Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 11	No. 4	pp. 671-674	2012

Original Research Paper

Assessment of Groundwater Quality in Shivpuri Town, Madhya Pradesh, India

Anand Kumar Mishra, Mohit Arya*, R. Mathur and R. B. Gupta*****
Department of Zoology, Govt. P. G. College, Shivpuri, M. P., India
*Department of Zoology, Govt. K. R. G. P. G. College, Gwalior, M. P., India
**School of Studies in Zoology, Jiwaji University, Gwalior, M. P., India
***Department of Zoology Govt. S.M.S. Model Science, College, Gwalior, M. P., India

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 10-4-2012
Accepted: 15-5-2012

Key Words:
Groundwater quality
Water quality index (WQI)
Shivpuri town

ABSTRACT

The present work is aimed at assessing the water quality index (WQI) for the groundwater of Shivpuri town. This has been determined by collecting groundwater samples and subjecting them to a comprehensive physico-chemical analysis. For calculating the WQI, the following 12 parameters pH, TS, TDS, TSS, EC, total alkalinity, magnesium, calcium, total hardness, chloride, sulphate and nitrate were considered. The high value of WQI was found to be mainly due to higher values of iron, nitrate, total dissolved solids, hardness, fluorides, bicarbonate and manganese in the groundwater. The results of analyses have been used to suggest models for predicting water quality. The analysis reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination.

INTRODUCTION

In the last few decades, there has been a tremendous increase in the demand for freshwater due to rapid growth of population and the accelerated pace of industrialization. Human health is threatened by excessive application of fertilizers and unsanitary conditions. Rapid urbanization, especially in developing countries like India, has affected the availability and quality of groundwater due to its overexploitation and improper waste disposal, especially in urban areas. According to WHO, about 80% of all the diseases in human beings are caused by water. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from the source. It, therefore, becomes imperative to regularly monitor the quality of groundwater and to device ways and means to protect it.

Water quality index is one of the most effective tools to communicate information on the quality of water to the user citizens and policy makers. It, thus, becomes an important parameter for the assessment and management of groundwater. The WQI can be used to monitor water quality changes in a particular water supply over time lapse, or it can be used to compare a water supply quality with other water supplies in the region or from around the world. The concept of indices to represent gradation in water quality was first proposed by Horton (1965). It indicates the quality by an index number, which represents the overall quality of water for any intended use. It is defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water (Deininger & Maciunas 1971, Harkins 1974, Tiwari & Manzoor 1988). The results can also be used to determine if a particular stretch of water is considered as healthy.

MATERIALS AND METHODS

For calculation of WQI, selection of parameters has great importance. Twelve physico-chemical parameters, namely pH, TS, TDS, TSS, EC, total alkalinity, magnesium, calcium, total hardness, chloride, sulphate, and nitrate were used to calculate the WQI. The calculation of WQI was made using a weighted arithmetic index method given by Brown et al. (1972) (Table 1). On the basis of the calculation, the WQI of various Wards of the city was determined. For all the calculations, standard values of BIS (1993) were taken into consideration. The physico-chemical parameters were analysed as per the procedures given in APHA (1986) and Trivedy & Goel (1986). Since the calculations of all the 39 Wards will be space occupying, results of the samples from Ward No. 1 have been depicted here. The rest are processed in the same manner and the results are given in Tables 2 to 6.

Calculation of sub index of quality rating (*qn*): Let there be *n* water quality parameters where the quality rating or sub index (*qn*) corresponding to the n^{th} parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value. The value of *qn* is calculated using the following expression.

$$qn = 100[(Vn - Vio) / (Sn - Vio)] \quad ...(1)$$

Where,
qn = quality rating for the n^{th} water quality parameter.
Vn = estimated value of the n^{th} parameter at a given sampling station.
Sn = standard permissible value of n^{th} parameter.
Vio = ideal value of n^{th} parameter in pure water.

All the ideal values (*Vio*) are taken as zero for drinking water except for pH = 7.0

Calculation of quality rating for pH: For pH the ideal value is 7.0 (for natural water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following relation:

$$qpH = 100\ [(VpH - 7.0)/(8.5 - 7.0)] \quad ...(2)$$

Where,
VpH = observed value of pH during the study period.

Calculation of unit weight (*Wn*): Calculation of unit weight (*Wn*) for various water quality parameters is inversely proportional to the recommended standards for the corresponding parameters.

$$Wn = K/Sn \quad ...(3)$$

Where,
Wn = unit weight for n^{th} parameters.
Sn = standard value for n^{th} parameters
K = constant for proportionality (K = 1.85445)

Calculation of WQI

WQI is calculated from the following equation

$$WQI = \sum_{n=1}^{n} qn\ Wn / \sum_{n=1}^{n} Wn \quad ...(4)$$

Table 1: Status of water quality based on WQI (Brown et al. 1972).

Water Quality Index	Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
< 100	Unsuitable for drinking

RESULTS AND DISCUSSION

As per WHO (2004) report, pollution of water has been reported to cause 80% of human diseases and 30% of infant mortality in developing countries. It is, therefore, very important to monitor the quality of groundwater as per its usage. Although, Patel (1991), Jain et al. (1997), Pradhan et al. (1998) and Singh & Parwana (1999) have studied the groundwater pollution in various States of India, there is need to precisely identify the standard of water quality. In the present investigation, samples of Water Quality Index (WQI), were taken from each Ward in winter, summer and rainy seasons taking into consideration the parameters like pH, electrical conductivity, total solids, total dissolved solids, total suspended solids, total alkalinity, chlorides, nitrate, sulphate, calcium, magnesium and total hardness. The calculation of WQI was made using arithmetic index method of Brown et al. (1972). Kausik et al. (2002) studied urban groundwater index of Hisar and Panipat in Haryana. They found that underground water in all the land use zones was fit for consumption in Hisar and Panipat but other areas showed varied magnitude of pollution (WQI > 52-100). Ramkrishnaiah

Table 2: Calculation of water quality index of Ward No. 1 during winter season.

Parameter	Observed value	Standard value	Recommended by agency	Unit Weight (W_n)	Quality rating (q_n)	$W_n q_n$
pH	7.67	6.5-8.5	BIS	0.219000	44.44	9.73
Electrical Conductivity	683.33	1000	BIS	0.001854	68.33	0.13
Total Solids	635.00	1500	BIS	0.001236	42.33	0.05
Total Dissolved Solids	435.00	500	BIS	0.003709	87.00	0.32
Total Suspended Solids	200.00	500	BIS	0.003709	40.00	0.15
Total Alkalinity	158.00	200	BIS	0.009272	79.00	0.73
Chlorides	113.33	250	BIS	0.007418	45.33	0.34
Nitrate	27.33	45	BIS	0.041210	60.74	2.50
Sulphate	5.33	200	BIS	0.009272	2.67	0.02
Calcium	55.00	75	BIS	0.024726	73.33	1.81
Magnesium	14.00	30	BIS	0.061815	46.67	2.88
Total Hardness	251.67	300	BIS	0.006182	83.89	0.52
~	Total	~	~	0.38940335	~	19.20

$WQI = \sum_{n=1}^{n} qn\ Wn / \sum_{n=1}^{n} Wn$
$\Sigma\ Wn = 0.3894034$
$\Sigma\ qnWn = 19.20$
$WQI = 49.29735$

Table 3: Quality of drinking water during winter, summer and rainy seasons.

Ward No.	Winter season	Summer season	Rainy season
1	49.2974	52.7359	51.2982
2	47.5693	49.6531	49.5955
3	42.0722	46.2044	44.7898
4	53.2732	55.4229	52.7386
5	46.6908	45.8422	44.9685
6	48.6196	52.1465	53.3785
7	54.2495	52.8272	57.1817
8	49.6099	51.0780	59.6883
9	30.8045	36.3340	33.4829
10	47.3522	48.0370	45.7836
11	48.7550	49.2619	49.8016
12	33.9059	34.7413	33.0156
13	36.4205	35.0910	35.9401
14	46.4898	47.9716	44.7151
15	44.3201	47.9879	56.0104
16	51.4115	51.6572	52.3368
17	33.7885	34.4269	35.2364
18	39.7572	48.0705	48.0186
19	50.3947	51.8900	52.8187
20	59.2063	52.1828	69.5824
21	43.3137	49.3341	44.3427
22	46.4982	53.8441	54.6007
23	44.3251	47.4279	49.2667
24	42.1014	44.1696	44.4075
25	48.6957	50.4758	54.3840
26	34.5076	34.5898	34.2024
27	34.3762	36.1698	33.0463
28	47.0764	46.4339	48.8474
29	49.6260	50.2428	55.8622
30	51.2755	51.2223	58.8789
31	42.1330	38.5121	48.7263
32	47.9871	48.2570	55.6798
33	46.4358	47.0389	47.1126
34	44.3940	48.0003	50.1690
35	51.7290	50.8154	46.8118
36	48.3990	52.8102	52.6399
37	70.5880	69.1284	68.7154
38	69.1733	70.1696	69.9763
39	69.1413	70.2218	67.9501

Table 4: Ward-wise status of water quality during winter season.

WQI	Status	Ward numbers	Total number of Wards
0-25	Excellent	Nil	0
26-50	Good	01, 02, 03, 05, 06, 08, 09, 10, 11 12, 13, 14, 15, 17, 18, 21, 22, 23, 24, 25, 26, 27, 28, 29, 31, 32, 33, 34	29
51-75	Poor	04, 07, 16,19,20,30,35,36,37,38,39	10
76-100	Very Poor	Nil	0
< 100	Unsuitable for drinking	Nil	0

Table 5: Ward wise status of water quality during summer season.

WQI	Status	Ward numbers	Total number of Wards
0-25	Excellent	Nil	0
26-50	Good	02,03,05,09,10,11,12,13,14,15,17, 18,21,23,24,26,27,28,31,32,33,34	22
51-75	Poor	01,04,06,07,08,16,19,20,22,25,29, 30,35,36,37,38,39	17
76-100	Very Poor	Nil	0
< 100	Unsuitable for drinking	Nil	0

Table 6: Ward wise status of water quality during rainy season.

WQI	Status	Ward numbers	Total number of Wards
0-25	Excellent	Nil	0
26-50	Good	02,03,05,09,10,11,12,13,14,17 18,21,23,24,26,27,28,31,33,34	29
51-75	Poor	01,04,06,07,08,15,16,19,20,22 25, 29,30,32,34,36,37,38,39	10
76-100	Very Poor	Nil	0
< 100	Unsuitable for drinking	Nil	0

et al. (2009) found WQI to vary from 89.21 to 660.56 and suggested some degree of treatment before consumption. Jayashankara et al. (2010) studied the microbial and chemical characteristics of water of temple ponds of Udupi district and found that water quality index varied from 30.76 to 38.46. They attributed the deviation from normal level to be due to total acidity, dissolved oxygen, free CO_2 and over growth of bacteria. Similarly Mishra & Shrivastava (2008) on the basis of the study of Kohargaddi dam of Balrampur district found the water quality to be completely unsuitable for human beings and cattle. In the present investigation throughout the year no water samples were found in excellence rank (0-25), however, 29 Wards showed good water quality (26-50), and 10 wards showed poor water quality (51-75). In summer, twenty two wards showed good water quality and seventeen wards showed poor water quality. In rainy season some of the water sources were degraded and 20 Wards showed good water quality, while 19 wards were in poor category. It is interesting to note that Ward Nos. 37, 38 and 39 showed poor ranking in all the seasons. The chemical analyses of water samples of these Wards showed comparatively high pH, electrical conductivity and dissolved solids. Since these Wards received water from sump well, it is likely that the distribution system of this area is contaminated on the way by sewage.

Sites showing high water quality index are suspected to be contaminated due to damaged distribution pipes. The authors, therefore, suggest that to maintain good quality of municipal filtered water, it is necessary that points of contamination must be identified and rectified so that the public opinion may be changed and dependence on groundwater be reduced.

REFERENCES

APHA 1986. Standard Methods for the Examination of Water and Wastewater. 15th ed., American Public Health Association, Washington D.C.

Brown, R.M., McCleiland, N.J., Deininger, R.A. and Connor, M.F.O. 1972. A water quality index-crossing the psychological barrier. In: Jenkis, S.H. (Ed.) Proc. Int. Conf. on Water Pollution. Res., Jerusalem, 6: 787-797.

Deininger, R.A. and Maciunas, J.J. 1971. Water quality of environmental and industrial health. School of Public Health, University of Michigan, Ann Arbor, Michigan.

Harkins, R.D. 1974. An objective water quality index. J. Water Poll. Cont. Fed., 3: 589-591.

Horton, R.K. 1965. An index number system for rating water. J. Water Poll. Cont. Fed., 3: 111-114.

Jain, C.K., Bhatia, K.K.S. and Vijay, T. 1997. Ground water quality in a coastal region of Andhra Pradesh. Ind. J. Environ. HIth., 39(3): 182-192.

Jayashanakara, M., Vijaya, R.G. and Shankar, P.H. 2010. Microbial diversity and water quality index in temple ponds of Udupi district Karnataka, India. Nat. Environ. Poll. Tech., 9(1): 197-202.

Kaushik, A., Kumar, K., Kanchan, T. and Sharma, H.R. 2002. Water quality index and suitability assessment of urban ground water of Hisar and Panipat in Haryana. J. Environ. Biol., 23(3): 325-333.

Mishra, D.K. and Shrivastava, R. 2008. Ground water quality of Tulsipur town at Indo-Nepal border. Nat. Environ. Poll. Tech., 7(2): 299-302.

Patel, S.K. 1991. Study of ground water pollution in and around Ujjain city Ind. J. Environ. Prot., 11(11): 822-825.

Pradhan, S.K., Patnaik, D. and Rout, S.P. 1998. Ground water quality, an assessment around a phosphatic fertilizer plant at Paradip. Ind. J. Environ. Prot., 18(10): 796-722.

Ramakrishnaiah, C.R., Sadashivaiah, C. and Ranganna, G. 2009. Assessment of water quality index for the ground water in Tumkur taluk, Karnataka State, India. E- Journal of Chemistry, 6(2): 523-530.

Sing, K.P. and Parawana, H.K. 1999. Ground water pollution due to industrial waste water in Punjab State and strategies for its control. Ind. J. Environ. Prot., 19(4): 241-244.

Tiwari, J.N. and Manzoor, A. 1988. Water quality for Indian rivers. In: Ecology and Pollution of Indian Rivers, R. K. Trivedy (Ed.), Aashish Publishing House, New Delhi, pp. 271-286.

Trivedy, R.K. and Goel P.K. 1986. Chemical and Biological Methods for Water Pollution Studies. Environmental Pub., Karad, 2nd Edition, 247 pp.

WHO 1996. The World Health Report, Fighting Diseases, Fostering Development. WHO, Geneva.