

# Analysis of Trace Metals in Underground Drinking Water of Bareilly

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**Abstract** – Quality of drinking water of the Bareilly has been studied and the results are presented in this paper. A total of 45 drinking water samples were collected from 15 different locations of the Bareilly and brought to the laboratory for analysis. Samples were analyzed for physico-chemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), temperature and seven trace metals (Zn, Cu, Mo, As, Ca, K, Mg) using standard procedures. The results were compared with other national (BIS) and international (WHO) standards.

pH of the tested samples was in the range of 7.06 to 8.46 while the temperature ranged between 31.2 to 34.6°C. EC of water samples was recorded in the range of 375 to 1994  $\mu\text{S cm}^{-1}$  whereas TDS in the range of 263 to 897 ppm. In all water samples, pH ranged in the permissible limit whereas EC and TDS of some of the samples were above the permissible limit.

Concentration of metals namely Zn, Cu, Mo, As, Ca, K and Mg were found in the range of 0.16- 2.29, 1.11 to 1.96, 0.016- 0.093, 0.001- 0.005, 30.44- 99.09, 2.16- 5.81 and 1.93- 12.53 mg/l respectively. All the metals were found in limit except copper, molybdenum and calcium which exceeded the limits set by WHO (2004) and (BIS 2003) at some studied sites.

**Keywords** – Water Quality, AAS, pH, EC, TDS, Metals.

## I. INTRODUCTION

Water is the most plentiful substance on the earth's surface that is essential for the survival for all organisms and plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances, industrial cooling and transportation. More than 70% of freshwater is consumed by agriculture [1]. In recent times, there has been an increasing health related concern associated with the quality of drinking water. Drinking water is obtained from a variety of sources like wells, tube wells, rivers, lakes, reservoirs and ponds. That poses the greatest risk to human health due to contamination of these sources. Water pollutants mainly consist of heavy metals, microorganisms, fertilizers and thousands of toxic organic compounds.

Heavy metals are the metallic elements of the periodic table and known as d-block elements and also referred as "trace elements". These trace metals are consistently of health concern due to their toxicity potentials at very low concentrations, and tendency to bio-accumulate in tissues of living organisms over time [2].

Metals such as arsenic (As), silver (Ag), aluminum (Al), cadmium (Cd), gold (Au), lead (Pb) and mercury (Hg) have no biological role and they are nonessential. Toxicity

of nonessential metals occurs through the displacement of essential metals from their native binding sites or through ligand interactions [3]. However, there are some essential metals also such as zinc, copper, iron and manganese those are required by the body in small amounts for metabolic activities. But these elements can cause adverse health effects or illness at higher concentrations [4]. For e.g. zinc toxicity leads to diarrhea [5], manganese may impede the intellectual development of the child [6]. Iron has been associated with genetic and metabolic diseases and, repeated blood transfusions [7] and copper toxicity is related to several health concerns, including stomach cramps, nausea, vomiting, diarrhea, cancer, liver damage and kidney disease [8].

Water systems have been subjected to maximum exploitation and severely polluted by heavy metals due to anthropogenic activities which include point sources such as emission, effluents and solid discharge from industries, vehicle exhaustion and metals from smelting and mining, and nonpoint sources such as soluble salts (natural and artificial), use of insecticides/pesticides, disposal of industrial and municipal wastes in agriculture, and excessive use of fertilizers [9, 10].

Metals in water occur only in trace levels but are more toxic to the human body. The quality of water should be necessarily checked from time to time in order to check upon the pollutants. Keeping in view the toxic nature of heavy metals contamination in water, it was imperative to initiate this study to assess the concentration of some selected metals (As, Mo, Cu, Zn, K, Ca, Mg) in drinking water of Bareilly. Data presented in this report will also be useful from public health point of view. Some of the important physicochemical properties of water such as pH, temperature, EC and TDS were also studied.

## II. MATERIALS AND METHODS

### A. Study Area

Bareilly is located at 28°10'N, 78°23'E and lies in Northern India. Bareilly has a humid subtropical climate with high variation between summer and winter temperatures. The annual mean temperature is 25° C (77° F), monthly mean temperature range from 14° C to 33° C (58° F to 92° F). The average rain fall is approximately 1714 (28.1 inches).

### B. Sampling

A total of 45 samples were collected from 15 sampling locations from Bareilly. These locations were Beharipur Civil Lines (L1), Pilibhit Bypass Road (L2), Choupla-

Kutubkhana Road (L3), Kunwarpur (L4), Madhinath (L5), Shamat Ganj (L6), Qila (L7), Nagar Nigam (L8), Choupla Railway Colony (L9), City Station (L10), MJPRU Campus (L11), Junction (L12), Suresh Sharma Nagar (L13), Rajendra Nagar (L14) and Rampur Garden (L15).

### C. Collection of Water Samples

Water samples were collected using 250 mL sterile bottles. The sampling bottles for heavy metal analysis were pre-soaked overnight with 10% HCl and rinsed with distilled water before sample collection. Sampling bottles for the preservation of water samples was done by adding 2 drops of concentrated HNO<sub>3</sub> to each water sample before storage below 4°C until analyzed.

### D. Physico-chemical Characterization

The physico-chemical properties such as hydrogen ion concentration (pH), electrical conductivity (EC), total dissolved solids (TDS) and temperature in water samples were analyzed by pH/EC meter (Oakton, Multi-parameter PCSTestr<sup>TM</sup> 35) using standard procedures [11].

### E. Metal Concentration Analysis

Concentrations of heavy metals (Zn, Cu, Mo, As, Ca, K and Mg) were determined with the help of Atomic Absorption Spectrometer (ECIL 4141) by using standard method [12].

## III. RESULT AND DISCUSSION

### A. Physico-Chemical Properties

pH of water samples were found in the range from 7.06 to 8.46, this is within the limit set by WHO (2004) and BIS (2003) (table 1). The pH of water indicates the degree of acidity or alkalinity of water. It is the most important water quality factor controlling levels of the metals in water. Temperature of water samples were found within the range of 31.2 to 34.6° C. EC of water samples ranged from 375 to 1994  $\mu\text{S cm}^{-1}$  which is in the range set by WHO (2004) and BIS (2003) excluding the three locations Pilibhit Bypass Road (L2), Shamat Ganj (L6) and Qila (L7) which have higher level of EC than these standards. TDS were found to be between 263 to 897 ppm. Most of the studied sites have higher TDS value than the standards of WHO (2004) and BIS (2003). High TDS shall be the results from the dissolution of soluble minerals such as halite or gypsum, and from anthropogenic influences. The physico-chemical properties of water samples for the study sites along with permissible limits are given in table 1.

Table 1. Physico-chemical parameters of drinking water from Bareilly along with permissible limits.

Location	pH	Temperature (°C)	EC ( $\mu\text{S cm}^{-1}$ )	TDS (ppm)
L1	7.89	34.6	1219	851
L2	7.27	31.8	1545	662
L3	8.46	33.4	1024	501
L4	7.50	32.5	967	680
L5	7.18	32.4	1063	745
L6	7.06	31.9	1510	868
L7	7.21	32.2	1994	491
L8	7.19	31.6	1541	897
L9	7.59	31.9	985	699
L10	7.31	31.9	1247	880
L11	7.96	32.1	375	263
L12	7.80	31.8	638	453
L13	8.06	31.7	470	333
L14	8.0	31.5	620	447
L15	8.02	31.2	565	397
<b>WHO (2004)</b>	<b>6.5-8.0</b>	--	<b>1500</b>	<b>&lt;600</b>
<b>Indian Standards (2003)</b>	<b>6.5-8.5</b>	--	<b>1500</b>	<b>2000</b>

(L1= Beharipur, L2= Pilibhit Bypass Road, L3= Choupla-Kutubkhana Road, L4= Kunwarpur, L5= Madhinath, L6= Shamat Ganj, L7= Qila, L8= Nagar Nigam, L9= Choupla Railway Colony, L10= City Station, L11= MJPRU Campus, L12= Junction, L13= Suresh Sharma Nagar, L14= Rajendra Nagar, L15= Rampur Garden)

### B. Concentration of Trace Metals in Drinking Water

The concentrations of metals detected in various drinking water samples from Bareilly are presented in

table 2 and are compared to the World Health Organizations [13] and Bureau of Indian Standards [14] maximum permissible limits.

Table 2. Mean concentrations of metals (mg/l) in drinking water samples collected from locations L1-L15 with permissible limits.

Location	Zn	Cu	Mo	As	Ca	K	Mg
L1	2.29	1.46	0.024	ND	65.13	2.16	3.12
L2	0.23	1.48	0.056	ND	87.28	3.64	1.93
L3	0.49	1.51	0.026	ND	30.44	2.53	3.96
L4	0.38	1.46	0.048	0.002	41.62	5.81	2.25
L5	0.16	1.48	0.063	ND	70.27	2.43	5.61
L6	0.72	1.37	0.031	ND	58.91	4.97	9.22
L7	0.27	1.44	0.044	0.005	89.94	5.13	5.97
L8	0.20	1.41	0.082	ND	80.18	4.41	7.91
L9	0.37	1.62	0.016	ND	69.74	2.98	7.13
L10	1.71	1.28	0.038	ND	99.09	3.20	2.91
L11	0.44	1.43	0.054	ND	69.36	3.45	2.44
L12	1.42	1.20	0.018	0.001	48.54	2.52	9.27
L13	0.98	1.96	0.093	ND	70.93	4.64	2.79
L14	2.06	1.11	0.028	ND	92.26	2.86	12.53
L15	1.93	1.53	0.064	ND	65.72	4.72	8.69
<b>WHO (2004) (mg/l)</b>	<b>5.0</b>	<b>1</b>	<b>0.07</b>	<b>0.05</b>	<b>75</b>	<b>--</b>	<b>50</b>
<b>BIS (2003) (mg/l)</b>	<b>5.0</b>	<b>0.05</b>	<b>--</b>	<b>0.05</b>	<b>75</b>	<b>--</b>	<b>30</b>

(L1 = Beharipur Civil Lines, L2 = Pilibhit Bypass Road, L3 = Choupla-Kutubkhana Road, L4 = Kunwarpur, L5 = Madhinath, L6 = Shamat Ganj, L7 = Qila, L8 = Nagar Nigam, L9 = Choupla Railway Colony, L10= City Station, L11 = MJPRU Campus, L12 = Junction, L13 = Suresh Sharma Nagar, L14 = Rajendra Nagar, L15 = Rampur Garden, ND = not detected)

**Zinc (Zn):** Zinc is an essential element for health but excess zinc can be harmful, and cause zinc toxicity. The data (table 2) showed the mean values of Zn in water samples were from 0.16 to 2.29 mg/l. The maximum level of Zn (2.29 mg/l) was detected in the sample taken from location L1 (Beharipur Civil Lines) while minimum level

(0.16 mg/l) was observed in the sample obtained from location L5 (Madhinath). The data indicated that Zn content of water was below the permissible limit of 5.0 mg/l reported by WHO (2004) and BIS (2003).

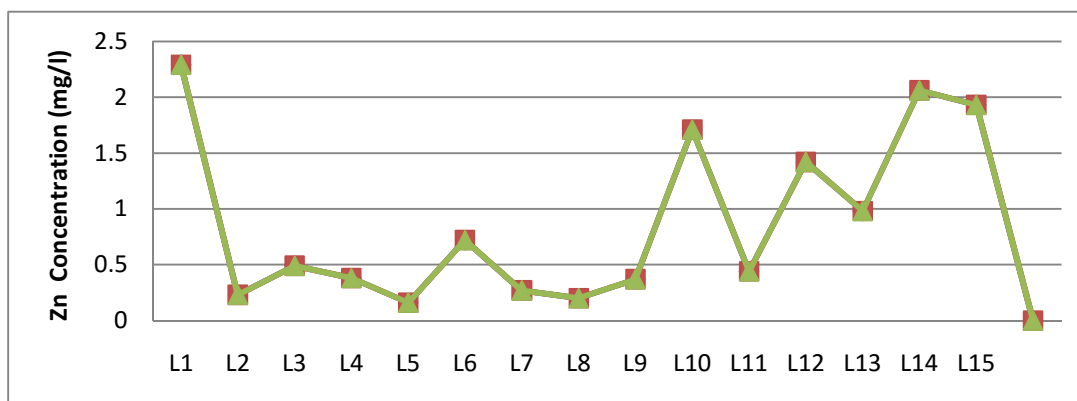


Fig. 1. Mean concentration of Zn in drinking water samples from location L1-L15

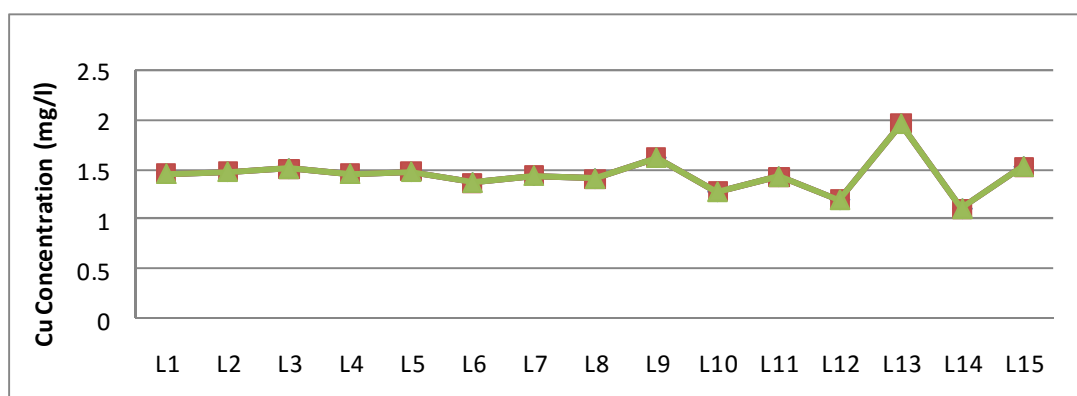


Fig. 2. Mean concentration of Cu in drinking water samples from location L1-L15



Fig. 3. Mean concentration of Mo in drinking water samples from location L1-L15

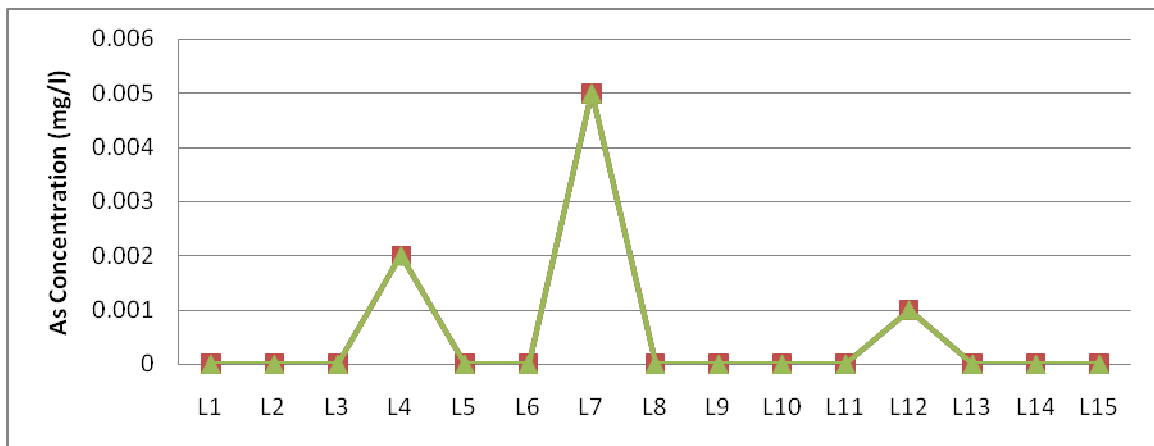


Fig. 4. Mean concentration of As in drinking water samples from location L1-L15



Fig. 5. Mean concentration of Ca in drinking water samples from location L1-L15



Fig. 6. Mean concentration of K in drinking water samples from location L1-L15



Fig. 7. Mean concentration of Mg in drinking water samples from location L1-L15

**Copper (Cu):** The concentration of Cu in the drinking water samples ranged from 1.11 to 1.96 mg/l and the permissible limit of Cu is specified as 0.05 mg/l by BIS (2003) and 1 mg/l is specified by WHO (2004) for drinking water. All the samples were found above the permissible limits of BIS (2003) and WHO (2004). Copper is essential substance to human life, but chronic exposure to contaminant drinking water with copper results in the development of anemia, liver and kidney damage [15].

**Molybdenum (Mo):** The concentration of this element in water was found in the range of 0.016-0.093 mg/l. The highest concentration of Mo was recorded at location L13 (Suresh Sharma Nagar) and lowest at L9 (Choupla Railway Colony) Table 2. The permissible limit for this metal is 0.07 mg/l (WHO 2004) and it is considered to be an essential element and no data are available on the carcinogenicity of this element on human beings [16].

**Arsenic (As):** The mean concentration of As in the drinking water samples ranged from 0.001 to 0.005 mg/l and the permissible limit of As is specified as 0.05 mg/l by BIS (2003) and WHO (2004) for drinking water. All the samples were within the permissible limits of BIS (2003) and WHO (2004). The high Arsenic concentrations were

observed at location L7 (Qila) and lowest at the location L12 (Junction). Aside from occurring naturally in the environment, arsenic can be released in larger quantities through volcanic activity, erosion of rocks, forest fires, and human activity. Inorganic arsenic is a known carcinogen and can cause cancer of the skin, lungs, liver and bladder. Lower level exposure can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of “pins and needles” in hands and feet. Ingestion of very high levels can possibly result in death. Long-term low level exposure can cause a darkening of the skin and the appearance of small “corns” or “warts” on the palms, soles, and torso [17].

**Calcium (Ca):** The determination of Ca in water is important since Ca salts in water very often cause the hardness, scale formation and has impart corrosive properties. The concentration of Ca in water samples was found to be 30.44 to 99.09 mg/l. Most of the samples had this element under limit set by BIS (2003) and WHO (2004) excluding five locations namely L2 (Pilibhit Bypass Road), L7 (Qila), L8 (Nagar Nigam), L10 (City station) and L14 (Rajendra Nagar). Usually there is no

known bad effect of calcium when it is slightly higher except in some cases kidney stone has been reported. This element became the “miracle” mineral of the 1980s with consumers increasing their intake in the hope of preventing osteoporosis and lowering blood pressure [18].

**Potassium (K):** The determination of K content in fresh and drinking water is important as K 40 is the major source of natural radioactivity found in water. Potassium in water samples is found to be in the range of 2.16 to 5.81 mg/l. Potassium maintains the electrolyte balance in blood and body fluids and also releases certain enzymes and hormones that prevent heart failure [18]. There is no specific data for comparison of this element for its permissibility.

**Magnesium (Mg):** It also causes hardness, scale formation, and corrosive properties of water. The concentration of this element in water samples were found to be in the range of 1.93 to 12.53 mg/l. The concentration of Mg was found highest at location L14 (Rajendra Nagar) and lowest at L2 (Pilibhit Bypass Road). Compared to BIS (2003) and WHO (2004) the water sample had low amount of Mg. This element enhances stamina and can help prevent heart disease and hypertension [18].

#### IV. CONCLUSION

The concentration levels of trace metals in the evaluated drinking water samples do not appear to be of serious concern for now, except for Cu and Ca. The study results provide evidence of gradual accumulation of Cu in water. The sources of this metal in drinking water is suspected from many practical uses in our society and is commonly found in coins, electrical wiring, and pipes. It is an essential element for living organisms, including humans, and-in small amounts-necessary in our diet to ensure good health. However, continuous exposure of copper can cause adverse health effects, including vomiting, diarrhea, stomach cramps, and nausea. It has also been associated with liver damage and kidney disease.

It is therefore suggested and advised that the concern contaminated sources be subjected to further treatments that will reduce drastically, the concentration of these trace metals which are capable of posing adverse threat to health of consumers and the society.

The result suggests the needs for close monitoring of these trace elements in drinking water and improves the water quality in the State so that the water reaching our home must be safe to drink. Many of environmental health problems are the result of long-term, low-level exposure to heavy metals as drinking water plays a key role in environment-human health interactions. It is recommended that drinking water sources in the study area should be routinely monitored to ascertain its suitability for drinking and other purposes.

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#### REFERENCES

- [1] L. Baroni, L. Cenci, and M. Berati, “Evaluating the environmental impact of various dietary patterns combined with different food production systems”. *European Journal of Clinical Nutrition*. 2007. pp, 61: 279-286.
- [2] C.C. Ikejimba and S. Sakpa, “Comparative study of some heavy metals’ concentrations in water and *Tympanotonus fuscatus* var. *radula* samples of Egbokodo River, Warri, Nigeria”. *International journal of Modern Biological Research*. 2014. pp, 2: 7-15.
- [3] J.R. Lloyd, A.N. Mabbett, D.R. Williams, and L.E. Macaskie, “Metal reduction by sulfate reducing bacteria: physiological diversity and metal specificity”. *Hydrometallurgy*. 2001. pp, 59: 327-337.
- [4] A. Valavanidis and T. Vlachogianni, “Metal pollution in ecosystem, ecotoxicology studies & risk assessment in the marine environment”. Dept. of Chemistry, University of Athens University Campus Zografou, 15784 Athens, Greece, 2010.
- [5] O. Osibanjo and A.O. Majolagbe, “Physicochemical quality assessment of groundwater based on land use in Lagos city, Southwest, Nigeria”. *Chemistry Journal*. 2012. pp, 2: 79-86.
- [6] J. Buschmann, M. Berg, C. Stengel, L. Winkel, M.L. Sampson, P.T.K. Trang and P.H. Viet, “Contamination of drinking water resources in the Mekong Delta floodplains: Arsenic and other trace metals pose serious health risks to population”. *Environment International*. 2008. pp, 34: 756-764.
- [7] C.G. Fraga and P.I. Oteiza, “Iron toxicity and antioxidant nutrients”. *Toxicology*. 2002. pp, 180: 23-32.
- [8] EPA, “Consumer Factsheet on: COPPER”. Retrieved March 25, 2013 from <http://water.epa.gov/drink/contaminants/index.cfm>, 2013.
- [9] J.O. Nriagu and J.M. Pacyna, “Quantitative assessment of worldwide contamination of air water and soils by trace metals. *Nature*. 1988. pp, 333:134-139.
- [10] S.P. McGrath, F.J. Zhao and E. Lombi, “Plant and rhizosphere process involved in phytoremediation of metal-contaminated soils”. *Plant Soil*. 2001. pp, 232: 207-214.
- [11] APHA (American Public Health Association), “Standard methods for the examination of water and waste”, 16th edition, Washington, D.C, 1985.
- [12] AOAC, “Official methods of analysis of the Association of official Analytical Chemists”. Arlington, VA, USA, 17th Ed, Chp. 17, 2000.
- [13] WHO, “Guidelines for Drinking Water Quality”, Vol. 1, 3<sup>rd</sup> edition Geneva, Switzerland, 2004.
- [14] BIS (Bureau of Indian standards), “Drinking water-specification”, edition 2.1, 2003. IS10500:1991
- [15] EPA, “Drinking water and Health”. EPA816-k-99-001, 1999.
- [16] WHO, “Guidelines for Drinking Water Quality: Health Criteria and Other Supporting Information”, Geneva: World Health Organization, 1993.
- [17] WHO, “Arsenic and arsenic compounds”. *Environmental Health Criteria*, vol. 224. Geneva: World Health Organization. 2001.
- [18] A.V. Wiesenberger, “The Influence of minerals in water”. Excerpted from ‘The Taste of Water’, 2001.