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Groundwater quality and its suitability for DCM Industrial Area, Kota, Rajasthan, India – A GIS approach

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Abstract

The drinking water need of Kota is mostly met by surface and groundwater resources, both being of vital importance for domestic, industrial and agricultural purposes. And so is the importance of quality versus quantity due to near vicinity of Chambal River. Realizing it, ground water quality and its suitability analysis was carried out for DCM industrial area by analyzing groundwater samples from various sources for geochemical variations during pre and post monsoon periods using geographical information systems (GIS). Geo reference map along with other analytical data sets have been utilized to extract information on groundwater storing, controlling and quality features. The comparison of drinking water standards for geochemical results with World Health Organization and Indian standards Institution indicate that most of the ground water samples are not up to the mark required for standards of potable water. Pre monsoon and post monsoon analyses of samples indicate significant changes too. The study reveals that quality of ground water changes in post monsoon period may be due to infiltration and seepage of rainwater in groundwater sources. As such, groundwater quality and its suitability is an area of concern in near future.

Keywords: *Groundwater, geographical information systems, quality, Kota.*

1. Introduction

The pollutants affect our life and that with present rate of pollution; we are not getting drinkable water as per defined standards. [1-2].Initial attempts by such studies carried out in different parts of Rajasthan also highlighted these impacts on quality of water [3-10]. Thus, regular monitoring to check the status of groundwater for ascertaining the pollutants is the need of hour. Keeping this in consideration, the spatial distribution maps of water quality parameters were produced using Geographic Information System (GIS) [10-11]. The distribution maps serve to understand ecological status of the groundwater systems and for the identification of groundwater quality parameters in potential areas where water treatment plants/technologies need to be targeted. [12]

2. Study Area

Kota is located along eastern bank of Chambal River in the southern part of Rajasthan. The cartographic coordinates are 25°11′N 75°50′E/ 25.18°N 75.83°E with an area of 318 km^2. It has an average elevation of 271 meters. The district is bound on the North and North West by. The Chambal river separates Sawai Madhopur, Tonk and Bundi districts from Kota district, forming the natural boundary. Total covered area [DCM industrial area and its adjoining areas in western part of Kota] of 10 sq. Kms. has been chosen as study area. The details of various spots selected for study are given in figure 1.

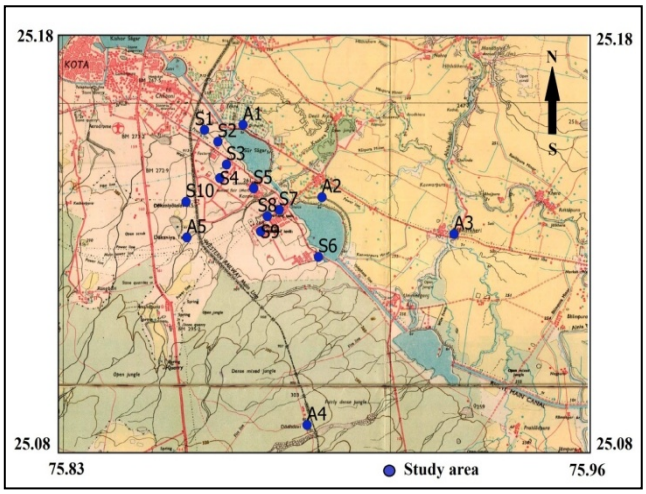

Fig.1 Location map of Study area, Kota.

3. Data Used and Methodology

Survey of India (SOI) toposheet (45 O 16 KOTA) was used for the preparation of the base map. GIS software package QGIS 2.8.1 is used to map and analyze the data for the evaluation of groundwater quality. For analyzing the chemical aspects of groundwater in the study area, total 15 samples of groundwater used for drinking purpose were collected from different sources like hand pumps or open wells at different spots spread over DCM Industrial area during Pre-monsoon, Monsoon & Post-monsoon season in 2014.These spots were specifically identified on the basis of frequent use and probability of contamination and were mapped (Figure 1). The season was selected because contamination often increases during rain and tends to the accumulation of ions and decreases after rainy season. The samples collection sites are Near Govt. School, Bombay Yogena (S1), Near Bombay Yogena Colony (S2),

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Near Samudayik Bhawan ,Kansua(S3), Near Shiv Mandir, Kansua (S4), Near Govt. Senior Secondary , Ram Nagar (S5), Near Govt. Senior Secondary School, Indra Colony , DCM (S6), Shri Ram Fertilizer Gate , Near Fly Over, Prem Nagar (S7), Samudayik Bhawan Ke Paas Prem Nagar III (S8), Papaji Ke Bhatte Ke Paas, Rayans Industry Boundary,Prem Nagar III (S9), Industrial Area, Near Dakaniya Station, Sanjay Nagar (S10), Raipura (A1), Daddevi (A2), Soorsagar (A3), Dhakerkhari (A4) and Dakniya talav (A5) respectively.

The samples were analyzed using standard methods of analyses to assess various physicochemical parameters according to APHA & WHO norms. [13-14] some parameters like temperature, color, and pH were measured on site. Water samples were analyzed by standard methods [15] for physicochemical parameters like water temperature (^{0}C), TDS, conductivity, turbidity, odor, nitrate, sulphate, phosphate, Dissolved Oxygen, hardness, chlorides, fluorides, nitrate, sodium, potassium and Chemical Oxygen Demand(COD),Biological Oxygen Demand(BOD), alkalinity.

4. Result and Discussion

Geo reference map along with other analytical data sets have been utilized to extract information on the groundwater storing controlling and quality features of this study area. GIS modeling technique of Interpolation and Contour formation was used to produce groundwater potential map. [16-17]
Most of the parameters studied were found in the permissible limit according to the WHO but EC, TDS and TH was found higher in the range and their statistical values of seasonal variation are presented in Table 1.

Table 1: Statistical value of TDS, Conductivity & TH

Parameter	*TDS (mg/L)*			*Conductivity(µmhos/cm)*			*TH (mg/L)*		
	Pre	*Monsoon*	*Post*	*Pre*	*Monsoon*	*Post*	*Pre*	*Monsoon*	*Post*
Mini	327.63	356.00	390.00	307.47	418.70	121.67	118.00	159.33	178.67
Max	905.82	841.70	826.67	794.62	819.33	813.33	492.00	460.00	453.32
Average	568.67	585.80	612.98	499.45	622.62	517.53	289.91	295.20	315.71
S.D.	194.33	152.032	127.72	137.72	116.66	166.74	113.35	91.4017	90.54

TDS:- Total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of Calcium, Magnesium, Sodium, Potassium, Manganese, organic matter salts and other particles.[18] When present in excessive quantities, they reduce the osmotic activities of the plants and may prevent adequate aeration.

The Total dissolved solids (TDS) in water samples in pre-monsoon ranged from 327.63(A1-Raipura) to 905.82 ppm (S6-Indra colony, DCM). Different range of TDS is shown in GIS Graphs by different colors i.e. red color shown higher TDS range whereas green color shown lower TDS range areas. (Table 1, Figure 2)

In 2014 pre monsoon period, the TDS results show higher concentration of (> 706) salts in central part of the study area. The lowest concentration of (< 428) salts was observed in southeast, southwest, northern part of the study area. (Figure 2)

During monsoon season green color shown are in lower TDS range i.e. 356 (A4-Dhakerkheri) and red color shown in higher TDS range i.e. 841.70 ppm (S6-Indra colony, DCM).

All area near Indra colony (S6) shows higher TDS by spatial distribution map. During Monsoon period, higher concentration of (> 716) salts was observed in central part of the study area and in east and west part range was observed [near to high]. (Table 1, Figure 3)

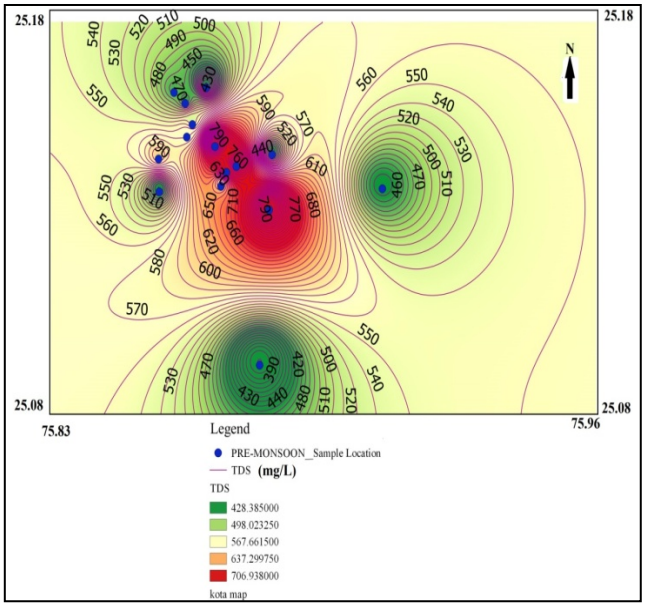

Fig.2: Spatial distribution of TDS during Pre-monsoon

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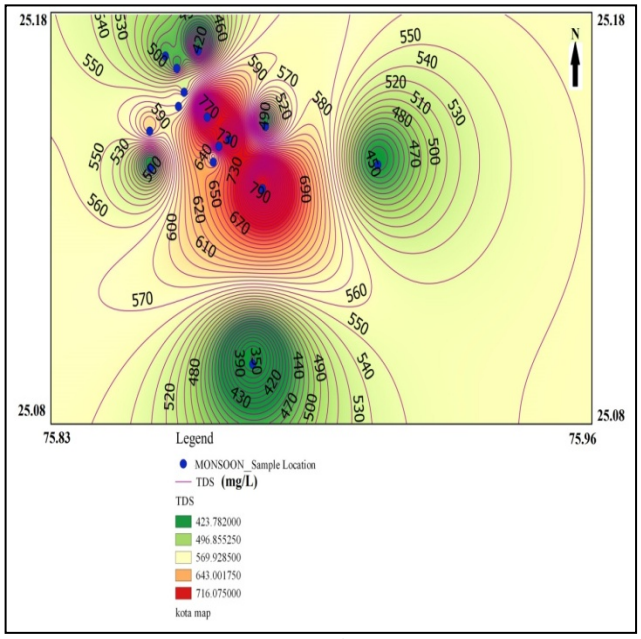

Fig.3: Spatial distribution of TDS during monsoon

During Post-monsoon season lower TDS range i.e. 390(A1-Raipura) is shown by green color and higher TDS range i.e. 826.67 ppm (S6-Indra colony, DCM) by red color in map. Area near Indra colony shows higher TDS by spatial distribution map. During Post-Monsoon period, higher concentration of (> 681) salts was observed in central part of the study area. (Table 1, Figure 4)

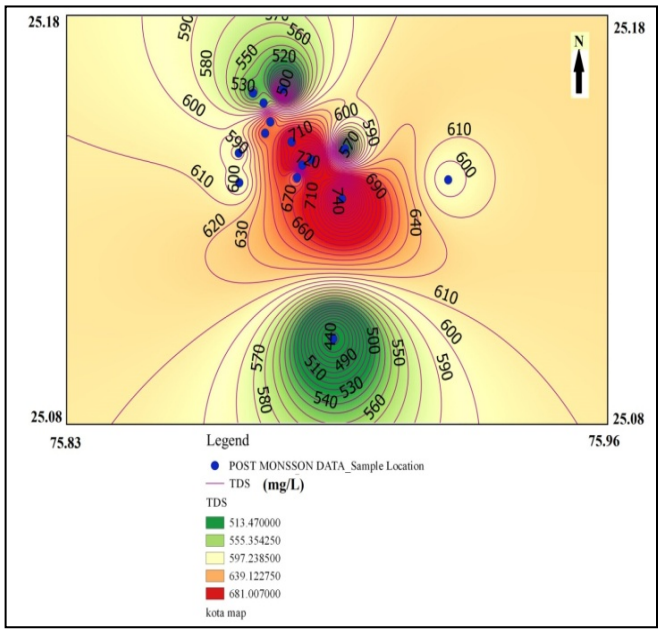

Fig.4: Spatial distribution of TDS during Post-monsoon

Thus, after comparisons of all TDS results in all seasons it is found that TDS in water samples of the study area [S3, S4, S5, S6, S7, S8, S9, S10, A4, A5 samples] are above the permissible limit of WHO and BIS (<500 ppm). They are generally in excess of 200 mg/L and can be classified as unsuitable irrigation water. (Table 1)It means high dissolved solids may cause "mineral tastes" in drinking water of study area. Corrosion or encrustation of metallic surfaces by waters high in dissolved solids appears to cause problems with industrial equipment and boilers as well as domestic plumbing, hot water heaters, toilet flushing mechanisms, faucets, and washing machines and dishwashers.

Conductivity: - According to salinity classification of Davis and De Wiest, [19] the results of pre monsoon, monsoon and post monsoon periods exhibit that 100 % samples fall under fresh water category. (Table 2) The electrical conductivity of water depends upon the concentration of ions and its nutrient status. Based on electrical conductivity values water quality can be classified as poor, medium or good [20]. In the present investigation maximum conductivity was observed at S2 (Near Bombay yogena colony, Kansua) in post monsoon period and minimum at S5 (Near govt. school, Ramnagar) in monsoon period. (Table 1), meaning thereby mineralization present in area of study, certain physiological effects on plants and animals and also notable variations or changes in natural water and wastewaters quickly.

According to irrigation water based classification of EC of water 93.33 % samples are in good category while only 6.66% samples are in doubtful category during pre-monsoon period. During monsoon period 86.66% samples are good category, 13.33% samples in doubtful category. During post-monsoon period only one sample (6.66%) was found in excellent category. (Table 3)These findings are indicative of monsoon and afterword effects on EC.

The electrical conductivity (EC) of ground water samples in pre-monsoon period lower range 307.47µmhos/cm (S1-Near govt. school, Bombay yogena) and higher range 794.62 µmhos/cm (A3-Soorsagar). The EC results shows higher concentration of (> 679) salts in northeast part of the study area which indicates by red color .The lowest concentration of (< 414) salts was observed in south, precisely southwest part of the study area which indicates by blue color. (Figure 5)
During monsoon period lower and higher ranges are observed as 418.70 µmhos/cm (S1- Near govt. school, Bombay yogena) range and 819.33 µmhos/cm(A3-Soorsagar) respectively. Higher concentration of (> 692) salts was observed in northeast part as well as in small area of central part of study area which is indicated by red color. (Figure6)

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Table 2: Condition of Water Quality with Reference to Concentration

Classification Pattern	*Categories*	*Ranges (Mg/L)*	*Number of Samples*		
			PRE	*MONSOON*	*POST*
TDS	Fresh Water	< 1000	15	15	15
	Slightly Saline	1000-3000	0	0	0
	Moderately Saline	3000-10000	0	0	0
	Very Saline	10000-35000	0	0	0
	Brine	>35000	0	0	0

Whereas in post-monsoon period EC lower range is 121.67 µmhos/cm (S1- Near govt. school, Bombay yogena) and higher range is 813.33µmhos/cm (A3- Soorsagar). Higher concentration of (> 708) salts was observed in northeast part, northern part and small area of central part of study area indicated by red color. (Figure 7)

The EC in study area was found above permissible limits of WHO and BIS [9] (300µmhos/cm) except for samples S1 & S2.

Table 3: Classification of Irrigation Water Based on Electrical Conductivity

Classification Pattern	*Categories*	*Ranges*	*Number of Samples*		
			PRE	*MONSOON*	*POST*
EC (Salinity Hazard class) (Wilcox 1955)	Excellent (C1)	100-250	0	0	1
	Good(C2)	250-750	14	13	13
	Doubtful(C3)	750-2250	1	2	1
	Unsuitable(C4 & C5)	>2250	0	0	0

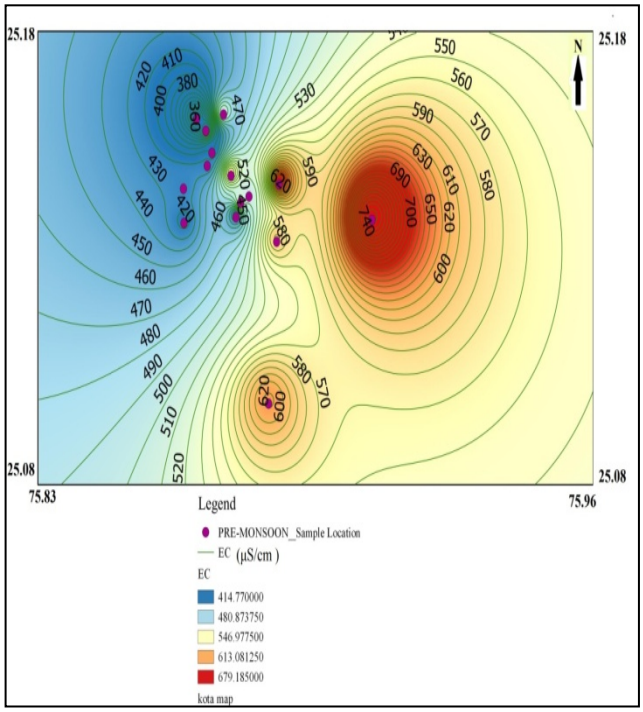

Fig.5: Spatial distribution of Electrical conductivity during Pre-monsoon

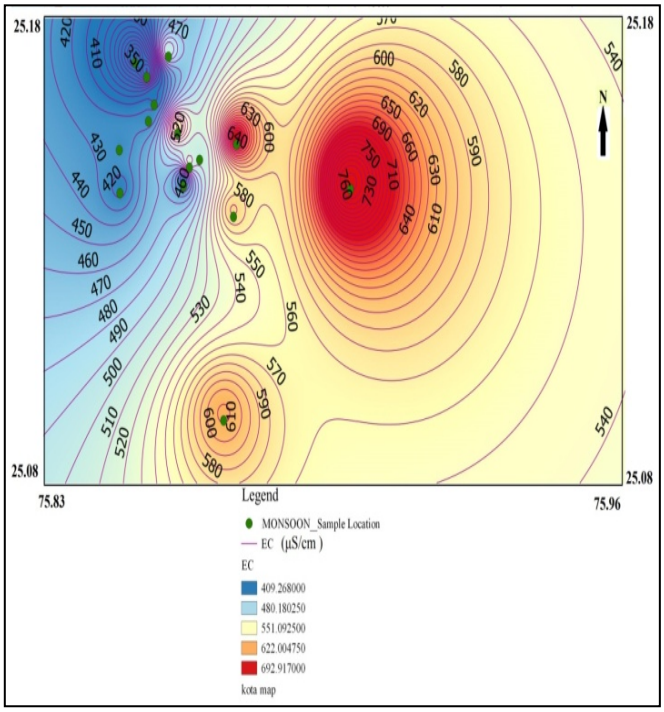

Fig.6: Spatial distribution of Electrical conductivity during Monsoon

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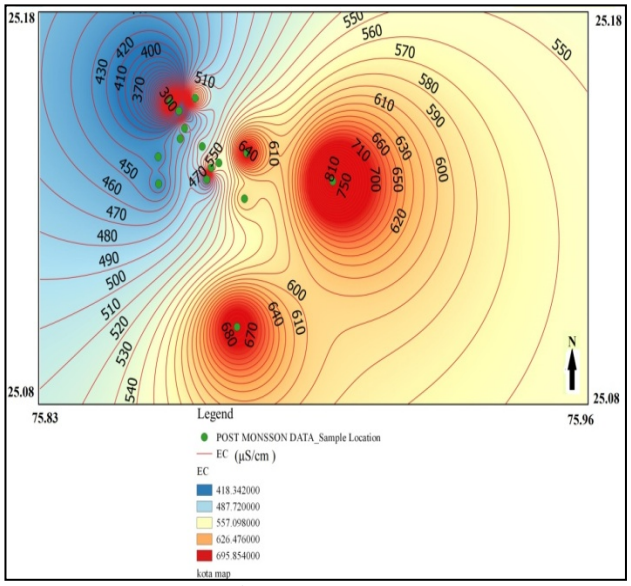

Fig.7: Spatial distribution of Electrical conductivity during Post-monsoon

Hardness: - Hardness of water mainly depends upon amount of calcium or magnesium salts or both. In our findings hardness value varied from 118 ppm to 492 ppm, these values are above the permissible limit in maximum samples (S3,S4,S5,S6,S7,S8,S9,S10) with regards to values prescribed by WHO. (Table 1)

According to Durfor and Becker's (1964) classification of total hardness, hardness ranges describe hardness of water. Total hardness was found to be in the category of "Hard to very hard" for the samples of all locations (Table 4). [21]

In pre monsoon period 80% of samples have been found under very hard category while only 20% samples were under hard category. During monsoon period about 86.6 % of samples fell under very hard category while only 13.33% of samples under hard category.

Table 4: Durfor and Becker's Classification of the water samples based on Total hardness

S. No.	***Description***	***Hardness (mg/L)***	***Range (No. of Samples) (Total-15)***		
			PRE	***MONSOON***	***POST***
1	Soft	0 – 60	-	-	-
2	Moderately Hard	61 – 120	-	-	-
3	Hard	121 – 180	118-173.67 (3/15)	159.33-174.67 (2/15)	178.67 (1/15)
4	Very Hard	>180	201-460.00 (12/15)	205.33-460.00 (13/15)	185.33-453.33 (14/15)

Whereas during post monsoon season about 93.33% of samples were observed under very hard category while 6.66% of samples under hard category. We also find that Ram Nagar (S5), Indra Colony (S6), Prem Nagar (S9) area samples have exhibited maximum hardness as compared to other areas and thus water quality is questionable for human use.

The Total hardness (TH) of ground water samples in pre-monsoon period have lower range of 118 mg/L (A5-Dkaniya talav) and higher range of 492 mg/L µmhos/cm (S6-Indra colony). The TH results show higher concentration of (> 377) salts in central part of study area (indicated by red color) .The lowest concentration of (< 205) salts was observed in south, east, west and north part of the study area indicated by blue color. (Figure 8)

Variations of TH in pre-monsoon period are in the range 159 mg/L (A3- Soorsagar) to 460 mg/L (S6-Indra colony). TH results show higher concentration of (> 372) salts in central part of study area indicated by red color while lowest concentration of (< 208) salts in south, east, west, northeast and north part of study area. (Figure 9)

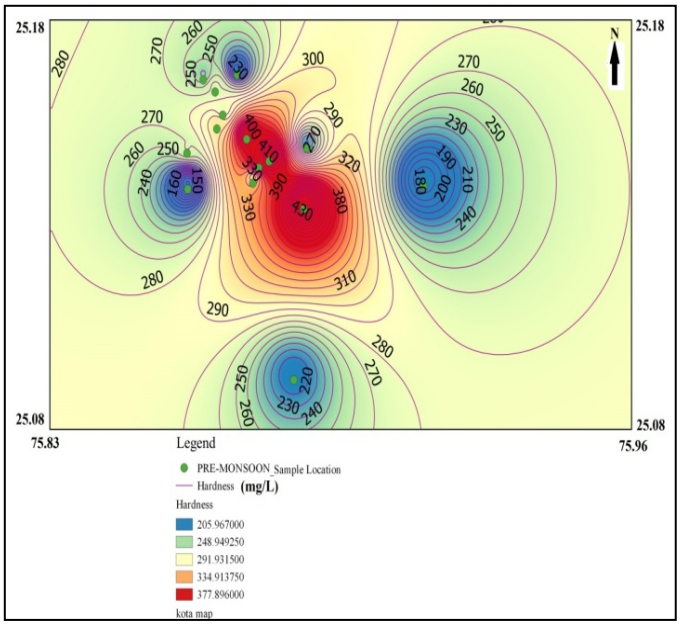

Fig.8: Spatial distribution of Total Hardness during Pre-monsoon

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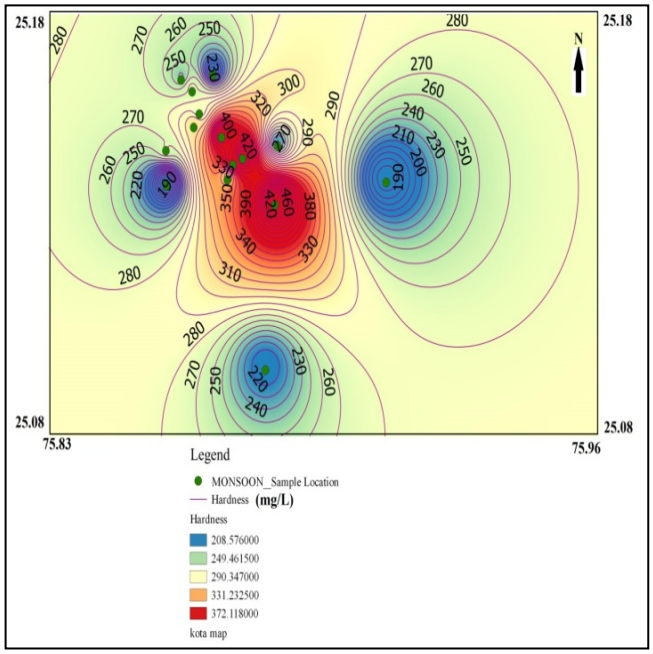

Fig.9: Spatial distribution of Total Hardness during Monsoon

TH in pre-monsoon period with lower range of 178 mg/L (A3-Soorsagar) and higher range 453 mg/L (S8-Samudayik Bhawan Ke Paas Prem Nagar III) was observed. Area wise central part has higher concentration (> 365) while south, east, northeast and north parts appear to have lowest concentrations of (< 231) salts. (Figure 10)

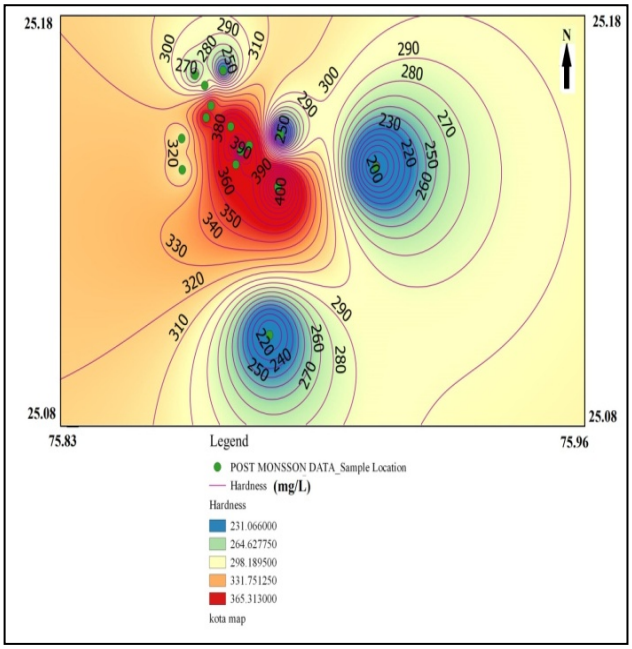

Fig.10: Spatial distribution of Total Hardness during Post-monsoon

However, GIS indicates no appreciable variation between the pre, during monsoon and post monsoon periods in water quality for TH. Almost all areas of study during pre monsoon, monsoon and post monsoon periods fall under low ion concentration of < 300 mg/l category. But central part alone falls under highest ion concentration of > 300 category it indicates higher possibility of corrosion. Hard water also forms deposits that clog plumbing.

4. Conclusions

Pre monsoon and post monsoon analysis of samples indicate significant changes. Electrical conductivity is high in all seasons in most of areas while some of them lie in doubtful category. Only one sample was found in excellent category and is of Bombay yogena (S1) during Post-monsoon. During pre monsoon period TDS content is above desirable limits and during Monsoon & post monsoon period TDS content is low in some locations. It can be assumed to be due to addition of rainwater into the groundwater regime through infiltration. The locations Bombay yogena (S1), Raipura (A1), Daddavi (A2), Soorsagar (A3), Dhakerkhari (A4) with low TDS point out that water is potable in these areas. In other locations TDS exceeds the desirable limit and water is non-potable. TH values indicate that quality of water is either hard or very hard thus requiring prior treatment of water. The study reveals that quality of ground water changes in all seasons. Ground water of central part of study area is mostly affected by pollution and sewage waste. Corrosion, pipe chocking, renal problems and abdomen pain like problems are present. As such, groundwater quality and its suitability is an area of concern in future as exhibited by GIS while taking TH, EC and TDS in consideration.

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