Chapter 3

Seasonal Variability of Geochemical Parameters of Surface Water

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3.1 INTRODUCTION

To study the characteristics of surface water quality various surface water samples were collected from different parts of the study area and physicochemical characteristics were analysed. In this chapter, the different water parameters such as *TDS, pH, EC, iron, magnesium, calcium, sodium, potassium, fluoride, lead, mercury* and *nitrite* were determined using standard procedures for monsoon, post-monsoon and pre-monsoon seasons (2013-2014). The seasonal variability of surface water was studied with respect to these parameters and thus an attempt was made to ascertain the quality of surface water.

3.2 CHARACTERISTICS OF SURFACE WATER

3.2.1 Concentration of *TDS*

During pre-monsoon, the concentration of *TDS* varied between 320.00 mg/l and 2108.80 mg/l. The average concentration was 1196.08 mg/l and standard deviation was 475.21. The high mean and standard deviation indicated significant variation in the concentration of *TDS* in surface water. High level was observed at *Nandesari* (2108.80 mg/l) and *Dasharath* (2041.60 mg/l).The former is adjacent to *Nandesari* GIDC while the

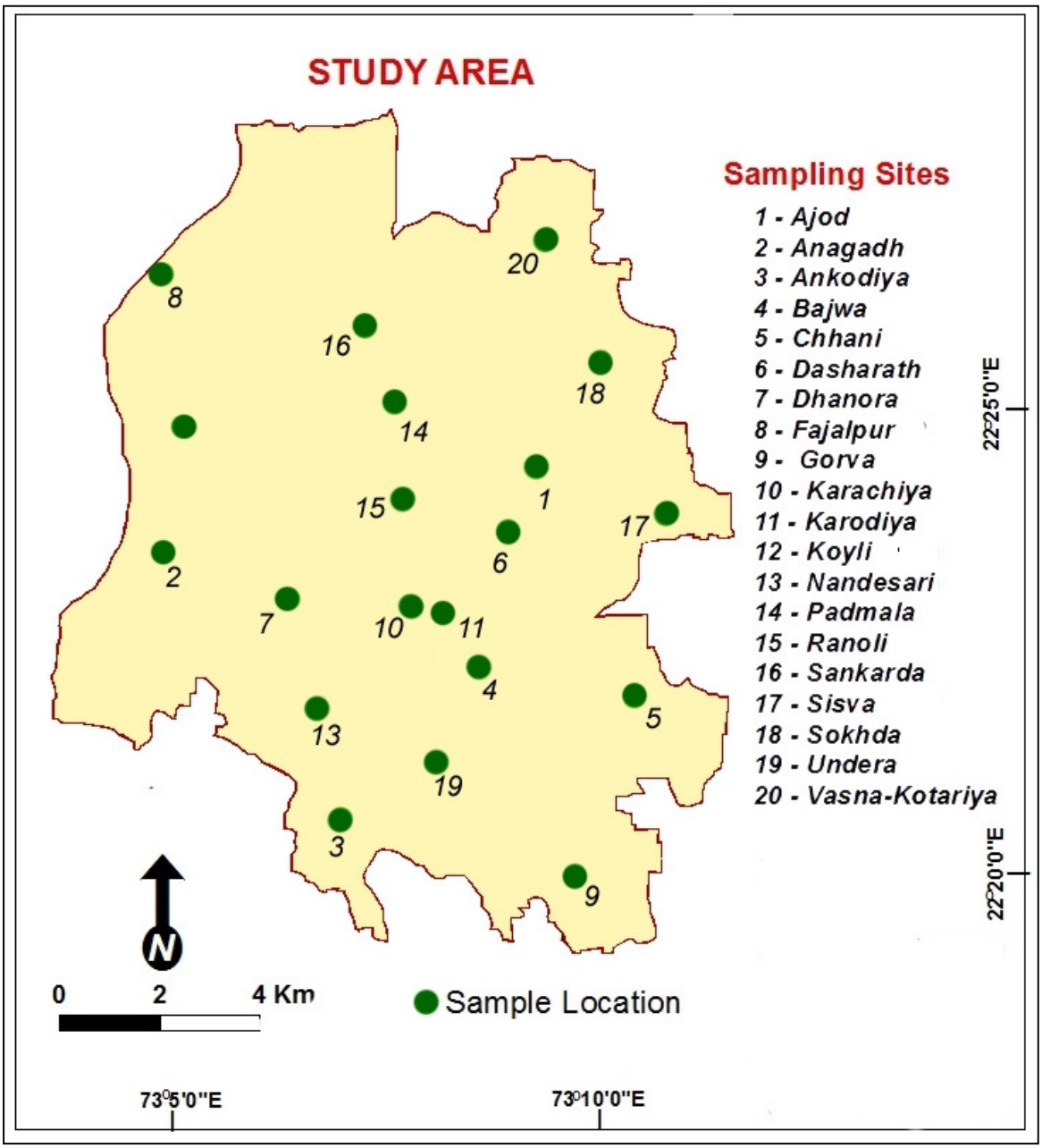

Fig.3.1: Surface Water Sample Location

latter is located near GSFC. Lower absorption was noted in *Fajalpur* (320.00 mg/l) and *Anagadh* (556.80 mg/l) villages.

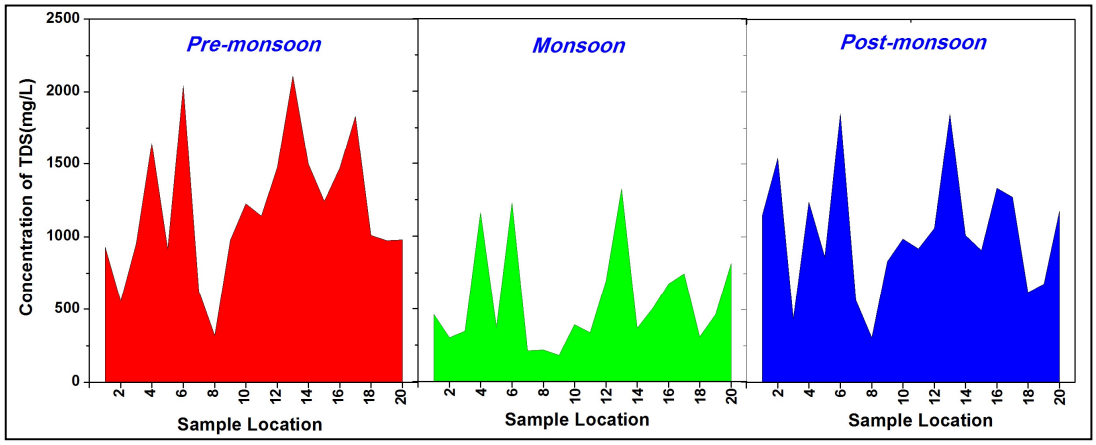

Fig.3.2: Concentration of *TDS* in Different Seasons

In monsoon season, the level of *TDS* decreased in all the sample locations (Fig.3.1). It ranged from 179.20 mg/l to 1323.20 mg/l with an average of 554.12 mg/l. The high standard deviation (344.62) denoted the spatial variability of the concentration. The sites near the industrial estates i.e. *Nandesari, Dashrath* and *Bajwa* had higher concentration of *TDS* (>1000 mg/l) while the least value (179.20 mg/l) was observed at *Gorva.*

In the post-monsoon period, the level of *TDS* varied between 307.20 mg/l and 1849.60 mg/l. The mean was 1029.48 mg/l. A considerably high variation in the concentration of *TDS* was observed in the study area (417.21). *Dasharath* had the highest *TDS* level (Fig.3.1) followed by *Nandesari* (1846.40 mg/l). The lowest (307.20 mg/l) was observed at *Fajalpur.*

3.2.2 *pH* Level

The level of *pH* during the pre-monsoon ranged from 7.00 to 8.00, indicating normal to alkaline condition. The mean of *pH* was 7.75 which showed the alkaline condition with low standard deviation (0.34). The higher *pH* value (8.00) was observed at many sites (*Anagadh, Ankodiya, Bajwa, Channi, Dasharath, Sankarda, Koyli, Nandesari,*

Padmala and Ranoli) of the study area while the normal value (7.00) was observed only at *Fajalpur.*

During the monsoon season, the *pH* value varied between 6.50 and 7.50 with the average value of 6.83. A less deviation from the mean was noted (0.34) (Table 3.11). Highest *pH* level was observed at *Koyli* only whereas the lower value was found in many parts *(Anagadh, Dasharath, Fajalpur, Gorva, Karodiya, Padmala* and *Ranoli)* of the study area.

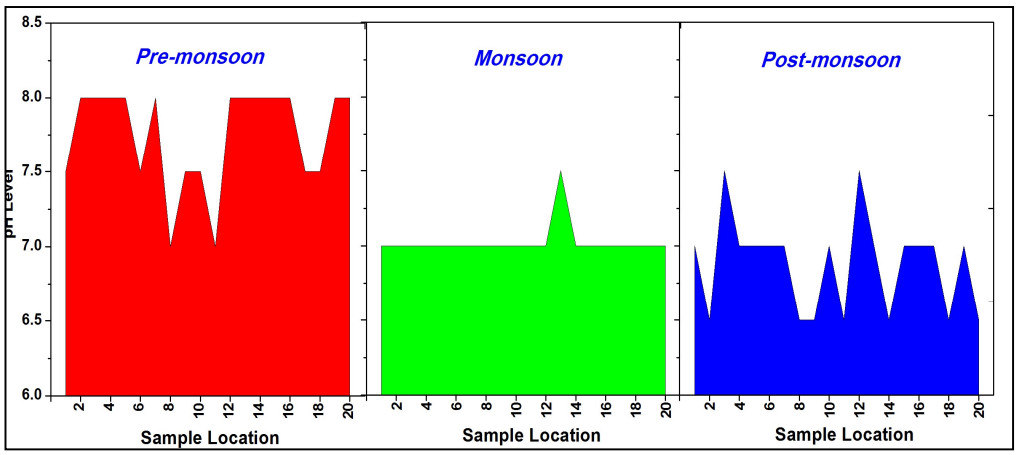

Fig.3.3: Concentration of *pH* in Different Season

In post-monsoon seasons, *pH* ranged from normal (7.00) to alkaline (8.00) condition. The mean depicted slightly alkaline condition. Less variation in *pH* value was observed in terms of standard deviation (0.36). The surface water of *Undera, Gorwa* and *Vasna-Kotariya* had alkaline water condition (8.00).

3.2.3 Concentration of *EC*

The level of *EC* during the pre-monsoon varied from 0.50 s/cm^{-1}x 10^{-3} to 3.30 s/cm^{-1}x 10^{-3} with the mean of 1.87 s/cm^{-1}x 10^{-3}. (Fig.3.3). The standard deviation showed relatively lesser variability (0.74 s/cm^{-1}x 10^{-3}) of *EC* throughout the study area. The high *EC* value (>3 s/cm^{-1}x 10^{-3}) was found at *Nandesari* and *Dasharath* whereas *Anagadh* and *Fajalpur* depicted comparatively lower (<0.5 s/cm^{-1}x 10^{-3}) level of *EC.*

During the monsoon, the level of *EC had* a minimum value of 0.28 s/cm^{-1}x 10^{-3} and maximum of 2.07 s/cm^{-1}x 10^{-3} (Fig.3.3) which were noted at *Gorva* and *Nandesari*

respectively. The average value was 0.87 and the deviation from the mean was 0.54. The high level of *EC* >1.5 s/cm^{-1}x 10^{-3} was also found in *Bajwa* and *Dasharath*. *Dhanora, Fajalpur and Gorva* showed the *EC* value <0.35 s/cm^{-1}x 10^{-3}.

Table 3.1: Surface Water Parameters in Different Seasons (2013-2014)

Parameter	Season	N	Average	Min.	Max.	St. Dev.
TDS	Pre-monsoon	20	1196.08	320	2108.8	475.21
TDS	Monsoon	20	554.12	179.2	1323.2	344.62
TDS	Post-monsoon	20	1029.48	307.2	1849.6	417.21
pH	Pre-monsoon	20	7.75	7	8	0.34
pH	Monsoon	20	6.83	6.5	7.5	0.34
pH	Post-monsoon	20	7.38	7	8	0.36
EC	Pre-monsoon	20	1.87	0.5	3.3	0.74
EC	Monsoon	20	0.87	0.28	2.07	0.54
EC	Post-monsoon	20	1.61	0.48	2.89	0.65

The unit of the parameters is in mg/l except EC (s/cm-1x 10-3) and pH, N=Total number of samples

Source: Computed

In the post-monsoon season, the level of *EC* varied between 0.48 s/cm^{-1}x 10^{-3} and 2.89 s/cm^{-1}x 10^{-3}. Both the mean value (1.61 s/cm^{-1}x 10^{-3}) and the standard deviation (0.65) were higher than in the monsoon season. An intensity >2.5 s/cm^{-1}x 10^{-3} was found in the surface water of *Dasharath* and *Nandesari*. Whereas, *Fajalpur* (0.48 s/cm^{-1}x 10^{-3}),

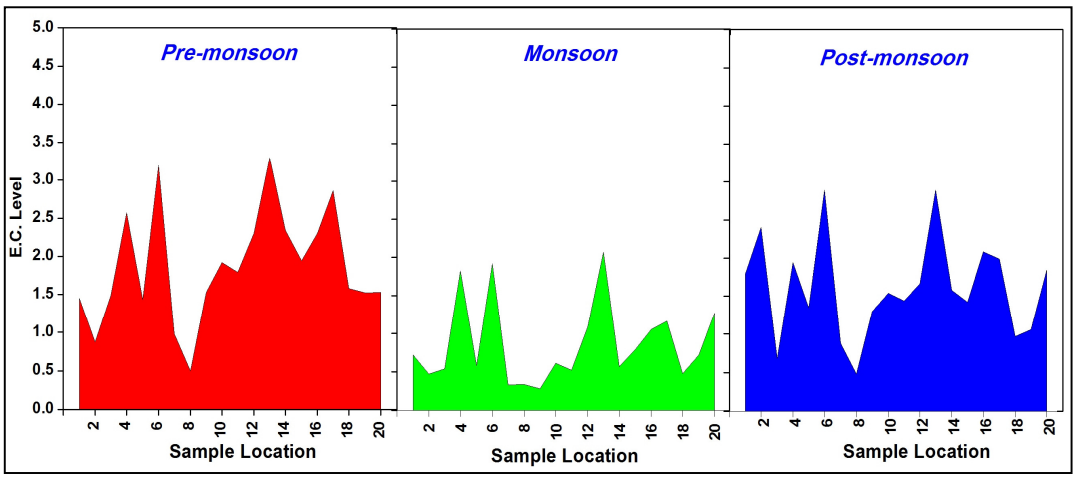

Fig.3.4: Concentration of *EC* in Different Seasons

Ankodiya (0.68 s/cm^{-1}x 10^{-3}) and *Dhanora* (0.88 s/cm^{-1}x 10^{-3}) had depicted the lower level of *EC*.

3.2.4 Concentration of *Iron*

The concentration of *iron* in surface water ranged between 1.76 mg/l and 4.03 mg/l during the pre-monsoon. The mean (2.82 mg/l) and standard deviation (0.68) value was low denoting a comparatively lesser variation in the level of concentration. *Bajwa* had the highest concentration of *iron* in surface water which was followed by *Dasharath* (3.98 mg/l) and *Nandesari* (3.52 mg/l). A relatively lower concentration was observed in the village of *Sankarda* (1.76 mg/l), *Ajod* (1.95 mg/l) and *Sisva* (1.98 mg/l).

In the rainy season, the concentration of *iron* varied between 0.79 mg/l to 2.16 mg/l (Fig.3.4). The average concentration of *iron* was 1.11 mg/l and deviation from the mean 0.37 indicating the less variation of *iron* concentration throughout the space. In this season, comparatively higher level of concentration was observed at *Bajwa* (2.16 mg/l) and *Nandesari* (2.00 mg/l). *Dhanora* (0.79 mg/l), *Chhani* (0.83 mg/l) and *Undera* (0.82 mg/l) depicted lesser concentration.

During post-monsoon, the *iron* concentration ranged from 1.11 mg/l to 3.60 mg/l with the lower average level (1.70 mg/l) and standard deviation (0.58). Higher concentration (≥2 mg/l) was noted in *Nandesari* and *Bajwa,* while the lower was observed at *Sankarda* (1.11 mg/l) and *Fajalpur* (1.12 mg/l).

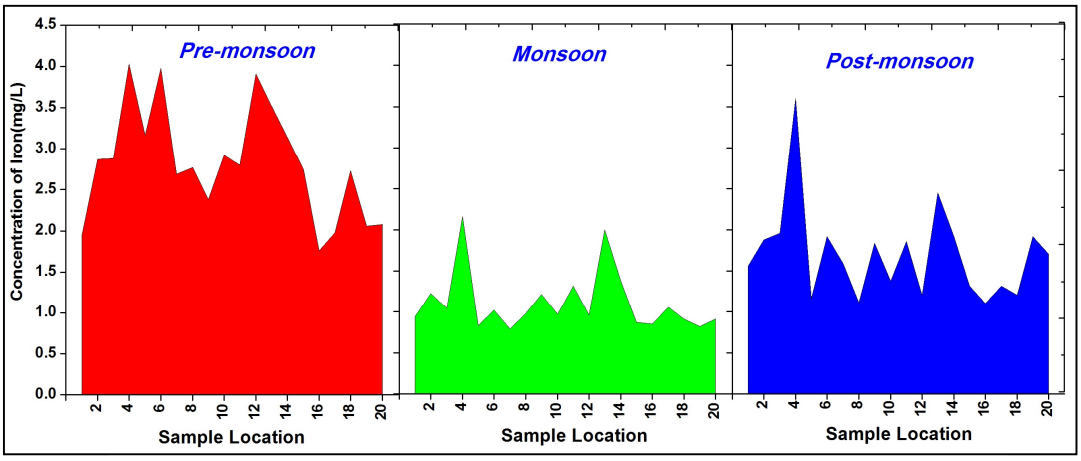

Fig.3.5: Concentration of *Iron* in Different Seasons

3.2.5 Concentration of *Magnesium* (*Mg*)

In the pre-monsoon season, the concentration of *magnesium* ranged between 9.00 mg/l to 108.00 mg/l. The mean value was 31.60 mg/l. A considerably high variation in the level of *magnesium* was observed (30.47 mg/l). The highest concentration (108.00 mg/l) was noted at *Dasharath* whereas dilution of 97.00 mg/l was found at *Sankarda* and at *Sisva* (93.00 mg/l). Only 9.00 mg/l of *magnesium* concentration was noted at *Dhanor*a.

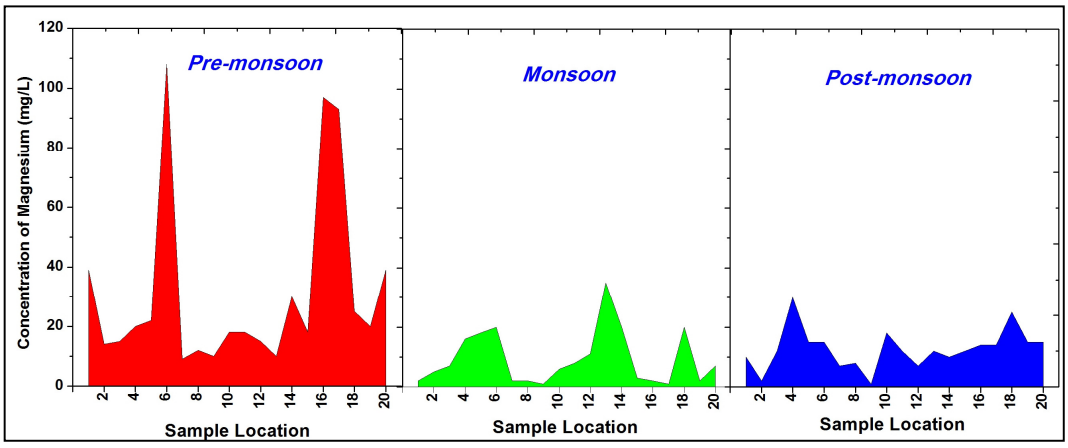

Fig.3.6: Concentration of *Magnesium* in Different Seasons

During monsoon, concentration of *magnesium* varied between 1.00 mg/l to 35.00 mg/l. The mean and standard deviation value were 9.40 mg/l and 9.21 respectively. (Fig.3.5). *Nandesari* had highest amount of *magnesium*. On the other hand, less concentration of *magnesium* was noted in *Sisva* and *Gorwa.*

Table 3.2: Surface Water Parameters in Different Seasons (2013-2014)

Parameter	Season	N	Average	Min.	Max.	St. Dev.
Iron	Pre-monsoon	20	2.82	1.76	4.03	0.68
Iron	Monsoon	20	1.11	0.79	2.16	0.37
Iron	Post-monsoon	20	1.7	1.11	3.6	0.58
Magnesium	Pre-monsoon	20	31.6	9	108	30.47
Magnesium	Monsoon	20	9.4	1	35	9.21
Magnesium	Post-monsoon	20	12.7	1	30	6.72
Calcium	Pre-monsoon	20	95.5	32	258	57.72
Calcium	Monsoon	20	48.5	20	108	22.92
Calcium	Post-monsoon	20	70.35	32	128	30.5

The unit of the parameters is in mg/l

Source: Computed

In the post-monsoon the concentration of *magnesium* ranged from 1.00 mg/l (at *Gorva*) to 30.00 mg/l (at *Bajwa*). The average value was 12.70 mg/l. The low standard deviation (6.72) indicated the lesser variability in concentration. *Gorva* depicted the same level of concentration during and after the rains.

3.2.6 Concentration of *Calcium*

In pre-monsoon, minimum concentration was 32.00 mg/l and maximum was 258.00 mg/l. 95.50 mg/l was the average concentration and 57.72 was the standard deviation. >150 mg/l of calcium was found in *Dasharath, Padmala* and *Sankarda* (Fig.3.6). While *Dhanora, Koyli* and *Vasna-Kotariya* had <50 mg/l of *calcium*.

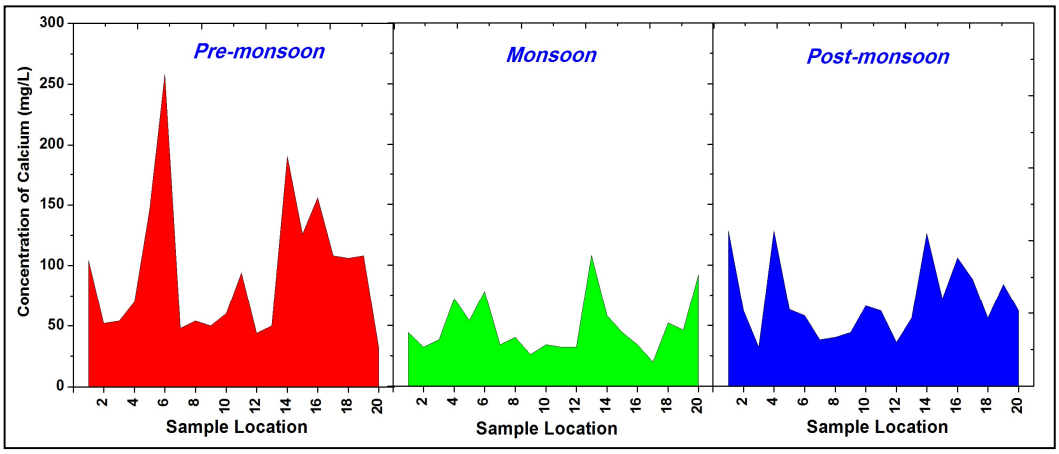

Fig.3.7: Concentration of *Calcium* in Different Seasons

During rainy season, the level of *calcium* in surface water varied from 20.00 mg/l at *Sisva* to 108.00 mg/l at *Nandesari*. The mean concentration was 48.50 mg/l and the deviation from the mean was 22.98. The concentration of >75 mg/l was noted at *Bajwa* (72.00 mg/l), *Dashrath* (78.00 mg/l), *Vasna-Kotariya* (92.00 mg/l) while *Gorwa* had *Sisva* village had lower concentration of *calcium*.

In the post-monsoon season, the minimum level of calcium was 32.00 mg/l in *Ankodiya* and the maximum was 128.00 mg/l at *Bajwa*. The mean dilution was 70.35 mg/l and high variability of concentration (30.50) was observed. >120.00 mg/l absorption was observed at *Ajod* and *Padmala*. *Koyli* and *Dhanora* had lower concentration (<39 mg/l).

3.2.7 Level of *Sodium*

The concentration of *sodium* ranged from 32.00 mg/l to 368.00 mg/l during pre-monsoon season indicating a large variation in the level of *sodium*. 137.90 mg/l and 92.29 were the average concentration and standard deviation respectively. *Padmala* and *Sisva* had very high concentration of *sodium* (350.00 mg/l) while low absorption (<50 mg/l) was observed at *Fajalpur and Gorva.*

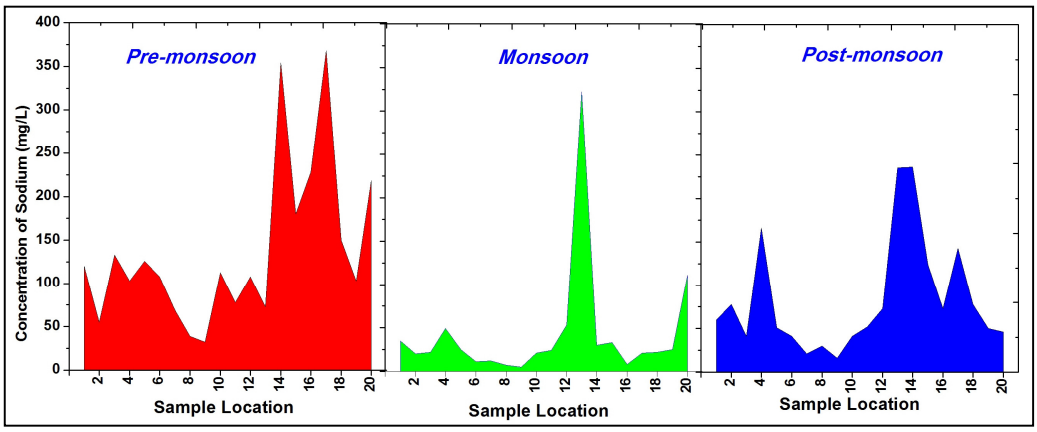

Fig.3.8: Concentration of *Sodium* in Different Seasons

In the monsoon season, level of *sodium* varied between 5.00 mg/l and 322.00 mg/l. The mean value was 42.80 mg/l while 69.69 was the standard deviation indicating larger deviation from the mean. Other than *Nandesari* and *Vasna-Kotariya*, all the sample locations depicted <50 mg/l of concentration.

After the rainfall, the minimum level of *sodium* was 16.00 mg/l and maximum was 236.00 mg/l with an average of 82.75 mg/l. Standard deviation was 65.03. The concentration drastically increased in *Padmala, Sisva* and *Bajwa* (Fig. 3.7) whereas, in *Nandesari* and *Vasna-Kotariya* it decreased.

3.2.8 Level of *Potassium*

During pre-monsoon season the level of *potassium* ranged from below detectable limit (BDL) to 10.00 mg/l. The mean value was 2.90 mg/l with the standard deviation of 2.25. All the sample location depicted <5.00 mg/l excluding *Sisva* (10.00 mg/l). The concentration was BDL at *Fajalpur* and *Gorva*.

During the monsoon, the amount of *potassium* varied between BDL to 8.00 mg/l (*Vasna-Kotariya*) with a mean of 1.90 mg/l. The low deviation from the mean denoted less variation in concentration. In this season, *potassium* was BDL in *Fajalpur, Gorva, Karachiya and Sankarda.*

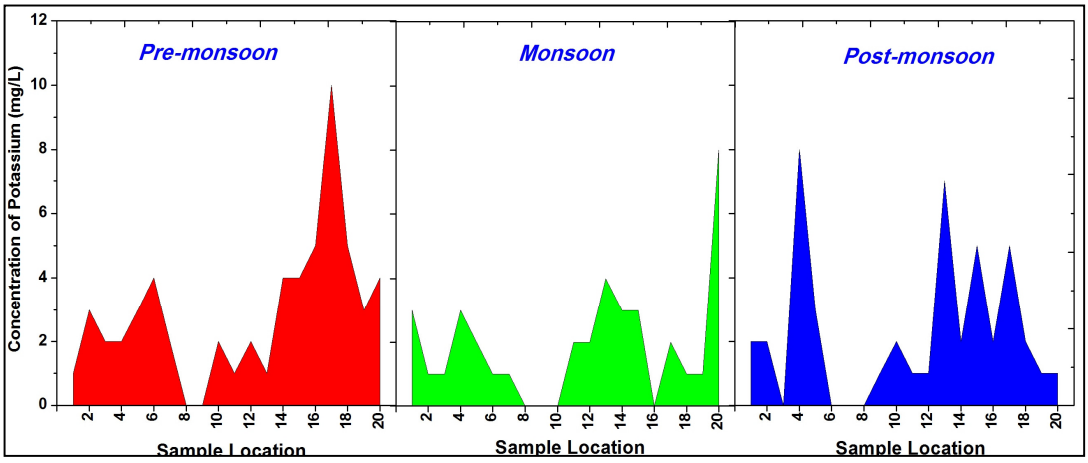

Fig.3.9: Concentration of *Potassium* in different Seasons

In the post-monsoon season, the level of *potassium* range was same as in the monsoon. The location of maximum concentration (8.00 mg/l) changed from *Vasna-Kotariya* to *Bajwa.* 2.25 mg/l was the average concentration and the deviation from the mean (2.29) increased after the monsoon. Thus, the overall level and spatial variability of concentration was higher in this season.

3.2.9 Concentration of *Nitrite*

During the pre-monsoon, the concentration of *nitrite* varied from 19.42 mg/l to 79.35 mg/l which were noted in *Sankarda* and *Vasna-Kotariya* respectively. The mean concentration was 52.32 mg/l and the deviation from the mean was low (16.76). *Ankodiya, Ajod and Dasharath* had higher level of concentration (Fig. 3.7) while the lower level was noted at *Sankarda, Ranoli and Sisva.*

The level of *nitrite* during the monsoon season, ranged from 16.97 mg/l to 68.12 mg/l and mean was 42.57 mg/l. A considerably low standard deviation (13.85) was observed indicating less variation in the level of concentration. *Ankodiya* had the highest

concentration (68.12 mg/l) which was followed by *Vasna-Kotariya* (67.15 mg/l) and *Dasharath* (58.18 mg/l). *Sisva, Sankarda* and *Padmala* depicted less concentration.

After the rainfall, the *nitrite* concentration in surface water varied from 54.27 mg/l to 117.84 mg/l. The average concentration was 80.04 mg/l with low standard deviation (15.36) which denoted the variability of concentration throughout the study area. The concentration >100 mg/l was observed at *Vasna-Kotariya* and *Ankodiya*. The minimum level of concentration (54.27 mg/l) was observed in *Padmala*.

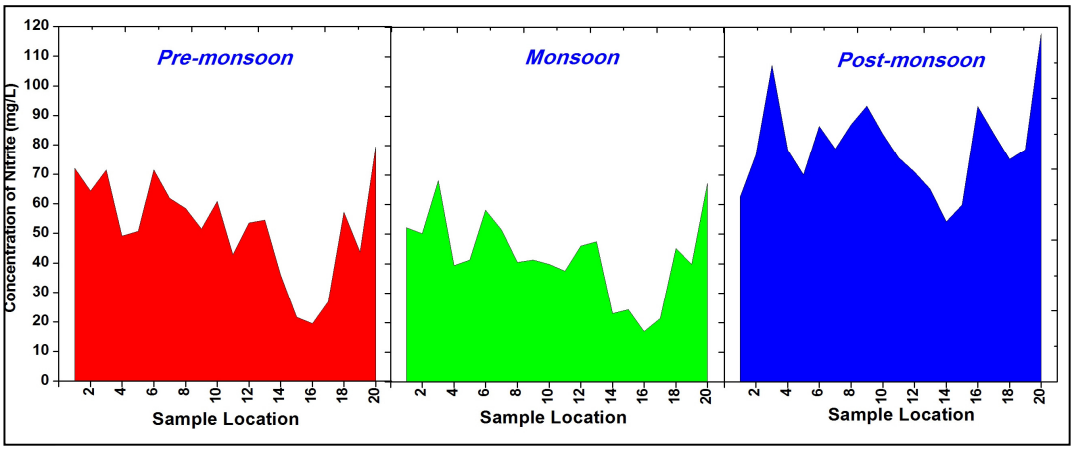

Fig.3.10: Concentration of *Nitrite* in different Seasons

Table 3.3: Surface Water Parameters in Different Seasons (2013-2014)

Parameter	Season	N	Average	Min.	Max.	St. Dev.
Sodium	Pre-monsoon	20	137.9	32	368	92.29
Sodium	Monsoon	20	42.8	5	322	69.69
Sodium	Post-monsoon	20	82.75	16	236	65.03
Potassium	Pre-monsoon	20	2.9	0	10	2.25
Potassium	Monsoon	20	1.9	0	8	1.86
Potassium	Post-monsoon	20	2.25	0	8	2.29
Nitrite	Pre-monsoon	20	52.32	19.42	79.35	16.76
Nitrite	Monsoon	20	42.57	16.97	68.12	13.85
Nitrite	Post-monsoon	20	80.04	54.27	117.84	15.36

The unit of the parameters is in mg/l

Source: Computed

3.3 SPATIAL AND SEASONAL PATTERN:

3.3.1 Concentration of *TDS*

During the pre-monsoon season, the highest level (>2000 mg/l) was observed in pockets on the west. The eastern and western parts represented the concentration of 1500-2000 mg/l of *TDS*. The maximum parts of the study area had the *TDS* level between 1000-1500 mg/l which was noted in the northern, central and southern parts. The north-west and south-west had the lowest level (>1000 mg/l).

During the monsoon season, the level of *TDS* reduced considerably. A small portion in the western and eastern segments depicted the level between 1000 mg/l to 1500 mg/l which was the highest concentration in this season. The northern, eastern and central parts had the level of 500 mg/l-1000 mg/l. Whereas <500 mg/l of concentration was found in the south-western, southern and north-western part.

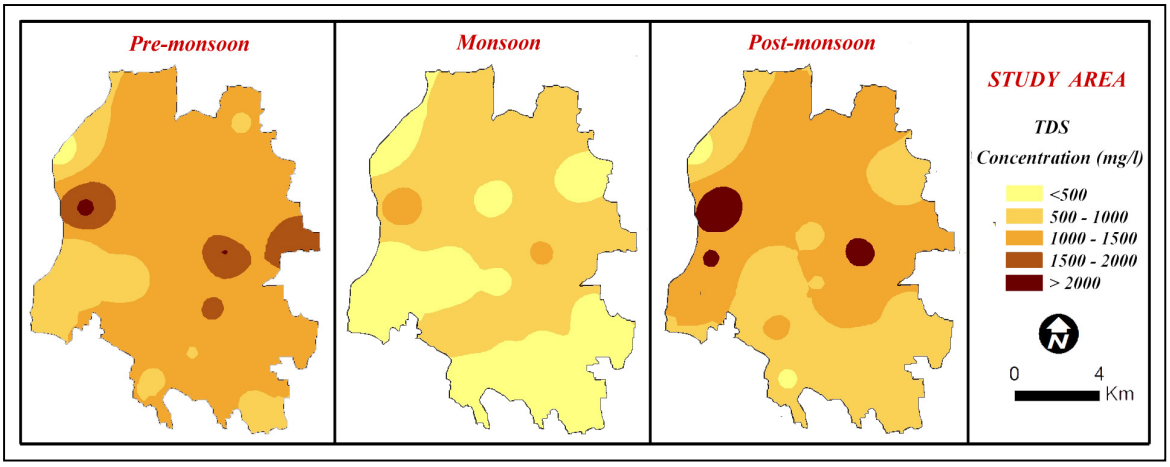

Fig.3.11: Concentration of *TDS*

After the monsoon, the intensity of TDS again increased. The maximum concentration was confined to the western and central part. The region of concentration having 500 mg/l to 1000 mg/l of *TDS* in the monsoon season was more or less replaced by 1000 mg/l – 1500 mg/l during post-monsoon. The southern, north-western and north-eastern region had 500 mg/l - 1000 mg/l.

3.3.2 Level of *pH*

The *pH* level in the entire region depicted less variation. During pre-monsoon, the entire study area had 7 to 8 *pH* value. The level between 7.5 to 8 was noted in the northern, eastern, western and central southern parts whereas the north-western and south-eastern depicted the *pH* level of 7 -7.5.

During the rainy season, the whole region was covered with *pH* level of 6.5- 7 excluding the south-western part which was occupied with 7 to 7.5. In the post-monsoon season, the area with 7 to 7.5 increased remarkably and was noted in the largest part of the study area. In the north-eastern and southern parts the *pH* level was >7.5.

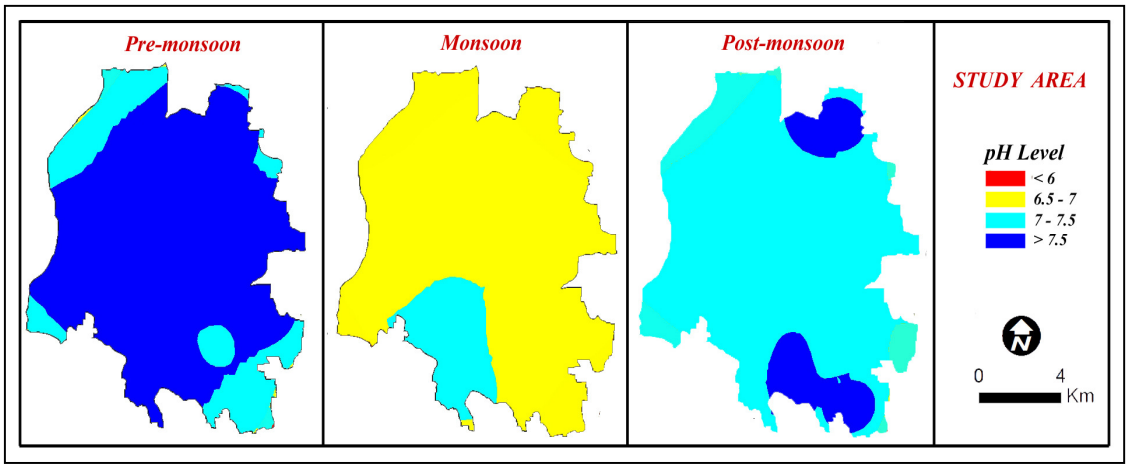

Fig.3.12: *pH* Level

3.3.3 *EC* level

In pre-monsoon, the high level of *EC* (>2 s/cm^{-1}x 10^{-3}) was noted in the segment extending from north-west to east. In the northern and southern sectors 1.5 s/cm^{-1}x 10^{-3} to 2 s/cm^{-1}x 10^{-3} of *EC* was noted. In the extreme north-western and south-western part the level was below 1.00 s/cm^{-1}x 10^{-3}.

During the monsoon, the maximum concentration (>2 s/cm^{-1}x 10^{-3}) was observed only in a very small pocket in the western part. The concentration of 1 s/cm^{-1}x 10^{-3} to 1.5 s/cm^{-1}x 10^{-3} was found in north-east, east and west. The major portion of the study area had 0.5 s/cm^{-1}x 10^{-3} to 1 s/cm^{-1}x 10^{-3} of *EC* during rainy season.

In post-monsoon, the concentration of *EC* was >2 s/cm^{-1}x 10^{-3} in the western and central eastern parts. The northern and central sectors denoted the 1.5 s/cm^{-1}x 10^{-3} to 2 s/cm^{-1}x 10^{-3} whereas, the extreme north-eastern depicted relatively lower concentration.

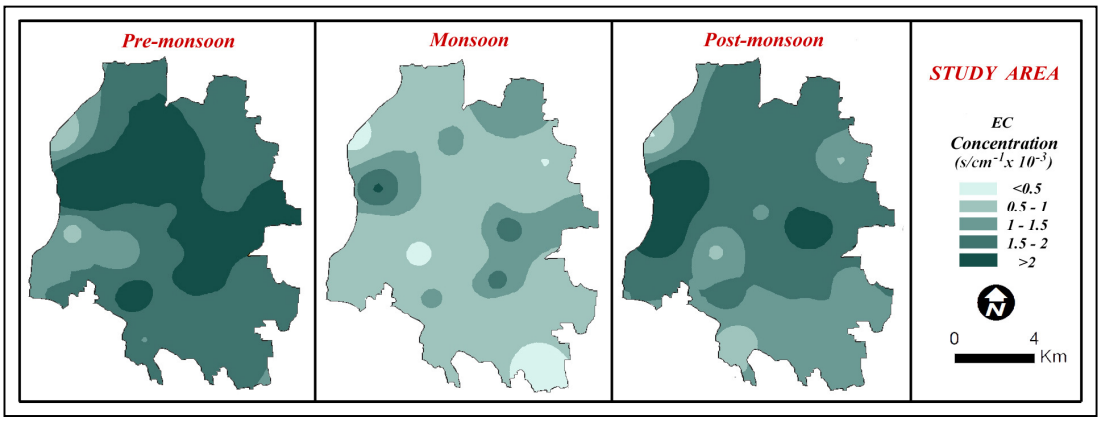

Fig.3.13: *EC* Level

3.3.4 Concentration of *Iron*

The concentration of *iron* during pre-monsoon was >1.5 mg/l throughout the space. The highest concentration (>3 mg/l) was observed in the western as well as in a belt extending from east to west lying in the southern part. In the remaining areas concentration of *iron* was 2 mg/l to 3 mg/l.

During monsoon, >1.5 mg/l was noted only in the western and in a small patch of central southern part. 1-1.5 mg/l of *iron* was observed at the western, central and southern part while the north-eastern segment had 0.5 mg/l - 1 mg/l of the elements.

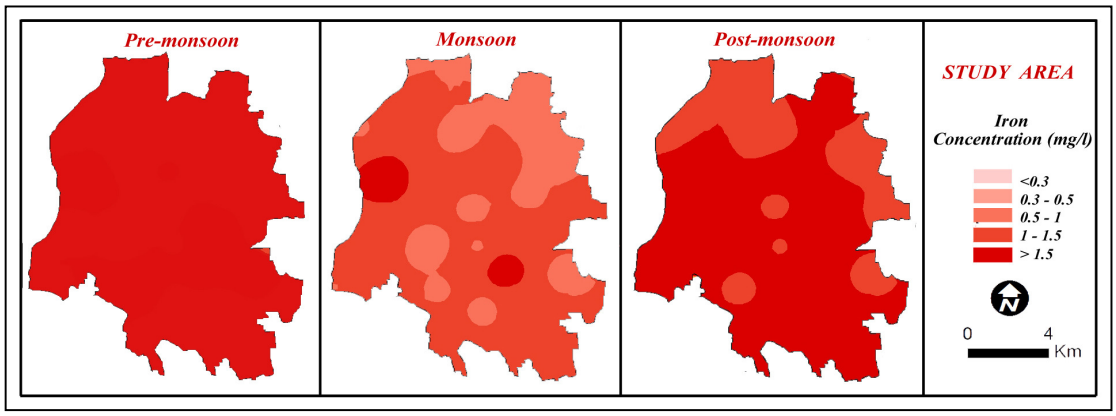

Fig.3.14: Concentration of *Iron*

In post-monsoon, the area of concentration with >1.5 mg/l of *iron* tremendously increased and extended in the western, central and southern sides. While the north-western, north-eastern and eastern portions showed the concentration of 1 mg/l to 1.5 mg/l.

3.3.5 Concentration of *Magnesium*

During pre-monsoon, the highest level of *magnesium* was noted in the belt extending from north to east. From this belt the concentration decreased towards south-west. The south-eastern and south-western had the concentration of 10 mg/l to 20 mg/l. Minimum level was noted at south-western part.

In monsoon, the major part of the study area depicted <10 mg/l of *magnesium*. The concentration of 10 mg/l -20 mg/l was noted in the segment extending from western to eastern and south-eastern part. The western portion denoted the highest concentration (>30 mg/l).

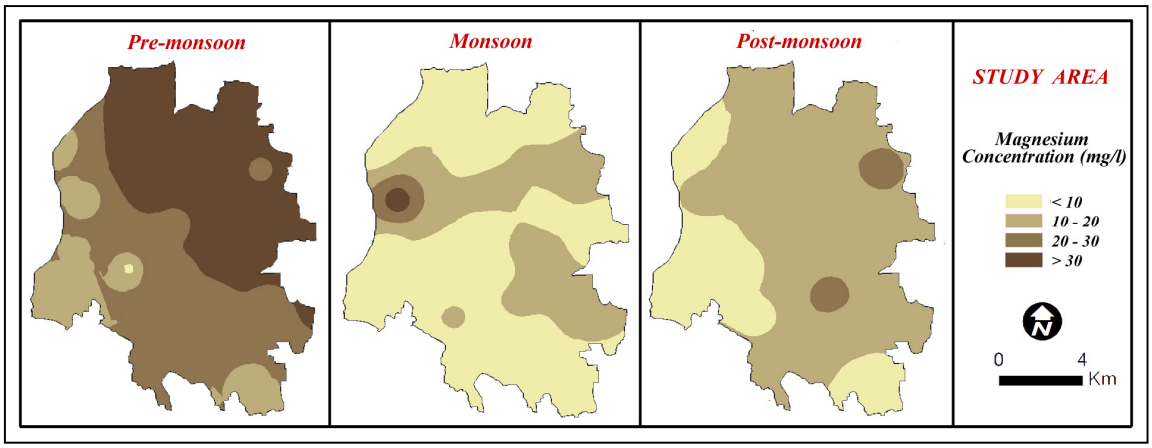

Fig.3.15: Concentration of *Magnesium*

After the monsoon, the level of 10 mg/l -20 mg/l *magnesium* was observed in the northern, central, eastern and southern sides. While the lower concentration (<10 mg/l) was confined to the extreme north-east, south-west and south-east. The intensity of 20 mg/l -30 mg/l was observed in north-eastern and southern sides.

3.3.6 Concentration of *Calcium*

During pre-monsoon, the region which stretched from north to south-east including the entire eastern part depicted the maximum concentration of *calcium*. On the western side of this segment the intensity decreased. The south-western and southern most part had 40 mg/l-60 mg/l. The concentration between 20 mg/l -40 mg/l was noted in a very small area on the north-eastern part.

During the rainy season, the patches in the northern and western part had >80 mg/l of *calcium*. The northern, central and south-eastern parts had 40 mg/l-60 mg/l occupying the major area. The southern and eastern segments portrayed <40 mg/l of *calcium*.

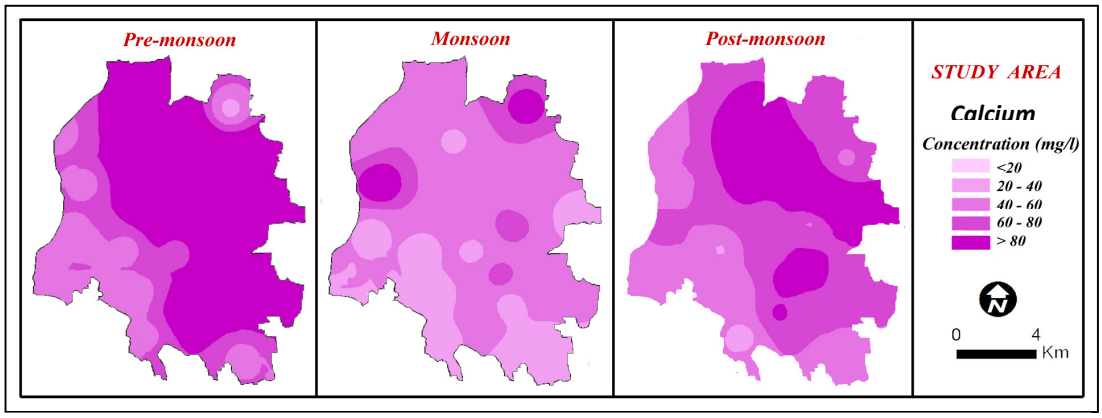

Fig.3.16: Concentration of *Calcium*

After the monsoon, >80 mg/l *calcium* was noted in the northern, eastern, central and southern parts. 60 mg/l-80 mg/l level was spread on the north-eastern, central and south-eastern region. While the western and southern portions had 40 mg/l - 60 mg/l.

3.3.7 Concentration of *Sodium*

The entire northern, central and eastern parts denoted the maximum concentration (>120 mg/l) of *sodium* during the pre-monsoon season. Western and south-eastern part had relatively lesser concentration (30 mg/l-60 mg/l). South showed 90 mg/l-120 mg/l excluding the southern tip of the study area.

During rains, the absorption was highest in western part (>120 mg/l). The northern, central and south-western sides showed 30 mg/l-60 mg/l of *sodium*. The lowest level (<30 mg/l) was observed in the eastern, central and southern region.

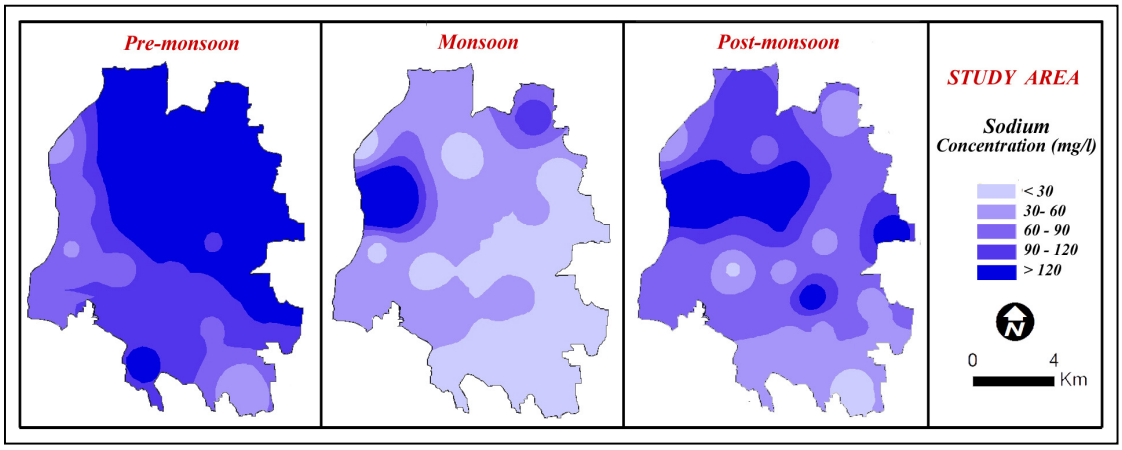

Fig.3.17: Concentration of *Sodium*

In post-monsoon, the area of higher concentration of *sodium* increased. The western, central and eastern denoted the maximum concentration (>120 mg/l). The dilution of 60 mg/l-90 mg/l was spread in the north-eastern, central and south-western sides. Whereas the lower concentration (<1 mg/l) was observed in the southern part.

3.3.8 Concentration of *Potassium*

During pre-monsoon, northern, north-eastern and eastern sectors had >4 mg/l of *potassium*. The concentration of 3 mg/l to 4 mg/l was observed in the central part. The

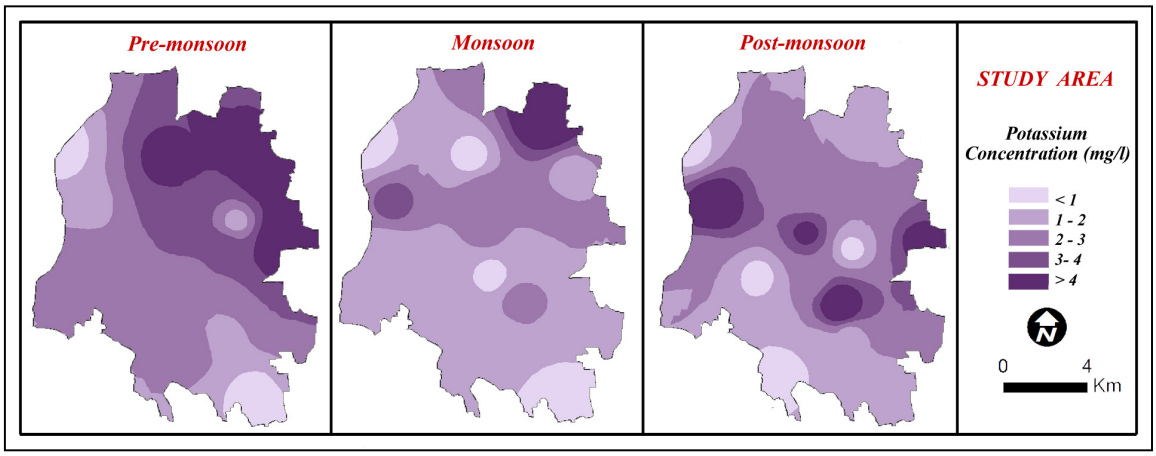

Fig.3.18: Concentration of *Potassium*

south-west sector had 2 mg/l to 3 mg/l. The lowest concentration was found at the border of north-west and south-east.

In the rainy season, the maximum concentration >4 mg/l was noted in the northern part only. The central, eastern and western segments had of 2 mg/l to 3 mg/l of *potassium*. The level of 1 mg/l to 2 mg/l covered the largest area spreading over northern and southern parts. While the lowest concentration (Fig. 3.17) was observed in the central part.

After the rains, the western, central and eastern portion indicated the highest concentration (>4 mg/l). The absorption between 2 mg/l to 3 mg/l was found in the central part while northern and southern segments had relatively lesser concentration (Fig. 3.17) of *potassium*.

3.3.9 Concentration of *Nitrite*

In pre-monsoon, the concentration of *nitrite* was >85 mg/l. The higher level (65 mg/l to 85 mg/l) was observed in the pockets in north, central and south. 45 mg/l to 65 mg/l absorption was spread in the largest area which extended from central to northern and the eastern parts.

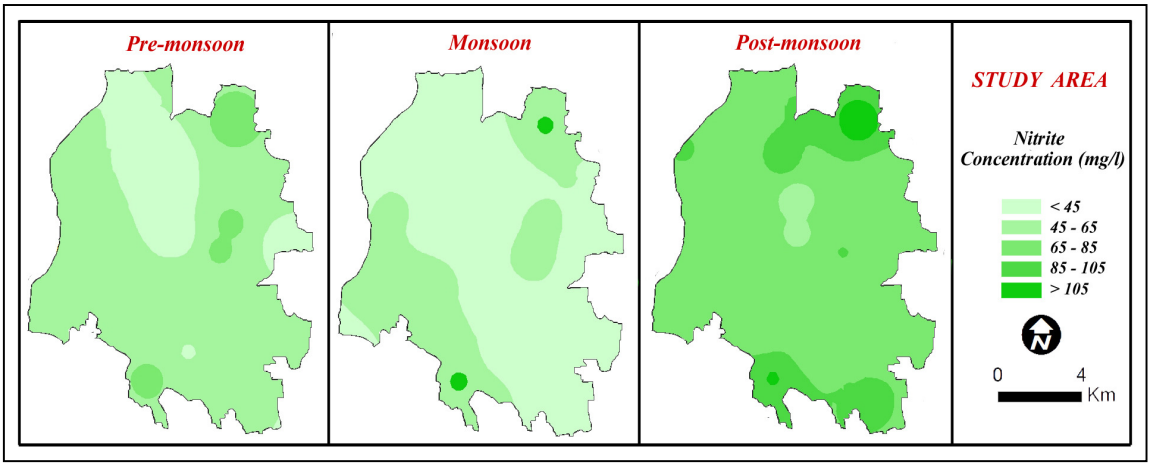

Fig.3.19: Concentration of *Nitrite*

During monsoon, >105 mg/l *nitrite* was observed in the north-eastern and southern sides. The region extending from north-east to south-east represented the

lowest concentration (<45 mg/l) covering the largest area. 45 mg/l to 65 mg/l was noted in the north-eastern and south-western parts.

In post-monsoon, the higher concentration of 85 mg/l -105 mg/l and >105 mg/l was noted on the north and south. The maximum area (Fig.3.18) had the concentration of 65 mg/l to 85 mg/l spreading in the western, central and eastern sectors.

3.4 SEASONAL VARIABILITY

The correlation and pair t-test were calculated for pre-monsoon, monsoon and post-monsoon seasons on 20 samples at 95% significance level. The outcome from the correlation indicated the relationship of level of parameters and the results of 't'-test signified the changing pattern in the mean of parameters in different season. To carry out the analysis, three pairs had been made for single parameter.

3.4.1 *TDS*

The correlation value of pair 1t, pair 2t and pair 3t for *TDS* were (+)0.821, (+)0.768 and (+)0.709 respectively which indicated the strong positive relationship in level of *TDS* among the seasons. The calculated t value of all three pairs (10.434, 7.927 and 2.162) was higher than the tabulated value i.e. 1.729. Thus, null hypothesis was rejected and it can be concluded that there was significant change in the concentration of *TDS* in different seasons.

3.4.2 *pH*

The pair 1p and pair 3p showed positive correlation (+)0.399 and (+)0.48 respectively) while pair 2p had negative relationship (-0.192). The t statistics of pair 1p, pair 2p and pair 3p was 11.103, 4.593 and 4.682 respectively which was greater than the tabulated 't' value. Hence, null hypothesis was rejected and the alternative hypothesis is accepted.

3.4.3 *EC*

The pair 1e, pair 2e and pair 3e of *EC* depicted positive correlation (+)0.821, (+)0.768 and (+)0.709). The 't' statistics (10.434, 7.927 and 2.162) was higher than the

table value which indicated significant change in the mean of *EC* level in different seasons. Thus, null hypothesis is rejected.

3.4.4: *Iron*

The correlation value of pair 1i, pair 2i and pair 3i for *iron* were (+)0.518, (+)0.850 and (+)0.451respectively. The 't' statistics for the pairs was 13.070, 8.050 and 7.487 respectively. The 't' statistics was higher than the table value. It indicated a remarkable change in the *iron* concentration. Hence, alternative hypothesis can be accepted.

3.4.5 *Magnesium*

The correlation value of pair 1m for *magnesium* showed the negative correlation (-0.045) while pair 2m and pair 3m had lower positive correlation (+0.359 and +0.191). For pair 1m and pair 3m the calculated 't' value (3.081 and 2.824) was greater than tabulated 't' value. Hence, null hypothesis was rejected. While in case of pair 2m the calculated 't' value (1.594) was smaller than the table value. It indicated no significant change in the concentration of *magnesium* in (monsoon and post-monsoon seasons). Thus, null hypothesis can be accepted.

3.4.6 *Calcium*

The correlation of the pair 1c, pair 2c and pair 3c showed low positive value (+0.124, +0.114 and +0.401) while pair 3c indicated relatively higher positive correlation. The 't' statistics of all the pairs (3.538, 2.715 and 2.107) of *calcium* was greater than the table value denoting the change in the concentration of *calcium* in the different seasons.

3.4.7 *Sodium*

All the pairs of *sodium* had negative correlation and the calculated 't' value was higher than the table value. Hence, significant change was observed in the level of *sodium* among the seasons.

3.4.8 *Potassium*

The correlation value of pair 1p, pair 2p and pair 3p were (+)0.123, (+)0.327 and (+)0.220 respectively. The 't' statistics for the three pairs (1.636, 0.643 and 1.026) were

smaller than the table value. It inferred that there was no significant change in the concentration of *potassium*. Therefore, null hypothesis can be accepted.

3.4.9 *Nitrite*

In *nitrite* the correlation values of the pairs were (+)0.941, (+)0.458 and (+)0.377 respectively. The calculated 't' value for the pairs was 7.282, 10.979 and 6.897 and was higher than the tabulated value representing significant change of *nitrite* level among the seasons. Hence, alternative hypothesis was accepted for all the seasons.

Table 3.4: Correlation and Paired 't' Statistics

Parameters	Pairs	Seasons Combination	Correlation	t	df	Sig.(2-tailed)
TDS	Pair 1t	pre-monsoon - monsoon	0.821	-10.434	19	0
TDS	Pair 2t	monsoon - post-monsoon	0.768	-7.927	19	0
TDS	Pair 3t	pre-monsoon - post-monsoon	0.709	-2.162	19	0.044
pH	Pair 1p	pre-monsoon - monsoon	0.399	-11.103	19	0
pH	Pair 2p	monsoon - post-monsoon	-0.192	-4.593	19	0
pH	Pair 3p	pre-monsoon - post-monsoon	0.48	-4.682	19	0
EC	Pair 1e	pre-monsoon - monsoon	0.821	-10.434	19	0
EC	Pair 2e	monsoon - post-monsoon	0.768	-7.927	19	0
EC	Pair 3e	pre-monsoon - post-monsoon	0.709	-2.162	19	0.044
Iron	Pair 1i	pre-monsoon - monsoon	0.518	-13.07	19	0
Iron	Pair 2i	monsoon - post-monsoon	0.85	-8.05	19	0
Iron	Pair 3i	pre-monsoon - post-monsoon	0.451	-7.487	19	0
Magnesium	Pair 1m	pre-monsoon - monsoon	-0.045	-3.081	19	0.006
Magnesium	Pair 2m	monsoon - post-monsoon	0.358	-1.594	19	0.127
Magnesium	Pair 3m	pre-monsoon - post-monsoon	0.191	-2.824	19	0.011
Calcium	Pair 1c	pre-monsoon - monsoon	0.124	-3.538	19	0.002
Calcium	Pair 2c	monsoon - post-monsoon	0.114	-2.715	19	0.014
Calcium	Pair 3c	pre-monsoon - post-monsoon	0.401	-2.107	19	0.049
Sodium	Pair 1s	pre-monsoon - monsoon	-0.078	-3.547	19	0.002
Sodium	Pair 2s	monsoon - post-monsoon	-0.078	-3.547	19	0.002
Sodium	Pair 3s	pre-monsoon - post-monsoon	-0.078	-3.547	19	0.002
Potassium	Pair 1p	pre-monsoon - monsoon	0.123	-1.636	19	0.118
Potassium	Pair 2p	monsoon - post-monsoon	0.327	-0.643	19	0.528
Potassium	Pair 3p	pre-monsoon - post-monsoon	0.22	-1.026	19	0.318
Nitrite	Pair 1n	pre-monsoon - monsoon	0.941	-7.282	19	0
Nitrite	Pair 2n	monsoon - post-monsoon	0.458	-10.979	19	0
Nitrite	Pair 3n	pre-monsoon - post-monsoon	0.377	6.897	19	0

Source: Computed

3.5 DISCUSSION

The average *TDS* level in surface water was higher than the desirable limit. In all the seasons the maximum concentration of *TDS* and *EC* was noted in *Nandesari* and *Dasharath* which are adjacent to the chemical industries of GIDC and GSFC. The wastes from these industries are injudiciously disposed in many places even near the pond or lakes also (Fig.3.19). When these waste mixed up with surface water during rainy season, it may pollute the surface water with high level of *TDS* as the industrial waste is one of the major source for high level of *TDS* in water (WHO, 2003 and Verma, 2011). *pH* is one of the important parameters for determining the hydro chemical characteristics of water and it is associated with further chemical reactions (Ghosh and Kanchan, 2014). During the pre-monsoon *pH* was slightly alkaline (Fig.3.11) while in monsoon season it was little lower down, it might be due to the mixing up with rain water because the rain water is slightly acidic in nature (Rodriguez et al., 2004). In all the time span, the level of *iron* was above desirable limit (0.3 mg/l). During the monsoon, it was relatively lower it may be due to the dilution with rain water. However, near the industrial estates of *Nandesari* GIDC, IPCL and GSFC the concentration remain high (Fig.3.13). The special distribution of *magnesium, calcium, sodium* and *potassium* level in the study area depicted more or less similar pattern. The high concentration of these parameters was observed during the pre-monsoon in the northern and eastern part. The high temperature in pre-monsoon season leads to evaporation of surface water resulting in the increase of concentration of water

Fig.3.20: Industrial Waste at *Sankarda* Village
Source: Photograph during Field Visit

parameters. During the rainy season, the level of these parameters was decreased and higher concentration was confined near the industrial estate. In the post-monsoon, concentration of all the four parameters (*Mg, Na, Ca* and *K*) increased with maximum concentration near industrial estate and eastern part, it indicating the influence of industries. Unlike the other parameters, the level of nitrite was higher in the northern and southern part near the agricultural field; it might be due to the application of nitrogen bearing pesticides and fertilizers in the agricultural land. *Fluoride, lead and mercury* in surface water were below detectable limit in the study area.

Fig.3.21: Change of Water Colour (Mini River) at *Nandesari*
Source: Photograph during Field Visit

Between the different seasons, significant change in concentration was observed in all the parameters. During monsoon, the level of parameters was relatively lower. Rainfall is one of the major factors for this change of characteristics of surface water.

Resume

In the present chapter, various water parameters such as TDS, pH, EC, iron, magnesium, calcium, sodium, potassium and nitrite were determined in surface water. More concentration of potassium, iron and TDS near industries was noted in the study area. Level of all the parameters decreased significantly during the monsoon season. Positive correlations existed between concentration in different season. The next chapter will focus upon the characteristics of top and sub-surface soil.