Int. J. Chem. Sci.: 11(2), 2013, 1173-1187
ISSN 0972-768X
www.sadgurupublications.com

COMPARATIVE HYDRO CHEMISTRY OF DIFFERENT GROUND WATER SOURCES IN HILLY ZONE OF BARWANI AREA (M.P.) OF NARMADA RIVER BASIN

PRAMOD PANDIT[*], DAVID SWAMI[a] and A. A. ANSARI[b]

[a]Department of Chemistry, S.B.N. Govt. Post Graduate College, BARWANI – 451551 (M.P.) INDIA
Devi Ahilya Vishwavidhyalaya, INDORE – 452001 (M.P.) INDIA
[b]Department of Chemistry, IK College, INDORE – 452001 (M.P.) INDIA

ABSTRACT

The proposed study area is the most southwestern part of the Barwani district of Madhya Pradesh. In the zone, good ground water potential was mainly found in weathered blocks of the rocks with characteristic aquifers. 90% Population of the area is tribal, which uses ground water for drinking, domestic and irrigation purposes.

In the present paper, the comparative study of ground water quality of different sources i.e. Dug wells, hand pumps (Shallow bored wells) and tube wells (Deep bored wells) were performed. Selected and important physico-chemical parameters like colour, odour, taste, turbidity, pH, EC, TDS, total alkalinity, total hardness, chloride, sulphate, phosphate, DO, MPN of total coliforms and MPN of faecal coliforms in all three seasons for all three type of sources were investigated. The overall water quality status and class were also calculated using water quality index for 12 physico-chemical parameters.

Obtained results show that overall ground water quality of all three sources and in all seasons, in general, is suitable for drinking and domestic purposes and belongs to good quality status according to WQI. Although, dug well water is not suitable for drinking in monsoon season, but deep bored ground water sources are contamination free.

Key words: Ground water, Physico-chemical, Bacteriological, Drinking, Domestic purpose, Hilly zone, Narmada river basin.

INTRODUCTION

Water is the matrix of life. No forms of life can exist without water. It is one of the five basic elements - Earth, Water, Air, Fire and Space from which creation emanates[1,2].

[*]Author for correspondence; E-mail: ppandit2011@gmail.com

Although water is the most common and abundant natural resource on the earth, cover 3/4 of the earth surface but a very small proportion of it is available and usable for multiple purposes i.e. 2.70%, fresh water[3,4].

The portion of fresh water that percolates into the soil and flows or collects under ground geological formations is called aquifers and below the earth surface is called ground water. It acts as a long-term reservoir of the natural hydrological cycle[5].

The geological conditions and topography of a particular area plays an important role in deciding the quantity and quality wise availability of the ground water[6,7]. However, ground water level is season dependent and variable. It is one of the earths renewable resources, which gets its annual recharge by meteoric precipitation through various sources like streams, lakes, ponds, rivers, canals and reservoirs by the process of infiltration and percolation[4,8] .

Study area

The proposed study area is the upper hilly zone, which is the most southwestern part of the district Barwani (M.P.) of Narmada river basin. It lies between the parallels of 74^0.27' to 75^0.07' E longitude and 21^0.44' to 22^0.04' N latitude. The south boundary of the area touches to the state of Mahashtra. Physiographically area lies in the Satpuda mountain ranges with hilly plains. The geology, geomorphology and systematic ground water studies in the hard rocks of Narmada river basin parts were also studied by remote sensing technique, satellite data[9,10]. Area has the older rock formations having good water potential with reasonably good quality. Climate of the area is sub-tropical type having average annual rainfall about 1100 mm. Agriculture and agriculture labour is the main occupation of the 90% population[11].

EXPERIMENTAL

Materials and methods

For the quality investigations, the samples were collected from different locations of the study area. At every location, three sampling stations having three different types of sources i.e. Open dug wells, hand pumps (shallow bored tube wells) and tube wells (deep bored tube wells) were taken.

To observe the changes in physico-chemical properties of water, sampling were done in three seasons - pre-monsoon (March to June), monsoon (July to October) and post-monsoon (November to February).

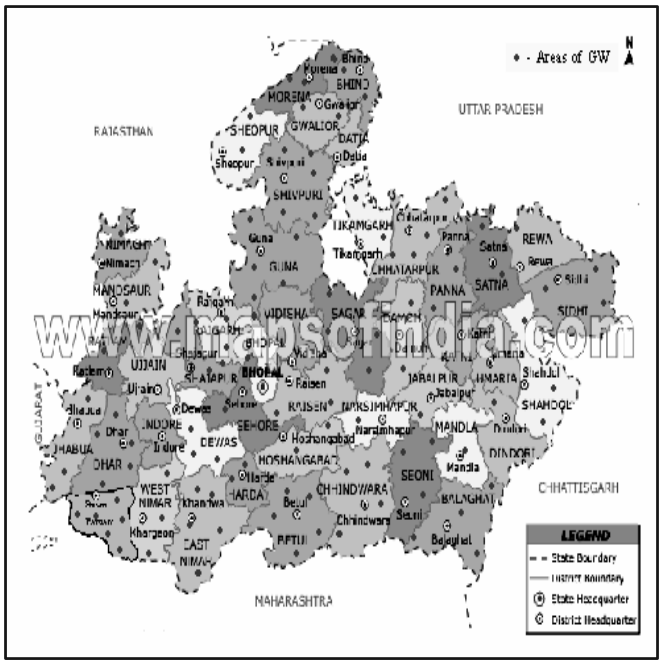

Fig. 1: Map of M.P. – Areas of GW potential[9]

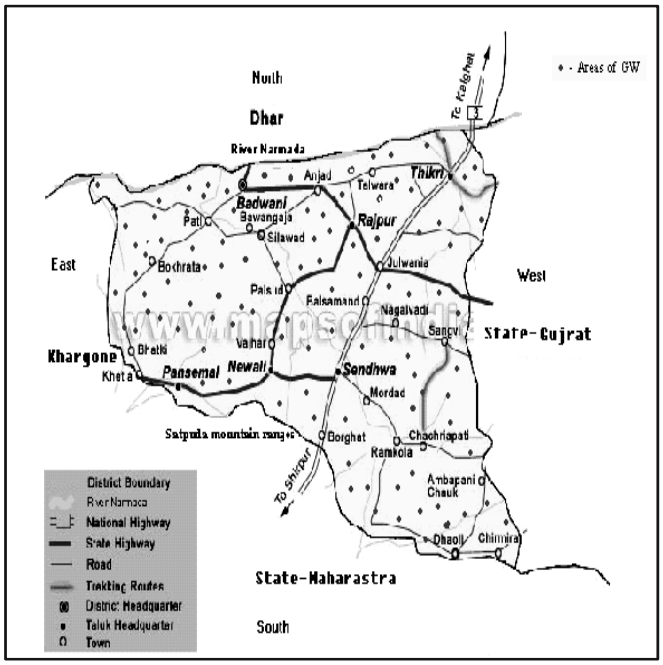

Fig. 2: Map of Dist. Barwani - Areas of GW potential[10,11]

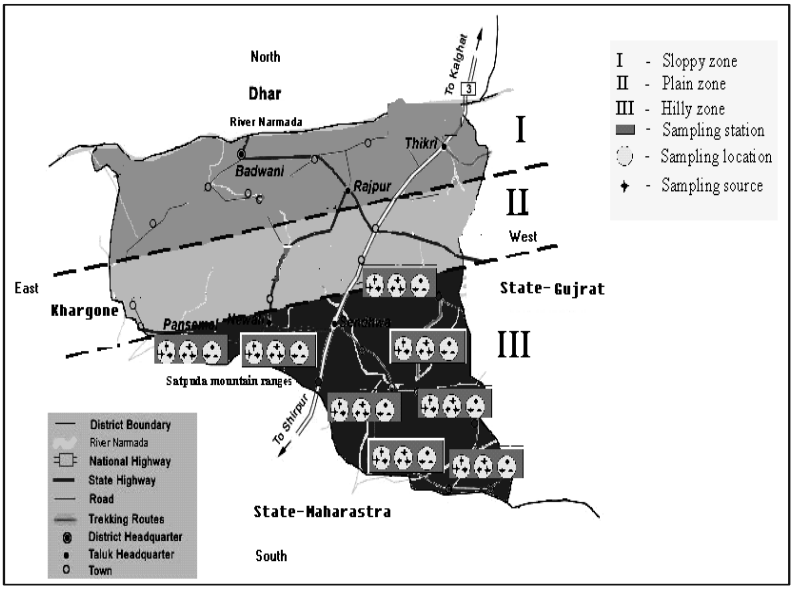

Fig 3: Map of study area-hilly zone showing sampling locations (Stations and sources)

Generally, one liter sample was collected at early hour of the day for analysis, for this well-cleaned double stopper polythene cans and glass bottles were used. All the samples were labeled properly indicating the season, sampling point, type of source, date and time of the sampling.

Preservation was done and the various physico-chemical-bacteriological parameters were determined to assess the ground water quality. Samples were analyzed by standard methods.[12.13,14]

In the present work, two types of investigations-physico-chemical and bacteriological, were performed in the laboratory to determine the ground water quality for drinking and domestic purposes.

RESULTS AND DISCUSSION

Hydro geo-chemistry of groundwater is a function of precipitation, chemical weathering and dissolution of minerals within the geological formations[15,16].

In the present study the obtained values of different quality parameters of the ground water samples of different sources in three seasons is presented in the Tables 1-4.

The results have been discussed and compared with standard values[17-20].

Table 1: Seasonal and spatial variations in mean values of colour, odour, taste and turbidity

Sources	Seasons	Colour			Odour and taste			Turbidity (NTU)		
		Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
DW	PRM	Deep green	Light green	Non-potable	Flat	Hard	Unacceptable	14.8	2.1	12.2
	MON	Dirty	Dusty	Unacceptable	Earthy	Foul	Non-potable	20.6	2.2	18.8
	POM	Light yellow	Clear	Potable	Flat	Pleasant	Potable	7.2	1.5	4.9
HP	PRM	Clear	Clear	Potable	Hard	Pleasant	Potable	2.1	0.95	1.2
	MON	Mudy	Dusty	Unacceptable	Foul	Earthy	Unacceptable	6.8	3.1	3.4
	POM	Clear	Clear	Potable	Pleasant	Pleasant	Potable	3.2	1.9	2.1
TW	PRM	Colourless	Clear	Acceptable	Pleasant	Salty	Potable	1.8	0.80	0.90
	MON	Yellowish tinge	Clear	Acceptable	Bitter	Pleasant	Potable	2.8	2.2	2.8
	POM	Clear	Clear	Potable	Flat	Pleasant	Acceptable	2.4	0.68	0.95

DW = Dug - well, HP = Hand -pump and TW = Tube - well.

PRM = Pre - monsoon, MON = Monsoon and POM = Post - monsoon

Physico-chemical parameters

Colour: It is imparted by various natural sources like metallic ions, humus, suspended matter, peat materials, phytoplanktons, weeds and industrial effluents. In monsoon season, DW and HP water were found non-potable but TW water was acceptable. Although in pre- and post-monsoon seasons, water of all three sources were acceptable and potable. According to BIS and ISI standards, drinking water must be colourless.

Odour and taste: Both depend upon the minerals, salts and soil constitution of the area. Odour also depends upon pH. HP and TW water were found quite potable in all seasons, where as DW water in pre-monsoon, monsoon and HP in monsoon season was unacceptable for drinking purposes. According to BIS and ISI standards, drinking water should be odourless and tasteless.

Turbidity: It results from the presence of suspended materials like clay, silt, organic matter, phytoplankton and other microscopic organism. Permissible limits are 10.0 and 5.0 NTU. Maximum mean values were found in DW water, 18.8 NTU, in monsoon season while lowest mean value in TW water was 0.90 NTU in pre-monsoon season. All other values are almost within permissible limits.

pH

It indicates the H^+ ion concentration. The source of pH is carbonic acid in various forms. It decides the acidity or alkalinity of water and in turn, its quality. pH range between 6.5 to 8.5 is acceptable for drinking and domestic purposes. The highest pH value 9.0 was observed in DW water in pre-monsoon season, which is higher than permissible value and lowest 6.5 was recorded in TW water in monsoon and post-monsoon seasons. All other values are within acceptable limits. Most of the waters are slightly alkaline due to presence of carbonate and bicarbonate ions.

Electrical conductivity (EC)

The presence of dissolved salts and minerals decides the value of EC. It greatly affects the taste of water and thus, a significant impact on the user's acceptance of the water as potable. It is used to determine the purity of demineralized water and a good and rapid measure of the total dissolved solids[21,22]. Highest value 2243 and lowest value 412 µs/cm was found in DW water in pre-monsoon and HP water in monsoon season, respectively. Results show that EC values go down in monsoon season due to dilution of ions by percolation of rain water while in pre-monsoon season, it is reverse[23,24]. Higher values than permissive values 400 and 750 µs/cm, in hilly area may be due to rocky and mineral rich

geological formations and mixing of salts in ground water, also an indication of water contamination.

Total dissolved solids (TDS)

In natural water, dissolved solids consist mainly of inorganic salts like CO_3^{2-}, HCO^-, Cl^-, SO_4^{2-}, PO_4^{3-} and NO_3^- of Ca, Mg, Na, K, Fe etc. High content of dissolved solids elevates the density of water, reduces solubility of gases and thus, reduces utility of water. Highest value 540 mg/L was detected in HP water in pre-monsoon season while lowest value 48 mg/L in TW water was found in monsoon season. Although all TDS values are almost within the permissive limits i.e. 500 mg/L as laid down by BIS and ISI for drinking and domestic purposes.

Table 2: Seasonal and spatial variations in mean values of pH, EC and TDS

Sources	Seasons	pH			EC (µs/cm)			TDS (mg/L)		
		Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
DW	PRM	10.8	6.80	9.0	14100	830	2243	7030	512.2	480
	MON	9.20	6.40	7.2	1810	183	544	2880	218.3	202
	POM	9.8	7.78	8.2	3950	573	640	3100	154.1	318
HP	PRM	8.20	7.80	7.6	13600	1180	1240	7290	198.6	540
	MON	7.00	6.80	6.90	2350	259	412	1920	202.0	304
	POM	8.44	7.99	8.1	8200	984	910	2800	197.8	408
TW	PRM	7.80	6.50	7.20	11200	954	1257	5140	157.9	195
	MON	7.70	6.40	6.5	1774	670	884	1010	88.9	48
	POM	8.41	6.20	6.5	7180	774	920	1120	93.2	97

Total alkalinity (TA)

It is caused by the presence of hydrooxides, carbonates and bicarbonates of various metals. Most of the alkalinity is also caused by dissolved carbon dioxide in water. It neutralizes the H^+ ions (acids) of water. It is measured as calcium carbonate ($CaCO_3$) alkalinity. The value of TA, 332 mg/L was highest in samples of DW in pre-monsoon season while lowest value 98 mg/L was observed in TW samples in monsoon season. Value of total alkalinity decreases with increase of depth of source and water table[25]. However, values were found well within limits i.e. 172-400 mg/L as laid down by BIS and ISI.

Total hardness (TH)

It's higher value prevents the lather formation with soap and increase the boiling point of water. Total hardness can be considered as concentration of soluble salts especially of calcium and magnesium, in the ground water. It is expressed as calcium carbonate content. In the study, values were found 460, 360 and 301 mg/L in HP, TW and DW water samples in pre-monsoon season, respectively while lowest value 96 mg/L was found in DW water in monsoon season. Higher values during pre-monsoon and post-monsoon seasons may be due to high concentration of salts while lower values in monsoon season is owing to dilution of ground water due to rainfall recharge. BIS and ISI has recommended a limit between 300-600 mg/L as desirable for drinking and domestic purposes. All samples were found well within these limits.

Table 3: Seasonal and spatial variations in mean values of TA, TH and chloride

Sources	Seasons	TA (mg/L)			TH (mg/L)			Chloride (mg/L)		
		Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
DW	PRM	450.0	105.4	332	350.7	179	301	497.2	10.5	102.3
	MON	189.2	90.6	117	167.6	40.2	96	589.6	17.8	140.2
	POM	310.5	80.5	198	310.0	70.3	176	512.8	16.7	136.1
HP	PRM	260.5	141.1	151	540.0	108	460	546.0	89.8	140.6
	MON	174.3	102.8	139	301.7	58.4	152	502.3	80.2	132.1
	POM	245.8	170.3	146	320.2	97.5	182	700.4	182	142.4
TW	PRM	480.9	189.9	147	580.3	144	360	376.7	27.6	36.6
	MON	138.4	79.0	98	390.1	113	180	210.9	29.4	30.9
	POM	348.4	99.0	133	490.4	136	204	95.5	25.2	27.8

Chloride (Cl^-)

The high chloride concentration serves as an indicator of pollution by domestic sewage. Chloride occurs almost in all natural waters. High mineral content, temperature and less rainfall also increase chloride contents. In the present study, highest value 142.4 mg/L was found in HP water in post-monsoon and 140 mg/L in DW water in monsoon season.

These higher values may be attributed to the percolation and mixing of chloride from domestic sewage, high temperature and less rainfall during study period. Lowest value 27.8

mg/L was found in TW water in post-monsoon season. It was observed that with the increase of depth of the source, chloride content decreases. Although all the values were found within the desirable limits 250 mg/L by BIS and ISI.

Sulphate (SO_4^{2-})

Sulphate occurs naturally in waters because of leaching from common minerals like epsom, gypsum, heavy spar and other salts[26,27]. High concentration may cause bad taste, diarrhea and cathartic action but lower concentration may induce laxative effect in human beings. In the study, highest concentration, 118 mg/L was found in HP water in pre-monsoon season where as lowest value 3.48 mg/L was noted in TW water in monsoon season. However, overall values of the sulphate in the water of all sources in all season was found well within the maximum permissible limit 150 mg/L as given by BIS and 250 mg/L by ISI.

Phosphate (PO_4^{3-})

In natural waters, earth's rocks in the form of orthophosphates is the main source of phosphates. Other biotic sources are domestic wastes, sewages, detergents and chemical fertilizers from agriculture runoff and industrial wastes. Phosphate in water indicates the degree of pollution and may create problem of taste and odour in hot climates where DO is already low.[28]

In the present study, highest value was observed 0.31 mg/L in DW samples in pre-monsoon while lowest value 0.002 mg/L was observed in TW samples in post-monsoon season. Although HP and TW sources have lower values than DW sources, which indicates that as the depth of water table and source increases, phosphate content decreases,[29] Results show that 50% sources have higher phosphate contents than permissible limit 0.10 mg/L as laid down by ISI.

Dissolved oxygen (DO)

It is one of the most important water quality parameter, which is the fundamental requirement of life. It's level in the natural water depends on the physical, chemical and biological activities going on in the water body[26,28].

In the present study, DO values was found highest, 8.60 mg/L in post-monsoon in DW water while lowest value was 3.72 mg/L in TW in monsoon season. Although in the water of all sources in all seasons, DO values were found within the acceptable limits i.e. 4.0 to 7.0 mg/L at 20-30^{0}C, which shows that sources are free from any major biodegradable organic matter pollution and thus, quite suitable for drinking and domestic purposes.

Table 4: Seasonal and spatial variations in mean values of sulphate, phosphate and DO

Sources	Seasons	Sulphate (mg/L)			Phosphate (mg/L)			DO (mg/L)		
		Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
DW	PRM	27.12	7.92	16.24	1.65	0.03	0.31	8.10	2.20	4.20
	MON	34.8	3.51	19.79	1.78	0.02	0.09	8.20	3.31	5.12
	POM	36.21	10.24	18.40	1.70	0.04	0.08	10.10	3.70	8.60
HP	PRM	178	4.84	118	1.72	0.05	0.07	5.70	2.99	4.02
	MON	26.3	2.71	16.64	1.43	0.03	0.11	4.92	3.10	4.11
	POM	26.09	9.04	20.42	1.84	0.18	0.21	6.72	2.02	5.29
TW	PRM	22.68	4.90	10.14	1.73	0.16	0.21	5.30	2.32	3.76
	MON	13.65	0.35	3.48	1.26	0.02	0.06	4.62	2.06	3.72
	POM	36.15	1.54	15.55	1.51	0.00	0.002	5.69	4.92	5.06

Bacteriological parameters

The bacteriological examination of groundwater has a special significance due to their deleterious effects on human health. The presence of faecal coliform in ground water, because of faecal matter, is a main source of various waterborne diseases in human beings.[30] Faecal coliform percolation generally occurs by domestic sewage, hospital disposals and dumping grounds into the aquifers. Faecal coliform test is more definitive than total coliform count.[31]

MPN of total coliforms

In the present study, highest and lowest values of the total coliforms were found 120/100 mL in monsoon and 82/100 mL in pre-monsoon season in DW water while HP water has values 128/100 mL in monsoon and 12/100 mL in pre-monsoon period. TW water values are 19/100 mL and 11/100 mL in monsoon and pre-monsoon season, respectively.

MPN of faecal coliforms

Faecal coliform were found highest, 89/100 mL, in DW water in monsoon season while lowest value was 3/100 mL, in pre and post-monsoon season in TW water.

Table 4: Seasonal and spatial variations in mean values of MPN of total and faecal coliforms

Sources	Seasons	Total coliforms (MPN/100 mL)			Faecal coliforms (MPN/100 mL)		
		Max.	Min.	Mean	Max.	Min.	Mean
DW	PRM	250	40	82	50	04	37
	MON	319	82	120	91	09	89
	POM	290	61	96	34	05	22
HP	PRM	169	04	12	31	0.0	21
	MON	202	09	128	47	03	38
	POM	192	12	22	15	04	5.0
TW	PRM	102	09	11	09	0.0	3.0
	MON	194	26	19	16	09	5.0
	POM	132	21	15	14	07	3.0

Results show that bacterial contamination is also season and depth dependent i.e. sources are more contaminated in monsoon season compared with pre- and post-monsoon seasons and also shallow and open sources i.e. DW's are more contaminated than HP and TW sources.

DW and HP water sources were found beyond the limit i.e. 50/100 mL of MPN of total and faecal coliform as laid down by BIS, ISI for human consumption.

Water quality index

In the present investigations, overall quality status and class of the ground water in the study area were calculated using water quality index.[32-34] Water quality index is the rating that reflects the composite influence of different water quality parameters on the overall quality of water[35]. On the basis of the standard values of WQI, the quality status, its class and accordingly the possible suitability for drinking and domestic purposes are shown in the Table 5.

For WQI calculations values of twelve, physico-chemical-bacteriological parameters i.e. pH, EC, turbidity, TDS, TH, TA, chloride, sulphate, phosphate, DO, MPN of total and faecal coliforms were taken into considerations. Standard permissible values of these parameters are prescribed by BIS, ISI and these were used for calculations.

Table 5: The standard values of WQI showing quality status, class and use of water for different purposes

WQI	Quality status	Class	Uses for different purposes
0 – 25	Excellent	I	All purposes – potable, agricultural, industrial
26 – 50	Good	II	Domestic and agricultural
51 – 75	Poor	III	Agricultural and industrial
76 – 100	Very poor	IV	Only for agriculture
101 and above	Worst	V	Can be used only after proper treatment

Final value of water quality index was obtained by aggregating these twelve sub - indices (Si) linearly using following formulae:

$$WQI = \frac{\sum_{i=1}^{12}(q_i.w_i)}{\sum_{i=1}^{12}(w_i)} \quad \ldots(1)$$

Where, q_i = Quality rating of i^{th} parameter

w_i = Unit weight of i^{th} parameter

Table 6: Obtained values of WQI, quality status and class of water of different ground water sources

Sources	Seasons	Value of WQI	Quality status	Class
DW	PRM	23.18	Excellent	I
	MON	31.81	Good	II
	POM	27.04	Good	II
HP	PRM	33.35	Good	II
	MON	31.69	Good	II
	POM	37.58	Good	II
TW	PRM	39.00	Good	II
	MON	28.27	Good	II
	POM	26.11	Good	II

Results show that WQI values obtained between 23.18 to 39.0 in all three seasons for different sources in the whole study area and the ground water quality belong to good quality status (II class), which is safe and suitable for drinking and domestic purposes, during study period. Also DW water in pre-monsoon season belongs to excellent quality status (I class).

CONCLUSION

Today at the global level, the ground water resources have been the most exploited natural system due to accelerated pace of development in various aspects.[36]

The present work has given an insight into ground water quality of this tribal hilly zone. Observations and results of various physico-chemical and bacteriological parameters show that mean values of these depend upon the geographical, geological and geochemical situation and constitution of the study area.

However, quality content is also influenced meteorological factors such as temperature, rainfall, evaporation etc.

Finally, it can be concluded that ground water quality of the study area is practically free form any major pollution or contamination hazards of all sources in all seasons, except DW's water in monsoon season and which is safe and suitable for drinking and domestic purposes. Thus, ground water of the study area is still maintaining the "Status of Reliable Source of Water".

ACKNOWLEDGEMENT

We are thankful to Department of Chemistry, Department of Zoology and Department of Soil Conservation and Water Management of S.B.N. Govt. P.G. College, Barwani (M.P.) for providing laboratory, equipment and library facilities to complete the work.

REFERENCES

1. H. M. Raghunath, Groundwater, 2nd Ed., New Age International Publishers, New Delhi (1987) pp. 344-369.
2. B. K. Sharma and H. Kaur, Goel Publishing House, Merrut, India (1998) pp. 3-121, 259-312.

3. H. Bouwer, Mc Graw Hill Publication Inc., Tokyo, Japan (1978).

4. D. K. Todd, John Wile and Sons. Inc., New York, USA (1995) pp. 282-535.

5. C. K. Jain, Indian J. Environ. Ecoplan., **8(2)**, 475-484 (2004).

6. P. K. Jain, Poll. Res., **17(1)**, 41-44 (1998).

7. K. A. Kaushik, T. Kanchan and H. R. Sharma, J. Environ. Biol., **23**, 325-333 (2002).

8. Sohani, Depali, S. Pande and V. S. Shrivastava, Indian J. Environ. Ecoplan., **5(2)**, 475-479 (2001).

9. CGWB, Ministry of Irrigation, New Delhi (1982).

10. K. Srinivasan, G. S. I. Report (1970).

11. K. Srinivasan, G. S. I. Report (1972).

12. APHA, AWWA, WEF, Published by American Public Health Association, American Water Works Association and Water Environment Federation, Washington, D.C., USA., (1998).

13. N. Manivasakam, Pragati Prakashan, Merrut, India (2000).

14. P. K. Gupta, Agrobios, Jodhpur, India (2004) pp. 5-92.

15. C. K. Jain, K. K. S. Bhatia and T. Vijay, Indian J. Env. Hlth., **42(4)**, 151-158 (1997).

16. C. K. Jain, K. K. S. Bhatia, C. P. Kumar and B. P. Purandara, Technical Report, 2000-01, National Institute of Hydrology, Roorkee (2001).

17. BIS, Bureau of Indian Standards, New Delhi, India (1991).

18. ISI, Indian Standard Institute, New Delhi, India (1993).

19. ICMR, Indian Council of Medical Research, New Delhi, India (1995).

20. WHO, World Health Organization, Geneva, Switzerland, 1-130 (1998).

21. B. D. Joshi, Deepali and K. K. Gangwar, Indian J. Environ. Ecoplan., **12(3)**, 599-606 (2006).

22. S. Tripathi, H. M. Patel, P. K. Srivastava and A. M. Bafna, Indian J. Environ. Ecoplan., **18(1)**, 177-184 (2011).

23. V. K. Garg, A. Chaudhary, S. Deepashikha and Dahiya, Indian J. Env. Prot. **19(4)**, 267-272 (1999).

24. R. Gopal, Indian J. Env. Prot., **19(8)**, 567-572 (1999).

25. S. S. Dhindsa, P. Bheel and Yashoda Musturia, Indian J. Environ. Ecoplan., **8(1)**, 129-136 (2004).

26. S. C. Gupta, Indian J. Env. Hlth., **23(3)**, 195-202 (1991).

27. S. C. Gupta, Indian J. Env. Hlth., **33(3)**, 41-349 (1991).

28. S. P. S. Barar, D. Kumar and S. R. Bishnoi, Indian J. Env. Hlth., **26(3)**, 202-211 (1984).

29. B. T. Abraham and T. M. Sajella Beegum, Indian J. Environ. Ecoplan., **5(3)**, 593-596 (2001).

30. G. K. Jais, R. M. Shrivastava, O. P. Jain and P. K. Shrivastava, Indian J. Env. Prot., **13(10)**, 758-760 (1993).

31. H. R. Meenakumari and S. P. Hosmani, Indian J. Environ. Ecoplan., **7(1)**, 79-82 (2003).

32. R. R. Horton, J. Water Poll. Conf. Fed., **37**, 300-306 (1965).

33. W. R. Ott, Ann. Arbor. Sci. Publis., Inc., 202-213 (1978).

34. D. K. Mishra and A. K. Shrivastava, Nat. Env. Poll. Tech., **7(2)**, 299-302 (2008).

35. B. B. Ahire, Indian J. Environ. Ecoplan., **18(1)**, 77-80 (2011).

36. P. K. Jain, Poll. Res., **15(4)**, 407-409 (1996).

Accepted : 29.05.2013