L of the poor quality category. Around 55% of groundwater samples were situated in good to permissible range. The 35% of the samples were lying in doubtful to unsuitable range during both the seasons. The Na/Cl *vs*. Cl requires 36% of tests in pre storm and 20% of tests during post rainstorm fall in the region which is more prominent than one on the grounds that the Na help because of silicate enduring measures. Moderate positive related HCO_3 with Ca, Mg, Na, and SO_4 specifies reverse ion exchange and silicate weathering for the period of both seasons. Positive correlated K with Na, Cl and Ca, clearly specifies agricultural activities. In the present study, most of the sample has positive ratio of CA-I and CA-II in the sample water exhibits the Ca-Mg water by Na-K mineral. The Chadda [23] plot reveals 85.6% in the pre storm and 75.30% in the post rainstorm. It revealed that the groundwater tests lying in Field 4 Na-HCO_3 base ion-exchange water and field 3 Na-Cl 13.30% of pre monsoon and 36.60% of post monsoon due to influence of ecological impact, anthropogenic impact, and geochemical processes in the research area. It indicated that the quality of underground water of this region may be recovered by improving the performance of the effluent treatment plant.

Reference

[1] Chen, W. F., *et al.,* Dissolved Oxygen and Nitrate of Groundwater in Choshui Fan-Delta, Western *Taiwan Environ. Geo. 44* (2003), 6, pp. 731-737
[2] Karanth, K. R., *et al., Groundwater Assessment, Development and Management*, McGraw Hill Publishing Company Limited., New Delhi, India, 1987, 720
[3] Apodaca, L. E., *et al.,* Water Quality in Shallow Alluvial Aquifers, Upper Colorado River Basin, Colorodo, *Jr. Amer. Wat. Resources Assn*, 38, (2002), 1, pp. 133-143
[4] Bahrgava, D. S., *et al.*, The Technology of Water Resources in Industries A Rational Approach, *Jr. Ind. Wat. Works Assn, 20* (1988), 1, pp. 107-112
[5] Raghunath, H. M., *Groundwater*, 2nd ed., Wiley Eastern Limited, New Delhi, India, 1992, 563
[6] Lakshmanan, E., *et al.*, Major Ion Chemistry and Identification of Hydrogeochemical Processes of Groundwater in a part of Kancheepuram District, Tamil Nadu, India, *Environ. Geo,10* (2003), 4, pp. 157-166
[7] Carrol, D., *Rainwater as a Chemical Agent of Geologic Processes: A Review*. United States: N. p., 1962. Web. Geol. Surv. Water-Supply Pap. (U.S.); (United States), 1962, pp. 15-35
[8] Subramani, T., *et al.*, Groundwater Geochemistry and Identification of Hydrogeochemical Processes in a Hardrock Region, Southern India, *Environ. Monit. Assess, 162* (2010), Feb., pp. 123-137
[9] Hegde, S. H., *et al.*, Groundwater Quality Deterioration in Hubli City Area, *Ind. Jr. Environ.Hlth, 34* (1992), 2, pp. 138-142
[10] Jeevan Rao, K., *et al.,* Groundwater Pollution from Refuse Dumps at Hyderabad, *Ind. Jr.Environ. Hlth, 37* (1995), 3, pp. 197-20

[11] Giridharan, L., *et al.*, Evaluation of the Seasonal Variation on the Geochemical Parameters and Quality Assessment of the Groundwater in the Proximity of River Cooum, Chennai, India, *Environ Monit Assess, 143* (2008), Sept., pp. 161-178
[12] Palma, P., *et al.,* Assessment of Anthropogenic Sources of Water Pollution using Multivariate Statistical Techniques: A Case Study of the Al Queva's Reservoir, Portugal, *Environ Monit Assess, 165* (2010), 1-4, pp. 539-552
[13] Ravikumar, P., *et al.,* Major Ion Chemistry and Hydrochemical Studies Of Groundwater Of Bangalore South Taluk, India, *Environ Monit Assess, 163,* (2010), 1-4, pp. 643-653
[14] ***, APHA (American Public Health Association), Standard Methods for the Examination of Water and Wastewater, 19th ed., American Public Health Association, Washington, DC., 2004
[15] ***, CGWB (Central Ground Water Board), District Groundwater Brochure, Coimbatore District. CGWB, Tamil Nadu, pp. 1-23, 2009
[16] Saxena, V. K., *et al.,* Use of Chemical Parameters to Delineation Fresh Ground Water Resources in Potharlanka Island, India, *Envi. Geo 44,* (2003)Aug., pp. 516-521
[17] Wilcox, L. V., *Classification and Use of Irrigation Water,* US Geol. Dept. Agric. Circ., 1955, 969:19
[18] Szabolcs, I., Darab, C., The Influence of Irrigation Water of High Sodium Carbonate Content of Soils. *Proceedings*, 8th International Congress of ISSS, Trans II, Addison-Wesley, Reading, Mass., USA, pp. 803-812, 1964
[19] Karanth, K. R., *Groundwater Assessment, Development and Management*, Tata McGraw-Hill Publishing Company Limited New Delhi, India, 1997
[20] Rajmohan, N., *et al.*, Identification and Evolution of Hydrogeochemical Processes in the Groundwater Environment in an Area of the Palar and Cheyyar River Basins, Southern India, *Envi. Geo, 46,* (2004), Mar., pp. 47-61
[21] Gibbs, R. J., Mechanisms Controlling World's, *Water Chemistry Sci, 170* (1970), 3962, pp. 1088-1090
[22] Pantelic, M., *et al.,* Water Quality of the Pannonian Basin Rivers the Danube, the Sava and the Tisa (Serbia) and Its Correlation with Air Temperature. *Thermal Science*, *19* (2015), 2, pp. 477-485
[23] Chadha, D. K., A Proposed New Diagram for Geochemical Classification of Natural Waters and Interpretation of Chemical Data, *Hydrogeology Journal*, *7* (1999), 5, pp. 431-439

Paper submitted: August 14, 2020
Paper revised: January 21, 2021
Paper accepted: April 18, 2021