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# An Investigation on Physical, Chemical and Bacteriological Quality of Drinking Waters and Health Issues of the Rural Areas in Uttar Pradesh, India

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**ABSTRACT: The aim of this research was to analyze the water quality and the health impacts associated with the water quality in rural population of Bareilly, Uttar Pradesh (UP), India. The parameters include pH, turbidity, conductivity; total dissolve solids (TDS), total hardness, calcium, chloride, fluoride and MPN were analyzed by using standard methods of APHA, 1998 and Trivedi and Goel, 1986. The heavy metals viz. Iron (Fe), arsenic (As) and chromium (Cr) were also analyzed by using Atomic Absorption Photometer. Semi-structured interviews were conducted with consumers of water in selected rural areas. The research highlights the health effects of rural people due to poor quality of water and key issues contributing to these problems in rural areas of Uttar Pradesh, India.**

**Keywords:** Water quality, heavy metals, fluoride, health, rural areas

## INTRODUCTION

Potable and domestic water supplies are the most important part in the oral-infection circle in humans. Due to rapid development in industrial, agricultural and urban areas in the nation and the lack of control mechanisms, water supplies in rural areas have been contaminated.

The extensive consumption of water in rural areas has long term impact due to presence of contaminants on human health. On the other hand, most of the elements such as magnesium and calcium in concentration below the recommended doses may reduce frequency of sudden death and osteoporosis, respectively (Garzon, 1998), and both may exert protective effects against gastric cancer (Yang *et al*., 1998), but the individuals with stones in the upper urinary tract are ill-advised to consume water that is high in magnesium and calcium and low in sodium (Garzon, 1998; Mayne and Edwards, 1990). Fluoride concentrations of 1.0mg per liter or greater will reduce the incidence of dental cavities. However, concentrations over 2.0 mg per litre can darken tooth enamel causing Fluorosis (USPHS, 1991). The presence of heavy metals in the drinking water is a serious concern. The presence of chromium in water may expose the consumers to increased risk of lung cancer, respiratory disorders, and kidney damage. Moreover, the presence of arsenic in water may cause damage to skin, circulatory system and has high risk of getting cancer.

The most frequently used microbial indicators of water quality are total coliforms (TC), fecal coliforms (FC) and fecal streptococci (FS) are all considered indicators of recent fecal contamination (Godfree *et al*., 1997). Fecal contamination of water is considered a human health risk, and there has always been a great deal of concern regarding the level of coliform bacterial counts in water.

In the rural areas of UP municipal and individual well water supplies were examined in order to evaluate status of water quality and to access the prevalence of water borne diseases. The WHO Water Quality Standards were taken into account as a base for evaluations as to whether the water samples are physically, chemically and bacteriologically up to the standards in the selected rural areas.

## MATERIALS AND METHODS

*A. Study area*

Water sample were collected from different eight sampling locations around the Reuna Kala at 28º18’23.38” N Latitude and 79º61’30.48’’E longitude located at about 15 km North of Faridpur and about 35 km from Bareilly District of Utter Pradesh. Groundwater samples were collected from the hand pump of reunakala, faridpur from different locations. The samples were taken in plastic canes of one litre capacity as per standard procedure of APHA 1998 and Trivedi and Goel, 1986.

*B. Reagents*

The following reagents, procured from different companies, were used as needed for the analysis of various parameters: KCl (99.5%, S.D. Fine Chemicals), Eriochrome Black-T (98%, Lobachemie), Murexide (99%, BDH Laboratory Reagent), NaCl (99.9%, Ranbaxy), $AgNO_3$ (99.8%, Qualigens Fine Chemicals), Phenol (98.7%, S.D. Fine Chemicals), SPADNS Reagent (99.7%, SISCO Research Laboratories), Sodium fluoride (99.9%, CDH Pvt. Ltd.). All the solutions were prepared in double distilled water to exclude any possibility of addition of impurity from raw water. Double distilled water was prepared from de-ionized water by distilling over acidified potassium permanganate and then over alkaline permanganate solution.

*C. Physico-chemical and heavy metal analysis*

The Physico-chemical analysis and heavy metal analysis of the water samples were determined by the methods as indicated in the Table 1.

**Table 1: The methods of analysis of different parameters for the drinking water in Rural areas.**

| Name of parameters | Instrument used for determination | Method used | Method reference |
|---|---|---|---|
| pH | pH Meter | - | APHA (1998) |
| Turbidity | Turbidity meter | - | APHA (1998) |
| Conductance | Conductometer | - | Trivedi & Goel 1986 |
| TDS | TDS meter | - | Trivedi & Goel 1986 |
| Total hardness | Titration | - | Trivedi & Goel 1986 |
| Calcium | Titration | - | Trivedi & Goel 1986 |
| Chloride | Titration | - | APHA (1998) |
| Fluoride | Spectrophotometer | SPADNS | APHA (1998) |
| Heavy metals | AAS | Standard addition | Khandekar & Mishra 1984 |
| MPN | - | Membrane filtration technique | APHA (1998) |

Heavy metal concentration in water samples were determined by atomic absorption spectrophotometer (Perkins Elmer-700) equipped with HGA graphite furnace, in the Department of Environmental Science, GB Pant University, Bareilly. Reliability and reproducibility of analysis were checked by analyzing blank, standard and pre-analyzed sample after every 5 samples. Total coli form bacteria as maximum probability number (MPN) in water samples were counted using standard method (APHA, 1998).

*D. Evaluation of water borne disease*

To find out the prevailing impacts of contaminated water on public health, a questionnaire survey was conducted among the resident's of rural areas though a survey team consulting of a physician and students of Environmental Science. 50%, 30%, 25%, 25%, 25%, 20%, 20%, 25% and 20% representative respondents at site I, II, III, IV, V, VI, VII and VIII were randomly selected from 8 sampling sites in Rewna Kala, Faridpur. The age group of respondents ranged from 30-50 years. During the questionnaire survey information regarding age, education, body weight, smoking and nonsmoking habits, waterborne diseases and other health related problems were collected. Questionnaires were filled from the respondents of the study area and questions were explained in their local language. Furthermore, meeting/interview was also conducted with doctors in local hospitals and basic health units to collect the data regarding the water borne diseases in the study area.

## RESULTS

*A. Physico chemical and microbiological properties*

The results of various physico-chemical and analyses are presented in table-1. The study showed that the pH of the water samples is in the slightly acidic to mild alkaline range of 6.66± 0.06 to 7.33±0.12. The maximum turbidity (5.80±0.09 NTU) was reported at site V and minimum at site VI (1.25±0.09 NTU). Conductivity measurements ranged from from189.56 µS/cm to 199.46 µS/cm with maximum value at site V and minimum value reported at site VII. Total dissolved solids of drinking water samples ranged from 510±10.66 mg/l to 843±9.84 mg/l. Total hardness ranged of water samples was found 104.37±6.62 mg/l to 303.66±5.51 mg/l with minimum at site VI and Maximum at site IV. Hardness of water were below the set guideline value of 500 mg/l. Calcium of the water samples were estimated between 39.75 mg/l to 157.13 mg/l. The amount of chloride (mg/l) was 122.13±2.48, 128.66±2.89, 142.33±2.31, 172.2±2.42, 201.66±2.89, 101.6±2.95 and 129±2.65 at site I, II, III, IV, V, VI, VII and VIII, respectively. The fluoride content in the water samples at the study sites was 5.47±0.08, 5.71±0.08, 5.03±0.06, 6.04±0.06, 7.85±0.08, 3.23±0.06, 6.03±0.06, and 5.43±0.06, at site I, II, III, IV, V, VI, VII and VIII, respectively. Water Contamination with total coliforms bacteria ranged from 4.33±0.58 MPN at site I and II to 14.33±0.55 MPN/100ml at site V (Table 2).

**Table 2: Physico-chemical and microbiological parameters of drinking water in rural areas of Faridpur, Bareilly (Uttar Prdesh).**

| Sampling Sites | pH | Turbidity (N.T.U) | Conductivity (µs/cm) | T.D.S. (mg/l) | Hardness (mg/l) | Calcium (mg/l) | Chloride (mg/l) | Fluoride (mg/l) | Iron (mg/l) | Arsenic (µg/l) | Chromium (mg/l) | M.P.N. /100ml |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Salempur (I)** | 6.66±0.06 | 4.36±0.11 | 192.16±0.28 | 710±10 | 190±5.0 | 46.7±2.86 | 122.13 ±2.48 | 5.47 ±0.08 | 0.38 ±0.01 | 7.11 ±0.12 | 0.17 ±0.004 | 4.33 ±0.58 |
| **Hasanjang (II)** | 6.83±0.06 | 3.71±0.07 | 198.2±0.35 | 815±8.6 | 120.33±4.04 | 43.5±1.73 | 128.66 ±2.89 | 5.71 ±0.08 | 0.35 ±0.01 | 8.76 ±0.10 | 0.15 ±0.005 | 4.33 ±0.58 |
| **Hemupur (III)** | 6.83±0.06 | 4.8±0.10 | 198.23±0.04 | 587.33±12.70 | 213.66±5.51 | 92.38±2.47 | 142.33 ±2.31 | 5.03 ±0.06 | 0.38 ±0.01 | 10.20 ±0.17 | 0.14 ±0.004 | 7.33 ±0.58 |
| **Rewnakala Gontia (IV)** | 6.66±0.06 | 3.76±0.12 | 198.86±0.32 | 591±10.39 | 303.66±5.51 | 122.66±2.02 | 172.2 ±2.42 | 6.04 ±0.06 | 0.33 ±0.01 | 9.41 ±0.12 | 0.17 ±0.005 | 7.66 ±0.58 |
| **Rewnakala Khas (V)** | 6.86±0.06 | 5.80±0.09 | 199.16±0.29 | 843±9.84 | 268.33±5.77 | 106.66±2.89 | 201.66 ±2.89 | 7.85 ±0.08 | 0.31 ±0.01 | 10.56 ±0.12 | 0.15 ±0.006 | 14.33 ±0.58 |
| **Chathiya Faiju (VI)** | 6.86±0.06 | 1.25±0.09 | 192.16±0.29 | 510±10.66 | 104.37±6.62 | 43.3±2.78 | 286.66 ±2.89 | 3.23 ±0.06 | 0.34 ±0.01 | 8.28 ±0.14 | 0.16 ±0.003 | 9.33 ±0.58 |
| **Rewnakala South (VII)** | 7.06±0.06 | 1.73±0.06 | 189.56±0.29 | 806.66±11.54 | 173.66±4.62 | 51.5±2.60 | 101.6 ±2.95 | 6.03 ±0.06 | 0.35 ±0.01 | 7.13 ±0.10 | 0.15 ±0.005 | 5.66 ±0.58 |
| **Madiya VIII)** | 7.33±0.12 | 2.21±0.08 | 190.86±0.32 | 709±9.53 | 216.33±7.51 | 101.33±3.18 | 129 ±2.65 | 5.43 ±0.06 | 0.27 ±0.01 | 7.16 ±0.10 | 0.15 ±0.004 | 7.66 ±0.58 |

Note: The values are represented as mean±SE

*B. Arsenic, iron and Chromium contamination*

Arsenic concentration of drinking water samples were found 7.11±0.12 µg/l at site I to 10.56± 0.12 µg/l at site V. The concentration of chromium mg/l is 0.17±0.004, 0.15±0.005, 0.14±0.004, 0.17±0.005, 0.15±0.006, 0.16±0.003, 0.15±0.005, 0.15±0.004 at site I, II, III, IV, V, VI, VII and VIII, respectively. The highest concentration (0.38±0.01) of was found at site I and III and the minimum concentration (0.27±0.01) was reported at site VIII (Table 1).

*C. Health disorders*

Fluorosis was reported in 70%, 50%, 32%, 40%, 10%, 5%, 0% and 0% at eight selected sites by the respondents in the study area (Fig. 1and 2). Chest pain and abdominal pain was reported by 30%, 36.6%, 20%, 32%, 25%, 35%, 24%, 15% and 24%, 46.6%, 24%, 20%, 30%, 15%, 36%, 30% at site I, II, III, IV, V, VI, VII and VIII respectively. Joint pain among respondents was maximum (70%) at site V and minimum (26.6%) at site II (Table 3).

**Fig 1.**

**Fig 2.** Mottling of teeth of the consumers due to fluoride in water.

**Table 3: Symptoms of Waterborne diseases among respondents in rural areas of Faridpur, Bareilly (U.P.).**

| **Diseases** | **Site I N= 50** | **Site II N=30** | **Site III N=25** | **Site IV N=25** | **Site V N=20** | **Site VI N= 20** | **Site VII N=25** | **Site VIII N=20** |
|---|---|---|---|---|---|---|---|---|
| Fluorosis | 35(70) | 15(50) | 08(32) | 10(40) | 10(50) | 05(25) | None | None |
| Joint Pain | 20(40) | 08(26.6) | 10(40) | 09(36) | 14(70) | 09(45) | 14(56) | 14(70) |
| Chest pain | 15(30) | 11(36.6) | 05(20) | 08(32) | 05(25) | 07(35) | 06(24) | 03(15) |
| Abdominal pain | 12(24) | 14(46.6) | 06(24) | 05(20) | 06(30) | 03(15) | 09(36) | 06(30) |
| Headaches | 30(60) | 10(33.3) | 05(20) | 08(32) | 13(65) | 05(25) | 07(28) | 04(20) |
| Vomiting | 10(20) | 09(30) | None | 02(8) | 08(40) | 03(15) | 05(20) | 07(35) |

Note: Values in Parenthesis represents percentage of the Number.

## DISCUSSION

The quality of drinking water in India is not good in most of the states as waterborne disease outbreaks continue to occur, and many more cases of endemic illness are estimated by researchers. The waterborne illness is mainly the outcome of pollution, technological failures or failure to treat the water as a result of that the change in physico chemical properties of water is obvious. Low pH levels are objectionable because of the corrosive effect on metallic water receptacles. Low pH could result in the metallic taste frequently associated with some packaged water. High pH levels are undesirable since they may impart a bitter taste to the water (SDWS, 1986). The electrical conductivity of water measures the capacity of water to conduct electrical current and it is directly related to the concentration of salts dissolved in water, and therefore, to the total dissolved solids (TDS). The concentration of total dissolved solids (TDS) indicated that all the samples contained varied concentrations of dissolved mineral elements for the mineral nutrition of consumers. The source of TDS in drinking water is attributed to natural sources, domestic wastewaters, municipal runoffs and industrial wastewaters. The desirable limit of total dissolved solids for drinking water is 500 mg/l according to WHO. High TDS increase density of water, decrease solubility of gases like oxygen and ultimately make the water unsuitable for drinking (WHO, 1984). Water with extremely low concentrations of TDS may also be unacceptable to consumers because of its flat, insipid taste (Bruvold and Ongerth, 1969). High TDS level (>500mg/L) result in excessive scaling in water pipes, water heater, boilers, and household appliances (Tihansky, 1974). The utilization of these ions by microorganisms must have caused the decrease in the concentration of the total hardness in the dry season (Mustapha, 2008) and to pH changes. Waters with their hardness less than 100 mg/l have a little buffering capacity and may cause corrosion of metallic receptacles (WHO, 2006), hence these water samples can't have higher concentrations of toxic metals. Calcium and magnesium salts play an important role in bone structure, muscle contraction, nerve impulse transmission, blood clotting and cell signalling (IOM, 1997). Calcium-deficient children show rickets, the condition of under-mineralized bone, resulting in structural deformities of growing bones, while bone under-mineralization. Chloride in surface and groundwater from both natural and anthropogenic sources, such as run-off containing road de-icing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas. Although excessive intake of drinking-water containing sodium chloride at concentrations above 2.5 g/l has been reported to produce hypertension, this effect is believed to be related to the sodium ion concentration. Chloride concentrations in excess of about 250 mg/l can give rise to detectable taste in water, but the threshold depends upon the associated cations. Consumers can, however, become accustomed to concentrations in excess of 250 mg/l, No health-based guideline value is proposed for chloride in drinking-water.

The main source of fluoride in ground water in Rewnakala is fluoride-bearing rocks such as fluorspar, fluorite, cryolite, fluorapatite and hydroxylapatite. Major health problems caused by fluoride are dental fluorosis, teeth mottling, skeletal fluorosis and deformation of bones in children as well as adults. Fluorosis is an important public health problem in 24 countries including India. India is one of the worst fluorosis affected countries, with large number of people suffering. This is because a large number of Indians rely on groundwater for drinking purposes and water at many places is rich in fluoride. Excess fluoride affects plants and animals also. In human beings, effects on dental and skeletal tissues (genu valgum) can occur in adolescents and young adults and even in children under 10 years of age among communities exposed to high levels of fluoride. It can interfere with carbohydrates, lipids, protein, vitamins, enzymes and mineral metabolism when the dosage is high. Skeletal deformation and weakening of joints are typical forms of fluoride at high levels of fluoride intake. Fluoride is primarily excreted in urine. The severity of injury is determined by duration of fluoride exposure and concentration. Fluoride concentrations in ground water in India vary significantly.

Arsenic (As) is introduced into soil and groundwater during weathering of rocks and minerals followed by subsequent leaching and runoff. It can also be introduced into soil and groundwater from anthropogenic sources. Researchers reported that food is the second largest contributor to arsenic intake by people after direct ingestion of arsenic contaminated water. Domestic, agricultural and industrial uses of arsenic in the form of insecticides, weedicides, rodenticides and arsine are becoming rarer because of advent of low toxic pesticides. Chronic hepatitis and hepatic cirrhosis have been described due to consuming arsenic contaminated beer (Southwick *et al*., 1983). Basically all samples consist of chromium ion either in dissolved or suspended form.

The natural total chromium content in water is approximately 0.5-2 ppb (WHO, 1996). Whereas the maximum allowable limit for chromium as per WHO guidelines is 0.05 mg/l. Chromium typically occurs in two oxidation states in the natural environment, water treatment processes and water distribution systems: trivalent chromium ($Cr^{+3}$) and hexavalent chromium ($Cr^{+6}$). Trivalent chromium has been considered an essential human nutrient (Di Bona *et al*., 2011). $Cr^{+6}$ may also occur in the natural environment, but human-caused $Cr^{+6}$ contamination has recently been the focus of much scientific discussion, regulatory concern, and legal posturing. Chromium and its associated salts may cause increased risks of lung cancer, respiratory disorders and kidney damage. Bacteriological water quality analysis is a process of analyzing water to estimate the number of bacteria present and if needed, to find out the consortium of bacteria (Mead *et al*., 1999). It is subsequently possible to draw inferences as regards to the suitability of the drinking water for use from these concentrations. The presence of *E. coli*, a faecal coliform in drinking water is a strong indicator of recent sewage or animal waste contamination. The detection of *Escherichia coli* in drinking water indicated strongly that water samples are contaminated by pathogens that may cause abdominal pain, vomiting, diahorea to the consumers in the study area.

## CONCLUSION

The study concluded that poor water quality in rural areas of Uttar Pradesh expose the consumers to several types of health disorders. Hence, it is very necessary to improve the water quality in rural areas of Uttar Pradesh that will not only reduce the burden of diseases, but may also raise the standard of living as well. Immediate visit of health officials in Rewnakala and their intervention to reduce the burden of water borne disease like fluorosis, joint pain and headache is the need of hour.

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