Asian J. Exp. Sci., Vol. 22, No. 3, 2008; 311-316

Pre- and Post-Monsoon Variation in Physico-Chemical Characteristics in Groundwater Quality of Bhopal "The City of Lakes" India

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Abstract : Ground Water quality plays an important role in groundwater protection and quality conservation, hence it is very much important to assess the groundwater quality not only for its present use but also a potential source of water for future consumption. The study area selected was ground water of Bhopal " The City of Lakes", Madhya Pradesh, India. In the present study an attempt has been made to identify the ground water quality of the city in Pre monsoon and Post monsoon phase in year 2007. The physico-chemical parameters like pH, Electrical conductivity, Total hardness, Total alkalinity, Chloride, Sulphate, Sodium, Potassium, Mg and Nitrate were studied to analyze the potable ground water quality of the city. Better water quality was found in Post-monsoon season than Pre-monsoon season. Extent of pollution occurred due to over exploitation of ground water, urbanization and anthropogenic activities.

Key words : Ground Water, Water Quality, Pollution, over exploitation, Anthropogenic activities.

Introduction

Ground Water is a renewable natural resource, which is replenished annually by the precipitation. Ground Water quality plays an important role in groundwater protection and quality conservation. Hence, it is very important to assess the groundwater quality not only for its present use but also from the viewpoint of a potential source of water for future consumption (Kori *et al.*, 2006). It is well known that occurrence of ground water and its availability for various uses is controlled by the nature of rock formation in which it occurs as well as geological structures, geomorphologic and hydrological setting and hydrometreological conditions. This resource is generally developed through ponds, lakes, wells and tube wells depending up on the need for which it is being used and its availability in the area (Raju, 1983).

According to the daily Newspaper, in Bhopal, 80,000 Borings are situated amongst the 4 lakhs buildings and only 3000 water harvesting system are in the city, so that water extraction is more than water recharging. An uncontrolled use of bore-well technology has lead to the extraction of ground water at such a high rate that often recharge is not sufficient.

Water intended for human consumption should be "safe and wholesome" *i.e*. free from pathogenic agent and harmful chemicals, pleasant to taste and useable for domestic purpose (Parashar *et al.*, 2006). The study area selected was all over urban area of Bhopal for ground water quality testing. The city is dividing into five different zones, and six samples are collected from each zone. The physico-chemical parameters like pH, EC, Total hardness, Total alkalinity, Chloride, Sulphate, Sodium, Potassium, Mg and Nitrate

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were studied to analyze the potable ground water quality of the city of lakes.

Water is the principal need of life on earth, the requirement of water in all lives, from micro-organism to man is a serious problem today because all water resource have been reached to a point of crises due to unplanned urbanization and industrialization (Singh *et al*., 2002). Water pollution is the state of deviation from pure condition, whereby its normal functioning and properties are affected. Aggravated environment problems often reflect the misuse or misunderstanding of technology (Petak, 1980).

Geology of Bhopal

Geologically rocks of upper Vidhyan group comprising of quartzitic sandstone, shales and Deccan trap, occupy Bhopal.

Basalts of Cretaceous Eocene age, literati and alluvial soil of sub-recent to recent ages are met within the relatively high grounds and river valley plains respectively (Geology of M.P., 1981).

Material and Methods

The study area selected was total urban area of the city of lakes, Bhopal, Madhya Pradesh, India. Water samples were drawn from bore-wells and hand pumps during Pre and Post-monsoon period of the year 2007. The water samples were collected in plastic container as possible to avoid unpredictable changes in physico-chemical characteristics. The testing of samples was done according to the procedure prescribed by APHA (1995).

Present study comprises of interpretation and analysis of water samples collected from thirty different stations at all over city. In our study, first we mark the sampling stations in five different zones of the city, then stations were established and water samples were collected. The samples were analyzed for different chemical, physical parameters and the results were carefully studied and analyzed.

Results and Discussion

The water quality analysis of different ground water has been carried out for Temperature, pH, Total hardness Total alkalinity, Chloride, Sulphate, Sodium, Potassium, Nitrate, Mg.

Temperature: The Temperature was in the range of 17.1^{0}C to 18.2^{0}C in Post-monsoon and 250C to 260C in Pre-monsoon. The variation in the water temperature may be due to different timings of collection and influence of season (Jayaraman *et al*., 2003).

Hydrogen Ion Concentration (pH): pH was found to be alkaline in nature in most of samples range between 7.0 to 8.5 in Post-Monsoon and 7.1 to 8.5 in Pre-Monsoon. WHO has recommended maximum permissible limit of pH from 6.5-to 9.2 (De, 2002). pH value of different samples is within the desirable and suitable range.

Electrical Conductivity: Electrical Conductivity is the measure of mineral content, was found varying from 240 mmho/cm to1490 mmho/cm in Post-monsoon and 357 mmho/cm to 1150 mmho/cm in Pre-monsoon.

Total Alkalinity: Alkalinity was found in the range of 40 mg/lit to 528 mg/lit in Post-monsoon and 68 mg/lit to 584 mg/lit in Pre-monsoon. Alkaline water may decrease the solubility of metals. The alkalinity varies in accordance with the fluctuation in the pollution load (Parashar *et al*., 2006)

Total Hardness: Hardness is very important parameter in decreasing the toxic effect of poisonous element. The hardness was found to be in the range of 72 mg/lit to 380 mg/lit in Post-monsoon and 140 mg/lit to 620 mg/lit in Pre-monsoon. In some areas of the city, the hardness is very high, also beyond permissible limit. It is due to rocks bearing salts of Calcium and Magnesium. BIS has prescribed desirable limit of total hardness is 300 mg/lit and permissible limit in the absence of alternate source is 600 mg/lit (De, 2002).

Physico Chemical Parameters of Groundwater of Bhopal in Pre-monsoon Season

Physico Chemical parameters of Groundwater of Bhopal in Premansoon season																					
SerialNo	Locations	Date of Collection	Temp	pH_GEN	EC_GEN	TDS	Alk-Phen	Alk-TOT	Nitrate	Har_Total	Har_Ca	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
		dd/mm/yyyy	deg C	pH units	µmho/cm	mg/L	mgCaCO3/L	mgCaCO3/L	mg/lt	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Kolar Road Zone																		
1	BSNL Extention	25/05/2007	25.0	7.3	1150	736	0.0	184.0	19.6	580	420	168.0	34.0	92	2.1	176	378	<0	224.5
2	Chunna Bhatti	25/05/2007	25.0	7.1	558	357	0.0	308.0	9.2	436	304	121.6	32.1	28	0.1	40	242	<0.324499	307.7
3	Near Kolar Bridge	25/05/2007	26.1	7.8	730	467	0.0	168.0	10.6	405	260	104.0	36.0	65	0.1	118	209	<0.990347	167.0
4	Kanha Kunj	26/05/2007	25.1	7.2	551	352	0.0	292.0	6.7	376	260	104.0	28.2	16	0.1	26	113	<0.38719	291.6
5	Lalita Nagar	26/05/2007	26.2	8.3	357	228	12.0	68.0	8.0	216	112	44.8	25.3	25	0.2	36	130	1.4	66.5
6	Ramgarh Chichli	26/05/2007	26.2	8.4	466	298	20.0	268.0	2.3	260	92	36.8	45.7	35	0.1	50	25	6.8	261.1
	New MarketZone																		
7	Harshvardhan Nagar	27/05/2007	26.0	7.8	410	262	0.0	120.0	2.2	180	124	49.6	15.6	25	1.2	44	59	<0.754506	127.2
8	Kotra Sultanabad	27/05/2007	26.0	7.3	669	428	0.0	288.0	5.9	360	240	96.0	29.2	41	0.4	62	154	<0.491773	287.5
9	Nehru Nagar	27/05/2007	25.3	7.2	447	286	0.0	248.0	2.5	264	200	80.0	15.6	30	5.2	46	83	<0.366809	247.6
10	Depo Chouraha	29/05/2007	26.1	7.3	596	381	0.0	208.0	5.5	280	236	94.4	12.6	47	11.2	64	162	<0.309365	207.6
11	New Market	29/05/2007	25.3	8.0	469	300	0.0	232.0	4.3	184	132	52.8	12.6	59	15.0	80	79	1.9	230.0
12	Professor Colony	29/05/2007	25.4	7.7	410	262	0.0	144.0	3.8	200	112	44.8	21.4	25	4.7	44	117	<0.61597	143.4
	Old City Area Zone																		
13	Bhopal Talkies Chouraha	04/06/2007	25.5	8.0	705	451	0.0	232.0	6.3	240	188	75.2	12.6	53	16.8	76	115	2.2	229.8
14	Bhopal Railway Station	04/06/2007	26.3	8.2	672	430	0.0	184.0	4.3	332	156	62.4	42.8	71	0.3	110	246	2.4	181.5
15	Teela Jamalpura	04/06/2007	25.5	8.3	666	568	8.0	176.0	6.2	252	92	36.8	38.9	105	3.0	144	167	9.6	195.2
16	Near UC Factory	06/06/2007	25.8	8.3	788	504	0.0	152.0	10.2	348	160	64.0	45.7	65	0.8	118	225	<0	185.4
17	Chola Ganesh Mandir	06/06/2007	26.4	8.4	660	422	12.0	228.0	6.3	304	228	91.2	37.9	66	1.0	90	220	4.8	223.1
18	NishatPura	06/06/2007	26.5	7.6	934	597	0.0	76.0	9.5	392	252	92.8	38.9	111	1.2	206	180	<0	92.7
	Arera Colony Zone																		
19	E-1 AreraColony	08/06/2007	26.5	8.4	963	616	12.0	220.0	37.2	620	372	148.8	60.3	79	1.2	144	300	14.4	239.1
20	E-3 Arera Colony	08/06/2007	25.8	8.5	524	335	28.0	256.0	3.7	360	220	88.0	34.0	32	1.3	46	142	7.4	248.5
21	E-7 Arera Colony	11/06/2007	26.0	8.3	558	357	8.0	152.0	12.5	276	180	72.0	23.3	42	0.9	67	174	2.8	149.1
22	E-8 Gulmohar Are. Col.	11/06/2007	25.8	8.3	460	294	8.0	256.0	4.4	312	204	81.6	26.2	49	1.6	88	101	4.7	251.2
23	E-8 Kris. Vih. Are. Col.	13/06/2007	25.8	7.5	497	318	0.0	252.0	6.3	288	132	52.8	37.9	20	1.1	30	96	<0.746813	251.2
24	Bawadia Kala Extention	15/06/2007	26.4	8.3	696	445	12.0	312.0	7.7	392	144	57.6	60.3	33	1.1	56	126	6.3	305.6
	Govindpura Zone																		
25	Dabbal Ind., Govindpura	15/06/2007	25.9	8.4	650	416	12.0	188.0	5.0	320	200	80.0	29.2	67	3.5	120	145	4.0	183.9
26	E- Sector Govindpura	15/06/2007	25.6	7.9	803	514	0.0	220.0	4.1	388	248	99.2	34.0	84	3.4	152	199	<0	268.4
27	H-Sector Govindpura	19/06/2007	25.7	8.3	1151	737	8.0	584.0	4.9	140	48	19.2	22.4	395	0.6	140	162	9.6	693.0
28	D-Sector Govindpura	19/06/2007	25.3	7.1	582	372	0.0	344.0	1.5	400	268	107.2	32.1	70	1.0	100	151	<0.362428	343.6
29	A- Sector Govindpura	21/06/2007	26.3	7.3	537	344	0.0	228.0	3.7	352	220	88.0	32.1	40	1.5	74	123	<0.30932	227.6
30	Rachna Nagar	21/06/2007	25.4	7.0	515	329	0.0	204.0	2.4	232	144	57.6	21.4	44	4.9	74	116	<0.200595	203.8

Physico Chemical Parameters of Bhopal in Post-monsoon Season

	Physico Chemical parameters of Groundwater of Bhopal in Post mansoon season																		
Serial No	Locations	Date of Collection	Temp	pH_GBN	EC_GBN	TDS	Alk-Phen	Alk-TOT	Nitrate	Har_Total	Har_Ca	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
		dd/mm/yyyy	deg C	pH units	µmho/cm	mg/L	mgCaCO3/L	mgCaCO3/L	mg/lt	mgCaCO3/L	mgCaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Kolar Road Zone																		
1	BSNL Extention	14/09/2007	18.2	7.1	819	524	0.0	128.0	9.5	220	100	40.0	29.2	22	1.9	30	92	<0	156.2
2	Chunna Bhatti	14/09/2007	18.3	7.2	465	298	0.0	144.0	1.3	144	80	32.0	15.6	23	0.1	32	56	<0.190938	143.8
3	Near Kolar Bridge	17/09/2007	18.7	7.3	776	496	0.0	116.0	10.2	284	136	54.4	36.0	40	0.1	55	232	<0.193565	115.8
4	Kanha Kunj	17/09/2007	18.1	7.5	447	286	0.0	120.0	7.1	140	60	24.0	19.4	18	0.1	26	28	<0.355601	119.8
5	Lalita Nagar	18/09/2007	17.1	7.1	644	412	0.0	180.0	7.8	244	68	27.2	42.8	27	0.1	44	63	<0.19857	179.8
6	Bairagarh Chichli	18/09/2007	17.8	7.0	860	550	0.0	200.0	12.9	280	172	68.8	26.2	44	0.6	60	79	<0	244.0
	New Market Zone																		
7	Harshvardhan Nagar	20/09/2007	17.6	7.3	692	443	0.0	136.0	7.6	248	168	67.2	19.4	43	5.0	80	142	<0.22694	135.8
8	Kotra Sultanabad	20/09/2007	17.8	7.2	970	621	0.0	212.0	8.6	260	148	59.2	27.2	37	0.5	48	96	<0	258.6
9	Nehru Nagar	20/09/2007	18.0	8.0	670	429	0.0	172.0	0.3	216	152	60.8	15.6	34	5.5	58	63	1.4	170.5
10	Depo Chouraha	24/09/2007	18.0	7.8	596	381	0.0	200.0	1.1	220	140	56.0	19.4	32	6.2	46	51	1.2	198.8
11	New Market	24/09/2007	17.8	7.1	442	283	0.0	124.0	1.1	140	100	40.0	9.7	33	4.0	60	59	<0.143227	123.9
12	Proftesor Colony	24/09/2007	17.6	8.1	287	184	0.0	112.0	0.1	120	80	32.0	9.7	14	2.6	20	27	1.3	110.6
	Old City Area Zone																		
13	Bhopal Talkies Chouraha	27/09/2007	17.6	7.4	240	154	0.0	100.0	0.1	100	68	27.2	7.8	10	2.8	18	40	<0.209974	99.8
14	Bhopal Railway Station	27/09/2007	18.0	7.3	966	618	0.0	136.0	4.3	324	144	57.6	43.7	52	0.6	90	132	<0	165.9
15	Teela Jamalpura	28/09/2007	18.2	7.6	1370	877	0.0	248.0	10.2	332	184	73.6	36.0	130	5.3	170	121	<0	302.6
16	Near IIC Foctory	03/10/2007	17.7	7.5	831	532	0.0	100.0	3.9	240	96	38.4	35.0	74	0.8	120	128	<0	122.0
17	Chola Ganesh Mandir	03/10/2007	18.2	7.2	794	508	0.0	152.0	2.0	280	152	60.8	31.1	42	3.7	80	85	<0	185.4
18	NishatPura	05/10/2007	18.2	7.6	1005	643	0.0	232.0	6.2	380	140	56.0	58.3	44	1.0	76	103	<0	283.0
	Arera Colony Zone																		
19	E-1 AreraColony	08/10/2007	17.7	7.1	531	340	0.0	108.0	2.9	152	72	28.8	19.4	34	0.4	60	36	<0.113761	107.9
20	E-3 Arera Colony	08/10/2007	17.6	8.3	480	307	4.0	124.0	4.8	192	60	24.0	32.1	26	0.4	46	83	2.3	121.6
21	E-7 Arera Colony	11/10/2007	18.0	7.2	707	452	0.0	84.0	16.8	224	108	43.2	28.2	52	2.2	67	167	<0.111377	83.9
22	E-8 Gulmohar Are. Col.	11/10/2007	18.0	7.7	572	366	0.0	40.0	0.7	78	30	12.0	11.7	60	0.3	76	104	<0.167445	39.8
23	E-8 Kris. Vih. Are. Col.	15/10/2007	18.0	8.3	806	516	16.0	168.0	13.1	332	88	35.2	59.3	31	0.1	50	156	19.2	165.9
24	Biswadia Kalla Extention	16/10/2007	17.8	8.4	600	384	24.0	268.0	4.1	244	36	14.4	50.5	25	0.1	34	43	6.2	261.7
	Govindpura Zone																		
25	Daulat Ind., Govindpura	18/10/2007	17.5	7.7	503	322	0.0	168.0	0.6	208	108	43.2	24.3	26	3.8	46	39	<0.7024	167.3
26	E- Sector Govindpura	18/10/2007	17.3	7.5	1000	640	0.0	196.0	8.3	336	192	76.8	35.0	66	2.2	148	66	<0	239.1
27	H-Sector Govindpura	18/10/2007	17.6	8.5	1490	954	68.0	528.0	10.3	72	28	11.2	10.7	282	0.8	148	83	81.6	478.2
28	D-Sector Govindpura	23/10/2007	17.4	7.8	924	591	0.0	180.0	8.3	244	128	51.2	28.2	84	2.3	118	120	<0	219.6
29	A- Sector Govindpura	23/10/2007	17.7	7.8	748	479	0.0	180.0	2.1	212	56	22.4	37.9	60	2.6	80	87	1.1	178.9
30	Rachna Nagar	23/10/2007	17.7	7.7	634	406	0.0	220.0	2.2	236	172	68.8	15.6	13	4.9	24	41	1.0	218.9

Sulphate: The Sulphate content in all the ground water samples is under the limit prescribed by BIS in both the seasons Post- and Pre-monsoon.

Chloride: Chloride content of the ground water samples ranges from 18 to170 mg/lit in Post-monsoon and 26.to 206 mg/lit in Pre-monsoon.

Sodium: Sodium is used in the normal functioning of some processes in the human body and as such is an essential element but its high concentration may adversely affect the cardiac, renal and circulatory functions (Srivastava, 2007). Sodium content is found in the limit in both Post- and Pre-monsoon. BIS has laid down the permissible limit of sodium which is 60 to 120 mg/lit.

Potassium: Natural waters normally contain low concentration of Potassium. High values of potassium should be looked upon with some suspicion as these may indicate pollution. Neither BIS nor any other organization lay down any limits for potassium content in drinking water (Srivastava, 2007). The potassium content in ground water have been found in the range of 0.1mg/lit to 6.2 mg/lit in Post-monsoon and 0.1mg/lit to 16.8 mg/lit in Pre-monsoon.

Nitrate: Nitrate indicates the pollution in ground water due to sewage percolation beneath the surface. The nitrate concentration is found to be in the range of 0.1 to 16.8 mg/lit in Post-monsoon and 1.5 to 37.2 mg/lit in Pre-monsoon. It is within the desirable limit. BIS prescribed desirable limit of nitrate is 45 mg/lit. Presence of nitrate in water indicates the final stage of mineralization (Nema *et. al*., 1984).

The physico-chemical status of Upper Lake (Bhopal, India) with special reference to phosphate and nitrate has been investigated during the year 2003-2004. The phosphate and nitrate are two important nutrients in the lake loading through point and non-point pollution sources such as washing, bathing, agricultural activities in fringe area, joining of domestic raw sewage, cultivation of trapa and huge growth of aquatic macrophytes. These nutrients support the fast growth of the aquatic plants (mainly *Eichhornia crassipes, Hydrilla, Ceratophyllum* etc.) as a result these plants lead to gradual shrinking of wetland area along with other complications like low light penetration, reduces oxygen concentration, clogging of water channels, lowers entertainment value of lake and some time the level of oxygen depletes so that it can lead to fish mortality also (Tamot and Sharma, 2006).

The parameters like Turbidity, Total Hardness, Dissolved Oxygen (DO), Biochemical Demand, (BOD) Chemical Oxygen Demand (COD), Oil and Grease have been *studied* to Upper and Lower lakes, Bhopal. Parameter Turbidity, Dissolved Oxygen (DO), Biochemical Demand (BOD) and Chemical Oxygen Demand (COD) become higher on immersion idols have grown in number and size over the years and urban water bodies are facing on increasing nutrient load (Vyas et al, 2006). Better water quality was found in winter season than summer. Extent of pollution occurred due to urbanization, anthropogenic activities; increased human interventions in the water bodies have been ascertained (Parasher et al, 2006).

The physico- chemical parameters like pH, Dissolved Oxygen, Biochemical Oxygen Demand (BOD) Chemical Oxygen Demand (COD) nitrate, phosphate and bacteriological status have studied to ascertain the effectiveness of aeration unit. The floating fountain cum ozonizer installed at Neelam park station is more effective unit as it increases Dissolved Oxygen Concentration, reduces Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) and the ozonizer installed at Khatlapura is also effective to increase Dissolved Oxygen concentration in the hypolimnion and control total coliform (MPN). Therefore, the present study indicates the aeration unit's especially dual systems are

very effective in improving the water quality of a degraded water body (Verma et al., 2006).

Conclusion

The present study reveals that the assessment of water quality deterioration is due to various reasons. The ground water quality of the Bhopal city is evaluated which is also an important potable water source in some area of the city during summer. Better water quality was found in the Post-monsoon season than that of Pre-monsoon season, because of water recharging due to rains. Extent of pollution occurred due to urbanization, anthropogenic activities increased human interventions in the ground water have been ascertained.

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