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Physico-Chemical Parameter Variations for Groundwater Detection in Manimuktha River basin, Tamilnadu, India

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ABSTRACT
The present study was determination of physico-chemical variations of water in seventy stations along the Manimuktha River, Villupuram and Cuddalore district of Tamil Nadu, India. Physico -chemical variable in water samples collected along Manimuktha River during summer and winter is analyzed for, pH, Electrical conductivity (Ec), Total dissolved solids (TDS) and major elements like Calcium, Magnesium, Sodium, Potassium, Chloride, Sulphate with addition of nutrients like Nitrate, Phosphates, Bicarbonate and Fluoride. The noted increase of electrical conductivity is found in summer whereas other parameters are more during winter. The study infers that the effluent flow, sewage drainage, catchment runoff and the tides are having great influence on the changes in physico-chemical parameters and fluctuation macronutrient. The degradation of our river ecosystem and water quality of various rivers all over the country is evaluated to understand the present status of Manimuktha River.

Keywords: Manimuktha River, Physico – chemical parameters, Ground Water.

I. INTRODUCTION

Fresh water sources like rivers are the major resources for dependent living beings. Due to anthropological activities, river waters are becoming un-usable due to the changes in physico-chemical nature brought about by various kinds of pollutants. On the other hand, due to the reduced rainfall as a consequence of climate change, these water resources are being depleted of water and increased in alarming rate of pollution. Recent report indicated that India is expected to face critical levels of water stress by 2025 and there will be serious water shortages (UN Climate Report, 2014). Water is necessary for metabolism and catabolism activity, and the importance of water cannot be over emphasized. It is difficult to understand the biological phenomenon clearly, because the chemistry of water revels much about the metabolism of the ecosystem (Basavaraja Simpi et al., 2011). It also serves agricultural, industrial and the environmental conditions, such as topography, water movement, stratification, oxygen, temperature and nutrients characterizing particular water mass in addition the composition of its biota (Karande, 1991). Distributions of nutrients are mainly based on the season, tidal conditions and freshwater flow from land source. The comprehensive ways in which man affect aquatic ecosystems is through altering nutrient dynamics (Boostman and Hecky, 1993). Water quality characteristic of aquatic environment arise from a multitude of physical, chemical and biological interactions (Deuzane, 1979; Dee, 1989). Through runoff nitrogen and phosphorus as nutrients for the growth of aquatic plants enter into lake water or estuary and also depends on the concentration limits of nitrogen and phosphorus elements. The use of rivers for various purposes has ended in with pollution for net outcomes of pollution. Water quality data is needed to integrate the chemical and biological information to evaluate the potential impacts to the freshwater ecosystem.

II. MATERIALS AND METHOD

Study Area

The study area lies between 78^{0}42'to 78^{0}59'E longitude and 11^{0}42' to 11^{0}59'N covering a total area of 497.11 km2 in which hilly area occupies 187.19 km2. Western side the study area covered by Kalvarayan hills which divide the Salem and Villupuram districts are seen to the extreme west of Kallakurichi Taluk. The average annual rainfall of the study area is 1070 mm bring the groundwater recharge in the area. The climate is moderate to hot, with the maximum temperature being 38° C and the minimum at 21° C. The study area chiefly consists of hard crystalline rocks of Archean age. The depth of dug wells and water table ranges from 15 to 20 m and 8 to 18 m, respectively (Venkateswaran and Deepa 2016). The flow of water in the river is reduced during the period from February to June, and as a result, in the region depends on groundwater for their use. A major part of the study area fall in the agricultural activities, where sugarcane, paddy, and groundnut are being cultivated. The upper reaches of the river basin comprises the precambrian peninsular Gneiss and its retrograded products (Krishna Kumar et al. 2008) the area mainly underlain by chornockites, fissile hornblende gneiss, hornblende biotite gneiss, pink granite and ultrabasic rocks. The depth of bore holes in upper ranges of Manimuktha basin from 90 to 150 ft (Krishna Kumar et al.2008). The study area map is shown in Fig. 1.

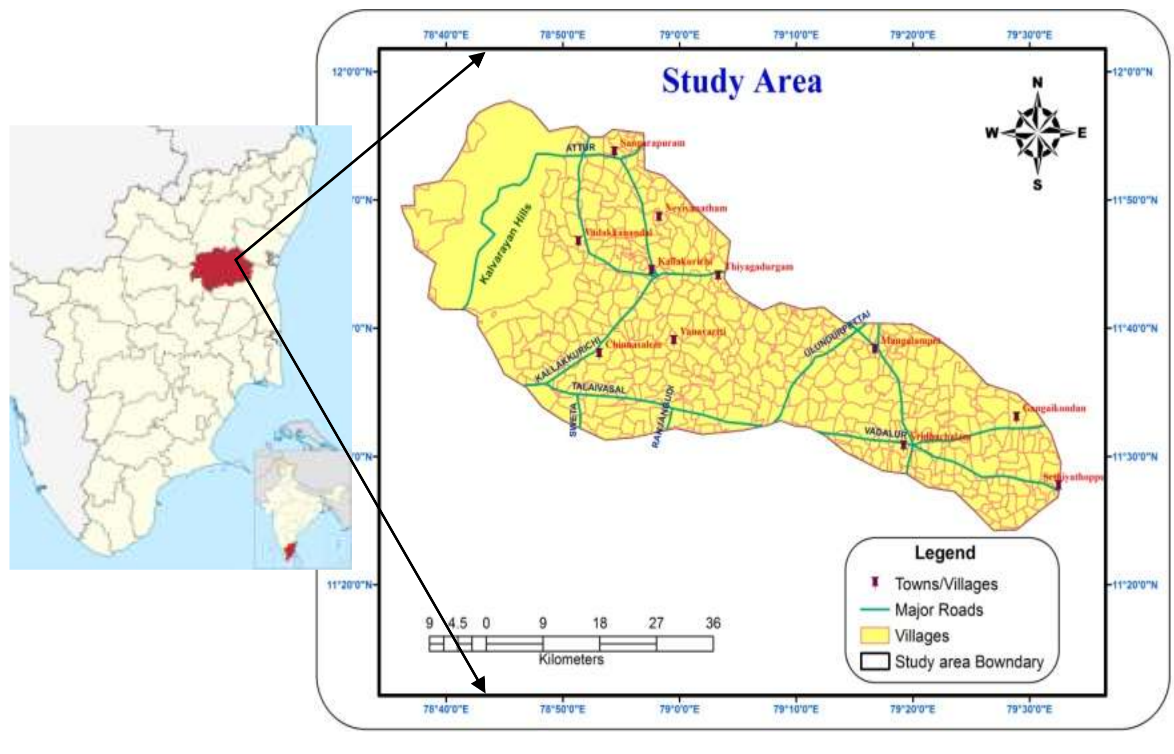


Figure.1. STUDY AREA

Sampling

In the study region seventy spots were identified and collected ground water samples. Water sample from each point during pre monsoon and postmonsoon is collected and stored in clean rinsed polyethylene bottles. The physical parameters like pH, EC and temperature of water samples are monitored during the field survey. A pre calibrated portable multi parameter kit PC TESTER 35 (Multiparameter) was used for measuring pH, Electrical Conductivity (EC) and Temperature. Water samples were analyzed using standard procedures (APHA, 1989, Ramanathan, 1992). Calcium, magnesium, and chloride were determined by a titrimetric method. Sodium and potassium were analyzed through flame photometry (ELICO CL 378). Sulphate, phosphate, and Nitrate were determined by spectrophotometer (HACH DR6000).

III. RESULTS AND DISCUSSION

The results obtained from the water samples of Manimuktha River for physicochemical parameters such as pH, Electrical conductivity (µS/cm), Total dissolved solids (mg/l), Calcium (mg/l), Magnesium (mg/l), Sodium (mg/l), Potassium (mg/l), Chloride (mg/l), Sulphate (mg/l), Nitrate (mg/l), Phosphate (mg/l) Bicarbonate (mg/l) and Fluoride (mg/l) are shown in Tables 1 and 2. The reported values refer the mean value of water samples collected during summer and winter seasons at different areas along the whole extends of Manimuktha River.

pH

The pH is a measure of the acid balance of a solution and is defined as the negative of logarithm to the base 10 of the hydrogen ion concentration. Industrial effluents and atmospheric deposition of acid-forming substances can affect the natural acid-base balance of a water body. The changes in pH can indicate the presence of certain effluents, particularly when measured and recorded continuously, together with the conductivity of a water body. The pH of most natural waters is between 6.5 and 8.5, although lower values can occur in dilute waters high in organic content and higher values in eutrophic waters, groundwater brines and salt lakes (Deborah Chapman 1992). The pH of premonsoon groundwater ranges from 6.4 to 8.2 with an average value of 7.2, indicating that the samples are neutral to basic overall. The pH value in the stations was found to be of distributive pattern, as shown in the spatio-temporal fluctuation diagram (Fig. 2). The pH of the groundwater during the postmonsoon period ranged from 7.0 to 8.7 with an average of 7.9, demonstrating a shift from acidic to basic due to the monsoonal effect. The pH value in the stations was found to be of distributive pattern, as shown in the spatio-temporal fluctuation diagram (Fig. 2).

Electrical conductivity (EC)

Electrical conductivity is directly related to the concentration of ionized substance in the water and may also be related to problems of excessive hardness and/or other mineral contamination. The high electrical conductivity indicates a larger quantity of dissolved mineral salts and making it unsuitable for drinking (Srivastava et al., 1996). The hydro-chemical study of electrical conductivity indicates an increase in concentration of major ions in the non-monsoon seasons (Benerjee and Gupta 2010). During the premonsoon, the electrical conductivity of the groundwater ranged from 260 to 4920mg/L with an average of 1524mg/L (Fig. 3). The EC ranged from 290 to 5010mg/L during postmonsoon, with a mean value of 1612mg/L. The maximum EC value was recorded at the Station 33 (Fig. 3).

Total dissolved solid (TDS)

Total dissolved solids (TDS) are the measure of combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. The total dissolved salts in premonsoon groundwater samples ranged from 182 to 3444mg/L , with an average of 1068mg/L (Fig. 4). TDS levels in most of the locations were found to be greater than the WHO standard of 1000 mg/L. TDS levels ranged from 194 to 3526mg/L during postmonsoon, with a mean of 1145mg/L . The greatest value was found in the centre section of the research region (Fig. 4).

Calcium

The calcium (Ca^{2+}) is an essential nutritional elements for humans and the optimum concentration of Ca^{2+} is required to prevent cardiac disorders and for proper functioning of metabolic processes. The calcium concentration in the research area's groundwater ranged from 17 to 290 mg/L during premonsoon, with an average value of 100 mg/L (Fig. 5). Calcium levels in the postmonsoon ranged from 21 to 348 mg/L , with a mean of 119 mg/L . The highest value was found near the middle of the research area (Fig. 5).

Magnesium

Magnesium levels in drinking water should not exceed 30 mg/L. (ISI, 1996). In these waters, magnesium is the third most abundant ion. Magnesium levels in drinking water should not exceed 30 mg/L . (ISI, 1996). In these waters, magnesium is the third most abundant ion. The magnesium concentration in the groundwater of the research area ranged from 3 to 115 mg/L during premonsoon, with an average of 43 mg/L (Fig.4.9). Mg levels in the postmonsoon ranged from 3 to 146 mg/L, with a mean of 59. Station 66 in the eastern part of the study region recorded the highest value (Fig. 6).

Sodium

Sodium in groundwater comes from both natural and man-made sources. The disintegration of various rock-forming minerals releases sodium into groundwater. Sodium is the most abundant cation among the cations, with Na+ > Ca2+ > Mg2+ > K+ as the order of abundance. The seasonal influence has little effect on the order of abundance, but it does affect the concentration of various ions in groundwater: Na+ > Ca2+ > Mg2+ > K+. The salt concentration in the area's groundwater ranged from 49 to 180 mg/L during premonsoon, with an average of 103 mg/L (Fig. 7). Sodium levels ranged from 73 to 310 mg/L during the postmonsoon, with a mean of 141 mg/L. The middle part of the study region recorded the highest value (Fig. 7).

Potassium

Potassium in groundwater comes from the weathering of feldspar rocks as well as pollution from anthropogenic sources. Potassium feldspars, unlike sodium, are resistant to water assault, hence it is always present at a lower concentration than sodium (Hem, 1985). The potassium concentration in the research area's groundwater ranged from 1.6 to 31.3 mg/L during premonsoon, with an average value of 5.1 mg/L . Station 61 in the northern part of the study region had the greatest value (Fig. 8). Potassium levels ranged from 1.4 l to 30.8 mg/L during the postmonsoon, with an average of 5.9 mg/L (Fig. 8).

Chloride

Chloride is a significant anion found in groundwater. Chloride ions are found in water due to their high mobility and solubility of chloride salts. Furthermore, because chloride ions are not involved in any geochemical (or) biological reactions, they can be utilized as a reliable indicator of groundwater pollution (Hem, 1985). Chloride levels greater than 100 mg/L in drinking water, according to ISO (2005), indicate a danger of corrosion in transport pipes. There is a possibility of the water's taste changing if the level exceeds 300 mg/L . During the premonsoon, the chloride concentration in groundwater samples from the study area ranged from 24 to 888 mg/L , with an average of 268 mg/L (Fig. 9). Chloride levels in the postmonsoon varied from 47 to 867 mg/L , with a mean of 318. The highest value was found in the Station 49, while the lowest value was found near the river's upper reaches at Station 57 (Fig. 9).

Sulphate

Sulphate is a significant anion found in groundwater, and because of solubility controls, its concentration levels are typically lower than those of chloride and bicarbonate. Due to the low levels of sulphur-containing minerals in hard rock locations, groundwater sulphate concentrations are typically minimal (Hem, 1985). Anthropogenic pollution, on the other hand, could result in increased levels. Increased use of fossil fuels and air emissions of sulphur oxides find their way into rainwater, where they accumulate over time and raise the concentration. Natural sources of sulphate in ground water include minerals such as gypsum anhydrite, Epsom, and the oxidation of pyrite minerals.

In the near-surface environment, sulphur easily undergoes oxidation-reduction reactions and transformations. It is oxidized (ultimately to sulphate, SO4) when subjected to weathering processes and is typically lost to the atmosphere as gaseous compounds or leached by groundwater in the near-surface zone. When sulphate ions interact with calcium or magnesium in water, the water becomes permanently hard. During the premonsoon, the sulphate content in the groundwater of the research area ranged from 10 to 212 mg/L , with an average of 84 mg/L . Station 33 had the greatest value, while Station 17 had the lowest (Fig. 10). Sulfate levels in the postmonsoon ranged from 23 to 218mg/L , with a mean of 109. The highest value was found at Station 49, while the lowest was found at Station 42 (Fig. 10).

Nitrate (NO_3)

One of the most important markers of pollution from anthropogenic sources is nitrate. Its persistent nature and transport through the ground water flow path are aided by the negative change and high mobility. Nitrate is the final oxidation result of all nitrogen-containing stuff, and its presence in groundwater can be linked to water penetration through soil holding domestic vegetable, animal, and fertilizer waste, as well as industrial contamination. Because lithogenic nitrogen sources are uncommon, its existence in ground water is virtually entirely owing to human activity. The presence of nitrate and nitrite in groundwater in excess of the allowed limit is not conducive to drinking (Rajmohan and Elango 2005). Surface pollution is the primary source of nitrate. During the premonsoon, nitrite concentrations in groundwater samples ranged from BDL to 120mg/L , with an average of 30mg/L . At Station 7, the highest value was found in the groundwater (Fig. 11). Nitrite levels in the postmonsoon varied from 0to 282mg/L , with a mean of 55mg/L . the maximum value was recorded at Station 11(Fig. 11).

Bicarbonate (HCO_3)

The hardness of groundwater is determined by the amount of dissolved cations in the water. Calcium and magnesium are the most common. Whether the hardness is permanent or transient is determined by the anions connected with these cations. The hardness is transient and can be removed if the anion is bicarbonate. Bicarbonate concentrations in groundwater samples from the research area ranged from 90 to 273 mg/L during premonsoon, with an average of 148mg/L . The highest value was found near the southernpart of the research area at Station 23 (Fig. 12). Bicarbonate levels in the postmonsoon varied from 103 to 363mg/L , with a mean of 207mg/L . The highest value was found near the river's mouth at Station 23, while the lowest was found at Station 68 (Fig. 12).

Fluoride (F)

Fluorine is a necessary component for both animals and humans. It protects against dental cavities at low doses, especially in children. The fluoride concentration in drinking water that is required to generate protective effects is around 0.5 mg/l. Fluoride is found in fluorite (CaF2), cryolite (Na3AlF6), topaz, tourmaline, muscovite, biotite, and villianmit, which are all naturally occurring minerals. Fluoride is found in ground water as a result of fluorite, apatite, and mica leaching and weathering. Premonsoon Fluoride content in groundwater ranges from 0.0mg/L to 1.4mg/L , with an average of 0.4mg/L (Fig. 13). The Postmonsoon ranged from 0.0 to 2.5mg/L. With an average value of 0.9 mg/L, During the Postmonsoon season, high F is detected in groundwater of the study area (Fig. 13).

IV. CONCLUSION

The seasonal variation pattern of surface water samples which highlights the diverse parameters were found to be influenced in two seasons. All the parameters values give a fluctuated proportion in post monsoon season than in pre monsoon season. The irregularity in monsoon precipitation and low water flow influences that variability in some parameters. The concentration variation in physico-chemical variables in the present study areas is subjected to wide spatial and temporal variations. It is concluded that other than the discharge of industrial effluents and domestic sewages, rainfall is also a criteria for the significant cyclic phenomenon in tropical countries that brings almost essential changes in the physical and chemical characteristics of the estuarine and coastal environments.

Table: 1 Physical chemical parameter of water sample in pre monsoon

Parameters	Minimum	Maximum	Average	R. Limit	P. Limit	< R. limit	> R.Limit	> P. Limit
pH	6.4	8.2	7.2	6.5-8.5		1	69	0
EC (µS/cm)	260	4920	1524	No limits recommended				
TDS (mg/L)	182	3444	1068	500	2000	9	58	3
Ca (mg/L)	17	290	100	75	200	29	37	4
Mg (mg/L)	3	115	43	30	100	25	42	3
Na (mg/L)	49	180	103	200 (WHO 2013)		0	200	0
K (mg/L)	1.6	31.3	5.1	20	-	69	1	0
Cl (mg/L)	24	888	268	250	1000	38	32	0
SO_4 (mg/L)	10	212	84	200	400	69	1	0
NO_3 (mg/L)	BDL	120	30	45	-	58	12	0
HCO_3 (mg/L)	90	273	148	No limits recommended				
F (mg/L)	0.0	1.4	0.4	1	1.5	64	6	0

Table: 2 Physical chemical parameter of water sample in post monsoon

Parameters	Minimum	Maximum	Average	R. Limit	P. Limit	< R. limit	> R.Limit	> P. Limit
pH	7.0	8.7	7.9	6.5-8.5	-	66	4	0
EC (µS/cm)	290	5010	1612	No limits recommended				
TDS (mg/L)	194	3526	1145	500	2000	8	57	5
Ca (mg/L)	21	348	119	75	200	24	37	9
Mg (mg/L)	3	146	59	30	100	13	51	6
Na (mg/L)	73	310	141	200 (WHO 2013)		63	7	0
K (mg/L)	1.40	30.80	5.99	20	-	68	2	0
Cl (mg/L)	47	867	318	250	1000	30	40	0
SO_4 (mg/L)	23	218	109	200	400	66	4	0
NO_3 (mg/L)	0	282	55	45	-	41	29	0
HCO_3 (mg/L)	103	363	207	No limits recommended				
F (mg/L)	0.0	2.5	0.9	1	1.5	42	16	12

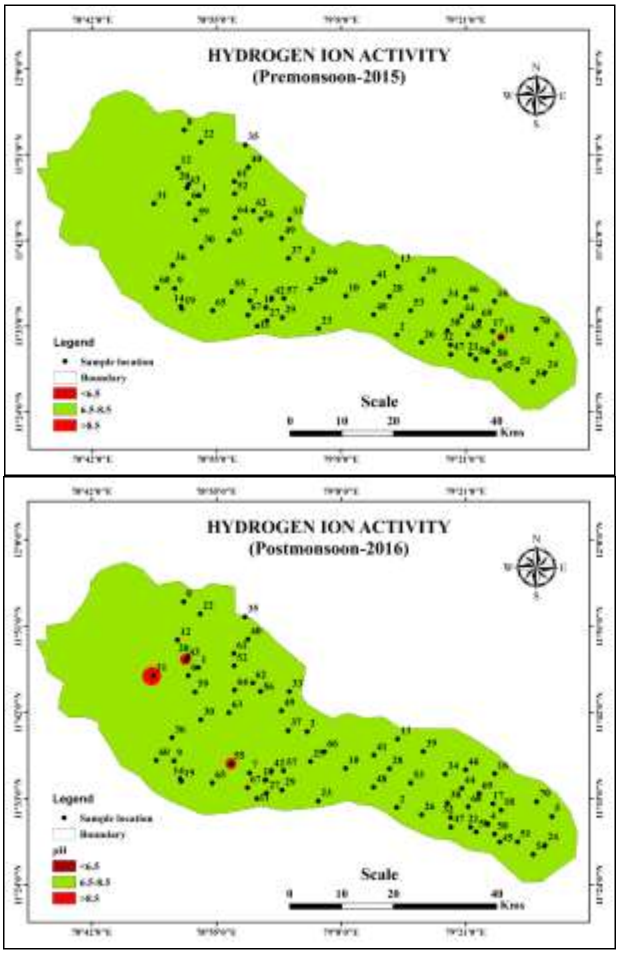
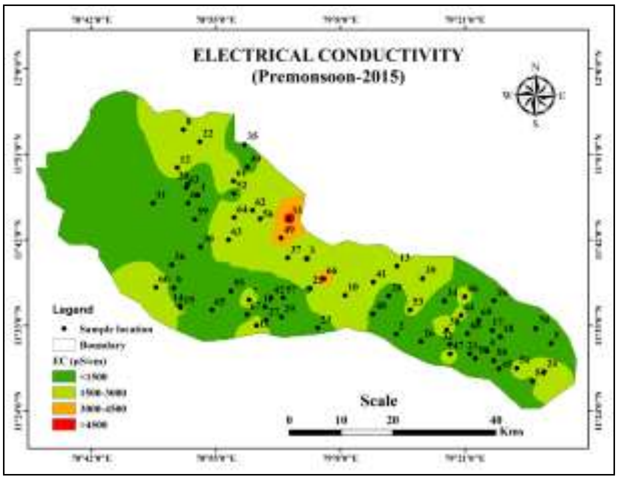


Fig. 2 Spatial distribution of Hydrogen Ion activity (pH) during Pre & Postmonsoon-2015.



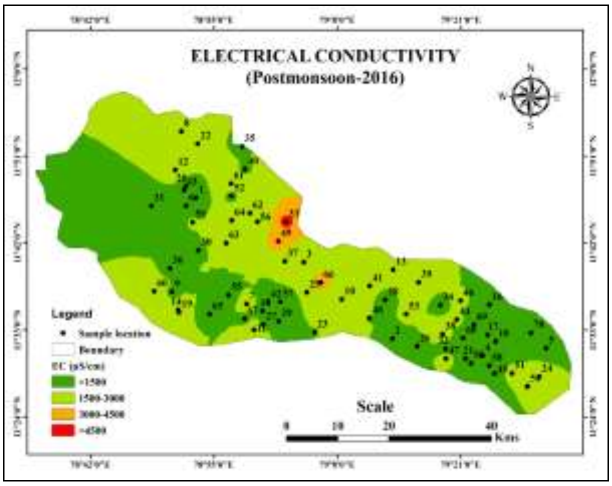


Fig. 3 Spatial distribution of Electrical Conductivity (Ec) during Pre & Postmonsoon-2015.

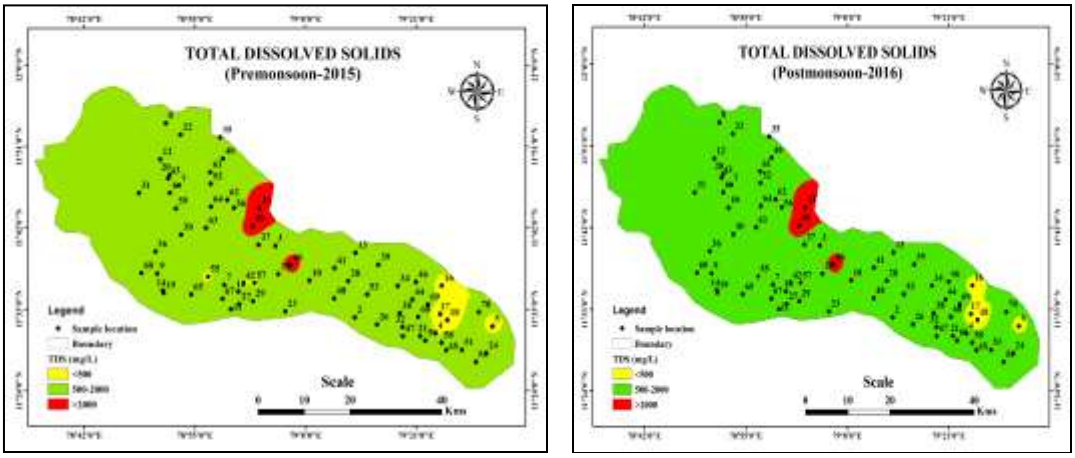


Fig. 4 Spatial distribution of Total Dissolved Solids (TDS) during Pre & Postmonsoon-2015.

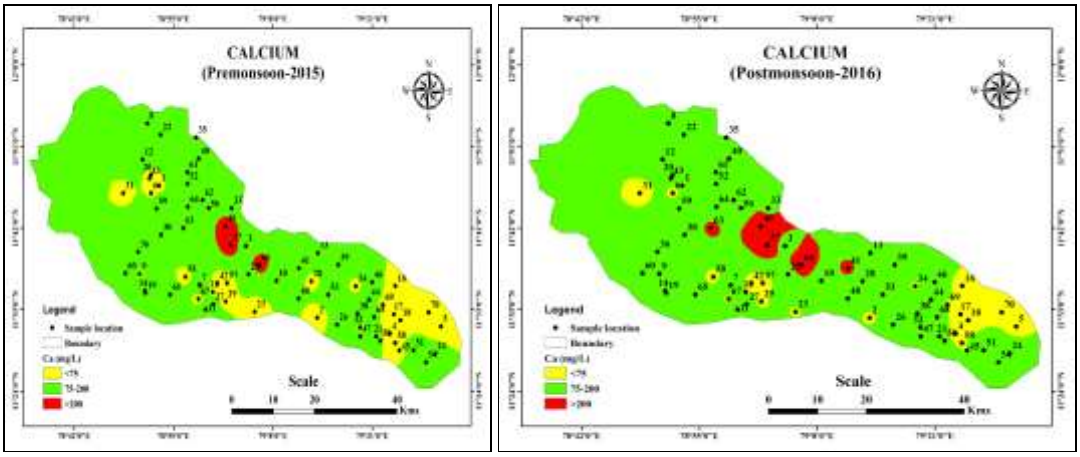


Fig. 5 Spatial distribution of Calcium (Ca) during Pre & Postmonsoon-2015.

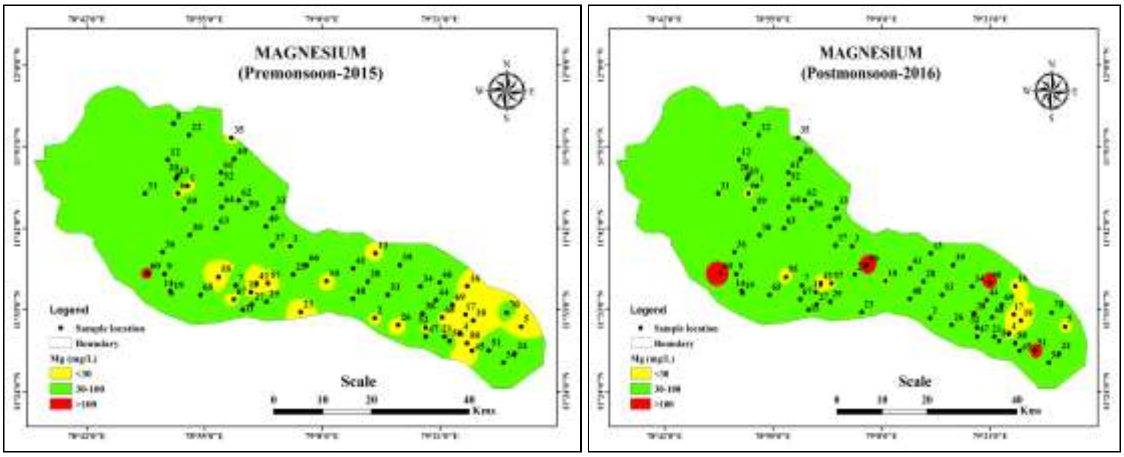


Fig. 6 Spatial distribution of Magnesium (Mg) during Pre & Postmonsoon-2015.

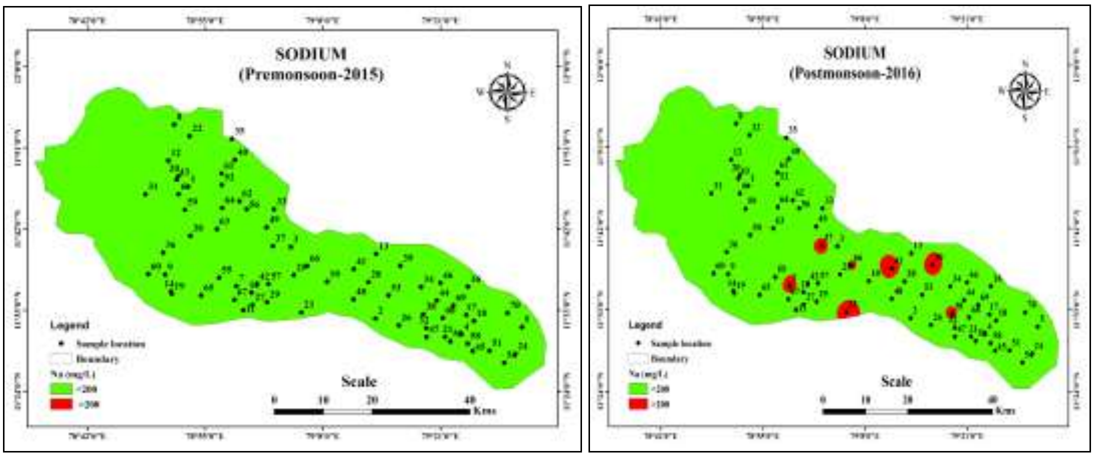


Fig. 7 Spatial distribution of Sodium (Na) during Pre & Postmonsoon-2015.

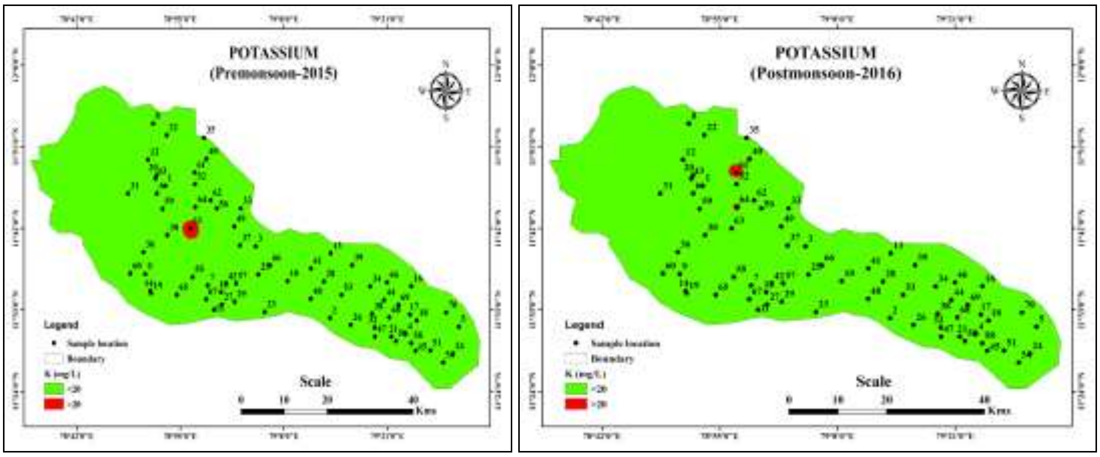


Fig. 8 Spatial distribution of Potassium (K) during Pre & Postmonsoon-2015.

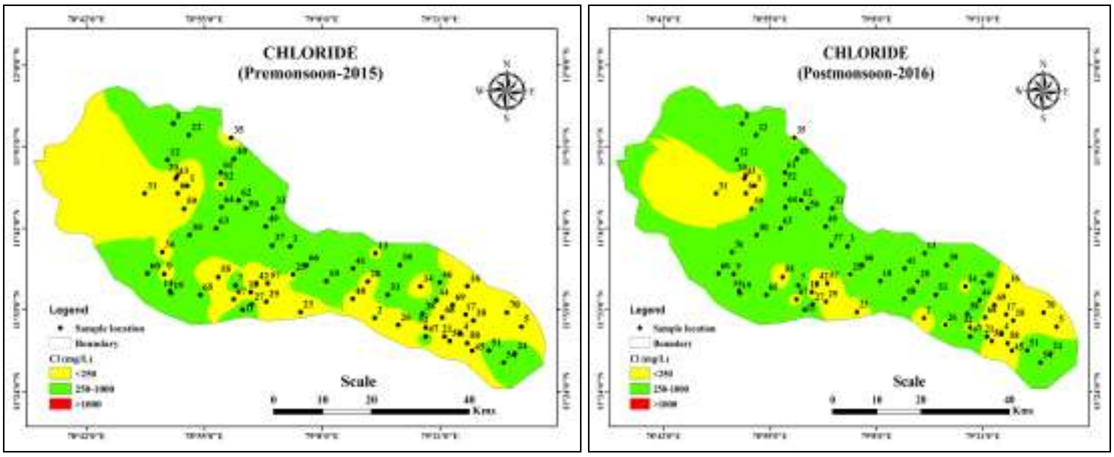


Fig. 9 Spatial distribution of Chloride (Cl) during Pre & Postmonsoon-2015.

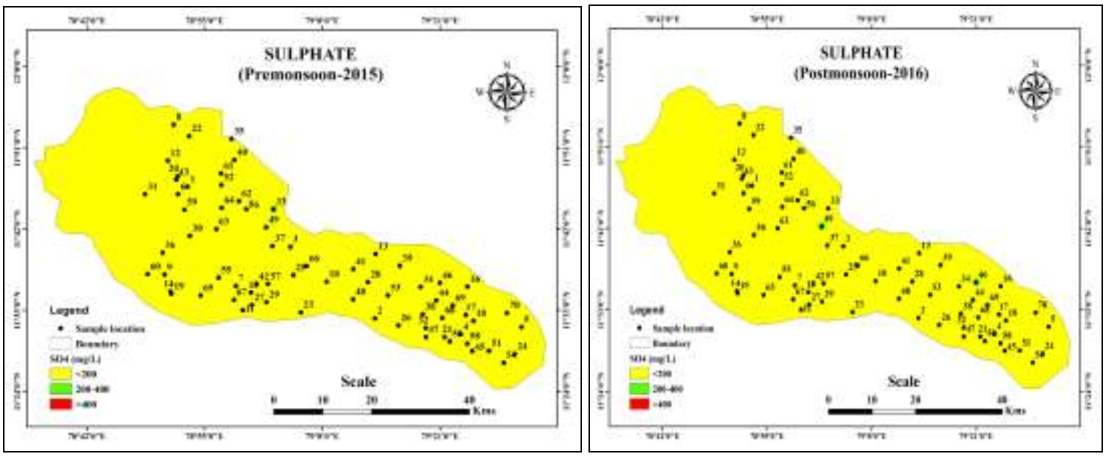


Fig. 10 Spatial distribution of Sulphate (So4) during Pre & Postmonsoon-2015.

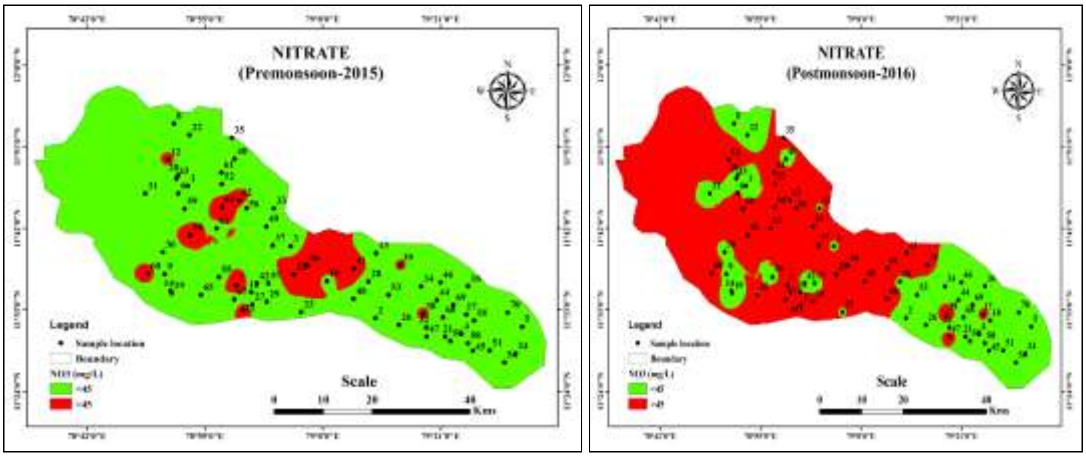


Fig. 11 Spatial distribution of Nitrate (No3) during Pre & Postmonsoon-2015.

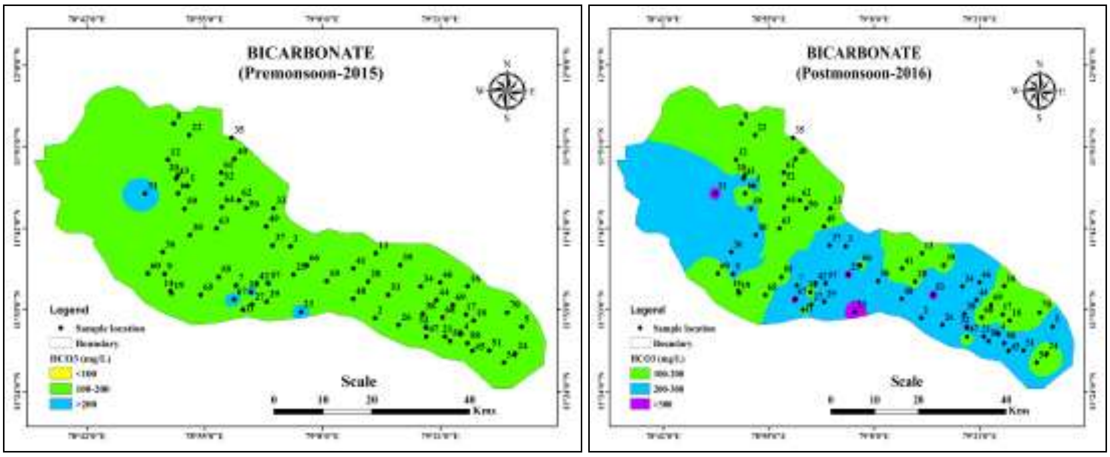


Fig. 12 Spatial distribution of Bicarbonate (HCO3) during Pre & Postmonsoon-2015.

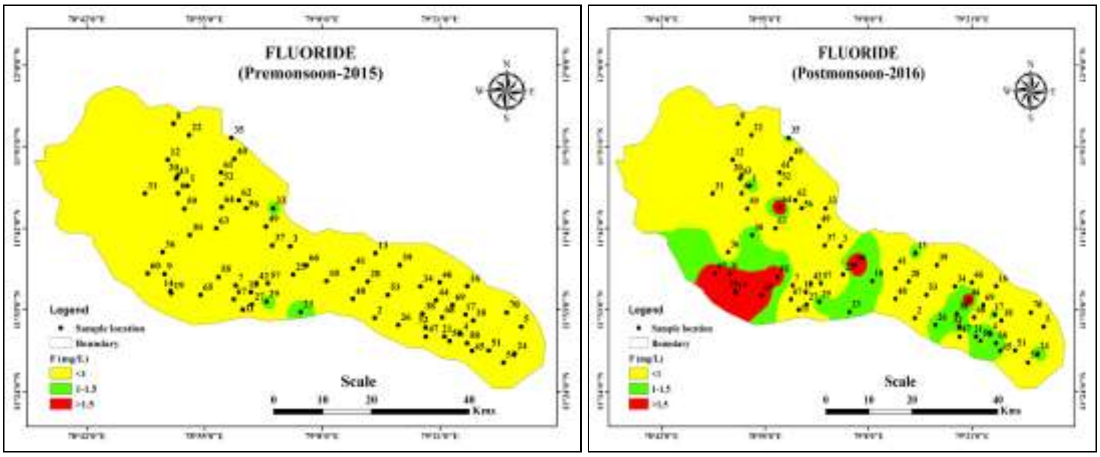


Fig. 13 Spatial distribution of Fluoride (F) during Pre & Postmonsoon-2015.

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