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Impact of Leather and Cosmetic Industries on Quality of Groundwater, in Nagalkeni, Kanchipuram District, Tamilnadu, India

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Abstract The area for the present study comprises, Pallavaram, Chromepet, and Nagalkeni, of the Chennai Metropolitan City. Thirty six groundwater samples were collected from open and bore wells during Pre-monsoon (July 2007) and Post-monsoon (January 2008). The parameters like EC, TDS, pH, Ca, Mg, K, Na, SO_4, Cl, and HCO_3 were determined by using standard methods of analysis. The trace elements like, Cu, Cr, Ni, and Pb were determined by using Atomic Absorption Spectrometer. Most of the standard parameters determined in the study area were above the permissible limit. Parameters like sodium, chlorine are found far above the permissible limit, especially in areas near the industrial sites. The type of water that predominates in the study area is (91.7%) Strong acids (Cl) exceed weak acids (HCO_3 and SO_4) during pre-monsoon and (100%) Strong acids (Cl) exceed weak acids (HCO_3 and SO_4) during post-monsoon based on the hydro-chemical facies. The chromium content was far higher than the permissible limit. Leather and cosmetic industries in the study area has deteriorated the quality of groundwater considerably. Thus, this study indicates the impact of effluents from tanneries. The groundwater quality of this region can also be improved by adopting rainwater harvesting thereby increasing groundwater recharge.
Keywords *Leather and Cosmetic Industries, Groundwater, Gibb's Plot, Trace Elements, Piper Diagram*

1. Introduction

Water quality analysis is one of the most important aspects in groundwater studies. The hydro-chemical study reveals quality of water that is suitable for drinking, agriculture and industrial purposes. Further, it is possible to understand the change in quality due to rock water interaction or any type of anthropogenic influence [1, 2]. Globally, groundwater is estimated to provide about 50% of current drinking water supplies. As groundwater is isolated from the surface, most people take it for granted that groundwater be relatively pure and free from pollutants. Although most groundwater is still of high quality, at some locations, it is becoming increasingly difficult to maintain the purity of groundwater [3]. Saline intrusions into coastal groundwater through aquifer penetration have become a major concern because it is the commonest source of pollution to groundwater [4]. Tanneries are one among those industries which cause high pollution to groundwater as they use a wide range of chemicals, such as sodium chloride, sodium sulphate, chromium sulphate, vegetable oils, lime and dyes. A large quantity of water is also utilized by these industries in the tanning process. Of the 1,200 tanneries in India, Tamil Nadu accounts for more than 75% of these leather processing industries [5]. One of the major problems caused by these industries is high salinity. In addition, there is also a huge quantity of solid waste which results from the hides and skins. Since the solid waste is carelessly disposed, it finds its way into the groundwater during the seasonal rain. It is established that a single tannery can cause the pollution of ground water around a radius of 7 km [6, 7, 8]. This study was carried with the aim of determining the concentration of physical and chemical parameters such as EC, TDS, pH, Ca, Mg, K, Na, SO_4, Cl, HCO_3 and trace elements to assess the present status on quality of groundwater and the impact of Leather and Cosmetic Industries.

2. Study Area and Geology

The study area includes Pallavaram, Chromepet and Nagalkeni areas of the Chennai Metropolitan city. The study area falls between the latitudes from 12º58′02.0″ N to 12º57′18.0″ N, and longitudes from 80º09′59.9″ E to 80º08′02.7″ E. The area serves as a hometown for lots of large scale and small scale tanning industries. Chrome tanning is the popular method practiced in this area and hence, the place got its name as chromepet. The study area is 13 km west of the Bay of Bengal. The climate of the area is with low humidity and high temperature. The temperature is around 20^0C during winter and reaches a maximum of 44^0C during summer. The vegetation in this area is not much varied. The subsurface geology consists of 1 m loamy soil; 2 to 15 m alluvium; 15 to 18 m weathered charnockite and below that there are jointed charnockites for about 20 m and then the bed rock charnockite. The study area with the location of samples is shown in (Figure 1).

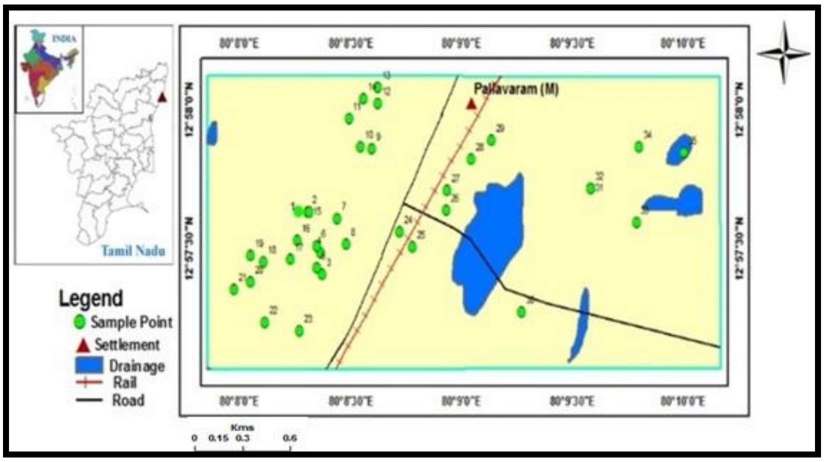


Figure 1: *Study Area with Sample Locations*

3. Methodology

The water samples were collected from open and boreholes in the study area. One liter of water samples were collected in polyethylene bottles from various wells during the month of July 2007 and January 2008 representing both Pre-monsoon and Post-monsoon. Thirty six groundwater samples were collected for each of the seasons mentioned, for analysis of various physical-chemical parameters. pH were measured using portable pH meter, EC were measured by Electrode in the field itself. Total dissolved solids (TDS) were computed by multiplying the EC by a conversion factor varying from 0.55 to 0.75 depending on the relative concentration of ions [9].

With respect to cation, Calcium, Magnesium was analyzed following volumetric method. Sodium, Potassium was analyzed by Flame photometer; with respect to anions, Chloride, Bicarbonate was done by volumetric method, Sulphate was estimated by turbidity method. Analyses were done following APHA method and the trace elements like, Cu, Cr, Ni, and Pb was determined using Atomic Absorption Spectrometer [10].

4. Results and Discussion

Minimum and Maximum concentration of different parameters and trace elements determined in the groundwater of the study area is presented in Table 1 and Table 2 respectively.

Table 1: *Minimum and Maximum Concentration of Different Parameters*

Parameters	Pre-monsoon		Post-monsoon	
	Min	Max	Min	Max
EC	200.0	5000.0	1100.0	4800.00
pH	6.1	7.8	5.6	7.90
TDS	128.0	3432.0	704.0	3072.00
Ca	12.0	150.0	20.0	360.00
Mg	1.0	1164.0	2.4	127.20
Na	53.0	1017.0	91.0	1656.00
K	3.0	34.0	1.0	21.00
HCO_3	54.9	990.6	24.4	104.00
SO_4	37.9	49.6	28.3	44.04
Cl	124.0	2463.7	26.5	939.42

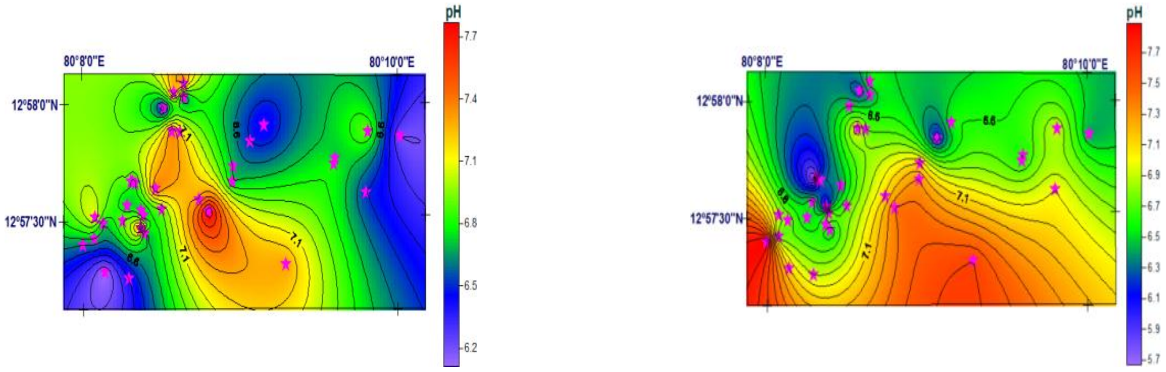
Table 2: *Minimum and Maximum Concentration of Trace Elements*

Trace Elements	Pre-monsoon		Post-monsoon	
	Min	Max	Min	Max
Cu	0.244	0.362	0.108	0.307
Cr	0.949	2.725	0.976	1.430
Ni	0.001	0.085	0.009	0.085
Pb	0.038	0.446	0.042	0.598

4.1. Spatial Distribution

A) **pH**

Groundwater is slightly acidic to alkaline with pH values from 6.5 to 8.3. The pH values of groundwater samples are within the permissible limit [11]. The pH of a solution is the negative logarithm of hydrogen ion concentration in moles per liter. In the pre-monsoon, the pH varies from 6.1 to 7.8 while in the post-monsoon it ranges from 5.6 to 7.9 indicating that the groundwater of the study area is well within the permissible limit. It shows a higher concentration in the northeastern part of the study area during the pre-monsoon season (Figure 2). The highest concentration in the central part during pre-monsoon season may be due to the water bodies that are seen in the study area.

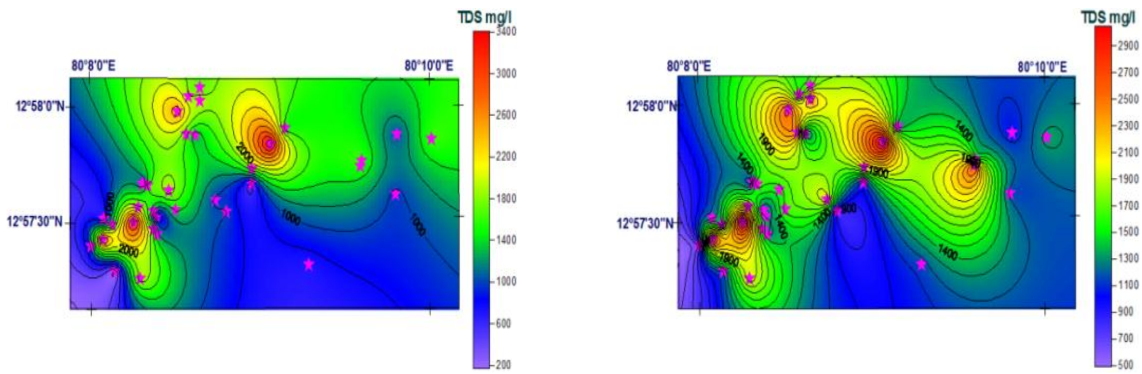


Pre-monsoon *Post-monsoon*

Figure 2: *Spatial Distribution of pH Concentration of Pre- and Post-Monsoon*

B) **Electrical Conductivity (EC) and Total Dissolved Solids (TDS)**

Electrical conductivity indicates the capacity of electrical current that passed through the water, which in turn is related to the concentration of ionized substances present in it. Most dissolved inorganic substances present in the water are in ionized form and contribute to electrical conductivity. In the study area, electrical conductivity varies from 200 to 5000 µS/cm for pre-monsoon water samples, while it ranges between 1100 and 4800 µS/cm for post-monsoon. Electrical conductivity of water is considered to be an indication of the total dissolved salt content [12]. A rapid estimation of total dissolved solids content in water is obtained by EC. In the pre-monsoon season, the values of TDS are varied from 128 to 3432 mg/l whereas, during the post-monsoon it ranges between 704 and 3076 mg/l. It shows a higher concentration in northern and southern part of the study area during pre-monsoon season (Figure 3).



Pre-monsoon *Post-monsoon*

Figure 3: *Spatial distribution of TDS concentration of Pre- and Post-Monsoon*

C) **Cations**

Most of the aquifers that contain calcium are dissolved in the groundwater and in that case, the calcium content generally exceeds the magnesium content [13]. Calcium ion concentration in groundwater samples in the pre-monsoon season varies from 12 to 150 mg/l while it ranges between 20 and 360 mg/l during post-monsoon. Magnesium ion concentration in groundwater samples in the pre-monsoon season varies from 1 to 116.1 mg/l while it ranges between 2.4 and 127.2 mg/l during post-monsoon. The concentration of Calcium and Magnesium in the study area may be due to rock weathering. Sodium concentration varies from 53 to 1017 mg/l and from 91 to 1656 mg/l during pre-and post-monsoon seasons respectively. The concentration of sodium in the groundwater of the study area may be due to rock weathering as well as irrigation return flow.

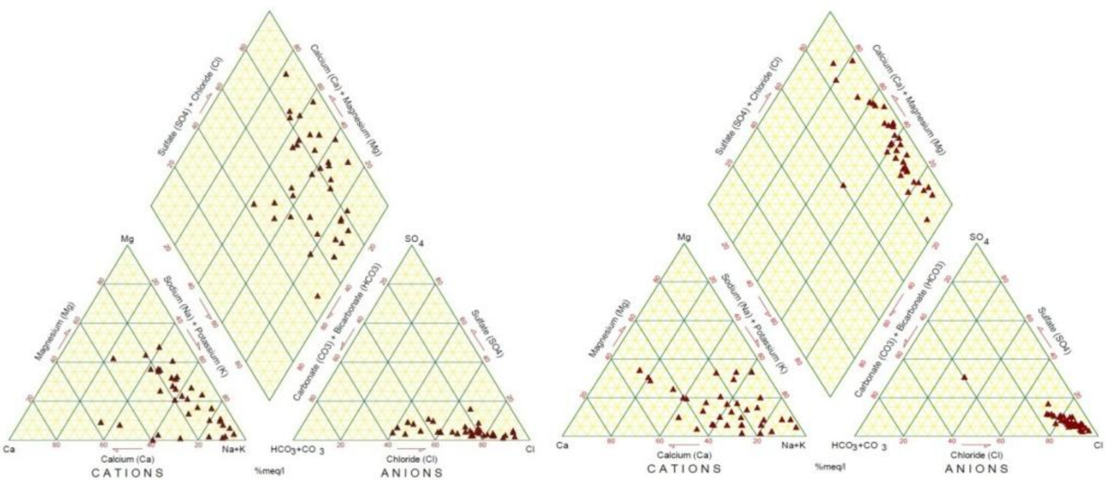
In general, sodium salts are not actually toxic substances to humans because of the efficiency with which mature kidneys excrete sodium. Higher values of sodium are found in the groundwater in the study area where tanning industries are more compare to other locations. Potassium is slightly less common than sodium in igneous rocks, but more abundant in all the sedimentary rocks. Potassium ion concentration in groundwater samples in the pre-monsoon season varies from 3 to 34 mg/l while it ranges between 1 and 21 mg/l post-monsoon samples.

D) **Anion**

Chloride concentrations vary widely in natural water and it is directly related to the mineral content of the water. Chloride concentration varies from 124 to 2463 mg/l and from 26.5 to 939.4 mg/l in pre- and post- monsoon seasons respectively. The higher chloride content in groundwater may be attributed to the presence of soluble chloride from rocks and saline water intrusion. Bicarbonate ion concentration varies from 54.9 to 990.6 mg/l and from 24 to 104 mg/l in pre- and post- monsoon seasons respectively. The source for high concentration of bicarbonate may be due to dissolution of CO_3 of the soil and percolation due to irrigation as well as rain water. Sulphate ion concentration varies from 37 to 49 mg/l and from 28 to 44.0 mg/l in pre- and post- monsoon seasons.

E) **Piper Diagram**

The concentrations of major ionic constituents of groundwater samples were plotted in the Piper trilinear diagram to determine the water type [14]. The classification for the cation and anion facies, in terms of major ion percentages and water types, is according to the domain in which they occur in the diagram segments [15]. The diamond shaped field between the two triangles is used to represent the composition of water with respect to both cations and anions. The points for both the cations and anions are plotted on the appropriate triangle diagrams. The plot of chemical data on diamond shaped trilinear diagram (Figure 4) reveals that the majority of groundwater samples of the study area during both the seasons fall under the facies strong acids exceed weak acids.

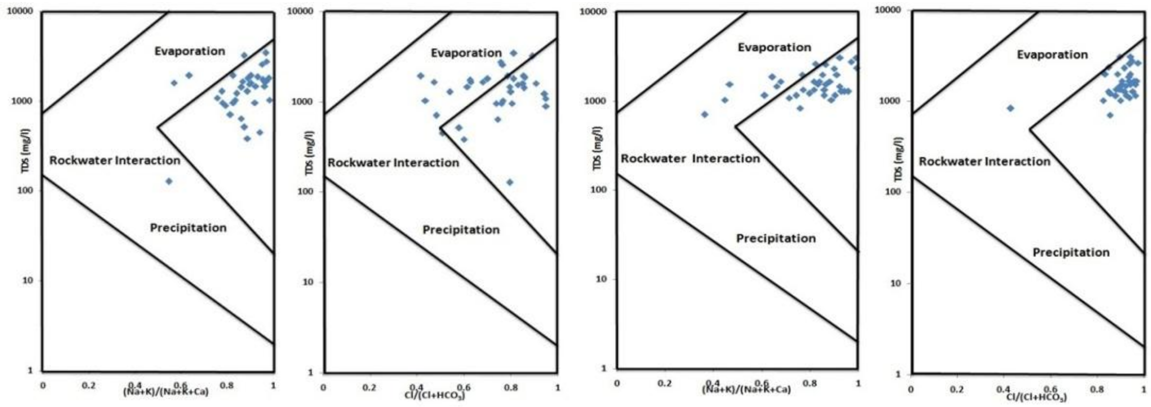


Pre-monsoon *Post-monsoon*

Figure 4: *Piper Diagram for Pre- and Post- Monsoon*

F) **Gibb’s Diagram**

Plots of (Na+K) / (Na+K+Ca) versus total dissolved solids (TDS) and Cl/ (Cl+Alk) versus TDS (Figure 5) indicate the importance of mineral dissolution [16]. Rengarajan and Balasubramanian; Sreedevi have also used the method to different areas for the evolution of groundwater in various parts of India [17, 18]. Three kinds of fields are recognized in the Gibb’s diagram, namely, precipitation, evaporation, and rock-water interaction. The results show that the anthropogenic activities, like, tanneries present in the study area, are responsible for the chemical composition of the ground water.



Pre-monsoon *Post-monsoon*

Figure 5: *Gibb’s Diagram in Pre and Post Monsoon*

G) **Chromium and Copper**

Tannery effluents are mostly characterized by salinity, high organic loading, and specific pollutants, such as chromium [19, 20]. Chromium which is present in effluents is usually present in the toxic trivalent form. But, when this effluent is discharged into the soil, due to varying environmental conditions, Cr (III) is oxidized to toxic hexavalent form which seldom remains as Cr [21, 22, 23]. Chloride concentration varies from 0.92 to 2.7 mg/l and from 0.97 to 1.43 mg/l in pre- and post-monsoon seasons respectively (Figure 6). Therefore, 95% of the samples are above the permissible limit and thereby creating an awareness to take suitable steps in curtailing the excess chromium concentration in groundwater by properly treating the effluent from tanning industries. Copper concentration varies from 0.24 to 0.36 mg/l and from 0.10 to 0.30 mg/l in pre- and post- monsoon seasons respectively (Figure 7). Copper is required for the synthesis of hemoglobin and several human enzymes whereas in high concentration when consumed, it may lead to neurological complications, like hypertension, liver and kidney problems [24, 25, 26, 27].

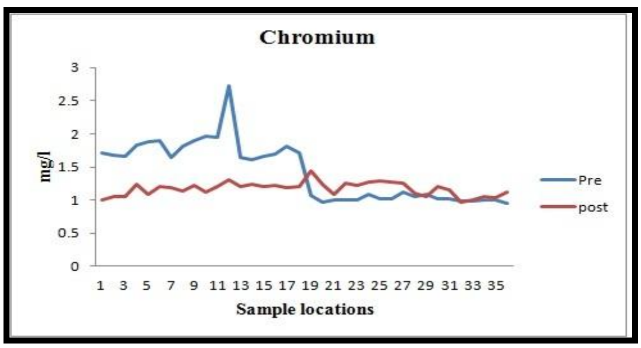


Figure 6: *Variation Graph for Chromium during Pre- and Post- Monsoon*

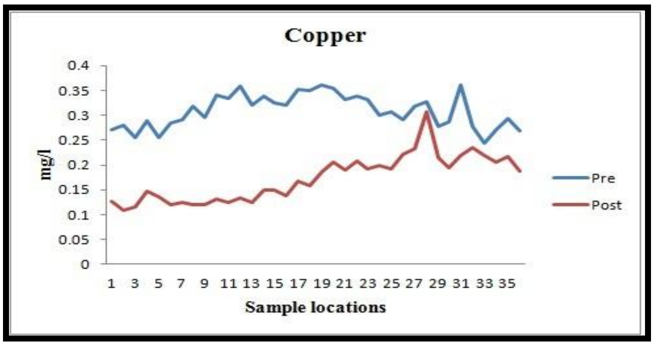


Figure 7: *Variation Graph for Copper during Pre- and Post-Monsoon*

5. Conclusion

The pH, EC, TDS, parameters analyzed in groundwater during pre-monsoon were relatively lower when compared to post-monsoon. TDS values are indicative of the extent of pollution. The TDS values were seen to increase during the post-monsoon. Ca, Na, Cl, HCO_3, and Mg are showing excessive concentration in some places, in both pre- and post- monsoon periods. The plot of chemical data on the diamond shaped trilinear diagram reveals that majority of groundwater samples of the study area for both the seasons fall under the facies of “Strong acids exceeds weak acids”. The chromium is above the permissible limit in both pre- and post- monsoon. The presence of nickel is below the permissible limit in almost all the samples. High levels of these elements were observed in some groundwater samples collected from sampling wells located very close to tannery industries, which indicates the impact of effluent from the tannery industries which are let onto land and sewerage systems without proper treatment. Artificial recharge and rainwater harvesting can be implemented to improve the present groundwater quality in this area.

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