Environment Conservation Journal 16(1&2) 51-56, 2015
ISSN 0972-3099 (Print) 2278-5124 (Online)
Abstracted and Indexed

Water quality assessment and mapping of natural and ground water resources in Pauri region of Uttarakhand

Mamta Baunthiyal ✉, Deepika Rai and Shweta Ranghar

Received:05.11.2014 **Revised:19.02.2015** **Accepted:23.03.2015**

Abstract

Ground water and surface water was analyzed for twenty different location of Pauri district, one of the populated cities of Himalayan region of Uttarakhand. To evaluate water quality of these sources, a study was carried during three seasons viz. monsoon, winter and summer. Sixty samples were analyzed for different physical and chemical parameters viz. Turbidity, Alkalinity, Total hardness (TH), Residual chlorine (RC), Chlorides, Fluorides, Iron and Nitrates. Results obtained were compared and correlated with standard values in Indian Standard specification (IS): 10500 along with mapping of these sources. The maximum mean value of turbidity, alkalinity, TH, RC, chlorides, fluoride, and nitrates were 12NTU in monsoon, 138.05 mg/Lin winter, 183.46 mg/L in winter,0.12mg/L in winter, 65.795 mg/L in winter, 0.25 mg/L in monsoon season, and 0.54 mg/L in monsoon season respectively.

Keywords: Ground water, Indian Standard Specification (IS), Natural water resources, Pauri, Uttarakhand, Residual chlorides, Total Hardness

Introduction

A water resource has a critical importance to both natural ecosystem and human development; as water is basic necessity of life. The water quality of a region defines various factors such as available resources which are there for the support of the ecosystem and human development (Ahmad and Ahmad, 2014).Therefore, to access the monitoring of water quality parameters it is essential to identify the magnitude and source of water resources. These parameters can suggest the conditions and control parameters which are ideal for the conservation and management strategies of water resources. A study conducted by World Health Organization (WHO), reports that approximately 36% of urban and 65% of rural Indian population is without access to safe drinking water (Bhalme *et al*., 2012; Kalra *et al*., 2012). This is due to increase in urbanization, industrialization, agriculture activity and various other anthropogenic activities that results in increment of pollution level in surface and ground water (Bhalme *et al.*, 2012). Fate and quality of any water resource depend upon the ecological factors along with the anthropogenic activities that influences and alters the watershed hydrology; these resources should be free from contaminants like organic and inorganic pollutants, heavy metals, pesticides, as they are crucial for the survival of human beings and ecosystem of that area (Claessens *et al.*, 2006).Uttarakhand is a state which provides enormous amount of hydropower to the country as it contains small and large sources of water in the form of rivers and waterfall. Despite the fact, this state is facing drinking water problem because of lack of development and usage of natural resources due to non-economic planning. Along with this, aquatic environment of water bodies is also disturbed and mismanaged as people are unaware of these factors (Verma *et al.*, 2012). Both urban and rural areas of state face drinking water problems (mainly during summer season) and depend on other sources such as; water tankers to fulfill basic need of water on daily basis. The State government is promoting traditional methods of water harvesting and had earlier allocated Rs. 521.97 crores in the budget for the year 2011-12 for availability of clean drinking water. In this study, identification, mapping and assessement of

Author's Address
Department of Biotechnology, G. B. Pant Engineering College
Pauri Garhwal Uttrakhand
E-mail: mamtabaunthiyal@yahoo.co.in

drinking water resources of Pauri region is done. Pauri city is situated between 29° 45' to 30°15' Latitude and 78° 24' to 79° 23' E Longitude in the state of Uttarakhand, India.

Materials and Methods

Water samples were collected from various water resources during three different seasons viz. summer, winter and monsoon (Table 1). The samples were collected in polyethylene bottle and were sealed immediately. A total of 60 samples were collected, out of which 18 water samples were from water supply, 33 samples from hand pump, 3 samples were from well and 6 from natural resources. These were coded as given in Table 1. Various physiochemical properties including turbidity, alkalinity, total hardness, residual chlorine, chlorides, fluoride, nitrate and iron were analyzed using 'Field test kit', issued from Swajal project, Pauri. The results were compared with Indian standard specification for drinking water IS-10500.

Table 1 Details of water sampling location from Pauri region (Uttarakhand)

S.No	Sample site	Source	Sample ID	Latitude	Longitude
1.	Alaknanda Girls Hostel, GB Pant Engineering College	Tap water	KW-1	30.18492	78.69088
2.	Agency Chowk, Pauri	Well water	KW-2	30.147145	78.778165
3.	Saint Thomas School, Pauri	Hand pump water	KW-3	30.1849	78.66824
4.	DAV School, Pauri	Hand pump water	KW-4	30.151057	78.774911
5.	Kwali Village	Source water	KW-5	30.19469	78.70575
6.	Ghurdauri	Hand pump water	KW-6	30.183155	78.694739
7.	Ghurdauri	Source water	KW-7	30.183155	78.694739
8.	Danda Pani	Hand pump water	KW-8	30.16656	78.69269
9.	Khandyusen	Hand pump water	KW-9	30.156	78.73505
10.	Khandyusen	Source water	KW-10	30.15632	78.73156
11.	Khirsu	Hand pump water	KW-11	30.15665	70.7301
12.	Kandoliya	Tap water	KW-12	30.147337	78.778261
13.	Kandoliya	Hand pump water	KW-13	30.146114	78.774422
14.	Pauri (near hospital)	Hand pump water	KW-14	30.147145	78.778165
15.	Baudkyakhal	Tap water	KW-15	30.1849	78.66824
16.	Baudkyakhal	Hand pump water	KW-16	29.8687	78.83826
17.	Minthi village	Water tank	KW-17	30.18938	78.68923
18.	Balmana village	Hand pump water	KW-18	30.18181	78.665403
19.	Jamlakhal village	Hand pump water	KW-19	30.18484	78.67763
20.	Ghurdauri	Water tank	KW-20	30.183155	78.694739

Results and Discussion

Various physico-chemical parameters for water samples collected from different sites were analyzed during three seasons. Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eyes (Mazhar *et al.*, 2013).The more total suspended solids in the water, the murkier it seems and the higher the turbidity. The turbidity was measured in NTU and recorded between the ranges of 0 - 20 NTU in all the seasons (Table 2).The mean value of turbidity was observed

Table 2: Values of Turbidity (NTU), Alkalinity (mg/L) and Total Hardness (mg/L) recorded during three different seasons

S.No.	Sample code	Monsoon			Winter			Summer		
		Turbidity	Alkalinity	Total Hardness (TH)	Turbidity	Alkalinity	Total Hardness (TH)	Turbidity	Alkalinity	Total Hardness (TH)
1	KW-1	10	75*	212.4*	0*	75*	215*	0*	100*	210*
2	KW-2	0*	75*	**971.7****	0*	75*	650**	0*	100*	**610****
3	KW-3	10	150*	94.8*	10	150*	98.2*	10	150*	140*
4	KW-4	20**	75*	118.5*	10	100*	125.8*	20**	183.35 *	175.66*
5	KW-5	10	100*	94.8*	0*	123*	98.3*	**NA**	**NA**	**NA**
6	KW-6	20**	150*	237*	20**	154*	250*	10	175*	159.8*
7	KW-7	0*	50*	260.7*	0*	100*	257.3*	**NA**	**NA**	**NA**
8	KW-8	10	150*	142.2*	10	163.3*	146.3*	10	175*	159.8*
9	KW-9	10	75*	189.6*	10	100.8*	194.2*	0*	150*	175*
10	KW-10	20**	100*	237*	20**	100*	239.8*	**NA**	**NA**	**NA**
11	KW-11	20**	125*	94.8*	20**	158*	135*	10	175*	150*
12	KW-12	10	125*	308.1	20**	139*	298.6*	0*	150*	210*
13	KW-13	20**	150*	284.4*	20**	168*	257.3*	10	100*	280*
14	KW-14	10	150*	163.5*	20**	150*	158*	20**	150*	140*
15	KW-15	10	272	268*	10	260	235.8*	0*	250	245*
16	KW-16	10	185*	237*	10	178*	218*	0*	150*	210*
17	KW-17	20**	165*	119*	20**	166*	286.3*	10	100*	147*
18	KW-18	10	150*	120.8*	10	139*	168*	0*	150*	168*
19	KW-19	10	185*	136*	10	128*	149.3*	0*	128*	125*
20	KW-20	10	148*	143*	10	134*	138*	0*	175*	142*
Mean value		12	132. 75	173.08	11.5	138.05	183.46	5	128.06 *	141.86

NA: Not Available **Exceed permissible limit *Lower than the permissible limit

maximum in monsoon (12.0 NTU) and minimum in summer season (5.0 NTU). The high turbidity in monsoon may be due to runoff or may be due to growth of aquatic vegetation as a result of rainfall (Swayer *et al*., 2003, Basavaraja *et al*., 2011). Alkalinity is acid neutralization capacity of water. The presence of carbonates, bicarbonates, and hydroxides is the main cause of alkalinity in natural waters (Rajankar *et al.*, 2009). Alkalinity in water samples was recorded in the range of 50 -272 mg/L during monsoon, 75-260 mg/L during winter and 100- 250 mg/L in summer (Table 2). The mean value of alkalinity was 132.7 mg/L in monsoon, 138.05 mg/L in winter and 128.06 mg/L in summer, which is below the permissible limit i.e., 200 to 500 mg/L. Sample KW-15 showed the maximum value272 mg/L in monsoon, 260 mg/L in winter and 250 mg/L in summer, which is within the permissible limit, whereas lowest value of 50mg/L was observed in KW-7 during monsoon season. Total hardness (TH) of water varies considerably fromplace to place. In general, surface waters are softer than ground waters.

The hardness of water reflects the nature of the geological formations with which it has been in contact and is derived largely from contact with the soil and rock formations. In general, hard water originates in areas where the topsoil is thick and limestone formations are present (Swayer *et al.*, 2003). The TH range was 94.8-971.7 mg/L in monsoon, 98.2-650 mg/L in winter and 140- 610 mg/L in summer. In present study, the mean of total hardness was 173.08 mg/L in monsoon, 183.46 mg/L in winter, 141.863 mg/L in summer (Table 2), which is below the permissible limit i.e. 300-600 mg/L (IS:10500, 1993). But among all the samples, total hardness was highest in KW-2 sample during all seasons i.e. 971.1 mg/L in monsoon, 650 mg/L in winter and 610 mg/L in summer, which is above the permissible limit. Lowest value was observed in KW-3 which was 94.8 mg/L during monsoon season. Excess of chlorine in water supply can be a problem as chlorine dissociates into ammonia and can also react with phenol to produce mono, di, tri- chloro phenols which can impart taste and odor to water and can also react with humus substances present in most water supplies forming a variety of halogenated products including tri-halomethanes (THMs) and halo acetic acid. THMs are suspected human carcinogens. The major THMs which can form are chloroform, bromo-di-chloromethane, di- bromo-chloromethane and bromoform (Swayer *et al.*, 2003). The mean value of residual chloride was 0.05mg/ L in monsoon, 0.12 mg/L in winter and 0.104 mg/L in summer (Table 3).

Table 3: Residual Chlorine (mg/L), Chlorides (mg/L) and Fluoride (mg/L) concentration recorded during three different seasons

NA: Not Available **Exceed permissible limit *Lower than the permissible limit

S.No.	Sample code	Monsoon			Winter			Summer		
		Residual Chlorine (RC)	Chlorides	Fluorides	Residual Chorine (RC)	Chlorides	Fluorides	Residual Chlorine (RC)	Chlorides	Fluorides
1	KW-1	0	30*	0*	0	32*	0*	0	30*	0*
2	KW-2	0	50*	0*	0	65*	0*	0	69*	0*
3	KW-3	0.15	40*	0*	0.5	58*	0*	0.1	46*	0*
4	KW-4	0.2	50*	0*	0.15	60*	0*	1.2	63*	0.15*
5	KW-5	0	50*	0.5*	0	56.7*	0.5*	**NA**	**NA**	NA
6	KW-6	0.15	40*	0.5*	0.5	45*	0*	0	54*	0*
7	KW-7	0	80*	0.5*	0	76.8*	0*	**NA**	**NA**	NA
8	KW-8	0.15	40*	1	0.15	48*	0.5*	0	54*	0*
9	KW-9	0.15	90*	0.5*	0.5	98*	0*	0.15	46*	0*
10	KW-10	0	100*	0.5*	0	110*	0*	**NA**	**NA**	NA
11	KW-11	0	60*	0*	0	68*	0*	0.05	69.7*	0*
12	KW-12	0	50*	0.5*	0	66.8*	0.5*	0	46*	0*
13	KW-13	0	70*	0.5*	0	85*	0.5*	0	69*	0*
14	KW-14	0.1	74.8*	0.5*	0.2	76*	0.5*	0.2	69*	0.5*
15	KW-15	0.05	59.3*	0*	0.15	53*	0*	0.15	46*	0*
16	KW-16	0	66*	0*	0	72*	0*	0	69*	0.5*
17	KW-17	0.05	58*	0*	0	74.8*	0*	0	35*	0*
18	KW-18	0	63*	0*	0.2	66*	0*	0.04	29*	0*
19	KW-19	0.01	67*	0*	0	56.8*	0*	0	25*	0.5*
20	KW-20	0	56*	0*	0.05	48*	0*	0.2	37*	0*
Mean value		0.05	59.70	0.25	0.12	65.79	0.12	0.10	42.83	0.08

The desirable value of residual chloride in drinking water is 0.2 mg/L, which is applicable when water is chlorinated. Samples KW-4 in monsoon, KW-14, KW-18 in winter, and KW-14, KW-20 in summer were within the permissible limit. The highest value (1.2 mg/L) was observed during summer in KW-4 location. Chloride, in the form of (Cl^-) ion, is one of the major inorganic anions in water. A high chloride content may harm metallic pipes and structures, as well as growing plants (Khanam and Singh, 2014). The mean value of chloride was 59.07mg/L in monsoon, 65.797 mg/L in winter and 42.835mg/L in summer, which was below the permissible limit i.e., 250 mg/L-1000mg/L (Table 3). The maximum value was observed during winter in KW-10 sample (110mg/L) and minimum (25 mg/L) in summers in KW-19 sample. The concentration of fluorides was below the permissible limit i.e. 1–100 mg/L (IS: 10500, 1993) in all the seasons (Table 3).The mean fluoride value was 0.25 mg/L in monsoon, 0.11 mg/L in winter and 0.005 mg/L in summer. Only sample KW-8 had the value 1mg/L within the permissible limit. To overcome, there is a need of addition of fluoride in water supply to achieve optimum level for the control of dental caries (Dutta *et al.*, 2006). In water different forms of nitrogen are of greatest interest, which occur in order of decreasing oxidation state, nitrate, nitrite, ammonia and organic nitrogen. Nitrate concentration was in the range of 0- 35mg/L (Table 4).

Table 4: Nitrates (mg/L) and Iron (mg/L) concentration recorded during three different seasons

S.No.	Sample code	Monsoon		Winter		Summer	
		Nitrate	Iron	Nitrate	Iron	Nitrate	Iron
1	KW-1	0*	0.05*	0*	0.05*	0*	0.05*
2	KW-2	25*	0.1*	10*	0.1*	35*	0.05*
3	KW-3	0*	0.05*	0*	0.3	10*	0.4
4	KW-4	0*	2**	0*	1.58**	10*	1.88**
5	KW-5	0*	0.1*	0*	0.1*	NA	NA
6	KW-6	0*	0.3	0*	0.36	0*	0.56
7	KW-7	0*	0.1*	0*	0.1*	NA	NA
8	KW-8	0*	0.3	0*	0.3	0*	0.56
9	KW-9	0*	0.1*	0*	0.1*	10*	0.3
10	KW-10	0*	0.3	0*	0.35	NA	NA
11	KW-11	0*	1.8**	0*	1.2**	0*	1.28**
12	KW-12	0*	0.6	0*	0.65	0*	0.3
13	KW-13	0*	1	0*	1	25*	0.4
14	KW-14	0*	2.3**	0*	1.6**	0*	1.5**
15	KW-15	0*	0.29*	0*	0.28*	0*	0.1*
16	KW-16	0*	0.8	10*	0.72	10*	0.6
17	KW-17	0*	0.3	0*	0.47	0*	0.05*
18	KW-18	0*	0.1*	0*	0.38	0*	0.4
19	KW-19	0*	0.3	0*	0.22*	0*	0.56
20	KW-20	0*	0.1*	0*	0.08*	0*	0.05*
Mean value		1.25	0.54	1	0.49	5	0.45

NA: Not Available **Exceed permissible limit *Lower than the permissible limit

The mean value of nitrate was 1.5 mg/L, 1 mg/L & 5 mg/L in monsoon, winter and summer respectively, which is below the permissible limit of 45– 400 mg/L. The maximum value of nitrate (35 mg/L) was in summer in KW-2 sample. Iron is commonly present in surface and drinking water. This occurs from dissolution processes of ironstones in nature and partially from the corrosion processes in pipes and from industries (Adebayo et al., 2011).Concentration of iron was in the range of 0.05-2.3 mg/L (Table 4). The mean value of iron was 0.54 mg/L in monsoon, 0.497 mg/L in winter and 0.452 mg/L in summer, which were within the permissible range of 0.3- 1.0 mg/l. However in KW-4, KW-11 and KW-14 samples, the iron concentration was above the permissible limit during all seasons which may be due to absence of dissolved oxygen and high carbon dioxide.

Conclusion

Sampling and analysis of drinking water resources is valuable to determine the physico-chemical properties of the water of a particular region. Iron content and total hardness in samples of drinking water of Pauri region were found above permissible limit as mentioned in Indian standard specification of drinking water. Fluoride and Chloride content of many water samples were below the permissible limit which can be overcome by supplementing them in potable water. From this study we conclude that regular water analysis of this area should be done to ensure that drinking water is not contaminated. Information provided by the present study can be used for further analysis of water impact on soil and crops of the area.

Acknowledgement

The authors acknowledge Swajal project, Pauri Garhwal (Uttarakhand) for providing field test kit for the present study.

References

Adebayo B.K., Ayejuyo S., Okoro H.K, and Ximba B.J., 2011,Spectrophotometric determination of iron (III) in tap water using 8-hydoxyquinoline as a chromogenic reagent. ***African Journal of Biotechnology***, 10 (7):16051-16057.

Ahmad A.,and Ahmad F., 2014. Evaluation of ground water quality of Aligarh city, India. ***International Journal Current Research Academic Review,***2(8): 323-327.

Bhalme S.P., and Nagrnaik P.B., 2012. Analysis of drinking water of different places. ***International Journal of Engineering Research***,3:3155-3158.

Basavaraja S., Hiremath SM., Murthy KNS., Chandrashekarappa KN., Patel A.N., and Puttiah E.T., 2011. Analysis of water quality using physico-chemical parameters Hosahalli Tank in Shimoga District, Karnataka, India. ***Global Journal of Science Frontier, Research***,1(3):31-34.

Claessens L., Hopkinson C., Rastetter N.,and Vallino J., 2006. Effect of historical changes in land-use and climate on the water budget of an urbanizing watershed. ***Water Resources Research***, 42(3): W03426, doi:10.1029/2005WR004131.

Dutta R.K., Saikia G., Das B Bezbaruah., Das H.B., and Dube S., 2006. Fluoride contamination in groundwater of Central Assam, India . ***Asian J Water Env Polln***, 3(2):93-100.

IS: 10500., 1993. Indian Standard Specification for Drinking Water. ***Central Pollution Control Board, India.***

Kalra N., Kumar R., Yadav S.S., and Singh R.T., 2012. Physico-chemical analysis of ground water taken from five blocks (Udwantnagar, Tarari, Charpokar, Piro, Sahar) of Southern Bhojpur (Bihar). ***Journal of Chemical and Pharmaceutical Research***,4(3): 1872-1832.

Khanam Z., and Singh V., 2014. Groundwater Quality Assessment near Polluted Canal area in Kichha Town, Uttarakhand, India. ***International Journal of Recent Scientific Research***, 5 (2):262-368

Mazhar S.M., Khan N., and Kumar A.R., 2013 . Geogenic Assessment of Water Quality Index for the Groundwater in Tiruchengode Taluk, Namakkal District, Tamilnadu, India. ***Chem Sci Trans***., 2(3): 1021-1027.

Rajankar P.N., Gulhane S.R., Tambekar D.H., Ramteke D.S. and Wate S.R., 2009. Water Quality Assessment of Groundwater Resources in Nagpur Region (India) Based on WQI. ***Journal of Chemistry,***6(3): 905-908.

Swayer C.N., McCarty P.L., and Parkin G.F., 2003. ***Chemistry for Environmental Engineering and Sciences***, 5th ed.,*Tata McGraw Hill Publication*.

Verma P., Chandawat D., Gupta U., and Solanki H., 2012. Water quality analysis of an organically polluted lake by investigating different physical and chemical parameters. ***International Journal of Research in chemistry and environment***.pp.105-111.