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Physico-Chemical &Microbial Assessment of Ground Water of DCM Industrial Area and Its Adjoining Areas, Kota [India].Part I

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ABSTRACT: Pre Monsoon Ground water samples were collected from different locations of DCM Industrial area and adjoining areas for physico chemical and microbial studies. Analysis of samples for P^H, TDS, Conductivity, Turbidity, Odour, Nitrate, Sulphate, Phosphate, Dissolved Oxygen, Hardness, Chlorides, Fluorides, Nitrate, Sodium, Potassium and Chemical Oxygen Demand(COD),Biological Oxygen Demand(BOD), Alkalinity, Free NH_4, Coli form Organism, Fe^{+2}, As, Cu, Zn along with EC and Coli form Organism indicate towards major health concerns of living beings. On comparing results with drinking water quality standards laid down by WHO, it is found that most of the water samples are non potable for human beings due high concentration of one parameters or the other. Most of the samples have EC, free NH_4, Coli form Organism much higher than the maximum permissible levels set up by WHO which are 300 µmhos/cm, 1.2 mg/L,<500 mg/L respectively. The high values of these parameters have health implications require adequate time bound remedial measures.

KEY WORDS: Ground water, physicochemical analysis, drinking water quality, health implications.

I. INTRODUCTION

"Water is the best of all things", said the eminent Greek philosopher Pinder. Water is one of the most important and abundant compounds of the ecosystem. All living organisms on the earth need water for their survival and growth. As of now water covers 71% of the earth's surface, and is vital for all known forms of life. On earth, 96.5% of the planet's water is found in seas and oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.001% in the air as vapour, clouds (formed of solid and liquid water particles suspended in air), and precipitation. Only 2.5% of the earth's water exists as fresh water, and 98.8% of that is in ice and groundwater form. Less than 0.3% of available freshwater is in rivers, lakes, and the atmosphere, and an even smaller amount as earth's freshwater (0.003%) is contained within biological systems and manufactured products[1-2].But due to increase in population, industrialization, use of fertilizers in the agriculture and man-made activity, it is highly polluted with different harmful contaminants. Therefore it is necessary that the quality of drinking water should be checked at regular intervals, because due to use of contaminated drinking water, human population suffers from variety of water borne diseases. It is difficult to understand the biological phenomenon fully because the Chemistry of water reveals much about the metabolism of the ecosystem and explains the general hydro - biological relationship. Still one has to accept that access to safe drinking water has improved over the last few decades in almost every part of the world. But still approximately one billion people lack access to safe water and over 2.5 billion lack access to adequate sanitation. Thus, there is a clear correlation between access to safe water and GDP per capita. Some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability. [3]

As a focus on available potable water and scarcity of water in Kota industrial area, an attempt has been made to systematically study groundwater issues of region with focus on sustainable development in the Kota region. Safe and adequate drinking water is the prime requirement. Pollution of water has been reported to cause 80% of human diseases and 20% of infant mortality. It is therefore important to monitor the quality of ground water pollution in various parts

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of our country. Keeping this in view, the present study aims to calculate the water quality index in order to assess the suitability of water for human use in DCM industrial area Kota.
The work in this paper is divided in two stages. 1) Analysis [Physico chemical as well as microbial] 2) Comparative studies with adjoining areas. The paper contains three sections. Section II describes materials and methods explaining sample collection, methodology used for carrying out different analyses and study area, in addition to results and discussion of conducted study in section III. Finally, section IV concludes the findings.

II. MATERIALS AND METHODS

[a] SAMPLE COLLECTION: A total of 10 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 season in the month of March and April, 2014.These spots were specifically identified on the basis of frequent use & probability of contamination and were mapped. The season was selected because contamination often increases due to low dilution and tends to the accumulation of ions. Before sampling, the water was left to run from the source for five minutes [in case of hand pumps] while water was taken out from a depth of 03 meters [in case of wells]. The water samples were collected in pre cleaned, sterilized polyethylene bottles of 1 L capacity. All water samples were analysed within 12 to 24 hrs after collection.

[b] METHODOLOGY: The samples were analysed using standard methods of analyses to assess various physicochemical parameters according to APHA & WHO norms. Some parameters like temperature, colour, p^H were measured on site. Water sample were analysed by standard methods [4-6] for physicochemical parameters like water temperature(^0C), TDS, Conductivity, Turbidity, Odour, Nitrate, Sulphate, Phosphate, Dissolved Oxygen, Hardness, Chlorides, Fluorides, Nitrate, Sodium, Potassium and Chemical Oxygen Demand(COD),Biological Oxygen Demand(BOD), Alkalinity, Free NH_4, Coli form Organism, Heavy Metals like Fe^{+2}, As, Cu, Zn. The Physico-chemical analysis of groundwater samples were carried out by instrument and non-instrumental methods. Temperature, p^H, conductivity and TDS were determined by using water analysis Kit. Hardness, DO, Chloride, CO_2 and all such parameters were analysed by standard procedure mentioned in APHA [7].The elemental analysis was carried out by digital Flame Photometer. All the reagents used for the analysis were AR grade. Double distilled water was used for preparation of solutions.

[c] STUDY AREA: Kota is located along eastern bank of the Chambal River in the southern part of Rajasthan. The cartographic coordinates are 25°11′N 75°50′E/ 25.18°N 75.83°E. It covers an area of 318 km^2 (3.63 per cent of the Rajasthan State). It has an average elevation of 271 meters (889 ft). The district is bound on the North and North West by Sawai Madhopur, Tonk and Bundi districts. The Chambal River separates these districts from Kota district, forming the natural boundary.

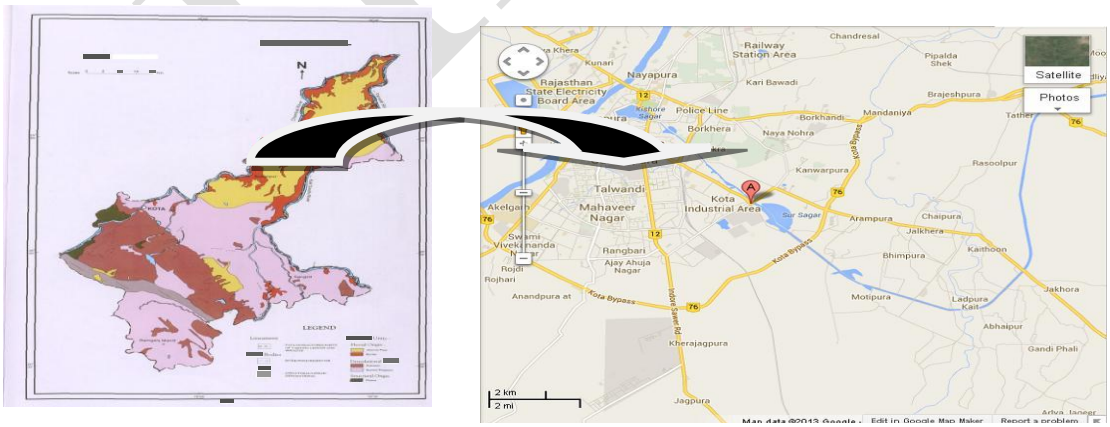

Fig: 1 Map of Kota District and DCM industrial area, Kota

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DCM industrial area and its adjoining areas have been chosen as area of study. Total covered area under study is 10 sq. Kms. The details of various spots selected for study are given in Table 1.

Table 1: Description of spots

Spot No.	Name of the spot	Source type	~ Distance between spots [In ms.]	Area [~1 sq. km.] Spot population
01	Near Govt. Girls Senior Secondary School, Bombay Yogena, Kansua	Tube Well	**500m**	**5000**
02	Near Bombay Yogena Colony, Kansua	Hand Pump	**550 m**	**5000**
03	Near Samudayik Bhawan, Near Maszid, Kansua	Hand Pump	**500m**	**2000**
04	Near Shiv Mandir, Kansua	Hand Pump	**750 m**	**3000**
05	Near Govt. Senior Secondary , Ram Nagar	Hand Pump	**1000 m**	**4000**
06	Near Govt. Senior Secondary School, Indra Colony , DCM	Hand Pump	**750 m**	**2000**
07	Shri Ram Fertilizer Gate , Near Fly Over, Prem Nagar	Hand Pump	**500 m**	**2000**
08	Samudayik Bhawan Ke Paas Prem Nagar III	Tube Well	**450 m**	**3000**
09	Papaji Ke Bhatte Ke Paas, Rayans Industry Boundary,Prem Nagar III	Tube Well	**500 m**	**2000**
10	Industrial Area, Near Dakaniya Station, Sanjay Nagar	Hand Pump	**1000 m**	**1000**
Adjoining area 1	Raipura	Dug Well	**1000 m**	**3000**
Adjoining area 2	Daddevi	Dug Well	**1000 m**	**500**
Adjoining area 3	Soorsagar	Pizometer	**1000 m**	**1000**
Adjoining area 4	Dhakerkhari	Dug Well	**850 m**	**1000**

III. RESULTS AND DISCUSSION

Various physicochemical parameters pH, electrical conductivity, total alkalinity, total hardness as well as calcium, magnesium, sodium, potassium, chloride, nitrate, sulphate and heavy metals were analysed with the determination of total coli organism. In general, the ground water had no colour, odour and turbidity except few samples.

The findings and their comparison with WHO health based drinking water guide lines [7] are presented in Table 2. The data revealed considerable variations in the water samples with respect to their pollutants. The results indicate that the quality of water varies considerably from location to location. The p^H concentration varied from 6.8 to 7.8 and was found to be within acceptable limits in samples collected from all spots. [8]

Many samples were observed to give electrical conductivity closure to the value of 500µS/cm and the value of conductivity of four samples [Sample 5, 6, 7 and 8] was higher than the acceptable limits [9].The WHO acceptable limit for alkalinity in drinking water is 200 -500 mg/l and values of all the samples were in acceptable limit.

Total dissolved solids comprised mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of Calcium, Magnesium, Sodium, Potassium, Manganese, organic matter salt and other particles[10]. In the present finding TDS value varied from 441 mg/l to 954 mg/l. Maximum TDS was recorded in Sample 6.TDS values are much higher in the study area in comparison to the other regions.

Except for some spots, the calcium hardness in water samples was present in higher proportions than the acceptable limit. Also the magnesium hardness was lower than the calcium levels in water samples with lower and higher values 100 and 200 mg/L respectively. Free ammonia was found to be higher [1.2 to 2.82 mg/l] than the acceptable limits in all samples; the permissible limit being 1.2 mg/l Total coli form organism was also found above the acceptable limit in 50 % some samples. [11-12]

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Table 2: Chemical characteristics of Ground water in DCM Industrial area, Kota and their Comparison with WHO guidelines

Parameter	WHO Permissible limit	Minimum Value	Maximum Value	Mean	SD*	Spot wise value results with spot Numbers		
						Below	Optimum	Higher
p^H	6.9-9.2	6.8	7.8	7.14	0.271621	-	10/10 [1 to 10]	-
EC	300 µmhos/cm	308.7	667.8	474.46	125.8213	-	-	10/10 [1 to 10]
F^-	1-1.5 mg/l	0.1	0.6	0.363	0.213232	10/10 [1 to 10]	-	-
TDS	500-1500 mg/l	441	954	677.8	179.7448	2/10[1,2]	8/10[3,4,5, 6,7,8,9,10]	-
Ca H	75-200 mg/l	150	300	223.5	56.96246	-	6/10[1,2,3, 4,9,10]	4/10[5,6,7 ,8]
Mg H	30-150 mg/l	100	200	150.5	38.90516	-	5/10[1,2,3, 4,10]	5/10[5,6, 7,8,9]
TH	100-500 mg/l	260	500	374	92.52027	-	10/10 [1 to 10]	-
Cl^-	200-600 mg/l	80	190	127.5	36.07477	10/10 [1 to 10]	-	-
Free NH^+_4	1.2 mg/l	1.5	5.1	2.82	1.565461	-	-	10/10 [1 to 10]
Coliform organism	<500 mg/l	15	2500	1394.375	1104.327	-	5/10[5,6,7, 8,9]	5/10[1,2,3 ,4,10]
Fe^{+2}	0.3 mg/l	1	1.5	1.228571	0.205866	3/10[1,2,4]	-	7/10[3,5,6 ,7,8,9,10]
NO_3^-	40-50 mg/l	0.5	55	23.15	20.73115	8/10[1,2,3, 4,7,8,9,10]	1/10[5]	1/10[6]
SO_4^{--}	200-400 mg/l	28	80	56.7	18.70264	10/10 [1 to 10]	-	-

*SD (Standard deviation):-

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}.$$

The Chloride concentration was ranged from 80 to 190 mg/L and is much below than the WHO acceptable limits. [8] Nitrate concentration varied from 0.5 to 55 mg/L and was found to be lower than the acceptable limits except some spots.[13] Similarly, the sulphate concentration [28 to 80 mg] has been found to be in comfort zone of WHO standards.[8]

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 "very hard" for the samples of at all the locations (Table 3). [14]

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Table 3: Classification of the water samples based on total hardness

S.No.	Description	Hardness (mg/L)	No. of Samples
1	Soft	0 – 60	-
2	Moderately Hard	61 – 120	-
3	Hard	121 – 180	-
4	Very Hard	>180	10 [1to 10]

All parameters of study area were compared to adjoining areas of the DCM Industrial Area. These other regions included RAIPURA, DADDEVI, SOORSAGAR and DHAKERKHARI. After comparing with data of adjoining areas, we found that TDS, Total Hardness, Chloride values are below range to study area but P^H, Nitrate values are in upper range in case of study area whereas Fluoride and Total Alkalinity values are in conflict to the study area. These variations have been plotted as Graphs using MatLab software to understand and derive conclusions with regards to variations/alarming situation in area of study and are available in Fig. 2 to Fig.10.

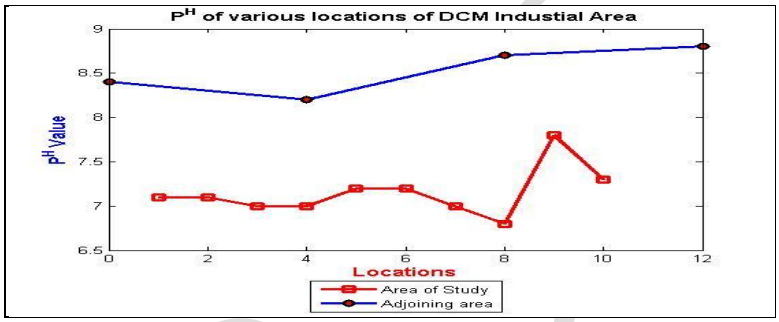

Fig. 2 pH value of Study area & Adjoining area

pH values of various spots in study area ranged between 6.8 and 7.8 while the range in adjoining areas has been reported is on higher side than of study area(Fig.2). However, the range in the areas of study appears to be in acceptable limits prescribed by WHO whereas alkaline range in adjoining areas may be observed as normal.

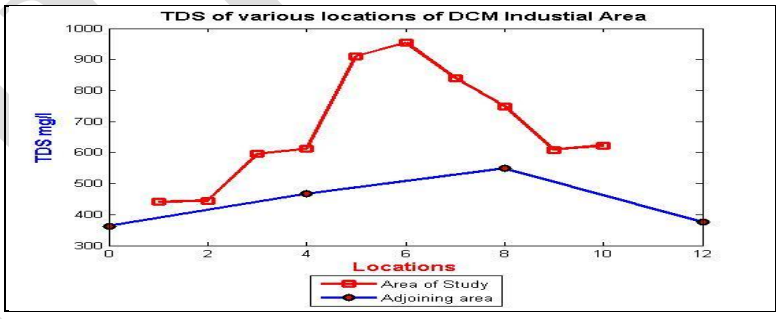

Fig. 3 TDS value of Study area & Adjoining area

TDS concentration in the samples studied varied between 441 mg/L and 954 mg/L (Fig 3). The prescribed permissible limit of TDS for drinking water is 500 mg/L. TDS concentrations above 500 mg/L was noticed in most of the samples. In water samples collected from Bombay Yogena and Kansua, TDS concentrations were found less than500 mg/L while it was maximum in sample of Govt. Sen. .Sec. School, Indra Colony, DCM (954 mg/L).The TDS values of Adjoining area varied between 363 mg/L and 549 mg/L and are in safe range.

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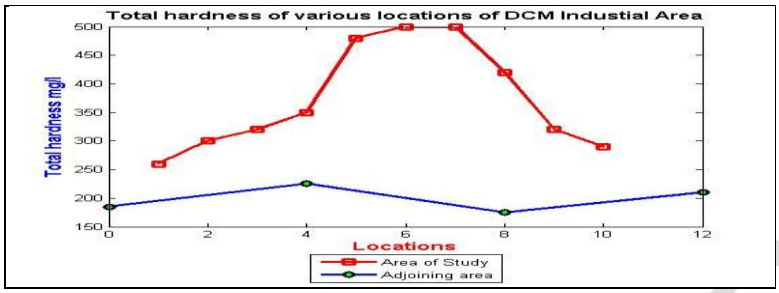

Fig. 4 Total Hardness value of Study area & Adjoining area

All samples showed lower concentrations of total hardness compared to the prescribed permissible limit for drinking water, i.e. 100 to 500 mg/L. The maximum hardness was found (500 mg/L) in sample No. 6 & 7, while the minimum concentration (260 mg/L) was found in sample No. 1 (Fig 4). The average value of hardness was found 374 mg/L. whereas the total hardness value of Adjoining areas varied between 175 mg/L and 225 mg/L.

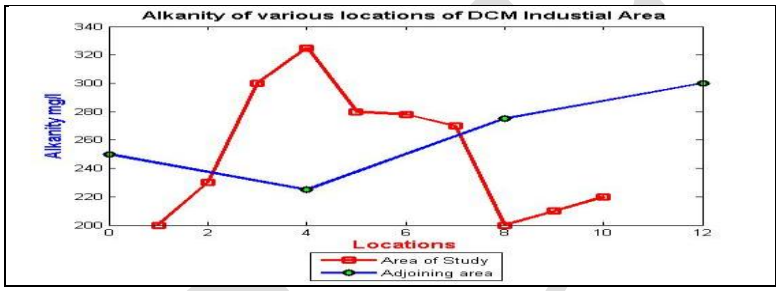

Fig. 5 Alkalinity value of Study area & Adjoining area

The samples showed higher concentrations of total alkalinity exceeding permissible limits for drinking water, i.e. 200 mg/L. The maximum concentration of alkalinity observed was 325 mg/L in sample No. 4, while the minimum being 200 mg/L in sample No. 1 & 8 (Fig 5). The average value of total alkalinity (251.3 mg/L) was found higher more than permissible limits whereas the alkalinity value of Adjoining areas varied between 250 mg/L and 300 mg/L.

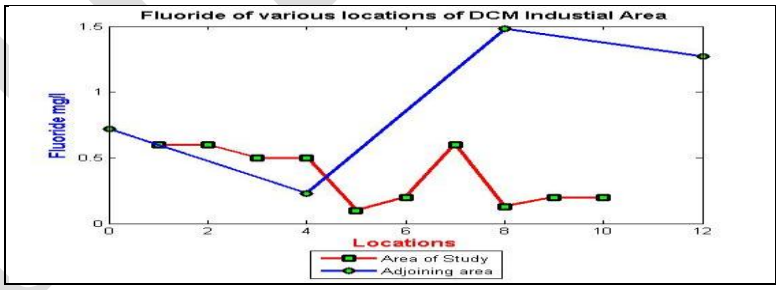

Fig. 6 Fluoride value of Study area & Adjoining area

Fluoride concentration in the study area is depicted in Fig 6. Fluoride concentrations in the study area varied between 0.1 to 0.6 mg/L. The average value of Fluoride (0.363 mg/L) was found in permissible limits whereas Fluoride value of Adjoining areas varies between 0.23 mg/L and 1.48 mg/L which are on higher side in comparison to the study area.

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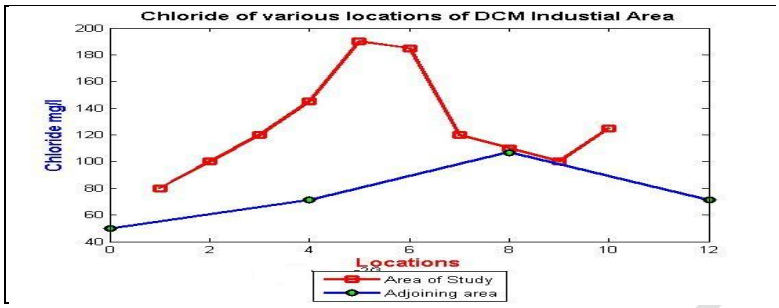

Fig. 7 Chloride value of Study area & Adjoining area

Most of the samples analysed showed lower concentrations of chlorides than the prescribed permissible limit for drinking water, i.e. 250 mg/L. Maximum concentration of chlorides observed was 190 mg/L in sample No. 5, while minimum being 80 mg/L in sample No.1 (Fig 7). The Chloride value of Adjoining area was ≤ 100 mg/L.

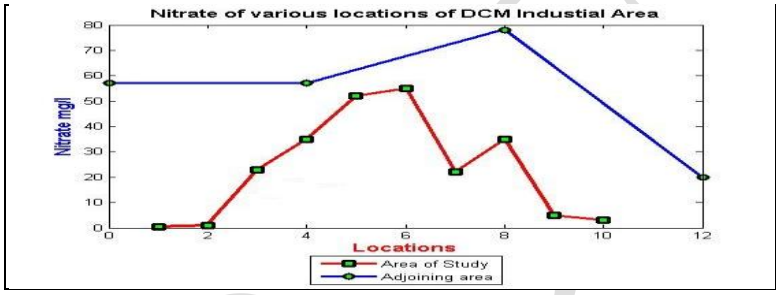

Fig. 8 Nitrate value of Study area & Adjoining area

The nitrate values showed permissible concentrations except was in sample No. 6 which was observed to be 55 mg/L, while minimum concentration of nitrate was 0.5 mg/L in sample No.1 (Fig 8). The average value of Nitrate (23.15 mg/L) was found higher than permissible limits whereas the nitrate value of Adjoining area varies between 19.84 mg/L and 57.04 mg/L.

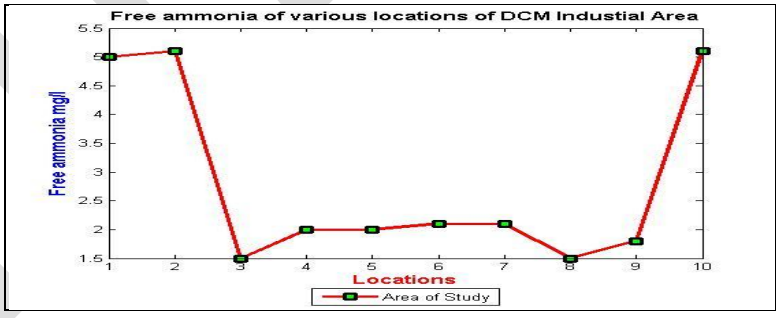

Fig: 9 Free Ammonia value of Study area

All samples showed higher concentrations of free ammonia exceeding the prescribed permissible limit for drinking water, i.e. 1.2 mg/L. The maximum concentration of free ammonia observed was 5.1 mg/L in sample No. 2 & 10, while the minimum concentration of free ammonia was 1.5 mg/L in sample No.8 (Fig 9). The average value of total free ammonia (2.82 mg/L) was found higher more than permissible limits whereas the free ammonia value data of Adjoining areas was not available.

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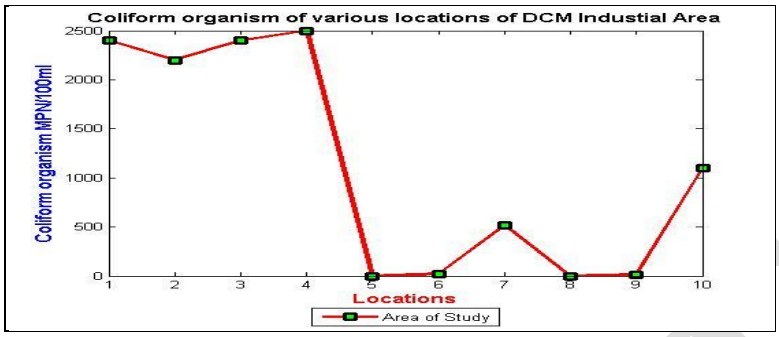

Fig. 10 Coli form Organism value of Study area

Samples showed higher concentrations of Total Coli form than prescribed limits for drinking water, i.e. 500 mg/L. The maximum concentration of Total Coli form observed was ~ 2500 mg/L in sample No. 2, 3 & 4, while minimum was 15 mg/L in sample No.8 and 9 (Fig 10). The average value of Total Coli form (1394.37 mg/L) was found higher more than permissible limits.

IV. CONCLUSION

The groundwater sources in the DCM Industrial area, Kota District were evaluated for their chemical composition and suitability for drinking and irrigation purposes. It is observed that about 95% of ground water exceeds the permissible limits of EC, Hardness, free NH_4, Coli form Organism & Fe^{+2} prescribed by (WHO: 2003). No doubt, the parameters like p^H, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, BOD and COD are within the permissible limits prescribed by WHO but appear to be falling in danger zone. Hence, it can be concluded that consumption of ground water in the area of study needs to be redressed by proper treatment before it is consumed by living beings as well as for irrigation purpose. An exhaustive study may be useful for providing a sustainable solution with reference to potable water.

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