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## Lead, iron and manganese contamination in spring, pond and well water in Nagaland, one of the Seven North-Eastern states of India: a future danger

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**ABSTRACT**

*Physicochemical parameters such as temperature, pH, conductivity, TDS, total hardness, dissolved oxygen, BOD and COD were determined. While the level of trace elements namely iron, copper, zinc, nickel, manganese lead, cadmium, silver and arsenic have been determined from five different districts/sub-divisions viz- Wokha, Tuensang, Zunheboto, Ungma in Mokokchung and Tseminyu in Kohima of Nagaland, India. 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 by human and/or industrial activities.*

**Key words:** physicochemical parameters, essential and non essential trace elements, spring and well water, pollutant, Nagaland.

## INTRODUCTION

Over the past two or three decades, occurrence of high concentrations of arsenic in drinking-water has been recognized as a major public-health concern in several parts of the world. There have been a few review works covering the arsenic-contamination scenario around the world [1-4]. With the discovery of newer sites in the recent past, the arsenic-contamination scenario around the world, especially in Asian countries, has changed considerably. Before 2000, there were five major incidents of arsenic contamination in groundwater in Asian countries: Bangladesh, West Bengal, India, and sites in China. Between 2000 and 2005, arsenic-related

groundwater problems have emerged in different Asian countries, including new sites in China, Mongolia, Nepal, Cambodia, Myanmar, Afghanistan, DPR Korea, and Pakistan. There are reports of arsenic contamination from Kurdistan province of Western Iran and Viet Nam where several million people may have a considerable risk of chronic arsenic poisoning.

Adverse health effects of arsenic depend strongly on the dose and duration of exposure. Specific dermatological effects are characteristics of chronic exposure to arsenic. Salient dermatological features are melanosis (pigmentation) and keratosis (rough, dry, papular skin lesions), both may be spotted or diffuse. Chronic exposure to arsenic may also cause reproductive, neurological, cardiovascular, respiratory, hepatic, haematological, and diabetic effects in humans [5]. Ingestion of inorganic arsenic is an established cause of skin, bladder, and lung cancer [5,6].

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 [7, 8].

Recently, the scale of Arsenic problem in West Bengal and other states with similar geology like Assam, Bihar, Uttar Pradesh, Tripura, Manipur, Arunachal Pradesh and Nagaland, has also been reported [9-12]. In Northeastern India, arsenic has been detected in 21 of the total 24 districts of Assam and three districts in Tripura, six in Arunachal Pradesh, one in Manipur and two in Nagaland [12]. The existence of contamination has been well established in the old Brahmaputra Plain of Bangladesh [13, 14] and field surveys [15]. Maximum As content was observed in Jorhat, Dhemaji, Golaghat and Lakhimpur, Assam; West Tripura, Dhalai and North Tripura districts, Tripura; Thoubal Manipur; Dibang valley, Arunachal Pradesh, and Mokokchung and Mon districts, Nagaland. No detailed information on contamination of groundwater by As is available for the mid and upper Ganges Plains. Hot spots for As contamination at the upper, mid and lower plains of the Ganges have also been reported [15].

Based on the reports of groundwater As contamination and its health effects on the Ganga-Meghna-Brahmaputra plains, it has been observed that significant portions of all the states on the Ganga plain and some parts of the Brahmaputra plain and most of the plains of Bangladesh are arsenic affected [16]. It has also been noticed that most of the arsenic affected floodplains in Asia are by the side of the rivers that originate in the Himalayas or Tibet Plateau. Thus it is considered that Himalayas and surrounding mountains are potential sources of arsenic bearing minerals. Because, the north Eastern Hill states are part of the Himalayan mountain range [17]. The affected aquifers of the region are mainly Holocene alluvial and deltaic sediments, similar to those in large parts of Bangaldesh [18]. Geologically, the Bengal basin is in intense neotectonic activity [19] and its west, north and east are bordered by the Indian Sheild, Shilong Plateau and Naga-Lusai orogenic belt respectively.

Although, increasing arsenic levels in ground water have been reported in neighboring states of North Eastern region, there were no detailed reports and studies in Nagaland, even though the history of geologically sedimentary basins located in West Bengal, and neighboring Bangladesh is similar to the north eastern states of India [13]. However, there was a recent report of As contamination beyond the permissible limits in four districts of Manipur [20].

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 [21]. 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 & Al were all within the WHO limits of potable water [22].

A Physiochemical 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 mg/L 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 mg/l, 0.058 mg/l 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 [23].

In this paper, as a continuation of our earlier work [24] , the authors would like to highlight the physiological studies and trace elemental analysis of spring, ponds and tube well water samples collected from five different districts of Nagaland in different seasons ( Summer: June-August; Winter: January- March) for the year 2005-2008.

## EXPERIMENTAL SECTION

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 five different districts/sub-division namely Wokha, Tuensang, Zunheboto, Ungma in Mokokchung and Tseminyu of Nagaland, India covering mainly the populated area. Samples were collected using 1(one) litre polythene container and was insured that the representative samples reflect the main body of water. Analysis of physiochemical characteristics such as pH, conductivity, temperature, TDS were done using water testing portable kit (Eutech model cyperscan, Singapore) on the spot. Dissolved Oxygen, BOD, COD, Total hardness, calcium hardness was determined following mainly the standards methods [25-28].

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 30 minutes. 10 mL of pre-reduced water were analysed

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 As with 50 sec pre-reaction purge time and 30 sec 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 [18, 25-28].

## RESULTS AND DISCUSSION

A total of 105, 109, 112 numbers of samples were collected for the years 2005-06, 2006-07, 2007-08 respectively. All the samples were collected from spring water, ponds and tube wells with an average dept of 10-90 m.

It was observed that the physiochemical parameters of water samples collected from different districts of Nagaland shows; pH in the ranges 6.31-6.87 (Wokha), 6.68-7.01 (Tuensang), 7.24-7.66 (Lumami, Zunheboto), 6.02-6.83 (Tseminyu, Kohima) and 6.37-7.56 (Ungma, Mokokchung) respectively. The values of PH in some locations; Ungma in Mokokchung was found to be alkaline in the ranges of 7.89-8.34. It was also observed that most of the samples collected during summer (monsoon) were more alkaline as compared to winter season. The electrical conductivity was found to be 169-669 μs $cm^{-1}$ in Wokha, 548-632 μs $cm^{-1}$ in Tuensang, 123-454 μs $cm^{-1}$ in Lumami, Zunheboto, 63-72 μs $cm^{-1}$ in Tseminyu,Kohima and 121-909 μs $cm^{-1}$ in Ungma, Mokokchung respectively. It was observed that of all the samples collected, the samples from Tseminyu shows the lowest electrical conductivity. The values of TDS found to be in the ranges 44-347 ppm in Wokha, 279-318 ppm in Tuensang, 64-232 ppm in Lumami, Zunheboto, 32-39 ppm in Tseminyu, Kohima and 61-450 ppm in Ungma, Mokokchung respectively. While the water temperature was in the ranges 15.2-23$^0$C in Wokha, 14.76-22 $^0$C in Tuensang, 15.7-23$^0$C in Lumami, Zunheboto, 15-23$^0$C in Tseminyu, Kohima and 14.5-23$^0$C in Ungma, Mokokchung respectively.

The analysis of dissolved Oxygen showed in the ranges 9-24 mg/L in Wokha, 11-25 mg/L in Tuensang, 10-24 mg/L in Lumami, Zunheboto, and 8.3-23 mg/L in Tseminyu, Kohima and 8.2-24 mg/L in Ungma, Mokokchung. The analysis of biological oxygen demand was found to be in the ranges 2.5-3.2 mg/L (Wokha), 1.9-3.2 mg/L (Tuensang), 2.5-3.2 mg/L (Lumami, Zunheboto), 2.5-3.3 mg/L (Tseminyu, Kohima) and 2.7-3.2 mg/L (Ungma, Mokokchung). It was observed that few samples from Ungma and Tseminyu showed BOD contents above the permissible limit. Nevertheless the analysis of DO, BOD and Chemical Oxygen demand (COD) of almost all the samples indicates negligible pollution as the samples adhered to ISI and WHO guidelines values [26, 27].

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. 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:1 physiochemical parameters of water samples in and around some selected districts of nagaland**

| SAMPLING DISTRICTS | POPULATION (PERSONS) SOURCES: CENSUS OF 2001 | pH | CONDUCTIVITY $\mu SCM^{-1}$ | TDS (mg/Ll) | WATER TEMPT. ($^0C$) | DO mg/L | BOD mg/L | COD mg/L | TOTAL HARDNESS as $CaCO_3$ mg/L |
|---|---|---|---|---|---|---|---|---|---|
| WOKHA | 161098 | 6.31-6.67 | 446-569 | 31-612 | 15-21 | 8.9-24 | 2.8-3.7 | 76-85 | 46.1-68.3 |
| TUENSANG | 414801 | 6.68-7.02 | 548-632 | 279-318 | 13.5-22 | 11-25 | 2.9-3.7 | 78-84 | 42-76.3 |
| LUMAMI, ZUNHEBOTO | 154909 | 7.24-7.66 | 123-454 | 64-232 | 15-23 | 10-24 | 2.5-3.8 | 73-83 | 42-76.4 |
| TSEMINYU, KOHIMA | 54212 | 6.02-6.83 | 63-72 | 32-40 | 15-22 | 8.3-23 | 2.5-3.9 | 71-84 | 32.9-48.9 |
| UNGMA, MOKOKCHUNG | 10000 | 6.36-7.56 | 121-909 | 61-450 | 14.5-23 | 8.2-24 | 2.7-3.8 | 73-83 | 32.0-69.5 |

**Table:2: Concentration of trace elements in water samples in and around some selected districts of nagaland**

| SAMPLING DISTRICTS | Ag (mg/L) | As (mg/L) | Cu (mg/L) | Fe (mg/L) | Pb (mg/L) | Cd (mg/L) | Mn (mg/L) | Zn (mg/L) | Ni (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| WOKHA | 0.00-0.001 | 0.00-0.001 | 0.03-0.27 | 0.45 - 0.46 | 0.13-0.29 | 0.001-0.002 | 0.02-0.27 | 0.27-2.39 | 0.01-0.003 |
| TUENSANG | 0.00-0.001 | 0.001-.001 | 0.02-0.26 | 0.05 - 0.31 | 0.01-0.04 | 0.00-0.001 | 0.02-0.13 | 0.07-1.89 | 0.01-0.002 |
| LUMAMI, ZUNHEBOTO | 0.00-0.001 | 0.00-0.002 | 0.04-0.08 | 0.02 - 0.18 | 0.03-0.10 | 0.00-0.001 | 0.12-0.21 | 0.45-0.78 | 0.00-0.001 |
| TSEMINYU, KOHIMA | 0.00-0.001 | 0.00-0.001 | 0.02-0.26 | 0.36 - 0.47 | 0.05-0.09 | 0.001-0.002 | 0.02-0.07 | 0.06-1.99 | 0.00-0.002 |
| UNGMA, MOKOKCHUNG | 0.00-0.002 | 0.00-0.002 | 0.02-0.06 | 0.06-0.67 | 0.13-0.29 | 0.001-0.002 | 0.00-0.18 | 0.13-0.99 | 0.01-0.003 |

Analysis of total hardness of almost all water samples under study was found to be soft in the ranges of 32-68 mg/l and have the values all within the permissible limits.

The Trace elemental analysis of water samples collected from all the areas under studies showed the concentration of As, Ag, Ca, Cd, Cu, Mg, and Zn, within the permissible limit. However the concentration of Pb (lead), Iron (Fe) and manganese (Mn) in some water sources under examination were found to be above the prescribed maximum permissible limit.

The concentration of lead in some water sources collected from Wokha *(sample no. w-1, w-2, of Wokha town near NST station)* and Ungma under Mokokchung *(sampleU-2, 13 & 14)* showed above the permissible limit in the ranges of 0.29 mg/L (maximum permissible limit is 0.05-0.10 mg/L as per Indian Standard & WHO).

**Table: 3: year wise comparative data of physiochemical parameters of spring and well water of nagaland**

| DISTRICTS Sampling Area | Years | Parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $P^H$ | EC $\mu scm^{-1}$ | TDS mg/L | DO mg/L | BOD mg/L | COD mg/L | Total hardness mg/L | Calcium hardness as $Ca^{2+}$ mg/L | Magnesium Hardness as $Mg^{2+}$ mg/L |
| WOKHA | 2005-06 | 5.69-6.92 | 285 | 142 | 9-24 | 2.6-3.9 | 85 | 44.4-66.3 | 18.6-29.8 | 21.2-31.4 |
| | 2006-07 | 5.68-6.93 | 290 | 145 | 9-24 | 2.7-3.8 | 91 | 47.4-69.4 | 19.9-29.8 | 21.5-33.4 |
| | 2007-08 | 5.76-6.92 | 291 | 146 | 8.9-24 | 2.7-3.8 | 87 | 46.1-68.3 | 17.9-29.2 | 20.7-33.3 |
| TUENSANG | 2005-06 | 6.68-6.70 | 575 | 288 | 10-26 | 2.8-3.7 | 84 | 29.4-43.3 | 15.6-22.7 | 12.7-19.4 |
| | 2006-07 | 6.86-6.90 | 617 | 309 | 10-25 | 2.7-3.7 | 83 | 31.1-42.7 | 14.8-23.9 | 12.8-19.4 |
| | 2007-08 | 6.73-6.74 | 579 | 290 | 11-25 | 2.6-3.7 | 85 | 29.6-43.1 | 16.6-23.7 | 13.0-19.4 |
| LUMAMI, ZUNHEBOTO | 2005-06 | 7.34-7.65 | 371 | 185 | 10-24 | 2.4-3.9 | 83 | 42.4-74.7 | 19.6-47.8 | 16.2-26.4 |
| | 2006-07 | 7.28-7.65 | 355 | 178 | 10-24 | 2.5-3.8 | 81 | 41.4-77.1 | 18.6-49.8 | 17.0-28.1 |
| | 2006-08 | 7.28-7.58 | 358 | 179 | 9.4-24 | 2.4-3.8 | 81 | 42.0-76.3 | 18.5-49.6 | 16.2-27.4 |
| TSEMINYU, KOHIMA | 2005-06 | 6.02-6.92 | 575 | 287 | 9-23 | 2.4-3.9 | 89 | 33.4-48.3 | 19.6-28.8 | 13.7-17.8 |
| | 2006-07 | 6.07-6.93 | 617 | 308 | 9-23 | 2.5-3.8 | 90 | 32.6-49.3 | 19.8-29.0 | 12.8-18.4 |
| | 2007-08 | 6.05-6.90 | 579 | 289 | 8.1-23 | 2.5-3.8 | 88 | 32.9-48.9 | 18.6-29.8 | 13.0-19.0 |
| UNGMA | 2005-06 | 7.25-7.39 | 345 | 173 | 8.7-24 | 2.6-3.7 | 81 | 32.4-67.3 | 15.6-37.8 | 16.2-19.4 |
| | 2006-07 | 7.02-7.91 | 631 | 315 | 8.5-24 | 2.5-3.7 | 82 | 32.7-69.3 | 18.6-35.8 | 17.0-21.7 |
| | 2007-08 | 7.17-7.86 | 537 | 268 | 8.2-24 | 2.5-3.6 | 81 | 32.0-69.5 | 18.5-36.6 | 16.2-22.4 |

The concentrations of iron in some water sources under Ungma (*sample no. U- 3, 4 & 13),* Tseminyu *(sample T- 3, 5)* and Wokha *(sample W-2)* were above the permissible limits in the ranges of 0.43-0.46mg/l (maximum permissible limit is 0.3 mg/L WHO).

The concentration of manganese (Mn) in some water sources of Lumami, Zunheboto district showed slightly above the permissible limit ranges 0.14 mg/l ( WHO permissible limit is 0.1mg/L).

**Table: 4. Physiochemical characteristics of surface and well water of selected districts of nagaland during summer and winter seasons**

| DISTRICTS Sampling Area | SEASONS | WATER TEMPT.($^0$C) | pH | CONDUCTIVITY µSCM$^{-1}$ | TDS ppm | DO mg/L | BOD mg/L | HARDNESS mg/L |
|---|---|---|---|---|---|---|---|---|
| WOKHA | SUMMER (Jun-Aug) | 16-23 | 6.31-6.67 | 246-569 | 229-284 | 8.9-24 | 2.8-3.7 | 44.2-64.9 |
| | WINTER (JAN-MAR) | 14-17 | 6.29-6.57 | 257-633 | 129-317 | 9-24 | 2.2-3.5 | 46.1-68.3 |
| TUENSANG | SUMMER (Jun-Aug) | 16-22 | 6.68-7.02 | 213-632 | 279-318 | 11-23 | 1.9-3.7 | 29.6-41.2 |
| | WINTER (JAN-MAR) | 13-17 | 6.58-7.02 | 256-723 | 128-362 | 11-24 | 1.4-3.6 | 31-43.1 |
| LUMAMI, ZUNHEBOTO | SUMMER (Jun-Aug) | 16-23 | 7.24-7.66 | 123-454 | 64-232 | 10-26 | 2.5-3.8 | 41.3-69.5 |
| | WINTER (JAN-MAR) | 15-20 | 7.12-7.45 | 144-467 | 72-234 | 11-27 | 2.1-3.8 | 42.0-76.3 |
| TSEMINYU, KOHIMA | SUMMER (Jun-Aug) | 15-23 | 6.02-6.83 | 63-272 | 32-39.6 | 8.1-23 | 2-3.9 | 31-46.3 |
| | WINTER (JAN-MAR) | 14-19 | 6.02-6.76 | 64-288 | 32-144 | 9-24 | 1.9-3.9 | 32.9-48.9 |
| UNGMA | SUMMER (Jun-Aug) | 16-22 | 6.36-7.56 | 121-909 | 61 -450 | 8.2-23 | 2.7-3.8 | 32-66.6 |
| | WINTER (JAN-MAR) | 14-20 | 6.35-7.46 | 201-1070 | 101-535 | 9-24 | 2.6-3.7 | 34.0-69.5 |

## 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 in some areas under Wokha and Ungma in Mokokchung district and Iron in some areas of Wokha, Tseminyu in Kohima and Ungma in Mokokchung, and its adjoining showed far above the permissible limit 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. However, we observed that As in almost all the samples collected were within the permissible limits as prescribed by WHO and Indian Standard. Based on the analysis of different physiochemical parameters and trace heavy metal elements in spring and well water (surface and ground water) it was observed that the physiochemical 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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