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Physico-chemical and Microbiological Studies for the Underground Water of East Dwarka Subcity of Delhi and the Impact of Rainwater Harvesting on its Quality

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ABSTRACT

Earlier work has suggested that with the increase in the consumption of water due to the growing population of Delhi, there is a continuous decrease in the water level in the parts of Delhi. Due to this decline water is getting saline which is making it harmful for vegetation; also its taste is being affected. To overcome such problems rainwater harvesting systems have been established. Rainwater harvesting dilutes the dissolved salts in ground water. In the present study water samples, from various societies of Dwarka subcity of New Delhi have been collected where rainwater harvesting systems are installed. The impact of rainwater harvesting on the quality of ground water has been studied by collecting water samples from these selected sites in the months before after and during the rain. The present study revealed that the rainwater harvesting suitably affected the quality of ground water.

Key words: Rainwater harvesting system, physico-chemical parameters, microbiological parameters, ground water quality.

INTRODUCTION

Water is one of the most important and essential elements in the development of the country. It is estimated[1] that the consumption pattern will increase as the time proceeds with the growing demand of the food production. The earlier work[1] suggests that in Delhi there is a continuous decline in the water level i.e. 30 cm per year. This decline not only makes the water get scare but also brings it to saline, hampering the plant growth or vanishing the vegetation cover from the top surface of the earth. It has been found that in India, per capita average annual fresh water availability has been reduced from 5177 cubic meters from 1951 to 1820 cubic meters in 2001 and it is estimated to further come down to 1341 cubic meters in 2025 and 1140 cubic meters in 2050[2]. The present study is related to overcome these problems, by using rainwater-harvesting system. We have studied that how rainwater harvesting dilutes the dissolved salts and increases the water level. In this regard, we have determined the physico-chemical and microbiological parameters for the underground water samples collected from the various societies of the said sub city where rainwater-harvesting systems are installed. The parameters have been determined before and after the monsoon. On the basis of the data available, it has been concluded that rainwater harvesting can solve the problems related to water. In such harvesting systems the rainwater-harvesting pit designed specially is connected to the drainage network. Through this network water is stored directly in underground aquifer layers to increase the ground water potential.

MATERIAL AND METHODS

Reagents and Instruments

The main reagents used for the analysis of water samples were obtained from CDH, GHC, E-Merk, Qualigens (India). All other reagents and

chemicals were of analytical reagent grade. A digital pH meter (Elico LI-10, India), a UV/VIS spectrophotometer (Elico EI 301E, India), a B.O.D. incubator, a water bath and a incubator shaker. All these instruments were used to determine the physico-chemical parameters

Collection of water samples

Each fifteen ground water samples were collected on 1st day of May 2004, 1st day of July 2004, 1st day of August 2004, 1st day January 2005 & Ist day of March 2005. All samples were tightly sealed and immediately taken to the laboratory for analysis. During the analysis all samples were stored in dark and cool environment (at 4C° approx.)

Sampling sites

Ground water samples collected from fifteen societies where rainwater-harvesting systems are installed. The names of the societies are as follows.

1) Sample No. 1: Princes Park, Plot No.33, Sector 6
2) Sample No. 2: Vidya sagar, Plot No.34, Sector 6
3) Sample No. 3: Surya, Plot No.14, Sector 6
4) Sample No. 4: Great India, Plot No.15, Sector 6
5) Sample No. 5: Akash Ganga, Plot No.17, Sector 6
6) Sample No. 6: Suruchi, Plot No.31, Sector 10
7) Sample No. 7: Shama, Plot No.32, Sector 10
8) Sample No. 8: Prabhavi, Plot No. 29, Sector 10
9) Sample No. 9: Man Bhavan, Plot No. 26, Sector 10
10) Sample No. 10: Rashi, Plot No.3, Sector 7
11) Sample No. 11: Shri Niketan, Plot No.1, Sector 7
12) Sample No. 12: HMM, Plot No. 6, Sector 10
13) Sample No. 13: Param Puneet, Plot No.27, Sector 6
14) Sample No. 14: Anusandhan, Plot No.22, Sector 6
15) Sample No. 15: RD., Plot No. 20, Sector 6

Data Analysis

All Physico chemical and microbiological parameters determined for the abovementioned samples, have been listed in tables 1-6. The physico-chemical parameters are, Alkalinity determined by acid titration[3], Hardness determined by the complexometric titration method[3], Chloride ions determined by Argentometric method (Mohr's Method)[3], Dissolved oxygen determined by the Winkler's Method[3] as well as NO_3^-, NO_2^- & SO_4^{2-} determined by UV/VIS spectrophotometer[3]. The coliform determination is done using Mackonkey broth as a media for the grouth of coliform.

RESULTS AND DISCUSSION

Physico-chemical and microbiological studies of underground water of eastern part of Dwarka subcity of New Delhi {Fig 7(a) & 1(b)} were performed in all the three seasons of year 2004 & 2005. For the present studies water samples from fifteen different stations were collected in May, July & August of year 2004 as well as January & March of Year 2005. These months were selected in a view to assess the quality of under ground water before monsoon, during monsoon and after monsoon. All the stations selected for collecting the water samples were provided with rainwater harvesting pits to study the effect of rainwater harvesting on the quality of under ground water. The results for all the determined parameters of the present study are listed in table 1 (befor monsoon) table 2 & 3 (during monsoon) and table 4 & 5 (after monsoon). The same parameters were also studied for the rainwater and listed in table 6.

It was found that the values of almost all the parameters for the water samples of all the fifteen sampling stations (collected before and after monsoon) are within the maximum desirable limits of the drinking water specifications (IS 10500:1991 & WHO). The pH values for all the studied samples collected before rain i.e. May 2004 are ranging from 6.7 to 8.2. However, these values for almost all the samples collected during monsoon, were slightly decreased due to harvesting of rainwater (pH=6.5). Variation in pH is shown in figures [Fig 1(a) & 1(b)]. As regards, TDS [Fig 2(a)&(b)] the values for the samples collected before rains were found to be ranging from 333.2 mg/L to 1011.9 mg/L .All the values are within the permissible limit. A decrease in the TDS values for all the samples collected during monsoon was observed. The observed values of

Table 1: Determined Parameters of the water samples collected on 1st day of May, 2004

	S.NO .1	S.NO. 2	S.NO. 3	S.NO. 4	S.NO. 5	S.NO. 6	S.NO. 7	S.NO. 8	S.NO. 9	S.NO. 10	S.NO. 11	S.NO. 12	S.NO. 13	S.NO. 14	S.NO. 15	WHO
pH	8	7.8	7.11	6.8	7.12	8.1	7.2	6.8	7.12	8.2	7.35	6.7	7	6.8	7	6.5 – 8.5
T.D.S.	880.2	760.5	1011.9	735	488.6	888.9	400	788.4	630.6	900.3	820.9	333.2	922	745.6	800.2	1000
Alk.	488.5	565	611.6	410.5	515	600.3	375	317.1	370.6	610.1	285	365.3	300	332.4	500	-
Ca^{2+}	63.5	51.9	150.7	130.4	65	132.4	120.5	110.2	150.1	145.3	98.7	98.2	75.8	99.4	198.2	-
Mg^{2+}	86.5	63.5	261	192.1	45.7	256.4	147.5	80.3	73.7	254.7	125.2	114.5	169	140.15	126.9	-
T.H.	150.1	115.4	411.7	322.5	110.7	388.8	268	190.5	223.6	400	223.9	212.7	245	239.55	325	500
D.O.	8.1	7.51	9.12	7.24	7.06	7.3	8.55	8.44	8	8	7.4	8.7	7.9	7.12	8.3	-
B.O.D	0.1	0.1	0.105	0.99	0.6	0.1	0.4	0	0	0	0.1	0	0.2	0	0.1	-
Cl^-	205.1	120	260.5	560.92	195.7	255.3	460.4	440.5	360.5	230.5	228.3	230.2	250	400.2	212.5	250
SO_4^{2-}	42.4	44.9	144	55.1	60	111.7	38	31.8	42.2	102.7	40.3	23.1	50	69.7	98	400
NO_3^-	4.1	5.5	10	10	6.2	8	6.02	13.1	9.2	7	8.8	7.5	9	5.9	6	10
NO_2^-	2	2.3	2.55	3	2.9	2	3.32	2	2.88	3	2	2.55	3.1	2.22	3.5	-
Coliform	3	0	2	1	2	0	2	1	2	0	2	3	4	0	3	10

Table 2: Determined Parameter of the Water samples collected on 1st day July, 2004

	S.NO .1	S.NO. 2	S.NO. 3	S.NO. 4	S.NO. 5	S.NO. 6	S.NO. 7	S.NO. 8	S.NO. 9	S.NO. 10	S.NO. 11	S.NO. 12	S.NO. 13	S.NO. 14	S.NO. 15	WHO
pH	8.2	8.1	6.9	7.11	6.8	7.5	7.33	8	6.7	7.3	7	6.8	7.2	6.5	7.23	6.5 – 8.5
T.D.S.	820.4	760.4	1070.2	800.4	502.3	989.6	420.4	800.5	650.6	788.3	840.6	335.6	923	755.6	700.8	1000
Alk.	500.3	580.2	620	420.6	520.1	618	380	322.9	322.3	620.2	300.2	368	350	340	521.2	-
Ca^{2+}	42.2	49.9	200.1	215.1	58.2	140.9	132.1	198.2	155.1	222.2	155.8	131.8	160	211.5	180.9	-
Mg^{2+}	93.2	77.54	210.4	139.9	94.2	227.5	148.4	13.3	85.7	178.5	94.9	98.9	141	42.35	129.4	-
T.H.	135.4	127.44	410.5	355	152.4	368.5	280.5	211.5	240.8	400.8	250.7	230.6	301	253.85	310.3	500
D.O.	8.16	7.67	9	7.34	7.14	7.2	8.67	8.97	8.7	8.1	9	8.87	8.2	7.34	7.7	-
B.O.D	0	0.1.2	0.1.8	0.102	0.51	0.1.3	0.61	0.102	0	0.1.4	0	0	0	0	0.1.	-
Cl^-	200.3	211.5	270.6	565.8	198.8	220	480.9	460.4	370.9	185.3	240.8	252.5	265	450.7	211	250
SO_4^{2-}	46.4	50.6	129.6	63.7	65.9	86.7	34.6	34.5	45.5	98.5	44.5	25.5	55	71.5	78.7	400
NO_3^-	4.5	6	10.12	10	6.32	9	6	15.4	9.5	9	6.5	7.7	6.9	6	8	10
NO_2^-	2.51	2.5	2.65	3.4	3.1	2.2	3.35	1.9	2.95	2.11	2.4	2.75	3.2	2.25	2.31	-
Coliform	5	0	4	4	4	0	5	0	6	0	2	2	5	0	5	10

Table 3: Determined Parameter of the Water samples collected on 1st day August, 2004

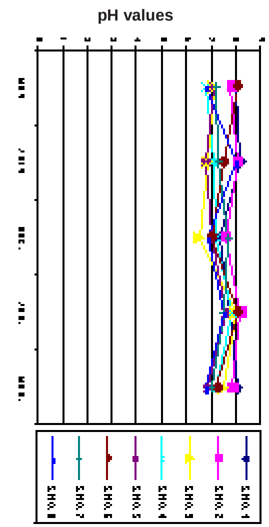
	S.NO .1	S.NO. 2	S.NO. 3	S.NO. 4	S.NO. 5	S.NO. 6	S.NO. 7	S.NO. 8	S.NO. 9	S.NO. 10	S.NO. 11	S.NO. 12	S.NO. 13	S.NO. 14	S.NO. 15	WHO
pH	7.4	7.6	8	7.2	7	7	7.7	6.9	6.8	6.6	7.5	7	7	6.9	7.4	6.5 – 8.5
T.D.S.	700.4	620.7	980.7	730.3	305.2	666.1	300.4	580.5	525.4	655.7	700.6	325.7	750	740.3	700.2	1000
Alk.	450.2	556.1	520.6	388.9	499.3	444.6	335.7	310	300.2	588.9	250.9	355.4	241.3	330.2	511.8	-
Ca^{2+}	55.2	28.9	120.8	110.1	100.5	200.1	110.2	101.5	97.2	120.7	110.2	97.2	180	160.3	101.2	-
Mg^{2+}	65.1	71.7	259.9	112.7	40.3	80.3	105.7	17.3	103.2	210	100.2	100.5	40.3	92.83	178.9	-
T.H.	120.3	100.6	380.7	222.8	140.8	280.4	215.9	118.8	200.4	330.7	210.4	197.8	220.3	253.13	280.1	500
D.O.	8	7.5	9.11	7.2	7	8.2	8.33	8.35	7.9	7.8	7.4	8.4	8	7.04	6.8	-
B.O.D	0.98	0.92	0.99	0.95	0.58	0.9	0.42	0	0	0.8	0.1	0	0	0	0.6	-
Cl^-	200.3	120.5	230.6	430.6	190.7	202	250.7	400.3	335.5	200.7	210.9	211.2	228	390.9	208	250
SO_4^{2-}	42.2	44.4	112.4	54.7	60.7	80.9	37.3	30.8	42.5	80	30.6	23	38.3	67.7	60	400
NO_3^-	4	504	10	10	6.18	4	6	13	9.1	6.9	7.7	7.2	8	5.2	7.1	10
NO_2^-	2	2.2	2.4	3	2.8	3	3.22	2	2.66	4	2	2.5	2.9	2.2	3.1	-
Coliform	8	2	4	4	8	0	12	3	6	2	3	6	6	0	5	10

Table 4: Determined Parameter of the Water samples collected on 1st day January, 2005

	S.NO .1	S.NO. 2	S.NO. 3	S.NO. 4	S.NO. 5	S.NO. 6	S.NO. 7	S.NO. 8	S.NO. 9	S.NO. 10	S.NO. 11	S.NO. 12	S.NO. 13	S.NO. 14	S.NO. 15	WHO
pH	7.8	8.2	8	7.9	7.6	8.1	7.5	7.5	7.1	7.2	8.1	7.5	7	7.1	7.5	6.5 – 8.5
T.D.S.	790.4	700.6	900.7	820.5	510.6	800.1	350.5	700.4	600.3	758.5	730.5	335.2	800.1	690.5	750.2	1000
Alk.	600.3	620	570.2	380.4	520	500.2	360.5	333.1	338.9	620	285.2	388.4	335.2	425.3	588.2	-
Ca^{2+}	67.2	50.9	200	110.9	70.5	130.7	112.7	76.4	105.2	150.4	18.1	170.5	110.1	170.2	120.1	-
Mg^{2+}	65	59.5	212.4	111.9	89.7	169.9	110.2	49.3	120.2	229.5	202.3	54.5	115.2	44.34	230.2	-
T.H.	133.2	110.4	412.4	222.7	160.2	300.6	222.9	125.7	225.4	380	220.4	225.1	225.3	214.54	350.3	500
D.O.	7.55	8	7.99	9.1	8	7.8	7	6.88	7.8	7.1	9	8	8.1	8	7	-
B.O.D	0	0	0.99	0.8	0.77	0	0.7	0.6	0	0	0	1.01	0	0	0.2	-
Cl^-	208.6	120.3	222.6	490.9	205.4	202.9	250.5	243.2	345.7	212.9	220.9	227.9	231.2	408.2	200.4	250
SO_4^{2-}	80.3	65.3	130.5	101.5	78.2	100.7	41.1	30	45.4	98.3	42.3	10.3	50.4	56.2	78.5	400
NO_3^-	4	6	8	3	5.2	7	8	6.4	7.5	6.8	6.5	6	7.2	6	5	10
NO_2^-	3	5	7	2	2.22	6	2.7	2.4	3	5.2	2.44	3.23	3.3	2.6	4.1	-
Coliform	6	1	6	3	6	0	3	2	8	0	4	2	6	0	4	10

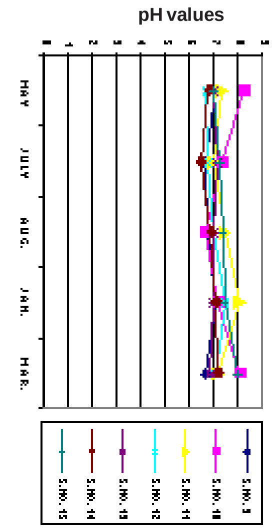
Table 5: Determined Parameter of the Water samples collected on 1st day March, 2005

	S.NO .1	S.NO. 2	S.NO. 3	S.NO. 4	S.NO. 5	S.NO. 6	S.NO. 7	S.NO. 8	S.NO. 9	S.NO. 10	S.NO. 11	S.NO. 12	S.NO. 13	S.NO. 14	S.NO. 15	WHO
pH	8.1	7.9	7.5	7.2	6.9	7.2	7	6.8	6.7	8.1	7.2	7.1	6.9	7.2	8	6.5 – 8.5
T.D.S.	800.4	780.1	1100	850.4	520.6	812.1	380.4	750.3	615.3	788.4	800.5	380.6	822.7	720.6	900.1	1000
Alk.	611.1	600.5	680.6	450.7	515	530.3	370.1	355.1	350.4	680	280.5	420.6	280.3	435.7	600.1	-
Ca^{2+}	50.2	44.5	170.1	110.2	110.2	200	120.5	80.9	120.9	130.1	90.9	120.2	110.32	98.2	140.2	-
Mg^{2+}	95	97.7	258.5	190.4	80.7	110.1	110.1	69.9	119	112.7	135	115.7	130.7	125.61	181.9	-
T.H.	145.2	142.2	428.7	300.6	190.9	310.1	230.6	150.7	230.9	352.8	225.9	235.9	240.9	223.81	322	500
D.O.	8	8.5	8	8.9	8.66	8.2	7.66	8	7.8	7.8	7.12	8	7	8	8.1	-
B.O.D	0.01	0.91	0.78	0.7	0.9	0.1	1	0	0	0.2	0	0	0	0.88	0.1	-
Cl^-	222.3	130.4	207.5	520.8	218.9	200.4	280.3	260.6	355.3	212.9	226.2	235.4	240.7	435.8	223.6	250
SO_4^{2-}	55.1	60.8	133.7	90.8	80.9	98.8	48	32.2	75.5	111.5	45.8	19	52.9	58.9	110.1	400
NO_3^-	5	7	8	6	5.2	7.5	8.3	7.2	7.5	6	7	7	7.4	7	9	10
NO_2^-	4	4.5	6	4	2.3	3	3	2.2	3	2.2	2.8	3.35	2	2.9	4.3	-
Coliform	8	0	8	3	5	0	5	1	10	0	5	5	7	0	6	10



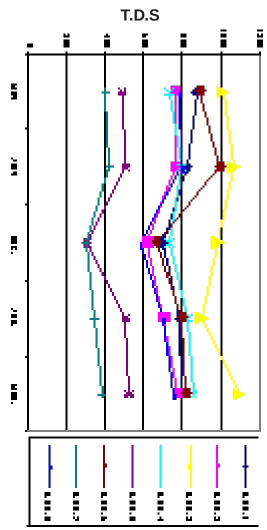
Months of sample collection

Fig. 1(a): pH values



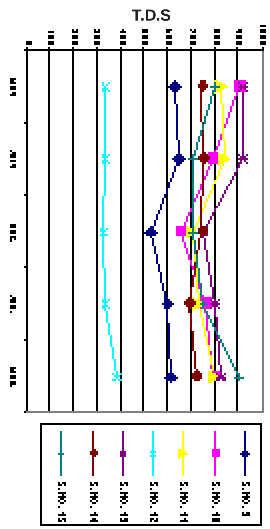
Months of sample collection

Fig. 1(b): pH values



Months of sample collection

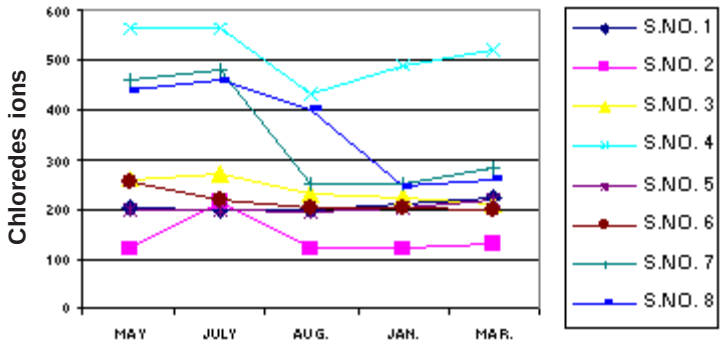
Fig. 2 (a): T.D.S



Months of sample collection

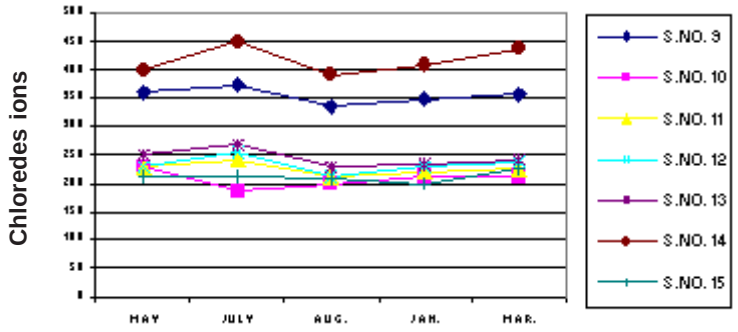
Fig. 2 (b): T.D.S

Total Hardness [Fig 4(a)&(b)] for all the samples collected in May 2004 is below 500mg/L, which is desirable for drinking water. For all the samples collected before the monsoon, the determined values for chloride ions (Cl^-) were ranging from 120 mg/L to 560.92 mg/L, for sulphate ions ($SO4^-$) from 23.1 mg/L to 144 mg/L and for alkalinity from 285 mg/L to 611.6 mg/L. (Table 1). For all the above parameters the values are well within the permissible limit of the drinking water. The amounts of Nitrate ($NO3^-$) and Nitrite ions ($NO2^-$) present in all the samples collected in May 2004 were sufficiently below the permissible limit of drinking water. All the above-mentioned parameters were



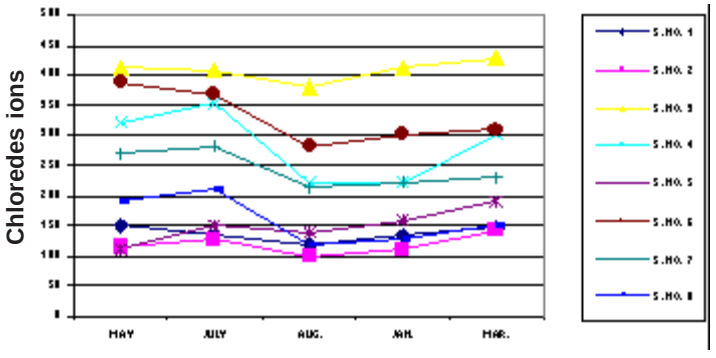
Months of sample collection

Fig. 3(a): Chloredes ions



Months of sample collection

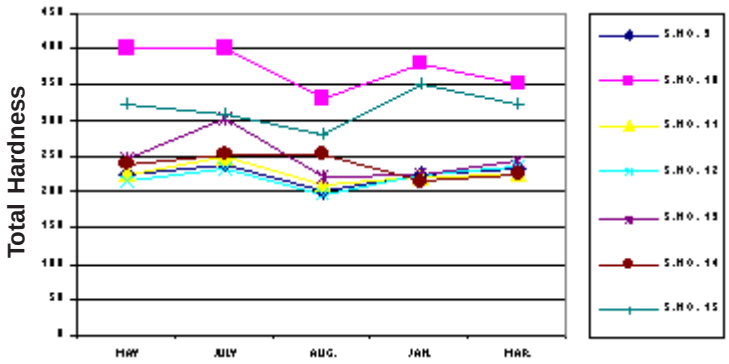
Fig. 3(b): Chloredes ions



Months of sample collection

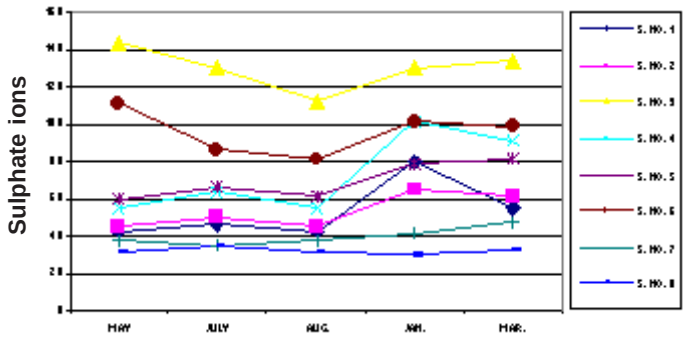
Fig. 4(a): Total Hardness

also determined for the water samples collected from the same stations during the monsoon i.e. during month of August and September 2004 as well as after the monsoon i.e. in the month of January & March 2005. It was observed that the values of TDS, total hardness, chloride ions and alkalinity for all the studied samples collected before monsoon were comparatively higher due to increased atmospheric temperature and decreased ground water level. However during monsoon, due to effective rainwater harvesting through specifically designed harvesting pits, these values were lowered. Similarly, after the



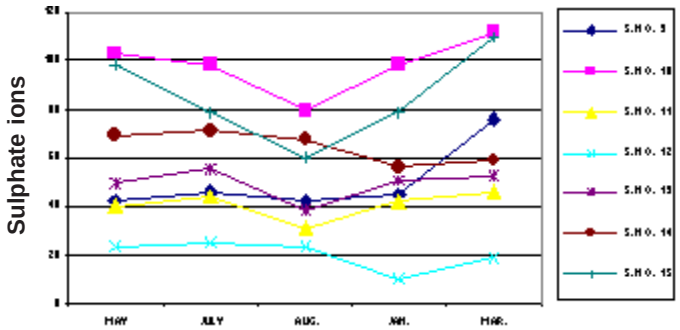
Months of sample collection

Fig. 4(b): Total Hardness



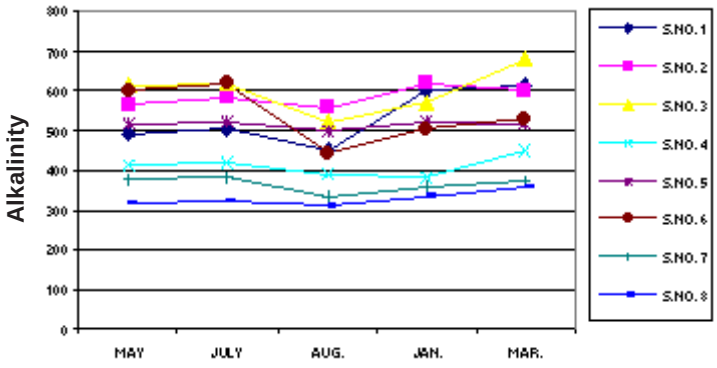
Months of sample collection

Fig. 5(a): Sulphate ions



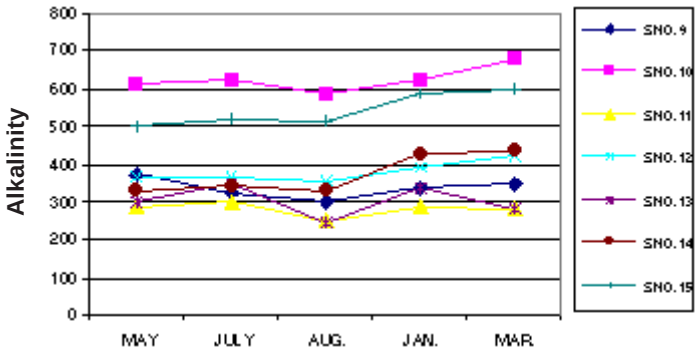
Months of sample collection

Fig. 5(b): Sulphate ions



Months of sample collection

Fig. 6(a): Alkalinity



Months of sample collection

Fig. 6(b): Alkalinity

monsoon i.e. in January and March when water level again started going down the values of these parameters started increasing gradually. A comparative trend for some studied parameters is shown in [Fig 1(a)&(b)], [Fig 2 (a)&(b)], [Fig 3(a)&(b)], [Fig 4(a)&(b)], [Fig 5(a)&(b)], [Fig 6(a)&(b)].

Dissolved oxygen contents for all the studied water samples were found very from 7mg/ L to 9mg/L, which were almost unaffected by rainwater harvesting. Very low values of BOD ranging from 0.00 to 1.60 mg/L for all the studied samples collected before and after harvesting indicate that all these water samples were free from microorganism as well as organic pollutants and are therefore safe for drinking.

It was found that for all the fifteen water samples collected before monsoon the coliform count was ranging from 00 to 4 coliform colony / 100 ml which is quite less than the permissible limit (<10 coliform colony/100 ml). However the number of coliform organism were detected more in few water samples (8 to 12 coliform colony /100ml) collected during monsoon but these numbers as per Bureau of Indian standard specification & WHO for drinking water were below the permissible limit except the numbers of one sample i.e. 12 coliform colony /100ml. The reason for more number of coliform present in the underground water during monsoon is attributed to the contamination of rainwater by the atmospheric organic pollutants and microorganism.

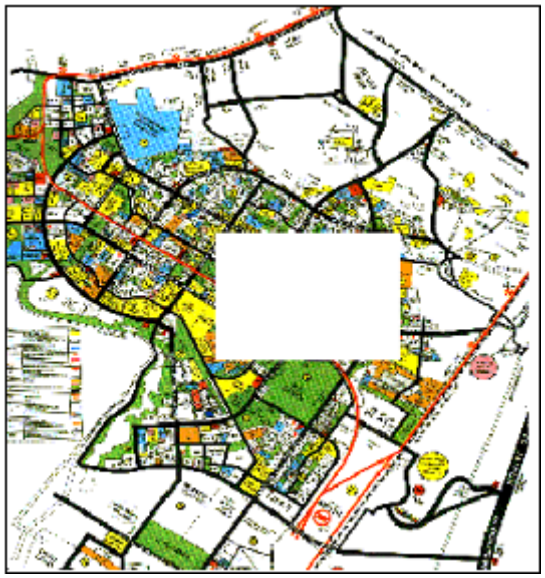


Fig. 7(a) Map of Dwarka (Delhi)

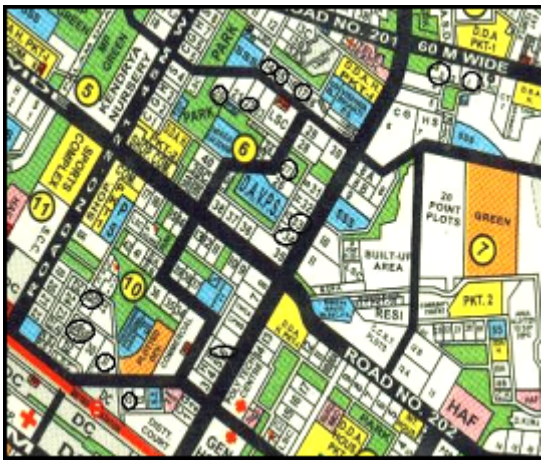


Fig. 7(b) Sampling Sites

Table 6: Determined Parameters of the Water samples collected from rainfall on 8th day of July, 2004 (R1) & 3rd day of August, 2004 (R_2)

	pH	T.D.S.	Alk.	Ca^{2+}	Mg^{2+}	T.H.	D.O.	B.O.D.	Cl^-	SO_4^{2-}	NO_3^-	NO_2^-
R_1	6.5	65	80	9.5	21.9	31.4	5.1	0.51	42.6	10	7.5	1.8
R_2	6.9	62	77	9	18.1	33	4	0	33	8.7	7.7	2.2

Note : From Table 1-6

T.D.S., Alk., Ca^{2+}, Mg^{2+},T.H., D.O.,B.O.D.,Cl^- and SO_4^{2-} in mg/ltr. ,NO_3^- and NO_2^- in microgram./ltr, whereas coliform in coliform colony /100ml

T.D.S. - Total Dossolved Solid
D.O. - Dossolved Oxygen
B.O.D. - Biological Oxygen Demand
S.NO .- Sample Number
T.H. - Total Hardness
Alk. - Alkalinity

Conclusion

The physico-chemical studies, which have been performed for various samples of water collected before and after monsoon, show that the hardness, alkalinity, T.D.S, NO_3^-, NO_2^- SO_4^{2-} and Cl^- of almost all the samples have been decreased appreciably due to the mixing of rain water to the under ground water. Thus, indicative parameters e.g. pH, T.D.S., alkalinity, etc. performed before and after monsoon indicate that rainwater harvesting suitably affects the quality of ground water. And rainwater harvesting has proved its utility for the above-mentioned sites.

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