Asian Journal of Chemistry Vol. 22, No. 6 (2010), 4657-4662

Physico-chemical Studies and Trace Elemental Analyses of Some Spring and Well Water in and Around Some Selected Districts of Nagaland, India

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Physico-chemical parameters such as temperature, pH, conductivity, TDS, total hardness, dissolved oxygen, BOD and COD were determined while the level of essential trace elements namely iron, copper, zinc, nickel, manganese and non-essential trace elements namely lead, cadmium, silver and arsenic have been determined from three different districts of Nagaland, India. It was found that the samples collected have physico-chemical parameters in the range of permissible limits prescribed by ISI and WHO. The concentrations of the essential and non-essential trace elements were evaluated by using atomic absorption spectroscopy. Comparing these results with the WHO guidelines for the domestic water revealed that the concentration of lead, iron and manganese in many samples under investigation were within the elevated values. These finding shows that waste materials have been passed into the rivers ponds by human and/or industrial activities.

Key Words: Physico-chemical parameters, Essential and non essential trace elements, Spring and well water, Pollutant, Nagaland.

INTRODUCTION

Nagaland is the sixteenth state of India Union and is situated in the North-East region of India. The state of Nagaland lies between 25º60' and 27º40' latitude North of equator and the longitudinal lines 93º20' and 95º15' E having an area of 16578 km^2. The total population of Nagaland as per 2001 census is 19.88 lakhs, with a population density[1,2] of 120/km^2.

In the North Eastern region of India, natural springs and the dug well are primarily the only viable means of fulfilling the needs of fresh water for present population. In hilly areas, most of the drinking water is harnessed from rivers, ponds and natural springs. However, many springs are reportedly becoming seasonal, dying and polluted. That 28.181 water sources located in Assam have been contaminated with this inorganic materials, followed by 2931 in Tripura, 566 in Arunachal Pradesh, 124 in Meghalaya, 76 in Sikkim, 37 in Manipur and 26 in Mizoram. In Nagaland alone, 136 water sources under studies were reported to be contaminated with excess inorganic materials and reported that the arsenic levels in Assam, Manipur, Tripura and Arunachal Pradesh were above 300 ppb[3,4].

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The distribution of arsenic in carbonaceous materials like coal and bituminous materials across the four North Eastern states of India including Nagaland has been reported. It is also reported the distribution of total arsenic content in carbonaceous matter, Assam (lignitic): 80.0-207.0, Assam (sub-bituminous): 44.0-78.0, Nagaland (lignitic): 56.0-68.0, Meghalaya (sub-bituminous): 106.0-238.0 and Arunachal Pradesh (graphitic): 39.0-50.0 mg/Kg and warned for immediate continuous monitoring of the situation as it may cause a serious public-health concern to these heavily populated developing states. Although, increasing arsenic levels in ground water have been reported in neighbouring country Bangladesh and arsenic has been occurring in various natural systems. However, there is no detail reports and studies available about the presence of arsenic and other toxic elements in the North Eastern region of India particularly, Nagaland, eventhough the history of geological solution of sedimentary basins geographically located in West Bengal and neighboring Bangladesh is similar to the North Eastern states of India. Our attention has been drawn to the recent havoc of increasing arsenic level in the ground water in West Bengal, covering an area of 37.493 km^2 lying close to the metropolitan city of Kolkata with a maximum concentration being 3.7 mg/L (permissible limit of potable ground water is only 0.05 mg/L) which has caused a serious public health concern, particularly Eastern part of India. Since the occurrence of such toxic elements are geologically related in the sedimentary environment with dominant carbonaceous materials and bears significant environmental consequences[5-14].

Reports have also been made of the presence of trace heavy metals in the surface water of Pachin river in Itanagar, Arunachal Pradesh above the permissible level. The trace metals like Fe and Co were amongst the highest concentration of the rivers, while these metals and Cr, Mn, Cu and Se each exceeded the world average value[15].

Analyses of trace elements in surface water in and around the uranium bearing area of Wahkyn uranium deposits West Khasi Hills district, Meghalaya is also reported and that in despite the close proximity of high grade uranium deposit, elemental concentrations such as Fe, Cu, Zn, Ni, Cr, Pb, Cd, Mo, V, As, Se, Fe and Al were all within the WHO limits of potable water[16].

A physicochemical characteristic of surface water samples of Loktak Lake in Manipur has also been reported. The study reflected the average mean value of the parameters pH, conductivity and TDS has the mean value of 7.03, 599.62 μmho cm^2 and 1180.5 mg/L, respectively. In chemical parameters, hardness and alkalinity, respectively has the mean of 31.62 and 121.87 mg/L. Among the cationic groups calcium has 8.015 mg/L, magnesium 304 mg/L, sodium 6.75 mg/L and potassium 2.25 mg/L; phosphate, sulphate and chloride have 0.0198, 0.058 and 12.6 mg/L, respectively and lastly total nitrogen has the mean of 40.6 mg/L. The study also revealed the dominance of calcium in cationic and chloride in anionic components and among the nutrient phosphate was found to be the lowest as compared to nitrogen[17].

EXPERIMENTAL

The water samples were collected seasonally (summer and winter) for three continuous years starting from June 2005 to Jan 2008. Samples were collected from 20-25 locations each from three different districts namely Kohima, Dimapur and Mokokchung covering mainly the city area. Samples were collected using 1 L polythene container and was insured that the representative samples reflect the main body of water[18,19].

Analysis of physico-chemical characteristics such as pH, conductivity, temperature, TDS were performed using water testing portable kit (eutech model cyperscan, Singapore) on the spot. Dissolved oxygen, BOD, COD, total hardness, calcium hardness was determined (Table-1) according to the standards methods[20-23].

TABLE-1
PHYSICO-CHEMICAL PARAMETERS OF WATER SAMPLES FROM KOHIMA, DIMAPUR, AND MOKOCHUNG DISTRICTS OF NAGALAND

Sampling districts	Population (persons) sources: census of 2001	pH	Conductivity (μs cm^{-1})	TDS (ppm and mg/L)	Water temp. (ºC)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
Kohima	314366	5.56-7.23	60-1380	31-612	13.6-21.0	10-23	2.1-3.7	78-87
Dimapur	308382	6.52-7.23	241-1820	122-910	15.6-24.0	6.9-19.0	1.8-3.2	89-98
Mokokchung	227230	6.65-7.42	120-912	60-461	14.6-22.0	9.5-22.0	2.2-3.8	82-90

Arsenic: To prevent interferences, As(V) was pre-reduced to As(III) prior to determination. Pre-reduction was performed with KI solution (KI + ascorbic acid) in semi-concentrated (5 mol/L) HCl solution. Time for pre-reduction was 0.5 h. 10 mL of pre-reduced water were analyzed using atomic absorption spectrophotometer (PerkinElmer AA200) with MHS-15 (mercury hydride generation system) at 193.7 analytical wavelengths and 0.7 nm slit width. Radiation source was electrodeless discharge lamp for arsenic with 50 s pre-reaction purge time and 30 s post-reaction purge time. The argon gas and sodium tetraborohydrate were used for hydride generation. Perkin-Elmer 3110 at 283.3 nm analytical wavelength and 1.2 nm slit width was used for lead; 249 nm analytical wavelength and 0.2 nm slit width for iron; 229 nm analytical wavelength for cadmium; copper at 324.8 nm analytical wavelength 1.2 nm slit width; 328 nm analytical wavelength for silver; 214 nm analytical wavelength 0.8 nm slit width for zinc; manganese at 279.5 nm analytical wavelength 0.5 nm slit width[20-23].

RESULTS AND DISCUSSION

It was observed that the physico-chemical parameters of water samples collected from three different districts of Nagaland shows pH in the ranges 5.56-7.23 (Kohima),

6.65-7.42 (Mokokchung), 6.52-7.23 (Dimapur), respectively. The pH values in some locations under Kohima (sample no K-14, 15, 16 of Lerie area) and Mokokchung town (sample No. 10, 11, 12 of Dilong area) were found to be acidic in the range of 5.56-5.61 and 5.64-5.80, respectively. The electrical conductivity was found to be 60-1380 μs cm^{-1} in Kohima Town, 120-912 μs cm^{-1} in Mokokchung town, 241-1820 μs cm^{-1} in Dimapur, respectively. The electrical conductivity was found to be high (2.62 m s^{-1}, 1.30 ppt) in some areas (Nagarjan area) in Dimapur. The values of TDS found to be in the ranges 31-612 ppm in Kohima Town, 60-461 ppm in Mokokchung Town, 122-910 ppm in Dimapur. The TDS was found to be high in some areas (Nagarjan area, Padumpukhari area) under Dimapur district in the range of 1.30 ppt. While the water temperature was in the ranges 13-23 ºC in Kohima Town, 14.6-25.0 ºC in Mokokchung town, 16.6-25.0 ºC in Dimapur.

The analysis of dissolved oxygen, biological oxygen demand and chemical oxygen demand of various water samples indicates less pollution as most of the samples adhered to ISI and WHO guidelines values[7].

As regard to the samples collected in different seasons, it was concluded that the value of dissolved oxygen marginally decreases in summer than in winter and the values of biological oxygen demand and chemical oxygen demand increases during summer season than in winter (Table-2). This may be due to the reasons that during summer the monsoon brings all the organic and inorganic load into the water bodies thereby increases the number of oxygen demanding microorganisms leading to the reduction of oxygen contents thereby decreases the dissolved oxygen and increases the values of biological and chemical oxygen demand.

TABLE-2
PHYSICO-CHEMICAL CHARACTERISTICS OF SURFACE AND WELL WATER OF KOHIMA, DIMAPUR AND MOKOKCHUNG DISTRICTS OF NAGALAND DURING SUMMER AND WINTER SEASONS

Sampling districts	Seasons	Water temp. (ºC)	pH	Conductivity (μs cm^{-1})	TDS (ppm)	DO (mg/L)	BOD (mg/L)	Hardness (mg/L)
Kohima	Summer (Jun-Aug)	16-22	5.57-7. 32	60-1380	31-612	8-21	2.1-3.7	32.9-42.1
	Winter (Jan-Mar)	13-17	5.56-7.23	77-1311	39-656	10-24	1.6-3.3	34-44.3
Dimapur	Summer (Jun-Aug)	17-24	6.52-7.23	241-1820	122-910	7.9-21	1.8-3.2	43-110
	Winter (Jan-Mar)	15-21	6.54-7.19	120-1910	135-955	9-21	1.8-3.2	45-121.3
Mokokchung	Summer (Jun-Aug)	17-23	6.65-7.42	113-912	60-461	9.5-23	2.2-3.8	42.4-60.5
	Winter (Jan-Mar)	14-17	6.64-7.26	269-899	60-450	10-24	2.1-3.1	42-65.3

Analysis of water samples further revealed the high presence of calcium and magnesium (43.4-120.3 mg/L total hardness) especially in the district of Dimapur.

The increased in concentration of calcium and magnesium is one of the reason for the cause of hardness of water. However in other districts of Nagaland, the total hardness of water was all within the permissible limits.

The trace elemental analysis of water samples collected from the municipal area of Kohima, Dimapur and Mokokchung showed the concentration of As, Ag, Ca, Cd, Cu, Mg and Zn, within the permissible limit. However the concentration of lead, iron and manganese in some water sources under examination were found to be above the prescribed maximum permissible limit.

The concentration of lead in some water sources (sample No. m-1, 2, 3, 15 and 16 of Sangtemla, Dilong and Penli ward area) under Mokokchung Town were above the permissible limit in the ranges of 0.15-0.22 mg/L (maximum permissible limit is 0.05-0.10 mg/L as per Indian Standard and WHO). Similarly higher concentration (above permissible limit) of lead was observed in some water sources under Kohima in the range 0.15-0.21 mg/L (sample No. k-5, 7, 21of Chandmari-Midlane, Lerie and Municipal garbage area national highway-39).

The concentrations of iron in many water sources under Dimapur district (sample No. D-3, 4, 11, 13, 19 Half Nagarjan, Naga Cemetery, Signal Colony, PWD, Kushabill colony area) were above the permissible limits in the ranges of 0.33-0.68 mg/L (maximum permissible limit is 0.3 mg/L WHO). Similar, concentration of iron was found in some parts of Kohima in the ranges of 0.34-0.58 mg/L (sample No. 2, 3, 4, 18, 19, 20 of Lower-Chandmari, Agri-Forest Colony area).

The concentration of manganese in some water sources of Dimapur were found to be in the ranges 0.13-2.1 mg/L (sample No. D-4, 8, 9, 11, 19 of signal, padumpukhuri area), Kohima in the range 0.14-0.19 mg/L (sample No. K-4, 7 , 17, 18, 19, 20 of Upper Chandmari, Garbage dumping area, Forest and Agri colony area), Mokokchung in the range 0.21-0.34 mg/L (sample No. m-7, 8, 9, 11, 12, 13, 14, 15 of Arkong, Dilong and Denli Colony area) which is above the WHO permissible limit of 0.1 mg/L.

Conclusion

The trace heavy metal elemental analysis of spring and well water shows some metals concentration above the maximum permissible limits. The concentration of lead and iron in some areas of Kohima, Dimapur, Mokokchung and its adjoining showed relatively higher than prescribed by WHO and Indian standard. This high concentration of lead in water confirms that many surface and ground water sources are unprotected from domestic sewage and industrial effluents as most of the heavy metals and in particular the lead metal is generate from street dust. Based on the analysis of different physicochemical parameters and trace heavy metal elements in spring and well water (surface and ground water) it was observed that the physic-ochemical characteristics of drinking water sources is found deteriorating slowly with the passes of years and need an immediate attention to restore the water quality in the state.

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(*Received*: 26 September 2009; *Accepted*: 17 February 2010) AJC-8457