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Assessment of Groundwater Quality of Chrompet Industrial Area by Water Quality Index Method

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Abstract: *Groundwater samples of bore wells (BW), open wells (OW), and Hand Pumps (HP) collected from different locations in Chrompet area in Kanchipuram District, Tamil Nadu was analyzed for their physicochemical characteristics. The ground water samples were studied during pre-monsoon (September 2013) and post-monsoon (December 2013-January 2014) seasons from 16 different places. The present study was undertaken to characterize the physicochemical parameters such as pH, Electrical Conductivity (EC), Calcium Hardness (CH), Magnesium Hardness (MH), Total Hardness (TH), Total Dissolved Solids (TDS), Sodium (Na), Chloride (Cl), Sulphate (So_4) Bicarbonate (HCO_3) and Potassium (K). Each parameter was compared with its standard permissible limit as prescribed by World Health Organization (WHO). The Water Quality Index (WQI) reflected that most of the samples are of poor and very poor quality. The type of water that predominates in the area is Na^+Cl- type, based on hydro geochemicalfacies. Groundwater in this area was unsuitable for drinking as it contains higher concentrations of calcium, magnesium, hardness, sodium, chloride, chromium and copper are toxic elements found in some well water exceeded the BIS guidelines level for drinking water and are health hazards especially for the people working in the tannery industries. This is due to the recharge of effluent discharged by tanning industries into open drains and lakes. The concentration of chromium was above the permissible limits (0.05 mg/l) in 67% of the groundwater samples; due to the use of chemicals in tanning processes is the major reason for the high concentration. On comparing the results against drinking quality standards laid by BIS, it was found that some of the water quality parameters were above the permissible limit and some were not. The pollution from tanneries has caused irrevocable deterioration of quality of groundwater in the area. The study reveals that the groundwater quality changed due to anthropogenic and natural influences.*
Keywords: Hydro geochemistry, Groundwater, domestic purpose, Tannery region.

INTRODUCTION:

Groundwater resource is a multidimensional concept; it is defined by its location, occurrence over time, size, properties, conditions of accessibility, the effort required mobilizing it and therefore, all of it is to be considered in the context of demand. Groundwater has become an essential commodity over the past few decades due to its increasing usage for drinking, irrigation and industrialization. Rural India has started facing water crisis due to its increasing dependency on depleting groundwater supply. Quality of groundwater is equally important as its quantity owing to the suitability of water for various purposes. Variation of groundwater quality in an area is a function of physical and chemical parameters that are greatly influenced by geological formations and anthropogenic activities. The major problem with the ground water is that once contaminated, it is difficult to restore its quality. Hence there is a need and concern for the protection and management of ground water quality.

The main objectives of the study are

- Collection of ground water samples from open wells, bore wells and hand pumps -Chrompet, Kanchipuram District, Tamil Nadu.
- Analysis of a few quality parameters *viz.*, pH, Electrical Conductivity (EC), Calcium Hardness (CH), Magnesium Hardness (MH) *etc*., as recommended by World Health Organization.
- Assessment of the water quality using water quality index (WQI).

Salient features of the study area

The southern suburbs of Chennai that are involved in the tanning processes involve areas of Pallavaram, Pammal, Nagalkeny and Chromepet. These areas include large scale, small scale and also cottage industries that promote tanning process. Both vegetable and mineral tanning processes are practiced. This study is to be carried out in Chromepet area, located in the southern part of Chennai city is shown in Fig1, which serves as a home town to a large number of tanning industries. The study area is 13 km away from Bay of Bengal and 20 kilometers from Chennai city.It is located in12°55'16"N to 12°57'56"N longitude and 80°8'19"E to 80°9'59"E latitude. In general, the climate of the area is with low humidity and high temperature.

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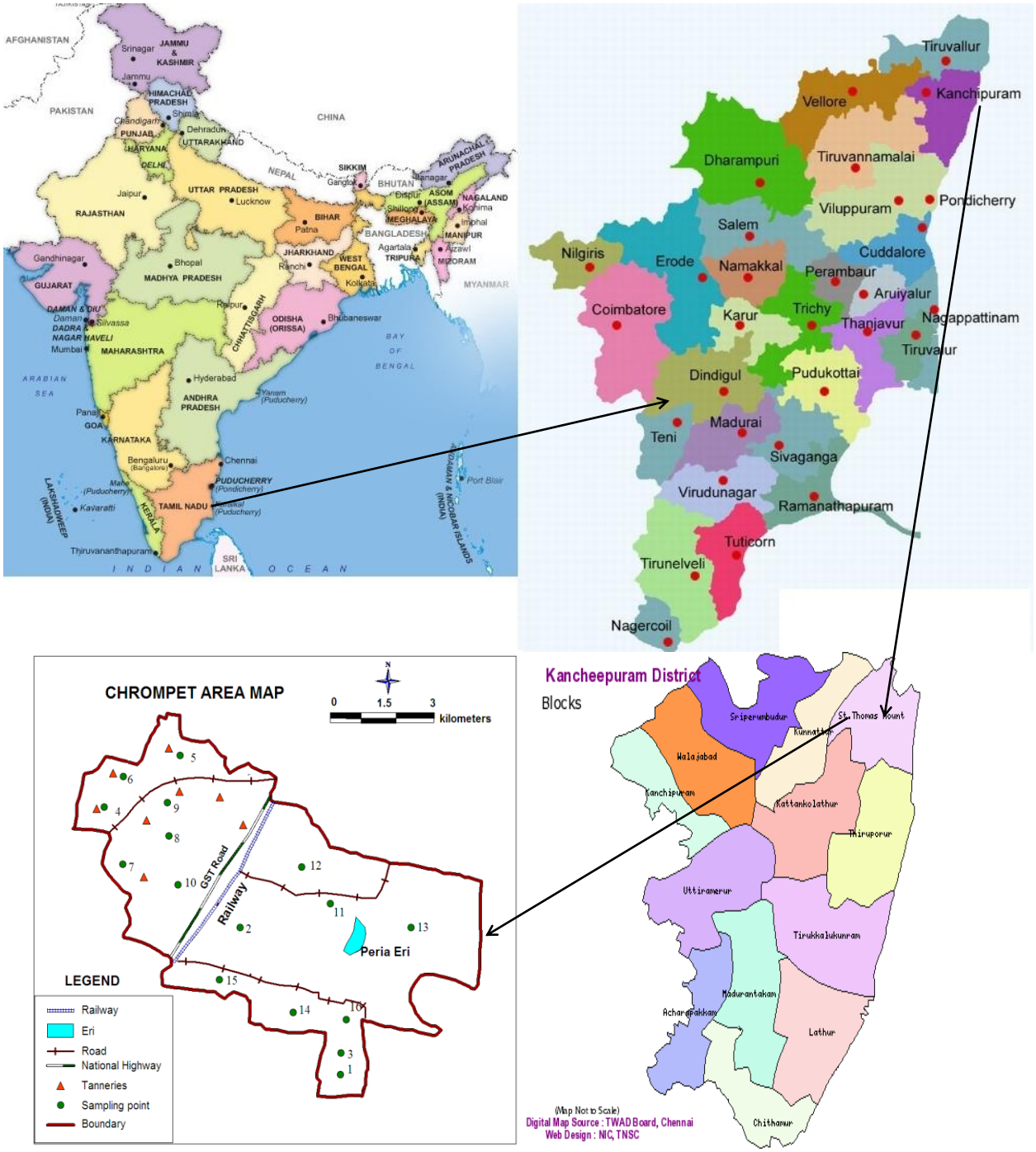
During winter the temperature is around 20°C. During the summer season the temperature increases up to a maximum of 44°C. The southwest monsoon from June to September contributes nearly 40% of the annual rainfall, which is about 1200 mm. The northeast monsoon is more important as it contributes to more than 60% of the annual rainfall from October to December.Topographically this region gently slopes towards west and east. The charnockite rocks of Archaean age occur as a basement rock in this area. Weathered charnockite rock occurs at the depth from 2 m to 4 m from the ground surface. The weathered rock is overlaid by soil of thickness ranging from 2 m to 4 m.



(Source: TWAD BOARD) **Figure 1 Location of Chrompet**

Methodology

Water quality data: Sampling was carried out during pre -monsoon and post monsoon using GPS survey. A total of sixteen water samples were collected from the selected locations throughout the study area. The graticules and altitude values of the selected sampling locations are given in Table 1. The collected samples were preserved by adding appropriate reagents in laboratory to determine the water quality analysis. These samples were analysed for different parameters as shown in Table 2.The obtained water Quality data form the attribute database which is used to generate the spatial distribution maps for the present study area.

Table 1Details of sampling locations of the study area

Sl. No	Sampling station	Latitude	Longitude	Type of source
1	Asthinapuram	12°55'53"	80°9'20"	Bore well
2	SBI colony	12°56'45"	80°8'32"	Bore well
3	AsthinapuramEri	12°58'4"	80°9'3"	Bore well
4	BhashiyamAppartment	12°58'4"	80°7'53"	Bore well
5	Muthuppalaniappannagar	12°57'55"	80°8'12"	Hand pump
6	Housing meadows	12°57'46"	80°8'22"	Open well
7	Lashmipuram	12°57'53"	80°9'20"	Bore well
8	Nagappanagar	12°57'34"	80°8'7.5"	Bore well
9	CBI colony	12°57'34"	80°8'2"	Bore well
10	New colony	12°57'2"	80°8'9"	Bore well
11	JameenRayapettai	12°56'52"	80°8'58"	Bore well
12	Ganapathipuram	12°57'49"	80°9'10"	Hand pump
13	Nemilichery	12°56'51"	80°9'50"	Open well
14	Venkatramannagar	12°56'15"	80°8'52"	Open well
15	Chitlapakkam	12°56'24"	80°8'27"	Bore well
16	Thirumalainagar	12°56'12"	80°9'25"	Open well

Table 2 Analytical methods adopted for physicochemical analysis

Sl. No	Analysis	Method/instrument
1	pH and Electrical conductivity (EC)	Field testing kit
2	Calcium hardness (Ca)	EDTA Titrimetry
3	Magnesium hardness (Mg)	EDTA Titrimetry
4	Sodium (Na) & Potassium (K)	Flame photometer
5	Bicarbonates + carbonates	Titrimetry
6	Chlorides (Cl)	Mohr'sTitrimetry
7	Sulphates (SO_4)	Spectrophotometry
8	Zinc (Zn), Chromium(Cr), Fluoride (F) and Copper (Cu)	Atomic Absorption Spectrometer

Results and discussion:

Hydrogen Ion Concentration (pH): The pH value of water indicates whether the water is acidic or alkaline. It controls by carbon-dioxide, carbonate and bicarbonate equilibrium. The combination of CO_2 with water form carbonic acid, which affects the pH of the water. Drinking water with a pH range 6.5 to 8.5 is generally satisfactory. If the pH is not within the prescribed, it damages mucous membrane present in eyes, nose, mouth, abdomen, anus etc. The pH value of water samples in the study area is within the safe limit in pre-monsoon ranged from 7.1 to 7.9 and in post monsoon ranged from 7.2 to 8.8 characterized by neutral to slightly alkaline.

Electrical Conductivity (EC): Electrical conductivity is a measure of water capacity to convey electric current. It is used to estimate the amount of dissolved solids. It increases as the amount of dissolved mineral (ions) increases. The most desirable limit of EC in drinking water is prescribed as 1500 µScm−1 and permissible limit 3000 µScm−1. In the study area, the value of conductivity in pre monsoon ranged between 1050 µScm−1 to 2990 µScm−1 and in post monsoon 1320 to 2140 µScm−1. Higher EC in the study area

indicates the enrichment of salts in the groundwater. Wells located near tanneries and their waste disposal sites showed higher EC values, which indicate that the contamination is due to the improper waste disposal.

Total Dissolved Solids (TDS): Based on the TDS content allowed for drinking water, all the groundwater of the study area exceeds the desirable limit of 500 mg/l and up to 2000 mg/l is maximum permissible limit. In the study area the TDS value in pre monsoon varies between 672 mg/l to 1914 mg/l and in post monsoon 678 to 1325 mg/l, indicating that most of the groundwater samples exceed the desirable limit. Generally, the higher TDS decrease palatability and causes gastrointestinal irritation in the human beings. It has also laxative effect, especially upon transits. But, the prolonged intake of water with the higher TDS can cause kidney stones, which are widely reported from different parts of the country.

Total Hardness (TH): Hardness is an important criterion in determining the suitability of water samples for domestic and industrial purposes as it involved in making the water hard. Total hardness was found in pre monsoon samples were ranged from 396 mg/l to 878 mg/l and in post monsoon 600 to 2140 mg/l water is not safe for drinking purpose. The hardness of the water is due to the presence of alkaline earths such as calcium and magnesium. The TH (in mg/l) was determined as:

$$TH=2.497Ca^{2+}+4.115Mg^{2+}$$

The classification of groundwater samples based on hardness revealed that most of the samples belong to hard to very hard category. High levels of hardness may affected water supply system, excessive soap consumption, calcification of arteries and cause urinary concentrations, diseases of kidney of bladder and stomach disorders.

Calcium (Ca^{2+}) and Magnesium (Mg^{2+}): Calcium (Ca^{2+}) and magnesium (Mg^{2+}) are the most abundant elements in the natural surface and groundwater. In pre monsoon Ca^{2+}concentrations were varying from 50 mg/l to 154 mg/l and in post monsoon 100 to 944 mg/l. The desirable limit of Ca^{2+} concentration for drinking water is specified as 75 mg/l .The higher Ca^{2+} content cause abdominal ailments and are undesirable for domestic uses as it causes encrustation and scaling. Mg^{2+} content in pre monsoon was varying from 40 to 121 mg/l and in post monsoon 96 to 310 mg/l. The maximum permissible limit of Mg^{2+} concentration of drinking water is specified as 30 mg/l (BIS 2012), most of samples beyond the limit.

Sodium (Na^{+}): The observed concentration of Na^{+} in pre monsoon was varied from 34mg/l to 1587 mg/l and in post monsoon 112 mg/l to 2396 mg/l. it higher than the recommended limit of 200 mg/l for safe, as it reveals that most of samples are exceeding the permissible limit as per BIS. It makes the water unsuitable for drinking because intake of high level of Na^{+} causes severe health problems like increased blood pressure, arteriosclerosis, oedema and hyperosmolarity.

Bicarbonate (HCO_3^-): The source of bicarbonate (HCO_3^-) ions in groundwater is from the dissolution of carbonate rocks. The HCO_3^- in pre monsoon groundwater samples were varied from 311mg/l to 580 mg/l and in post monsoon it varied from 324 mg/l to 651mg/l. The higher concentration of HCO_3^- in the groundwater is due to mineral dissolution. The HCO_3^- has no known adverse effects on human health.

Chloride (Cl-): In the study area, the concentration of Cl^- in pre monsoon was between 184 mg/l to 511 mg/l and in post monsoon 137 to 347 mg/l. A limit of 250 mg/L chloride has been recommended as desirable limit and 1000 mg/L as the permissible limit for drinking water. High concentration of Cl^- may be injurious to some people suffering from diseases of the heart and kidney, taste, indigestion, corrosion and palatability are affected.

Chromium (Cr-): The concentration of groundwater by heavy metals has received great significance during recent years due to their toxicity and accumulative behaviors. The tanning process using Cr- is applied to 90% of leather produced in the world [21]. These metals are toxic and even in small concentrations cause diseases in humans and animals. The Cr- is highly toxic to humans even in low concentrations. The major sources of heavy metals in groundwater are the discharge of waste effluent and sewage on land. A concentration of 0.05 mg/l has been recommended as a desirable limit for drinking water [5]. In pre monsoon groundwater samples ranges from 0.02 to 6.96 mg/l. Studies of groundwater in this area have high concentrations of Cr-, which is much more than the permissible limit in drinking water. The standard gives no relaxation for Cr- concentration in drinking water. The tanneries are polluting the groundwater causing ecological degradation and health hazards.

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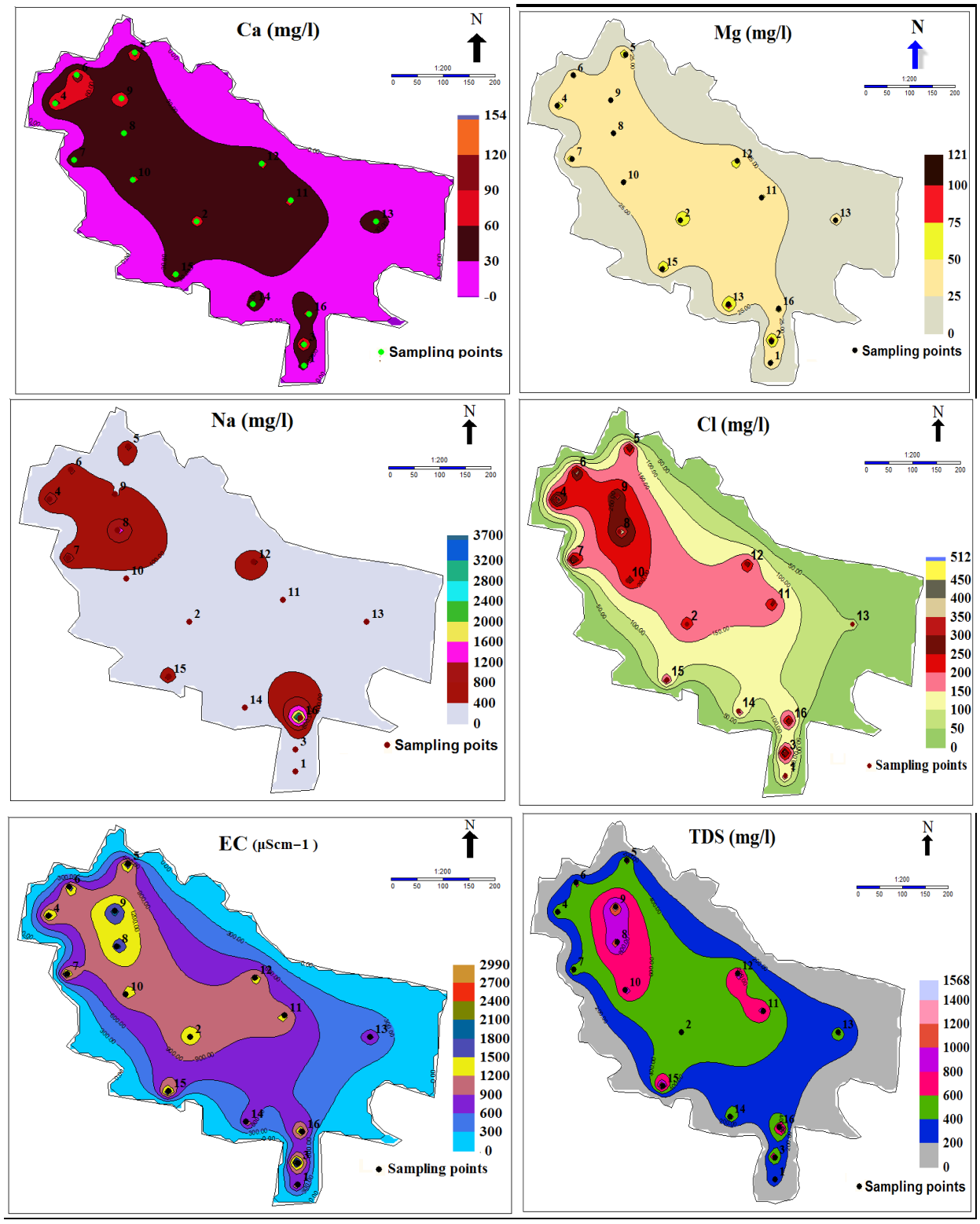

Fig 2 Spatial variation of pre monsoon water quality data

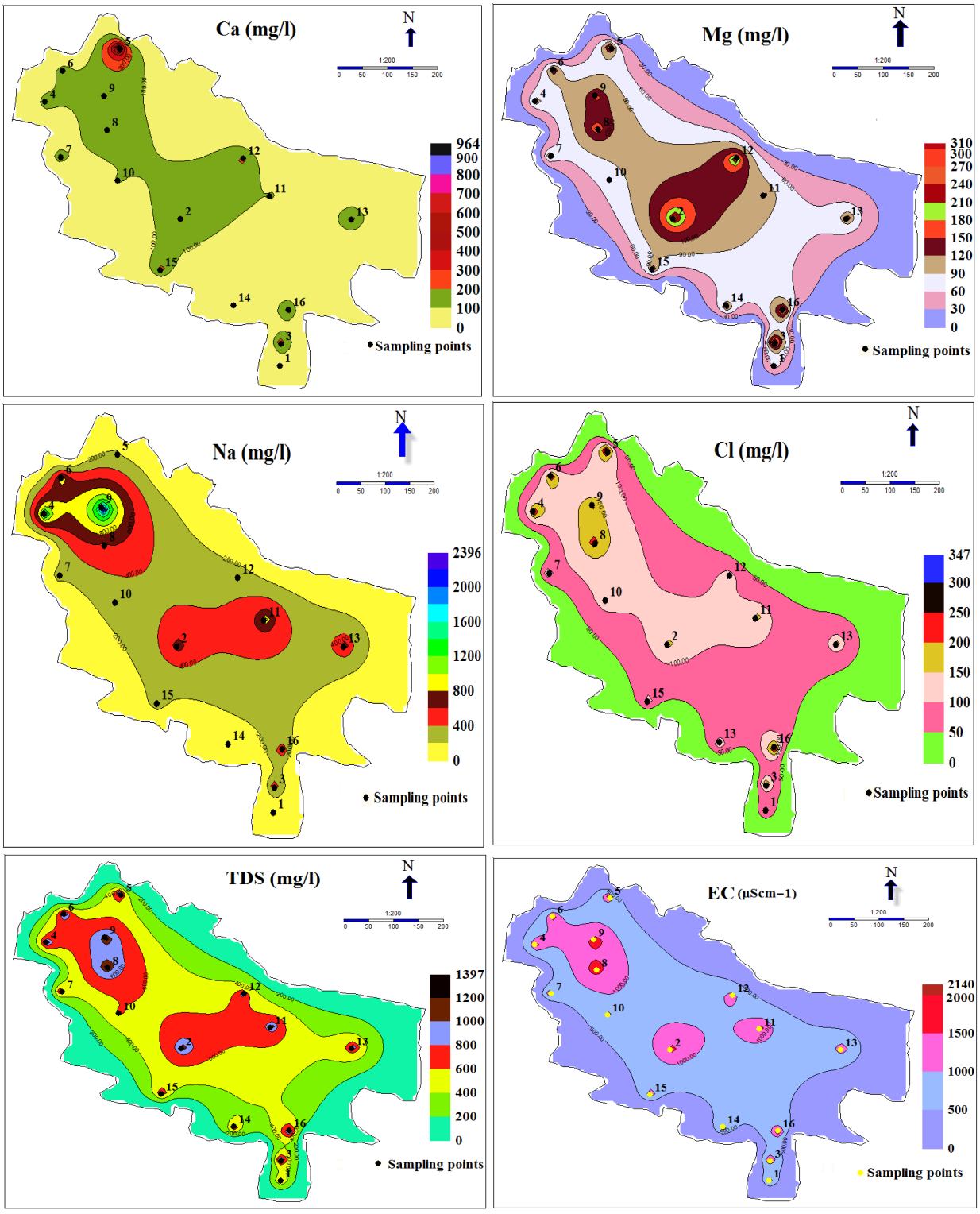

Fig 3 Spatial variation of post monsoon water quality data

Copper (Cu-): Copper (Cu-) is essential to human life continued inhalation of Cu- containing and health but, like all heavy metals, is potentially toxic as well spray is linked with an increase in lung cancer among exposed worker. The copper concentration in the pre monsoon season was found 0.02 to 0.2 mg/l and in post monsoon it ranged from 0.07 to 0.25mg/l in groundwater samples. The BIS has recommended 0.05 mg/l as the

desirable limits and 1.5 mg/l as the permissible limit in the absence of alternate source. Beyond 0.05 mg/l the water imparts astringent taste and cause discoloration and corrosion of pipes, fittings and utensils. In general the principal sources of copper in water supplies are corrosion of brass and copper pipes and addition of copper salts during water treatment for algae control.

Fluoride (F-): Fluoride is present universally in almost water, earth crust, many minerals, bedrock etc. It is also present in most of the everyday needs, viz. tooth paste, drugs, chewing gums, mouth washes, cosmetics and so on. The formation of high fluoride in groundwater is governed by geochemical dissolution of fluoride containing minerals, fast urbanization and modern industrialization. A small amount of it is beneficial for human health for preventing dental carries and high concentration of F^- ion causes dental fluorosis. The amount of fluoride in groundwater varies greatly in this region. The fluoride content of groundwater in pre monsoon ranged from 0.13 to 1.13 mg/l and in post monsoon 0.1 mg/l to 1.23 mg/l. The desirable limit for fluoride in drinking water is 0.6 to 1.5 mg/l. it reveals that all the samples are within the safe limit.

Water Quality Index

WQI is computed to reduce the large amount of water quality data to a single numerical value. WQI reflects the composite influence of different water quality parameters on the overall quality of water. Water quality index was computed by to determine the suitability of the groundwater for drinking purposes. It can be calculated by using the formula given below

$$\mathbf{WQI = Antilog\ [SW_{nn=1}\ log_{10} q_n]},$$

Where, W_n, Weightage = K/S_n and K, constant = $1/(S_{nn=1}1/S_i)$, S_n and S_i correspond to the WHO / ICMR standard value of the parameters. Quality rating (q) is calculated as $Q_{ni} = [(V_{actual} - V_{ideal}) / (V_{standard} - V_{ideal})] \times 100$, where q_{ni} = quality rating of i^{th} parameter for a total of n water samples, V_{actual} = value of the water quality parameter obtained from the laboratory analysis, $V_{standard}$ = value of the water quality parameter obtained from the standard tables. V_{ideal} for pH =7 and for the other parameters it is equivalent to zero.

Water quality types, were determined on the basis of WQI. The WQI range and type of water can be classified as below.

Table 3 WQI range and its corresponding water type

Range	<50	50-100	100-200	200-300	>300
Type	Excellent	Good	Poor	Very poor	Unsuitable

The WQI of the water collected during pre-monsoon and post monsoon season has been computed and given in the table 4.

Table 4 Physiochemical parameters of Pre monsoon season

Ion	**Minimum concentration**		**Maximum concentration**		**Mean concentration**		**BIS (IS 10500: 2012)**
	Pre monsoon	**Post monsoon**	**Pre monsoon**	**Post monsoon**	**Pre monsoon**	**Post monsoon**	
pH	7.1	7.2	7.9	8.8	7.481	8	6.5-8.5
EC (μScm^{-1})	1050	1320	2990	2140	1909	1600	1500-3000
Ca(mg/l)	50	100	154	944	91.63	272	75-200
Mg (mg/l)	40	96	96	310	73.50	203	30-100
Cl (mg/l)	184	137	511	347	344	242	250-1000
SO_4(mg/l)	14.7	16	39.55	49	27.544	32.5	200-400
Na (mg/l)	17	112	1587	2396	1051	1254	200
K (mg/l)	0.5	0	103.4	24.2	15	12.1	-
HCO_3(mg/l)	311	324	580	651	458	487.5	30-600
TH (mg/l)	372	600	878	2140	531	1370	200-600
TDS (mg/l)	672	678	1913.6	1325	1222	1001.5	500-2000
Cr (mg/l)	0.02	0.04	0.21	0.3	0.115	0.17	0.05
Cu (mg/l)	0.05	0.07	0.2	0.25	0.125	0.16	0.05- 1.5
Zn (mg/l)	0.02	0.03	0.36	0.42	0.19	0.32	5-15
F (mg/l)	0.13	0.1	1.13	1.23	0.63	0.68	1-1.5

The WQI of the water collected during pre-monsoon and post monsoon season has been computed and given in the table 5.

Table 5 WQI for pre-monsoon and Post monsoon

Sampling points	Pre monsoon		Post monsoon	
	WQI	Type	WQI	Type
Asthinapuram	96	Good	121	Poor
SBI colony	124	Poor	253	Very Poor
AsthinapuramEri	193	Poor	275	Very Poor
BhashiyamAppartment	200	Poor	225	Very Poor
Muthuppalaniappannagar	190	Poor	254	Very Poor
Housing meadows	172	Poor	224	Very Poor
Lashmipuram	195	Poor	171	Poor
Nagappanagar	167	Poor	213	Very Poor
CBI colony	234	Very Poor	248	Very Poor
New colony	112	Poor	122	Poor
JameenRayapettai	112	Poor	182	Poor
Ganapathipuram	150	Poor	230	Very Poor
Nemilichery	76	Good	190	Poor
Venkatramannagar	121	Poor	138	Poor
Chitlapakkam	190	Poor	188	Poor
Thirumalainagar	259	Very Poor	257	Very Poor

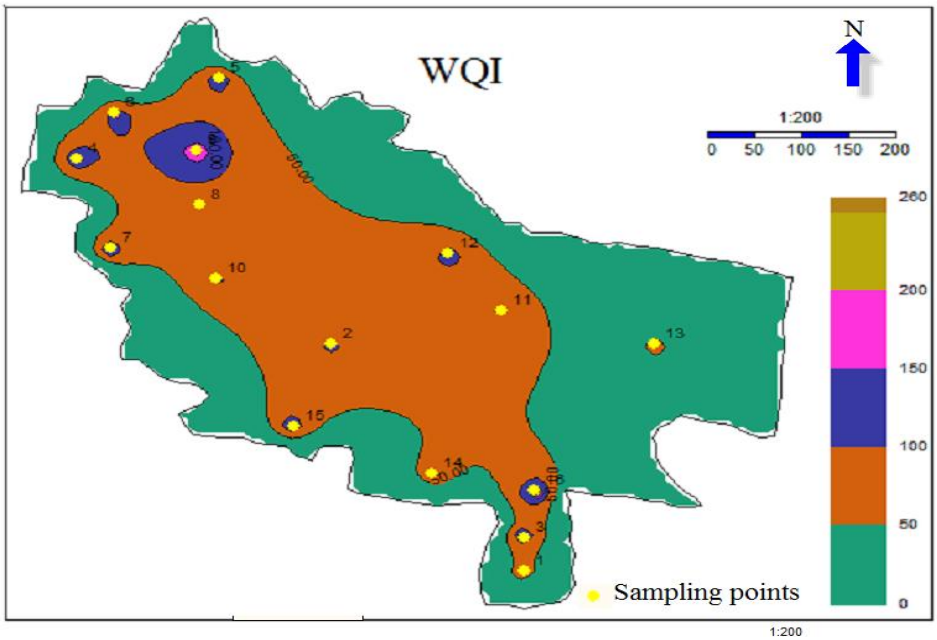

Figure 4.1 WQI for pre-monsoon

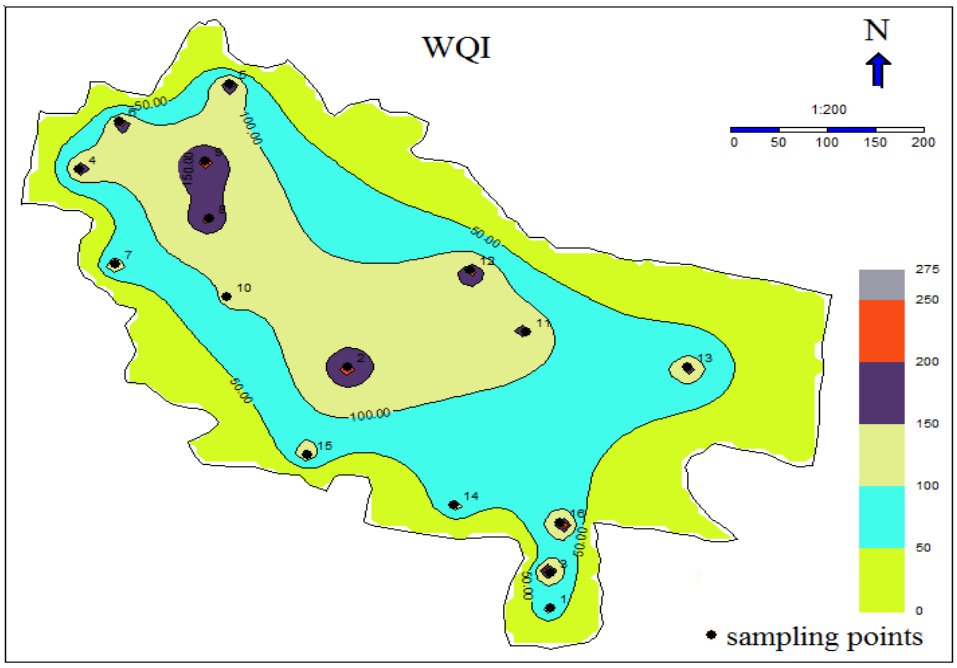

Figure 4.2 WQI for Post monsoon

Groundwater samples of bore wells (BW), open wells (OW), and Hand Pumps (HP), collected from different locations in Chrompet in Kanchipuram District, Tamil Nadu was analyzed for their physicochemical characteristics. The ground water samples were studied during pre-monsoon (July-September 2013) and post-monsoon (January 2014) seasons from 16 different places. The present study was undertaken to characterize the physicochemical parameters such as pH, Electrical Conductivity (EC), Calcium Hardness (CH), Magnesium Hardness (MH), Total Hardness (TH), Bicarbonate (HCO_3), Chloride (Cl), Sulphate (SO_4), Sodium (Na), Potassium (K) Total Dissolved Solids (TDS). Each parameter was compared with its standard permissible limit as prescribed by World Health Organization (WHO). The Water Quality Index (WQI) was calculated and it reflected that 12.5% of the samples were of good quality in pre monsoon, 75% of samples were poor quality and 12.5% of samples were of very poor quality in pre monsoon and in post monsoon 44% of samples were of poor quality and 56% of samples were of very poor quality.

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