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Assessing The Urbanization And Climate Change Impact On Quality Of Groundwater Resources InMangalore City Of Dakshina Kannada Dist, Karnataka, India.

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Abstract

The effects of urbanization and climate change are converging in dangerous ways by impacting on Water Resources. Cities are a key contributor to climate change, as urban activities are major sources of greenhouse gas emissions. Estimates suggest that cities are responsible for 75 percent of global CO2 emissions, with transport and buildings being among the largest contributors. This study aims to assess the impacts of urbanization and climate change on the physical and chemical conditionsof Mangalore City. The samples are collected from 50 sampling points in most populated and urbanized areas of Mangalore City, where both in- situ and ex-situ analysis are conducted. Totally50 open well samples and 50 bore well samples are collected during monsoon, Pre- monsoon and Post – Monsoon months. The gained values are tabulated and compared with WHO standard guidelines. According to Indian Meteorological Department, this year (2023), the arrival of monsoon itself is very late. Till August, 2023, there was a shortage of 19 percent of rain in the district of Dakshina Kannada. Due to the El Nino effect, the formationof clouds over the Indian Ocean was reduced (Subramanya K- 2016). That is why the intensity of rains were less in Mangalore, D.K, Karnataka, India, and hence conjunctive use of water is need of the hour.

Keywords: Water Quality, Groundwater, Urbanization, Climate Change, Mangalore City, Population.

1. Introduction

Increasing population and urbanization result in land use and land cover changes, pollution of water resources (Both Surface and Sub surface) from local to global scales. The increase in urbanization not only affect land use and land cover changes, and it majorly affect on climate, the change in climate due to urbanization causes pollution. This process, in turn, can profoundly disrupt the structure and functionof ecosystems. As reported by Grimm et al. (2000), although urban areas account for only 2% of Earth’s land surface, they produce 78% of greenhouse gases, thus contributing significantly to global climate changes. Throughout history, people have settled on the coasts to take advantage of the amenities the oceans offer– a food supply, a source of transport, a defensible position and a healthy location. Half of the world’s population lives within 100 kilometres of the sea and three quarters of all large cities are located on the coast. The seas and oceans are under pressure from pollution and much of this pollution comes from urban centers. One of the most damaging ways in which cities pollute coastal areas is the discharge of waste water and sewage. Many coastal cities discharge sewage, industrial effluent and other waste water directly into their surrounding seas (UN, 2005).

Urbanization and Climate Change Impact on Water Quality

Unplanned urbanization is driven some seriouslong-term impacts on human life and the environment; water contamination due tourban mess and climate change due to traffic smoke is very evolving and widespreadproblems. The clean drinking water is gettingscarcefor people day by day in unplannedcities, and water from the municipal supplies isnot assured. The leaking of sewerage pipes isalso impacting groundwater supplies. People usually deal with water shortages due to climate change, and thishappens on a regular basis. Another importantelement that makes the water impure in urbanareas is the human wastes and insufficientsewage system, which is a big source of waterpollution and infiltrate to underground watersources.

A practical feature of the urbanizationprocess is the discharge of domestic waste intowater resources, and this activity induceschanges, which affect the environmentalstability and water quality for many purposes.However, Urbanization is one of the mostdevastating factors affecting the quality ofwaterways and one of the greatest problemsfacing groundwater planners. Major damage towater supplies and human health is caused by industrial waste. Waste discharged frommanufacturing operations, such as untreated effluents, heavy metals, toxins, alkalinesubstances, and pollutants, adversely harms the ecological environment and natural resources.

Urbanization in Dakshina Kannada district

Dakshina Kannada (South Kanara) is the southern coastal district of Karnataka State with an area of 4866 sq. km. The district lies between 12^0 57' and 13^0 50' North Latitude and 74^0 and75^0 50' East Longitude. It is about177 kms, in length and 40 kms in breadth at itsnarrowest and about 80kms at its widest part. It has a population of. 20,83,625 asper 2011 census. The district is surrounded by Udupi district in the North, Shimoga, Chickmagalur and Hassan districts in the East,Kasaragod district of Kerala state and Coorg district in the South and Arabian Sea in the West. Dakshina Kannada district is having the highest literacy rate in Karnataka (88.62%) and it is well known throughout India for banking and higher and professional educational institutions. It is the second most densely populated district inKarnataka with a population density of 457 persons per sq. km. The coastal area of DakshinaKannada (DK) district has witnessed a phenomenal development in the last couple of decades. Increased commercial activity after the setting up of all weather, major sea port at Panambur, and industrial development in the form of petrochemicals, fertilizers, and iron ore pelletisation marked the growth of this area. Further it is expected that the trend ofDevelopment will continue at a much faster, there is an increase of more than 10%every year in the number of vehicles registered. According to Regional Transport Office, Mangalore, the number of vehicles registered in 2010 and 2011 were around thirty thousand,in the year 2012 up to Marchitself, thirty-five thousand vehicles were registered. As per information obtained from the regionaltransport office Mangalore, June 2019 and May 2020, 22,659 two wheelers and 6,574cars had been registered. Till May 2021 thereafter, a nominal increase witnessed, with 25,702 two wheelers and 7,957 cars having been registered.

Demography

The population in Mangalore urban area has increased from 44 thousand in 1901 to 601 thousands in 2001 (Census of India, 2001). The growth of Mangalore urban population from 1901-2001 is shown in Fig 1.0. The population growth rate which was 1% per year during 1901-1911 has increased to 4% during 1991-2001. Population of Mangalore in 2011 is 488,968. Although Mangalore city has population of 488,968; its urb~~an~~ / metropolitan population is 623,841. In 2021 the population of Mangalore city was 724,159. According to the 2011 Indian census, the male literacy rate was 96.49 percent and the female literacy rate was 91.63 percent. About 8.5 percent of the population was under the age of six years. About 7726 people lived in slumsin Mangalore city which was 1.55 percent of the total population.

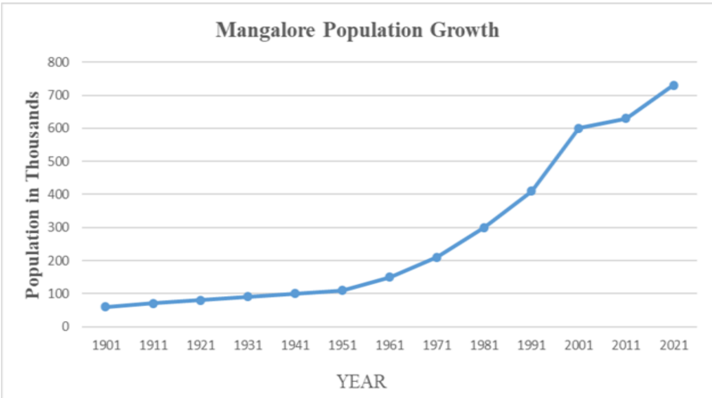

Fig.1.0-Growth of Mangalore Urban Population during1901-2021

Study area

The study area (Fig.2.0) consists of the coastal region of the DK district in Karnataka state in India, lies between 12°45' N to 12.9141N latitude and 74°45' E to 74.8560 E longitude. The study area is about600 square kilometers. The two major rivers flows in the study area are Nethravati and Gurpur. In this study we have considered only centraland southernparts of city.

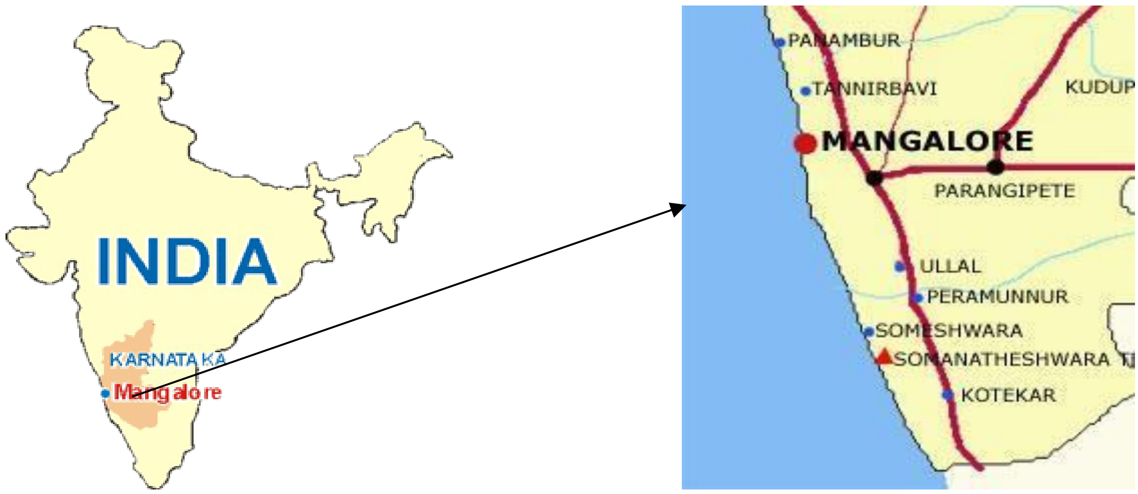

Fig.2.0 –Study area map

Topography and Climate

The average annual rainfall in the study areais 3955 mm of which 87% is received during South-West monsoon (June to September). The climate is tropical with high humidity and the temperatures vary between 17° and37° degrees Centigrade. The topography of the study area is undulating with dense vegetation. Lateritic soil overlies granitic gneisses and friable sandstones. Alluvial deposits occur along the river courses. The beaches are composed of sand deposits. The mean depth to water table ranges from 7 to 9m and the mean fluctuation ranges 6 to 7m.

Objectives of the Study

The following specific objectives were framed for the study.

I. To collect water samples from bore wells and open wells in differentlocations of Mangalore City and to conduct standard laboratory tests for important water quality parameters.

II. To Analyse Groundwater quality, the laboratory results were compared withWHO guidelines to assess the urbanization and climate change impact on groundwater quality.

Impacts of urbanization and climate change on Groundwaterquality Urbanization and Climate Change impacts on groundwater quality includes the increased concentration of major ions, changes in oxidation- reduction conditions,

increased concentration of minor elements, increased detection frequencies of Volatile Organic Compounds (VOCs). The adverse impact of land use changes on water quality is more substantial in low urbanized sub-urban areasthan those in highly urbanized central cities. In this study groundwater(both bore well and open well) resources areconsidered for water quality analysis. 50 bore wells and 50 openwells samples collected for the analysis, in this paper 10 bore wells and 10 open wells samples locations are shown in Table 1.0. A very useful index of summer rainfall over the Indian region in any year is the, All India Summer Monsoon Rainfall (ISMR), this is a weighted average of June-September rainfall of 306 well-distributed rain gauge stations across the country. It is a convenient measure of a monsoon rainfall in a year. El Nino is an abnormal warming of surface ocean waters in east tropical Pacific and is a part of Southern Oscillation(SO).El Nino eventsaffect weather pattern in large parts of the world (Subramanya K- 2016).

Table. 1.0 Open Well and Bore Well Sample Locations

SL.NO.	Sample ID	Locations	Latitude	Longitude
1	OW -01 & BW-01	Bajpe	12^{0} 58' 49.351"	74^{0} 52' 57.305"
2	OW -02 & BW-02	Idya	12^{0} 58' 56.124"	74^{0} 47' 52.915"
3	OW -03 & BW-03	Baikampady	12^{0} 57' 16.160"	74^{0} 49' 04.279"
4	OW -04 & BW-04	Karambar	12^{0} 57' 38.047"	74^{0} 52' 14.727"
5	OW -05 & BW-05	Bajpe Airport	12^{0} 57' 50.526"	74^{0} 53' 33.591"
6	OW -06 & BW-06	Chitrapur	12^{0} 57' 23.416"	74^{0} 48' 07.302"
7	OW -07 & BW-07	Kaikamba	12^{0} 57' 35.000"	74^{0} 56' 15.000"
8	OW -08 & BW-08	Panambur	12^{0} 56' 48.052"	74^{0} 48' 38.915"
9	OW -09 & BW-09	Kunjathbai	12^{0} 56' 32.999"	74^{0} 51' 16.211"
10	OW -10 & BW-10	Jyothinagar-Markada	12^{0} 55' 45.000"	74^{0} 51' 45.000"

Water quality analysis

The water samples were analyzed for twelve physico-chemical characteristics as per the procedures given in *Standard Method*. The list of the tests performed, and method used are shown in Table 2.0.

Table. 2.0 Water quality analysis (APHA 2017)

SL.NO	PARAMETERS	METHOD USED
1	Calcium	Flame Photometric method
2	Magnesium	Calculation method
3	Sodium	Flame Photometric Method
4	Potassium	Flame Photometric method
5	Bicarbonates (HCO3-)	EDTA Titration Method
6	Total Hardness	EDTA Titrimetric method
7	Chlorides	Argentometric method
8	Nitrates	Brucine method
9	Sulfates	Turbidimetric method
10	TDS	Conductivity-TDS meter
11	Conductivity	Conductivity-TDS meter
12	pH	Electrode

WHO guidelines

WHO guidelines divide water quality parameters into two categories.

Health guidelines, which take into account chemical and radiological constituents that have the potential to directly adversely affect human health; and Acceptability guidelines, which include parameters that may not have any direct health effects but result in objectionable taste or odour in the water (WHO, 2017). The World Health Organization (WHO) guidelines for water quality are presented in Table 3.0.

Table. 3.0 -World Health Organization Drinking Water guidelines (WHO, 2017)

Parameter	Unit	Guideline	Guideline Type
Calcium	mg/l	100	Health

Magnesium	**mg/l**	50	Acceptability
Sodium	**mg/l**	200	Health
Potassium	**mg/l**	20	Health
Bicarbonates (HCO3-)	**mg/l**	250	Health
Total Hardness	**mg/l**	200	Acceptability
Chlorides	**mg/l**	250	Acceptability
Nitrates	**mg/l**	50	Health
Sulfates	**mg/l**	250	Health
TDS	**mg/l**	600	Health
Conductivity	**Ms/cm**	400	Acceptability
pH	-	6.5-8.5	Acceptability

4.0 Results and Discussions

Water quality assessment is an essential process in the development of water resources. Water quality may be defined in terms of specific characteristics of water usually physical, chemical and biological (including bacteriological) that are important with regards to a certain services and human health is at risk if values exceed acceptable limits (Tahera *et al.*, 2016). The chemical properties Calcium(Ca+), Magnesium(Mg+),Sodium(Na+),Potassium (K+), Bicarbonates (HCO3-), Total Hardness (TH) as CaCO3, Chlorides (Cl-), Nitrates (NO3-), Sulfates (SO4-), Total Dissolved Solids (TDS), Electrical Conductivity (EC) and Ph of the samples tested are shown in Table. 4, 5,6,7,8 and 9. Graphical Variations of groundwater quality in Pre Mansoon, Mansoon and Post Mansoon shown in Fig. 3 to 26.

Table. 4.0 -Test Results of Open Well Locations

Parameters	Ca+			Mg+			Na+			K+		
WHO	100 mg/l			50 mg/l			200 Mg/l			20 mg/l		
Month and Year	Jan –May	une –Sept	Oct – Dec	Jan –May	une –Sept	Oct – Dec	Jan –May	une –Sept	Oct – Dec	Jan –May	une –Sept	Oct – Dec
Locations	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon
OP 1	**8.34**	8.29	8.75	**20.11**	20.1	20.5	**31.96**	31.98	31.6	**1.7**	1.7	1.7
OP 2	**6.15**	6.2	5.83	**3.01**	3.12	2.8	**5.36**	5.45	5.2	**2.11**	2.12	2.3
OP 3	**6.5**	6.5	6.97	**1.06**	1.12	1.1	**21.26**	21.8	21.3	**2.54**	2.57	2.7

OP 4	**5.11**	5.11	5.11	**7.18**	7.18	7.2	**15.10**	15.1	15.1	**1.10**	1.1	1.1
OP 5	**6.9**	3.4	3.47	**0.12**	0.12	0.1	**2.54**	2.5	2.5	**1.5**	1.5	1.5
OP 6	**7.56**	7.56	7.56	**15.82**	15.82	15.8	**23.6**	23.6	23.6	**6.9**	6.9	6.8
OP 7	**6.32**	6.32	6.32	**5.38**	5.39	5.4	**2.48**	2.5	2.5	**1.24**	1.2	1.4
OP 8	**10.24**	10.24	10.24	**9.37**	9.33	9.3	**21.34**	21.3	21.3	**6.58**	6.5	6.5
OP 9	**6.76**	6.76	6.76	41.33	41.33	41.3	**7.88**	7.9	7.9	**0.86**	0.9	0.9
OP 10	**4.96**	4.96	5.29	**1.60**	1.6	1.7	**9.8**	9.8	9.8	**1.5**	1.5	1.5

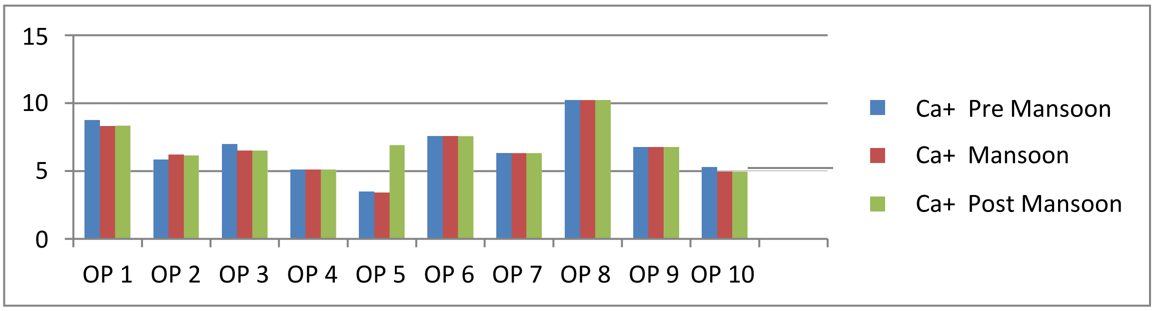

Fig. 3.0 Variation of Ca^{+} during Pre Mansoon, Mansoon and Post Mansoon.

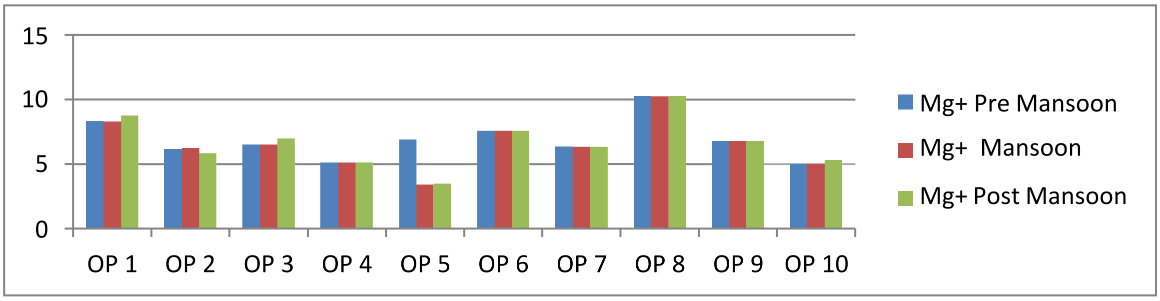

Fig. 4.0 Variation of Mg^{+} during Pre Mansoon, Mansoon and Post Mansoon.

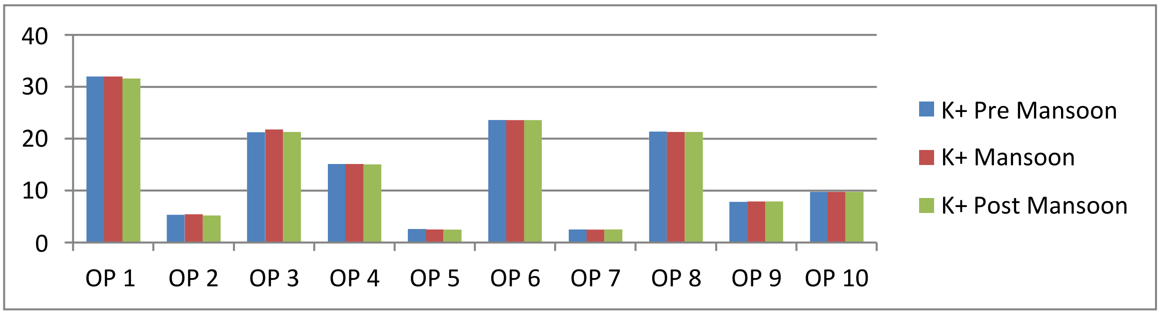

Fig. 5.0 Variation of K^{+} during Pre Mansoon, Mansoon and Post Mansoon.

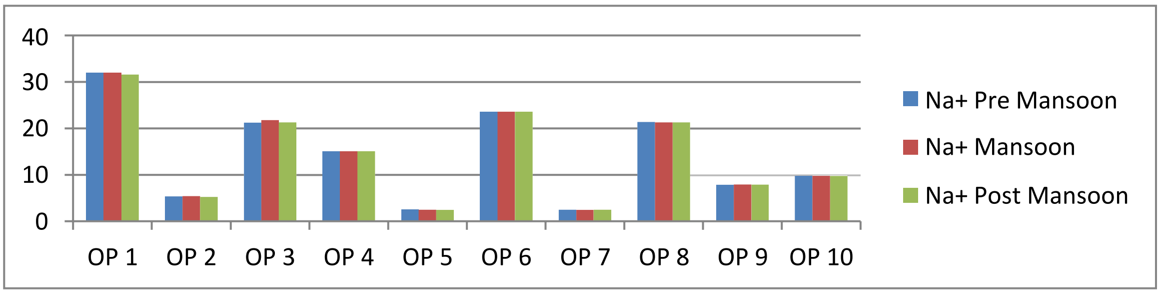

Fig. 6.0 Variation of Na^{+} during Pre Mansoon, Mansoon and Post Mansoon

Table. 5.0 –Test Results of Open Well Locations

Parameters	HCO_3^-			TH			Cl^-			NO_3^-		
WHO	250 mg/l			200 mg/l			250 mg/l			50 mg/l		
Month and Year	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec
Locations	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon
OP 1	61	65	65	233	233	101	49	49	49	19.04	19.06	19.06
OP 2	22	20	26	51	51	82.6	18	18	18	5.37	5.35	5.38
OP 3	17	15	17	86	86	21	30	30	31	10.11	10.12	10.22
OP 4	33	33	33	128	128	41	27	27	27	12.31	12.34	12.34
OP 5	10	10	10	07	07	9	12	12	12	2.13	2.13	2.33
OP 6	66	66	66	137	137	84	46	46	46	10.28	10.28	10.28
OP 7	26	28	28	33	33	38	14	14	14	2.64	2.64	2.64
OP 8	21	21	21	153	153	64	39	39	39	20.56	20.46	20.16
OP 9	152	158	158	262	262	187	48	48	48	25.67	25.69	25.69
OP 10	14	14	12	63	63	19	18	18	18	18.79	18.79	18.79

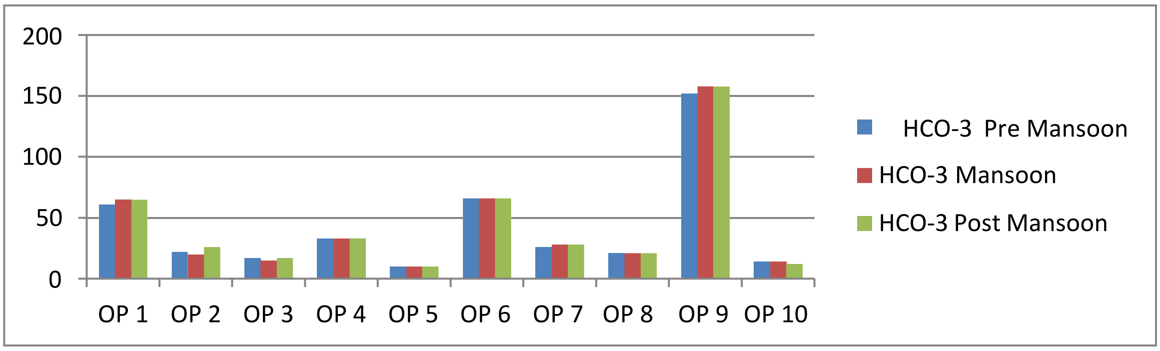

Fig. 7.0 Variation of $HCO3^-$ during Pre Mansoon, Mansoon and Post Mansoon

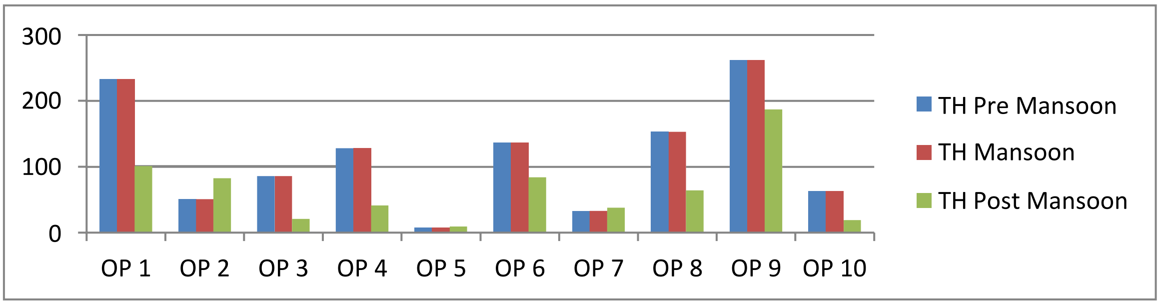

Fig. 8.0 Variation of TH during Pre Mansoon, Mansoon and Post Mansoon

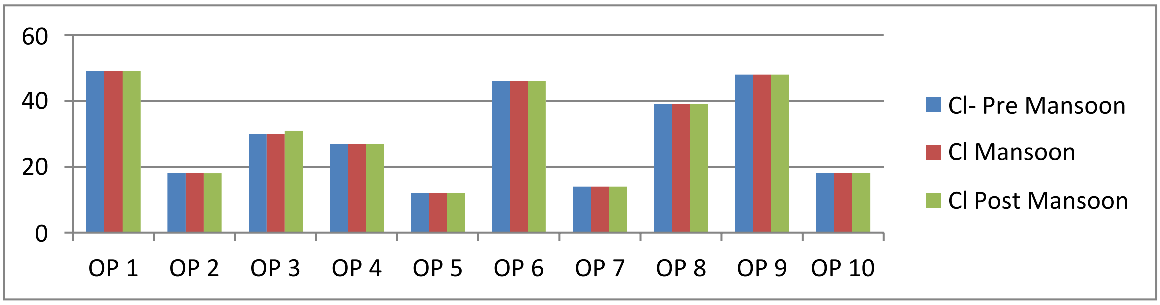

Fig. 9.0 Variation of Cl⁻ during Pre Mansoon, Mansoon and Post Mansoon

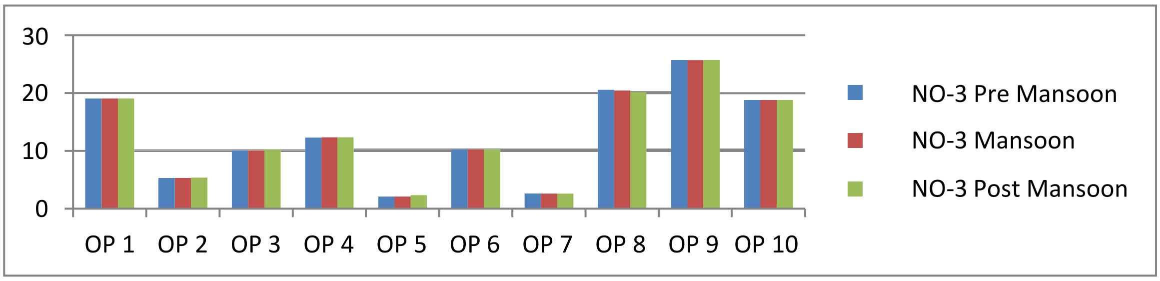

Fig. 10 Variation of NO3⁻ during Pre Mansoon, Mansoon and Post Mansoon

Table. 6.0 –Test Results of Open Well Locations

Parameters	SO_4^-			TDS			EC			pH		
WHO	250 mg/l			600 mg/l			400 Ms/cm			6.5-8.5		
Month and Year	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec
Locations	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon
OP 1	30.18	30.10	30.10	230	233	233	360	362	362	6.52	6.52	6.52
OP 2	1.48	1.49	1.49	51	51	51	85	83	83	5.73	5.73	5.73
OP 3	9.66	9.62	9.62	84	86	86	141	140	140	5.11	5.11	5.11
OP 4	8.13	8.13	8.13	128	128	128	212	212	212	6.76	6.76	6.76
OP 5	1.43	1.43	1.53	07	07	10	12	12	12	5.46	5.46	5.46
OP 6	16.49	16.49	16.49	137	137	137	221	221	221	6.88	6.28	6.28
OP 7	0.49	0.49	0.49	33	33	33	54	59	54	6.98	6.18	6.18
OP 8	10.38	10.28	10.28	155	153	153	246	246	246	6.15	6.15	6.15
OP 9	10.45	10.47	10.47	260	262	267	421	423	423	6.59	6.59	6.59
OP 10	1.75	1.75	1.75	63	63	63	102	102	102	6.85	5.85	5.85

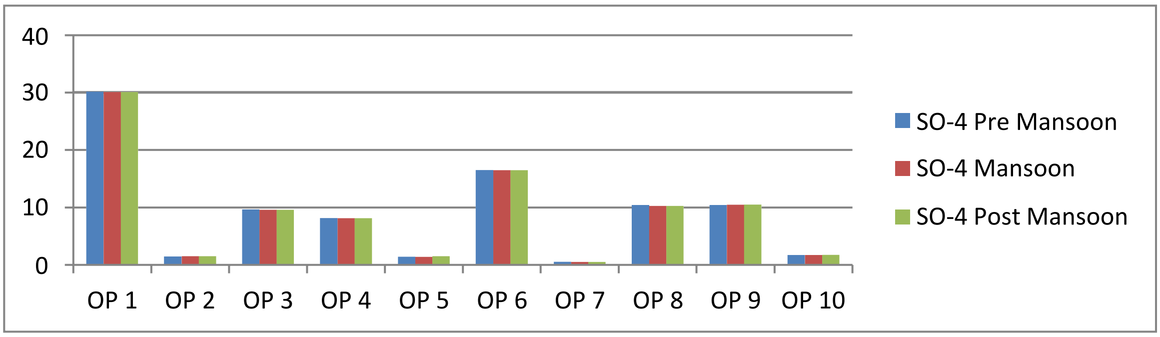

Fig. 11 Variation of SO4¯ during Pre Mansoon, Mansoon and Post Mansoon

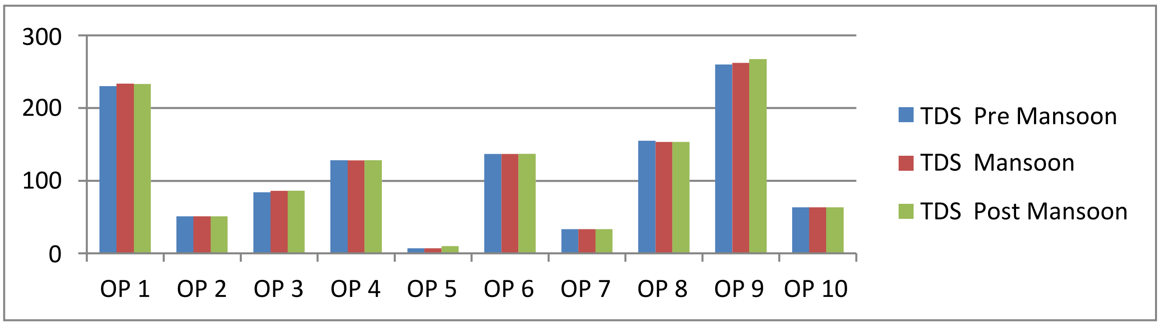

Fig. 12 Variation of TDS during Pre Mansoon, Mansoon and Post Mansoon

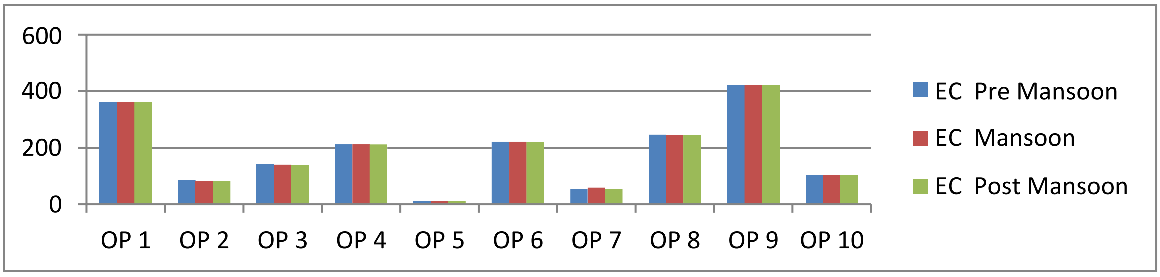

Fig. 13 Variation of EC during Pre Mansoon, Mansoon and Post Mansoon

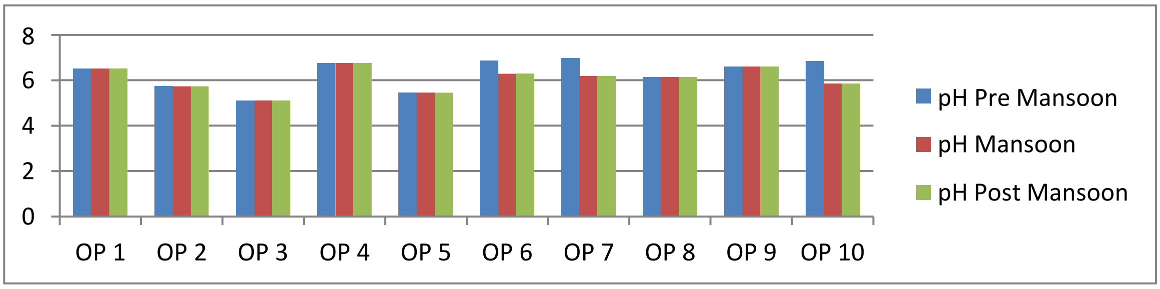

Fig. 14 Variation of pH during Pre Mansoon, Mansoon and Post Mansoon

Table. 7.0 –Test Results of Open Well Locations

Parameters	Ca+			Mg+			Na+			K+		
WHO	100 mg/l			50 mg/l			200 Mg/l			20 mg/l		
Month and Year	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec

Locations	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon
BW 1	3.11	3.12	3.12	62.90	62.93	62.93	49.35	49.37	49.37	2.5	2.3	2.3
BW 2	3.73	3.75	3.75	12.77	12.79	12.79	45.96	45.98	45.98	2.20	2.21	2.21
BW 3	3.77	3.79	3.79	10.59	10.58	10.58	28.71	28.70	28.70	3.49	3.47	3.47
BW 4	6.17	6.19	6.19	17.14	17.44	17.44	26.75	26.75	26.75	2.23	2.43	2.43
BW 5	3.11	3.12	3.12	3.56	3.58	3.58	28.71	28.70	28.70	5.13	5.13	5.13
BW 6	6.39	6.19	6.19	3.96	3.98	3.98	13.29	13.25	13.25	3.17	3.17	3.17
BW 7	6.29	6.29	6.29	3.51	3.51	3.51	13.45	13.45	13.45	2.57	2.57	2.57
BW 8	6.67	6.67	6.67	10.81	10.81	10.81	14.35	14.35	14.35	3.19	3.19	3.19
BW 9	4.88	4.88	4.88	11.82	11.82	11.82	16.81	16.81	16.81	3.13	3.13	3.13
BW 10	4.41	4.41	4.41	9.28	9.28	9.28	18.82	18.82	18.82	4.53	4.53	4.53

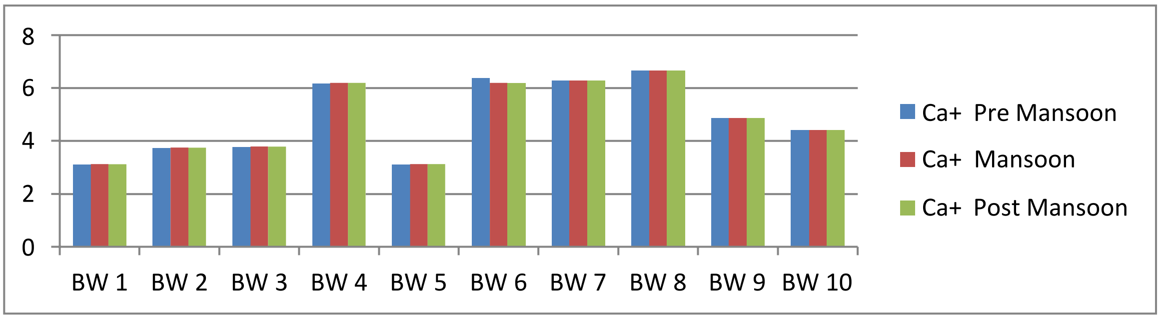

Fig. 15 Variation of Ca^{+} during Pre Mansoon, Mansoon and Post Mansoon

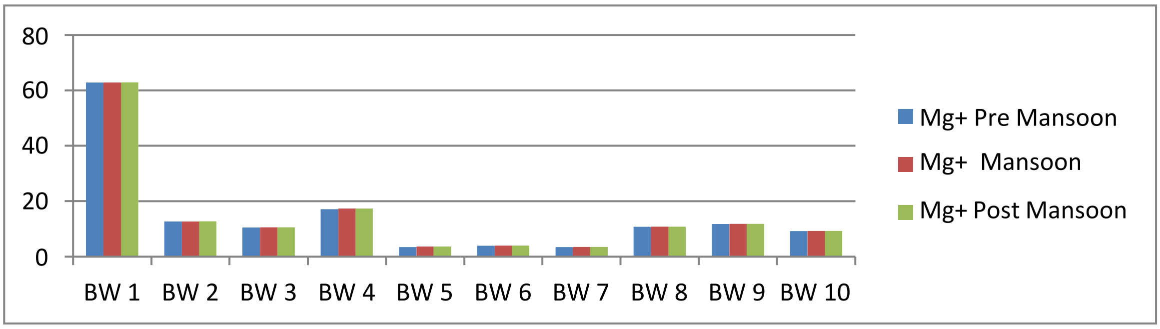

Fig. 16 Variation of Mg^{+} during Pre Mansoon, Mansoon and Post Mansoon

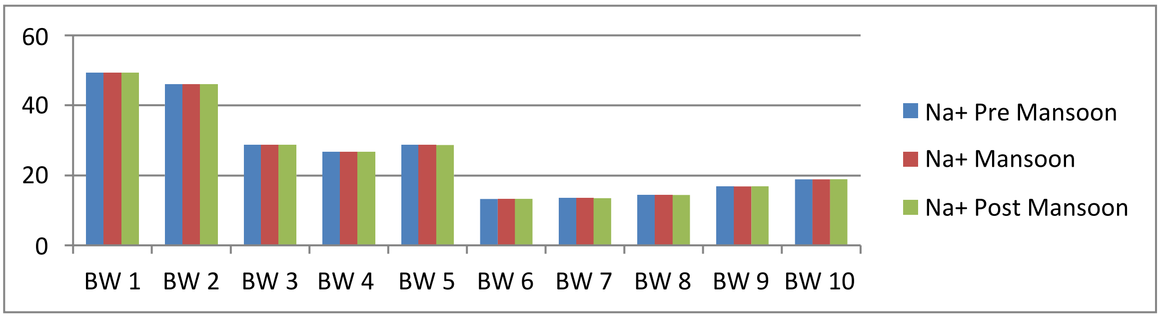

Fig. 17 Variation of Na^{+} during Pre Mansoon, Mansoon and Post Mansoon

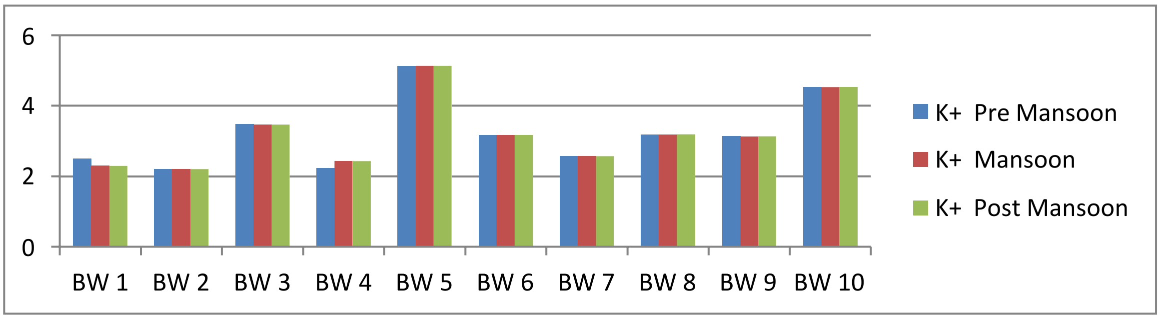

Fig. 18 Variation of K^{+} during Pre Mansoon, Mansoon and Post Mansoon

Table. 8.0 –Test Results of Open Well Locations

Parameters	HCO_3^-			TH			Cl^-			NO_3^-		
WHO	250 mg/l			200 mg/l			250 mg/l			50 mg/l		
Month and Year	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec
Locations	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon
BW 1	52	54	54	54. 56	54.58	54. 58	25.7 7	25.75	25.7 5	14.60	14.61	14.61
BW 2	19	18	18	60. 40	60.42	60. 42	26.7 6	26.78	26.7 8	6.10	6.12	6.12
BW 3	15	13	13	81. 06	81.08	81. 08	12.9 6	12.98	12.9 8	14.00	14.01	14.01
BW 4	29	29	29	23. 92	23.92	23. 92	11.2 5	11.25	11.2 5	5.52	5.52	5.52
BW 5	12	12	12	63. 08	64.08	64. 08	25.6 5	25.7	25.7 5	4.55	4.57	4.57
BW 6	10	10	10	37. 28	37.08	37. 08	13.1 6	13.61	13.1 6	3.99	3.99	3.99
BW 7	10	10	10	47. 09	47.09	47. 09	13.6 9	13.61	13.6	24.65	24.63	24.63
BW 8	26	26	26	60. 92	60.92	60. 92	13.6 7	13.67	13.6 7	13.48	13.48	13.48
BW 9	138	138	138	70. 12	70.12	70	16.9 8	16.9	16.9	13.18	13.18	13.18
BW 10	12	12	12	70. 75	70	70. 75	16.7 8	16.7	16.7 8	13.28	13.28	13.28

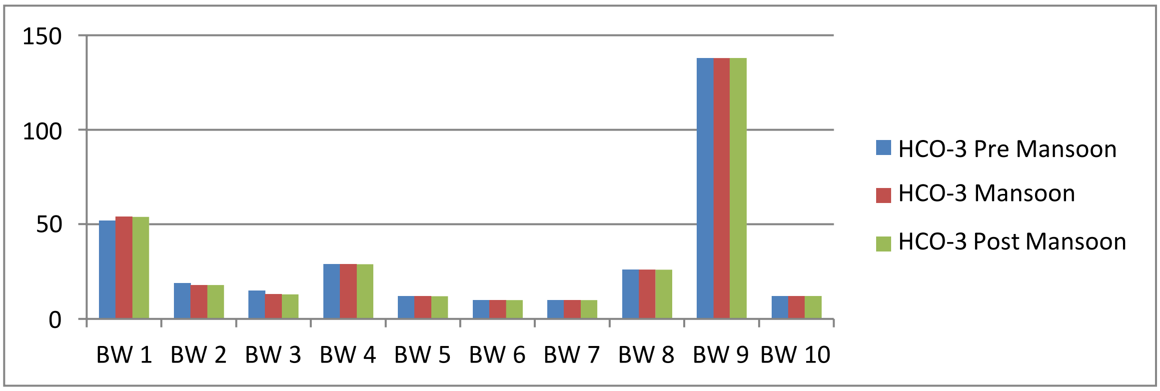

Fig. 19 Variation of $HCO3^-$ during Pre Mansoon, Mansoon and Post Mansoon

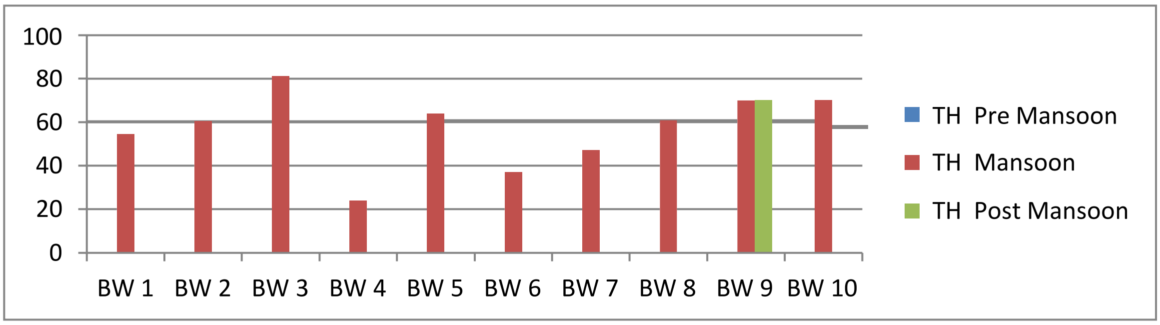

Fig. 20 Variation of TH during Pre Mansoon, Mansoon and Post Mansoon

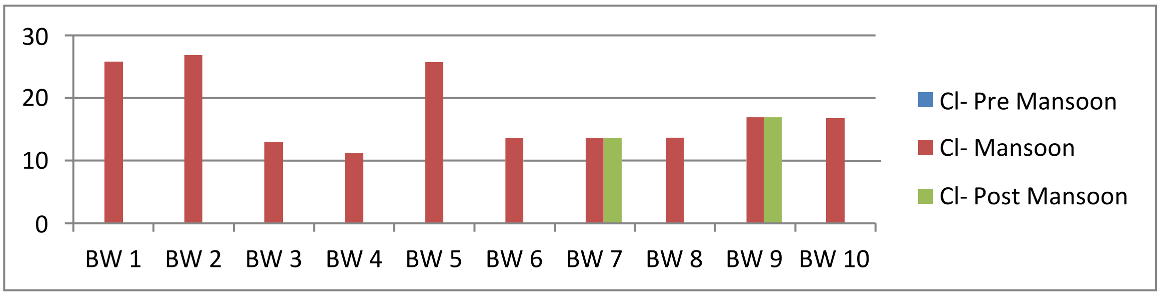

Fig. 21 Variation of Cl^{-} during Pre Mansoon, Mansoon and Post Mansoon

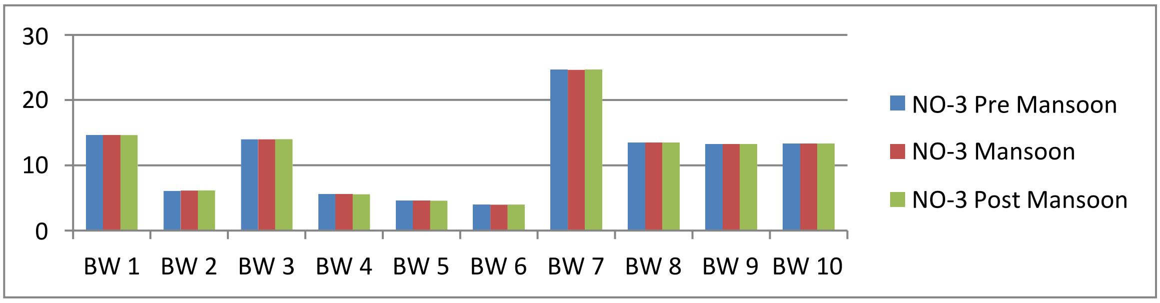

Fig. 22 Variation of $NO3^{-}$ during Pre Mansoon, Mansoon and Post Mansoon

Table. 9.0 –Test Results of Open Well Locations

Parameters	SO_4^-			TDS			EC			pH		
WHO	250 mg/l			600 mg/l			400 Ms/cm			6.5-8.5		
Month and Year	Jan - May	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec	Jan -	June - Sept	Oct - Dec	Jan - May	June - Sept	Oct - Dec
Locations	Pre Mansoon	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon	Pre	Mansoon	Post Manoon	Pre Mansoon	Mansoon	Post Manoon
BW 1	27.08	27.06	27.06	897	899	899	156	158	158	7.52	7.56	7.56
BW 2	27.01	27.03	27.03	156	159	159	236	238	238	6.73	6.72	6.72
BW 3	23.03	23.05	23.05	167	169	169	220	225	225	6.51	6.54	6.54
BW 4	19.13	19.33	19.33	136	146	146	69	79	79	6.59	6.28	6.28
BW 5	14.32	14.36	14.36	143	145	145	443	445	445	7.11	7.12	7.12
BW 6	25.08	15.08	15.08	146	146	146	138	148	148	6.97	6.90	6.90
BW 7	16.08	16.09	16.09	131	132	132	150	150	150	5.96	5.96	5.96

BW 8	14.37	14.37	14.37	136	136	136	163	163	163	6.98	6.98	6.98
BW 9	14.37	14.37	14.37	138	138	138	173	173	173	6.96	6.98	6.96
BW 10	14.38	14.38	14.38	96	96	96	176	176	176	6.98	6.98	6.98

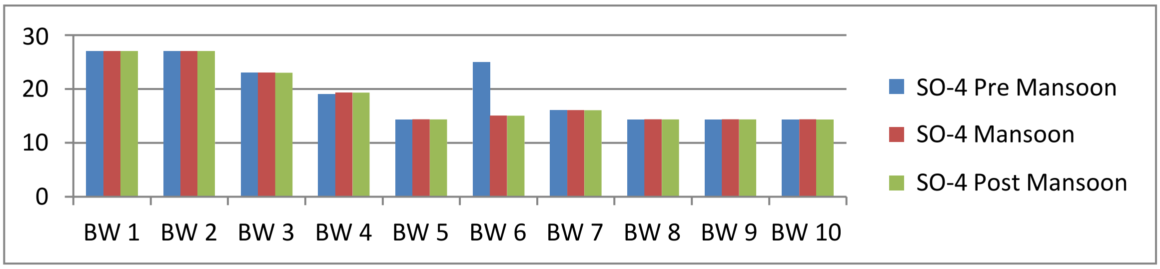

Fig. 23 Variation of SO4⁻ during Pre Mansoon, Mansoon and Post Mansoon

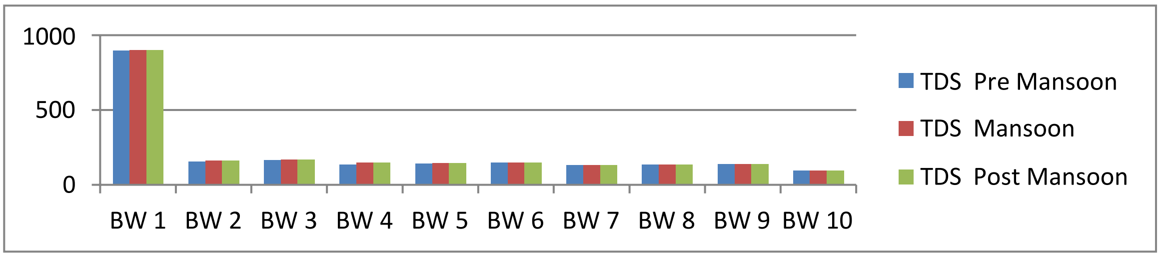

Fig. 24 Variation of TDS during Pre Mansoon, Mansoon and Post Mansoon

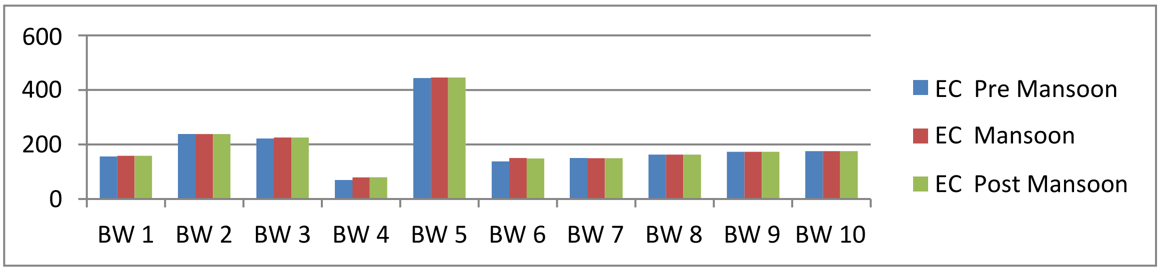

Fig. 25 Variation of EC during Pre Mansoon, Mansoon and Post Mansoon

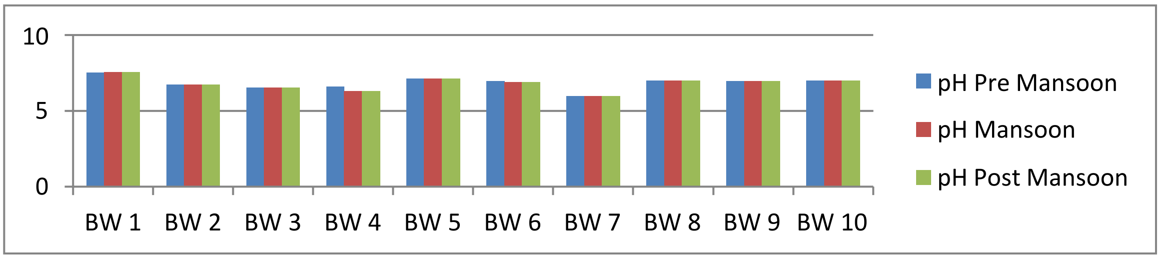

Fig. 26 Variation of pH during Pre Mansoon, Mansoon and Post Mansoon

Discussions

Groundwater quality is dependent on the type of the pollutant added to the open wells and the nature of mineral found at particular zone of bore well. Monitoring of the water quality of ground water is done by collecting representative water samples and analysis of physicochemical characteristics of water samples at different locations of Mangalore City.

The pH value of OP2, OP3, OP5, OP6, OP7, OP8, and OP10 samples was less than 6.5, in onelocation (OP 9), Magnesium, bicarbonates, TDS, EC and nitrates was excess, It's shown in Fig. 7, 8, 10, 12, 13 and 14, This may be due to salt water intrusion, as the above open well locations are located within 500 m to 600 m, from the coast.

The pH value of BW4, BW5, BW6 and BW7, samples was less than 6.5. Iron, magnesium, TDS, EC and Nitrates was also showing increasing order (Fig 14, 16, 22, 25 and 26). The geological formation and salt water intrusion may be the reason for this.

Conclusion

The overall quality of groundwater in Mangalore city is deteriorating. In 50% of the open well samples and 20% of the bore well samples pH is less than 6.50. The concentration of Nitrates is showing an increasing trend, groundwater resources of Mangalore city, needs certain degree of treatment (oxidation, coagulation/clarification process, filtration, and disinfection) before consumption. According to Indian Meteorological Department, this year (2023), the arrival of monsoon itself was very late. Except for heavy rains for a few days, the monsoon has weakened now. Even in august 5, 2023, there was a shortage of 19 percent of rain in the district of Dakshina Kannada. El Nino effect has weakened the Monsoon, winds and dry weather, potentially resulting reduced rainfall in the monsoon season. Hence conjunctive use of water is very essential. Strategic use of groundwater for global water andfood security in a changing climate is becoming more and more important. Optimum usage of water, conservation and groundwater recharge plays very important role to solve water scarcity problem in the Mangalore.

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