Hydrochemical Profile of Banjosa Lake Poonch, Kashmir

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The hydrochemical profile study of Banjosa Lake was conducted through systemic sampling, spacially and temporally, during 2004-2005. The pH averaged 7.25, EC 231 μS/cm and TDS 148 mg/L. Chlorides, sulphates, nitrate nitrogen, total nitrogen, orthophosphates and total phosphates, showed corresponding mean values as 24.63, 15.32, 2.81, 1.30, 0.16 and 0.20 mg/L. November and February (2004 and 2005) samples for BOD and COD indicated COD exceeding threshold values set by WHO. Atomic absorption spectrometry determination of major (Na^+, K^+, Ca^{2+}, Mg^{2+}) and trace level metals (Fe^{2+}, Cu^{2+}, Ni^{2+}, Zn^{2+}, Cd^{2+}, Pb^{2+}, Co^{2+}) was also carried out. Estimation of sodium absorption ratio, percentage sodium and residual sodium carbonate values recommend it for agricultural uses.

Key Words: Hydrochemical profile, Banjosa lake, Poonch, Kashmir.

INTRODUCTION

Banjosa Lake: Location and Ambiance: Rawalakot, the district headquarter, is situated in the heart of district Poonch. The altitude of this saucer shaped valley is 1615 m above the sea level. Banjosa a site of immense scenic beauty, houses a Lake with boating facilities is, situated at an altitude of 1981 m above sea level about 20 Km from Rawalakot. The paradisiacal beauty of this area may be attributed to its exotic beauty, pretty landscape and nourishing water stocks of great ecological and socio-economic impact; Banjosa Lake with multi-faceted eco-system being outstanding of these.

Water inflows of this lake are ice melts, spring ooze and precipitation. The average yearly rainfall is 1500 mm[1]. The quality of Lake water may change by anthropogenic activity, geological nature of the catchment's areas and yearly degree of precipitation[2]. The lake is periodically drained and recharged to maintain the quality of its water.

Khan and Zutshi[3] reported primary productivity and trophic status of Naranbagh Lake and limnological studies on Dal Lake of Kashmir[4]. Leghari *et al.*[5] reported limnological studies of Tatta Pani Hot springs and River Poonch at Tatta village of District Poonch, Kashmir an under studied area. Mirza *et al.*[6-11] demonstrated the quality of waters of springs, torrents, wells, ponds, snow melt and precipitation in the targeted area. The present work examines the water quality of Banjosa Lake both for dinking and irrigation.

The targeted area of Kashmir stretches between longitude 73º-75º and latitude 33º-36º and the altitude rises steeply from 360 m to 6325 m above sea level. There are the hot plains of the Bhimber and Mirpur districts and the coldest lands of Rawalakot, Leepa, Kel, Trarkhal. Weather conditions vary across landscape because of the lofty mountains like the Pirpanjal that check the moisture-laden air from entering the valley. In summers, the outer plains and the outer hills receive rainfall from monsoon winds while in winters, winds from the Mediterranean cause snowfall and rainfall in the Valleys of Kashmir. The moisture-laden winds cause rainfall in the forests on the hills pushing the temperature down in summer.

Geology of the area: Geological study of the area was carried out by Meddlicott[12], Lydekker[13] and Middlemiss[14]. The area consists of Siwalik group of rocks in mostly the western part of the Poonch District along with the eastern bank of the Jhelum river. These rocks crop out between Kohala and Pattan. The eastern contact runs in an irregular fashion from Hajeera through Rawalkot to Dhirkot. Wadia[15] carried out more detailed work on this area and divided the Siwaliks of Kahmir into Lower Palandri, Middle Mang and Upper Sand Rock Stage. It may be pointed out here that both Palandri and Mang were located in Poonch District. Kotli area indicated Precambian rock formation[16]. The rocks consist of granite and crystalline groups. The rocks of the area mainly composed of chlorite, muscovite schists, mica granite, sand stone, quartzite, calcite and pyrite. The geological formation of the area, *i.e.* the fractured mica schists interbedded with thin bends of quartzite, granite gneiss and non-foliated granitic rocks act as a barrier to the ground water flow, forming springs. In the area, fractured mica schists covered with thin layer of top soil (0.1-1.0 m) provide a permeable recharge zone for groundwater[17].

EXPERIMENTAL

Hydrology and sampling strategy: Prior to systematic sampling the lake was observed for its locations and stratified for its sampling. Each stratum was sampled for predetermined number of sub samples. The sub samples were mixed to form a composite sample. The samples were also *in situ* tested for basic physico-chemical parameters as pH, TDS, EC, DO, temperature. The sampling mode was simple grab method. Pre-washed high density polythene bottles were suspended, at predetermined depths through a Secchi disc, from the surface and stopper removed by a sharp jerk through an attached line. The Lake was navigated by boat. For elemental analysis each sample was acidified to pH < 2; for organic matter, fixed with $HgCl_2$. Separate samples were taken for specific analysis.

The dissolved oxygen (DO) in the samples was determined by Wrinkler method[18]. Chemical oxygen demand (COD) was estimated by micro-dichromate oxidation method[19]. Hardness, chloride and alkalinity were determined by titration with standard EDTA, silver nitrate and hydrochloric acid. Conductivity, salinity and total dissolved solids (TDS) were evaluated with Orion 115 conductivity meter. The pH was recorded with Orion 420 A pH meter. Kjeldahl nitrogen was determined

by using standard procedure[18]. Orthophosphate, nitrate and nitrite were determined by spectrophotometery. Orthophosphate was determined by reducing phosphomolybdic acid formed with ascorbic acid to molybdenum blue. Total phosphate was estimated by persulphate acid hydrolysis, followed by determination as for orthophosphate. Nitrate was determined after derivatization with brucine sulphate. Nitrite was estimated using N-naphthyl ethylenediamine as derivatizing reagent as reported[18]. Sulphate was determined by turbidimetery as $BaSO_4$ using Hitachi 220 spectrophotometer. The metal ions Na, K, Ca, Mg, Fe, Pb, Cu, Zn, Ni, Cd, and Co were determined with Varian Spectr AA-20 atomic absorption spectrometer with standard burner head and air acetylene flame at the conditions recommended by the manufacturer. The analysis was carried out in triplicate with integration time 3 second and delay time 3 s. Na, K, Ca and Mg were determined after appropriate dilution. Sample (250 mL) containing nitric acid (1 mL) was heated gently at 90- 95 ℃ and was concentrated to about 5-8 mL. The solution was transferred to volumetric flask and final volume was adjusted to 10 mL. The solution was analyzed for the contents of Fe, Pb, Cu, Zn, Ni, Cd, and Co by air acetylene flame atomic absorption spectrometer.

RESULTS AND DISCUSSION

pH, Electrical conductivity and total dissolved solids: The pH varied between 6.64 to 7.99 in one hydrological year with average value 7.25. The pH < 7 (lower value) may be because of leaching of acidic water by the decomposition of pine litters over the ground surface[19]. However, the pH value 7.99 may because of addition of calcium and magnesium due to rock erosion. The seasonal changes in pH are insignificant and fall within the WHO water quality standards[20] (Table-1). The electrical conductivity (EC) and total dissolved solids (TDS) (Table-1) indicated a significant inter seasonal variation among the samples. EC and TDS varied within the range 180-282 µS/cm and 116.5 -180.5 mg/L. The possible source of higher EC and TDS values in the Lake water may the dissolution of the salts due to soil erosion by high degree of precipitation during monsoon and winter. However, throughout the hydrological year, EC and TDS values were observed within prescribed limits of WHO[21,22].

Dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD): The DO, BOD and COD seasonal values range from 8.62-11.5, 9.0-16.4 and 37-48 mg/L, respectively. Dissolved oxygen exceed the limit of WHO for the samples collected in November 2004 and February 2005 may possibly because of high solubility at lower temperature. In the values of BOD and COD, a trend in higher side was observed may be due to accumulation and microbial decay of organic matter from thick forest (Fig. 1 and Table-1).

Nitrite, nitrate and Kjeldahl nitrogen (KN): Kjeldahl nitrogen (KN), nitrite and nitrate are different forms of nitrogen and may be present in the water due to the decomposition of proteinous compounds which enter in waste water[23]. Presence

TABLE-1
PHYSICO-CHEMICAL ANALYSIS OF WATER OF BANJOSA LAKE

Parameters	Minimum	Maximum	Mean
Temperature of air (ºC)	4.00	20.00	12.00
Temperature of water (ºC)	4.50	15.00	9.75
pH (25 ºC)	6.64	7.99	7.25
Conductivity (µS/cm)	180	282	231.30
TDS (mg/L)	116.5	180.5	148.49
Salinity (g/L)	0.1	0.1	0.1
Bicarbonate (mg/L)	25.15	43.65	35.20
T-Hardness (mg/L)	68	77	72.75
Chloride (mg/L)	10.1	30.9	24.63
Sulfate (mg/L)	2.64	29.09	15.32
NO_2-N (mg/L)	BDL	BDL	BDL
NO_3-N (mg/L)	0.19	4.5	2.81
T- Nitrogen (mg/L)	1.30	1.40	1.35
ortho-PO_4 (mg/L)	0.01	0.42	0.16
Total-PO_4 (mg/L)	0.03	0.49	0.20
DO (mg/L)	8.62	11.5	10.06
BOD (mg/L)	9.00	16.5	12.87
COD (mg/L)	37.0	48.0	41.67

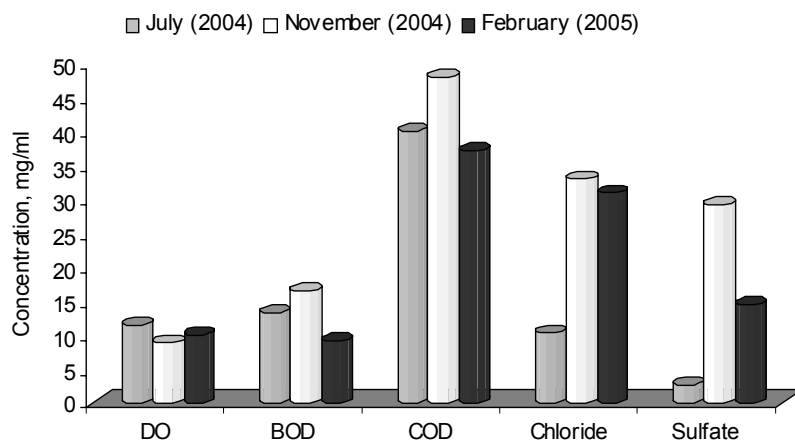BDL = Below detection limit; *CO_3^{2-} concentration was observed below detection limit.

Fig. 1.   Seasonal variations of DO, BOD, COD, chloride and sulfur contents in the water of Banjosa lake

of nitrogen of mineral origin is rare in natural waters and presence of nitrogen compounds like Kjeldahl nitrogen, nitrite and nitrate in water indicate pollution by domestic waste water. Nitrate nitrogen is highest oxidized form of nitrogen in water and WHO standards prescribe 10 mg/L as maximum permissible nitrate concentration of potable water[20]. Nitrogen is first fixed from the atmosphere and then mineralized by soil bacteria into ammonia. Under aerobic conditions nitrogen is finally converted

into nitrate by nitrifying bacteria[24]. The consequences of high concentration of nitrogen in drinking water are toxic and cause blue baby disease, methaemoglobinaemia in children and gastric carcinomas[25,26].

Nitrite and Kjeldahl nitrogen are highly toxic forms of nitrogen. Maximum permissible limit of WHO for both is 1.0 mg/L. Nitrite was found absent and Kjeldahl nitrogen concentration (1.3-1.4 mg/L) exceed the permissible limits of WHO in all the 3 seasons (Table-1 and Fig. 2). Nitrate nitrogen indicated values within 0.19-4.5 mg/L and average value of 2.81 mg/L and was well within the prescribed limits for drinking water. Seasonal variations in nitrate and Kjeldahl nitrogen content were insignificant (Fig. 2).
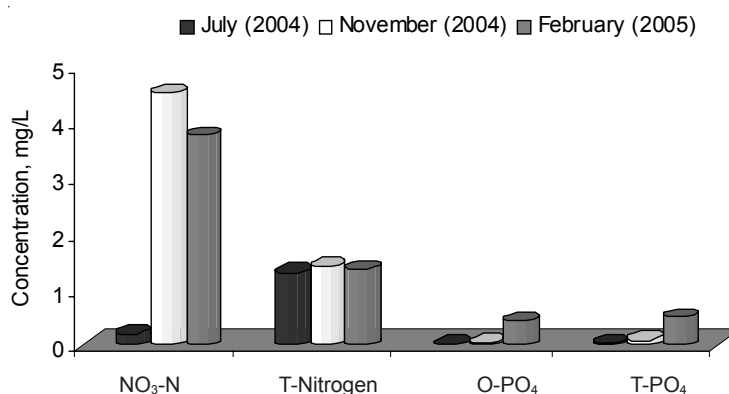

Fig. 2.   Seasonal variations of nitrate-nitrogen, total nitrogen, orthophosphate and total phosphate contents in the water of Banjosa lake

Total chlorides and sulphates: The chloride concentration of Lake water varied between 10.1-30.9 mg/L and average value was observed 24.63 mg/L (Fig. 1). The variations in the chloride content among different seasons suggest a difference in the input level of impurities that contaminate the Lake water. However, seasonal variation was little and was mostly due to dilution by the degree of precipitation (Fig. 1). Sulfate concentration in the hydrological year 2004-2005 range from 2.64 to 29.1 mg/L with average value of 15.32 mg/L. No significant seasonal alterations were observed in sulfate content (Fig. 1). All the values of chlorides and sulfates were in the range of WHO[21,22] drinking water standards.

Phosphorous: The orthophosphate and acid hydrolyzable phosphate contents in water may be due to the composition of the soil or waste generated by human, particularly from the detergents. The results of analysis for the Lake water were orthophosphate 0.01-0.42 mg/L and total phosphate 0.3-0.49 mg/L with average values 0.16 and 0.2 mg/L, respectively (Table-1). Seasonal variation was insignificant.

Metal ion chemistry: The concentration of Na^+, K^+, Ca^{2+} and Mg^{2+} varied considerably within the seasonal Lake water samples and Ca^{2+} was dominant throughout (Table-2) in the following sequence: $Ca^{2+} > Mg^{2+} > Na^+ > K^+$. The concentration range for the samples investigated varied within Ca^{2+} 11-74.7 mg/L; Na^+ 1.36-7.43 mg/L; Mg^{2+} 5.12-16.81 mg/L and K^+ 2.25-4.24 mg/L. No specific trend of Na^+, K^+, Ca^{2+} and Mg^{2+} with seasons was observed. It was observed that the concentration of K^+, Ca^{2+} and Mg^{2+} was higher in autumn as compared to monsoon because of higher dilution by rains in the catchment's areas (Fig. 3).

TABLE-2
PHYSICO-CHEMICAL ANALYSIS OF WATER OF BANJOSA LAKE

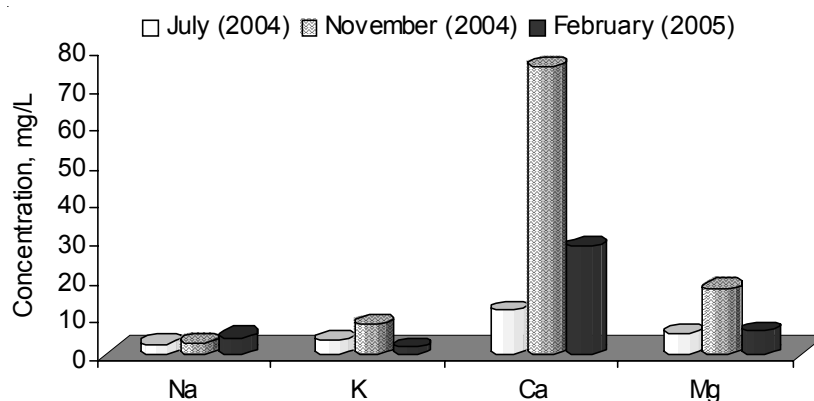| Parameters	Minimum	Maximum	Mean
Na (mg/L)	1.36	7.43	4.02
K (mg/L)	2.47	4.24	3.09
Ca (mg/L)	11.0	74.68	37.83
Mg (mg/L)	5.12	16.81	9.27
Fe (mg/L)	0.01	0.05	0.03
Cu (mg/L)	BDL	BDL	BDL
Zn (mg/L)	0.02	0.05	0.04
Ni (mg/L)	0.01	0.04	0.02
Cd (mg/L)	BDL	0.12	0.04
Co (mg/L)	0.04	0.08	0.06
Pb (mg/L)	0.01	0.03	0.09
SAR	0.14	0.38	0.28

BDL = Below detection limit.

Fig. 3. Seasonal variations of Na, K, Ca and Mg contents in the water of Banjosa lake

Trace elements like Cu^{2+}, Ni^{2+}, Zn^{2+}, Fe^{2+} and Co^{2+} were determined lying within the permissible limits of WHO for metal ions. Lead in November 2004 (0.03 mg/L) and cadmium in February 2005 (0.12 mg/L) exceed the permissible limits (0.01 mg/L) and (0.005 mg/L, respectively. The metal ions were measured as Fe^{2+} 0.01-

0.05 mg/L; Cu^{2+} below detection limit; Zn^{2+} 0.02-0.05 mg/L; Ni^{2+} 0.01-0.04 mg/L; Co^{2+} 0.04-0.08 mg/L; Pb^{2+} 0.01-0.03 mg/L and Cd^{2+} 0.0-0.12 mg/mL in the following order:

$$Pb^{2+} > Co^{2+} > Cd^{2+} = Zn^{2+} > Fe^{2+} > Ni^{2+} > Cu^{2+}$$

Major elemental ion composition was almost independent of seasonal change (Fig. 3). Among trace metal ions lead in November 2004 and cadmium in February 2005 showed higher concentrations compared to other months may possibly be due to mixing of spring water from surrounding areas with higher Pb and Cd composition (Fig. 4).
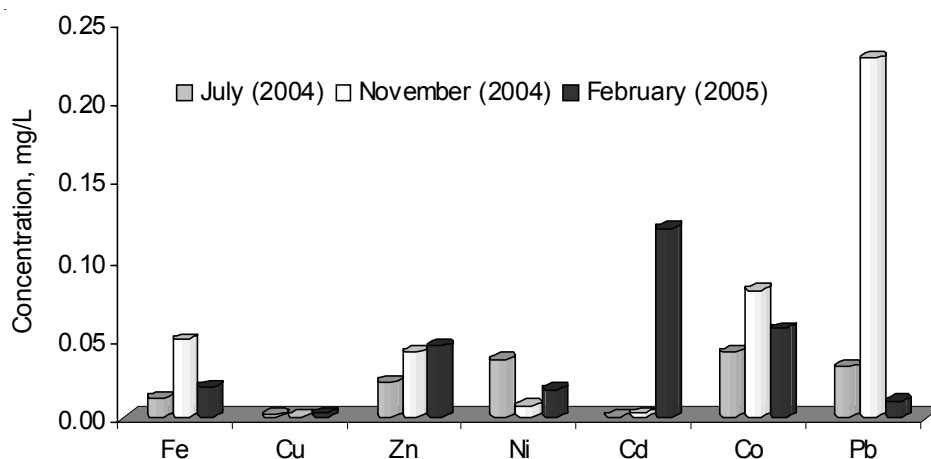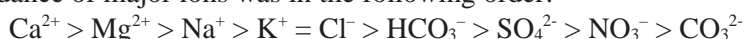

Fig. 4.　　Seasonal variations of Fe, Cu, Zn, Ni, Cd, Co and Pb contents in the water of Banjosa lake

Mass charge balance of major ions: Mass charge balance of major cations and anions was caculated considering concentrations in meq/L. The sequence of the abundance of major ions was in the following order:

$$Ca^{2+} > Mg^{2+} > Na^+ > K^+ = Cl^- > HCO_3^- > SO_4^{2-} > NO_3^- > CO_3^{2-}$$

Major cations and anions indicated concentrations 1.61 and 1.63 meq/L, respectively. Hence it is suggested that a good mass charge balance between major cations and anions is maintained throughout the hydrological year of the Lake water.

Irrigation water quality

Alkalinity and salinity hazards: Lake water samples were also tested to suggest their suitability as an irrigation water. Two parameters EC and TDS were specifically monitored as these are lineally correlated and are a measure of salinity hazard to crops. Since it reduces osmotic activity of plants and interferes with the absorption of nutrients[27], sodium adsorption ratio (SAR) was specifically calculated to determine the suitability of Lake water for irrigation[28] as follows:

$$SAR = \frac{Na^+}{(Ca^{2+} + Mg^{2+})^{1/2} / 2}$$

where the concentrations are in meq/L.

The SAR values range from 0.14 -0.38 with an average value of 0.28 during the one hydrological year (2004-2005). Lake water samples fall in the low sodium class. This implies that no alkali hazard is anticipated to the crops. If the SAR value is greater than 6-9, the irrigation will cause permeability problems on shrinking and swelling types of clays[27].

**Sodium %:** The sodium percentage (Na %) is defined by

$$Na\ (\%) = \frac{(Na^+ + K^+)\ 100}{(Ca^{2+} + Mg^{2+} + K^+ + Na^+)}$$

where all the concentration are expressed in meq/L. The average sodium % of the Lake water was observed 19.85 *i.e.* < 20 that indicates that the Lake water is excellent for irrigation[29].

Residual sodium carbonate: The quality of irrigation water based on residual sodium carbonate test[29] with value 0.89 *i.e.* <1.25 puts Lake water samples into good category of irrigation water.

Conclusion

Interpretation of hydro chemical analysis reveals that the abundance of major ions in the Lake water in one hydrological cycle is in the following order:

$$Ca^{2+} > Mg^{2+} > Na^+ > K^+ = Cl^- > HCO_3^- > SO_4^{2-} > NO_3^- > CO_3^{2-}$$
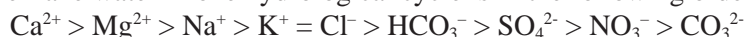
Alkaline metal ions ($Ca^{2+} + Mg^{2+}$ = 1.353 meq/L) exceed alkaline metal ions ($Na^+ + K^+$ = 0.237 meq/L) and strong acids ($Cl^- + SO_4^{2-}$ = 1.271 meq/L) exceed weak acids ($HCO_3^- + CO_3^{2-}$ = 0.577 meq/L). This leads to Ca-Mg-Cl type of Lake water. The concentrations of major ions are within the permissible limits for drinking. Major elemental ion composition is almost independent of seasonal change. Among trace metal ions lead in November 2004 and cadmium in February 2005 shows higher concentrations compared to other months may possibly be due to mixing of spring water from surrounding areas with higher Pb and Cd composition. Ashraf and Choudary[16] reported lead contents in the rock bed within the targeted area. Uaffected by seasonal variations, K-nitrogen concentration also exceeded the WHO recommended values. These higher values at areas under thick forest are mainly due to presence of humus matter specially organic acids that are neutralized only at places where the forest coverage is less dense and the lake bed has adequate lime-stone presence a conjecture supported by the overall average pH (7.25) of the lake water. The elevated levels of K-N and Pb and Cd may be lowered through pretreatment before drinking. Sodium adsorption ratio (SAR), sodium per cent (Na %) and residual sodium carbonate (RSC) categorize the quality of the Lake water as suitable for agricultural use.

REFERENCES

1. http://www.ajk.gov.pk/main/index.html
2. J.D. Hem, Study and Interpretation of the Chemical Characteristics of Natural Water, USGS Water Supply, p. 2254 (1985).
3. M.A. Khan and D.P. Zutshi, *Hydrobiologia*, **68**, 3 (1978).
4. D.P. Zutshi and K.K. Vass, *Indian Natl. Sci. Acad B*, **48**, 234 (1982).
5. S.M. Leghari, A. Bano, M.Y. Khuhawar and T.M. Jahangir, *Scientific Khyber*, **13**, 73 (2000).
6. M.A. Mirza, M.Y. Khuhawar and R. Arain, *Asian J. Chem.*, **20**, 5915 (2008).
7. M.A. Mirza, M.Y. Khuhawar and R. Arain, *Asian J. Chem.*, **19**, 5279 (2007).
8. M.A. Mirza, G.M. Arain and M.Y. Khuhawar, *J. Chem. Soc. Pak.*, **28**, 430 (2006).
9. M.A. Mirza and M.Y. Khuhawar, *Sindh Univ. Res. J. (Sci. Ser.)*, **38**, 25 (2006).
10. M.A. Mirza, G.M. Arain and M.Y. Khuhawar, *The Nucleus*, **44**, 25 (2007).
11. M.A. Mirza, M.Y. Khuhawar and A.J. Kandhro, *Pak. J. Anal. Chem.*, **6**, 72 (2005).
12. C.S. Meddlicott, *Rec. Geol. Surv. (India)*, **9**, 49 (1876).
13. R. Lydekker, *Rec. Geol. Surv. (India)*, **9**, 155 (1876).
14. C.S. Mddlemiss, *Mem. Geol. Surv. (India)*, **26**, 302 (1896).
15. D.N. Wadia, *Mem. Geol. Surv. (India)*, **2**, 2 (1928).
16. M.N. Chaudhry and M. Ashraf, *Kashmir J. Geol.*, **2**, 1 (1984).
17. K.D. Kumar, S. Rawat and R. Joshi, *Environ. Geol.*, **31**, 150 (1997).
18. APHA, Standard Methods for Examination of Water and Wastewater, American Public Health Association, Washington DC, edn. 17, p. 1497 (1989).
19. S.E. Alen, Chemical Analysis of Ecological Materials Blach Well Scientific Publ., Oxford, edn. 2 (1989).
20. W. Fresenius, K.E. Quentin and W. Schneider, Water Analysis, Berlin, Springer, p. 725 (1988).
21. WHO International Standards for Drinking Water, World Health Organization, Geneva (1971).
22. WHO Guidelines to Drinking Water Quality, World Health Organization, Geneva, p. 186 (1983).
23. N.F. Voznaya, Chemistry of Water and Microbiology, Moscow: Mir Publishers, p. 347 (1981).
24. J.A. Tindall, R.L. Petrusak and P.B. McMohan, *J. Hydrol.*, **169**, 51 (1995).
25. H.H. Comly, *J. Am. Mwd. Assoc.*, **129**, 12 (1945).
26. G. Gilly, G. Corrao and S. Favilli, *Sci. Total Environ.*, **34**, 35 (1984).
27. A. Saleh, F. Al-Ruwaih and M. Shehata, *J. Arid Environ.*, **42**, 195 (1999).
28. K.R. Karanth, Groundwater Asswssment, Development and Management, Tata McGraw Hill New Delhi, India, p. 720 (1987).
29. H.M. Ragunath, Groundwater, Wiley Eastern Ltd., New Delhi, India, p. 563 (1987).