

Quantitative estimation: An approach for quantification of essential trace elements in drinking water from natural sources

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ABSTRACT

The present study designed for quantitative estimation of some essential trace elements from natural sources like well, bore well and river from different regions of Nagpur district like Kamptee (21.2275°N, 79.1901°E), Kanhan (21.2297°N, 79.2381°E), Parsheoni (21.3757°N, 79.1520°E) and Nagpur (21.1412°N, 79.1260°E). In this study Bureau of Indian Standard (BIS) guidelines and parameters were followed for determination of essential trace elements which includes calcium, zinc, copper, chloride and nitrate using UV/VIS spectroscopy, titrimetry and other evaluation methods which include microbial testing were used. Concentration of essential trace elements like calcium, zinc, chloride, copper and nitrate were found high in water samples of well than bore well in all four regions. Microbial testing showed that none of the water samples of all four regions are safe or fit for drinking unless otherwise purification systems are not used. Further water samples from Nagpur and Kamptee regions showed significant low concentration of all elements. It has been concluded from the study that water from well and river is rich in essential elements but within the range compared to bore well may because of geographical condition and depth of bore-well to fetch water. Further population residing especially in Kamptee and Nagpur regions requires parallel consumption of supplementary products apart from food, dairy products, and water to fulfil the adequate intake of essential trace elements.

Key words: Water, Well, Bore-well, Zinc, Nitrate

INTRODUCTION

Improved drinking water source is defined as a drinking water source or delivery point that, by nature of its construction and design, is likely to protect the water source from outside contamination, in particular from fecal matter.[1]

There are some common reasons need for drinking water quality testing such as ensure safe drinking water, identify problems, adopt precautionary measures, raise awareness, determine the effectiveness of the house hold water treatment (HWTS) process, selection of an appropriate water source and influence government to supply safe water. [2]

Having safe drinking water is human need and right for everyone. People need clean water to maintain their health. Safe drinking water should have the following microbiological, chemical and physical qualities like clear, tasteless, colourless, and free of pathogens, Low in concentration of toxic material, free from chemicals, free from microbes and other harmful and hazardous substances.

Million of peoples are expos to unsafe levels of chemical contaminants in their drinking water. This may linked to a lack of proper management of urban and industrial wastewater or agricultural run-off water – potentially giving rise to long-term exposure of pollutants, which can have a range of serious health implications. [3] The surface of our planet is nearly 71% water, only 3% of it is fresh. Of these 3% about 75% is tied up in glaciers and polar icebergs,

24% in groundwater and 1% is available in the form of fresh water in rivers, lakes and ponds suitable for human consumption. [4]

Calcium, Zinc, Chloride, Copper and Nitrate etc. are some essential trace elements present in water which are needed by the human body to regulate the cell functioning various processes in body. [5] These elements are very essential for the body to perform cell functions at biological, chemical and molecular level, mediate vital biochemical reactions by acting as cofactors for many enzymes, as well as act as centres for stabilizing structures of enzymes and proteins. Some of the trace elements control important biological processes by binding to molecules on the receptor site of cell membrane or by alternating the structure of membrane to prevent entry of specific molecules into the cell. The functions of trace elements have a dual role. In normal levels, they are important for stabilization of the cellular structures, but in deficiency states may stimulate alternate pathways and cause diseases. These trace elements have clinical significance and these can be estimated using different analytical methods. [6]

MATERIALS AND METHODS

Material which includes chemicals, reagents for determination of various essential trace elements such as EDTA, Eriochrome black-T, Murexide, Potassium Chromate, Potassium nitrate, Silver sulphate, EMB Agar, Lactose Broth, etc. were procured from Sigma Aldrich, Loba chemicals and Hi-media.

Methods used for determination of organoleptic, undesirable substances testing such as UV/Vis spectroscopy, titrimetry and other evaluation methods which includes microbial testing were used and performed as Per Bureau of Indian Standard (BIS).

RESULTS AND DISCUSSION

Table. No.1: Concentration in Mean±SEM of essential trace elements in well and bore-well in mg/L

Well (mg/L)				
Elements	Regions			
	Kamptee	Kanhan	Parsheoni	Nagpur
Calcium	104.872±7.162	150.965±3.546	146.685±16.924	128.892±5.249
Zinc	9.952±0.519	16.800±1.835	18.297±2.010	19.428±3.015
Chloride	114.915±10.219	103.333±0.371	52.453±0.369	98.862±19.068
Copper	1.562±0.078	5.258±0.168	15.683±0.600	9.040±0.633
Nitrate	0.3680±0.004	0.3790±0.001	0.3810±0.003	0.3810±0.003
Bore-well (mg/L)				
Elements	Regions			
	Kamptee	Kanhan	Parsheoni	Nagpur
Calcium	90.822±25.043	104.872±7.162	113.598±2.153	89.632±11.242
Zinc	15.365±1.202	8.940±0.472	9.117±0.435	15.842±1.245
Chloride	32.505±1.556	114.915±10.219	93.633±3.524	44.573±1.962
Copper	6.887±0.338	4.135±0.289	2.348±0.302	5.498±0.536
Nitrate	0.3720±0.003	0.3680±0.004	0.3690±0.001	0.3710±0.003

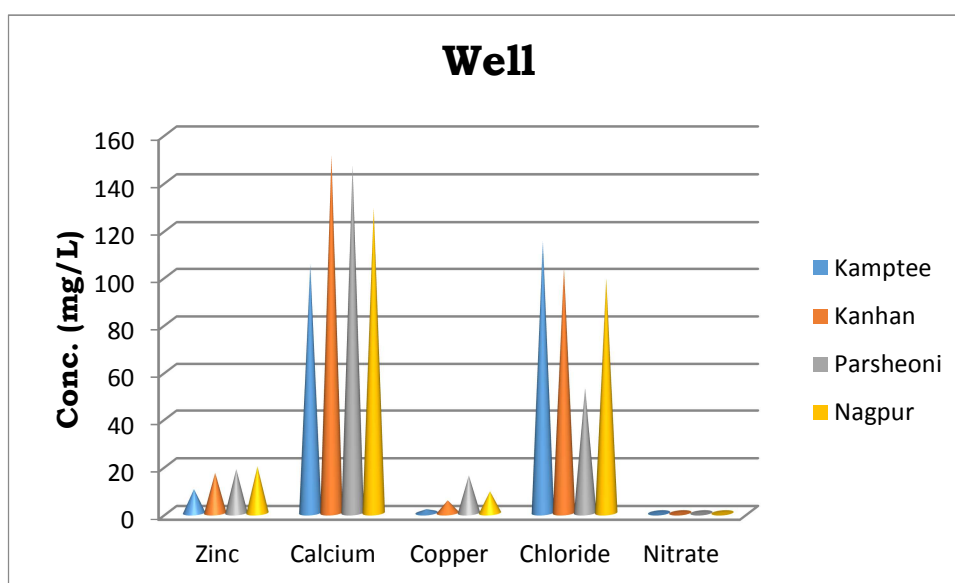


Fig. 1 Concentration of trace elements in Well of different regions

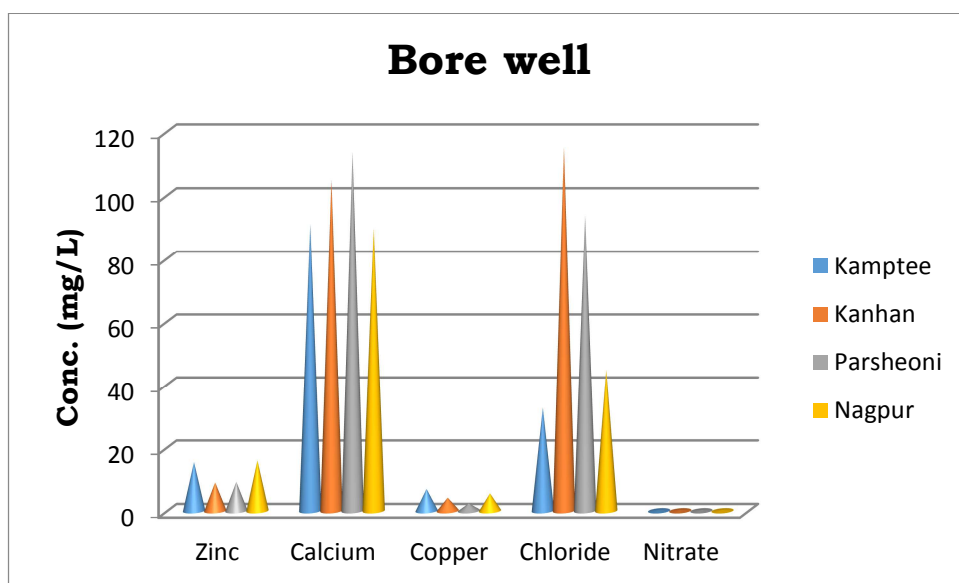


Fig. 2 Concentration of trace elements in Bore-Well of different regions

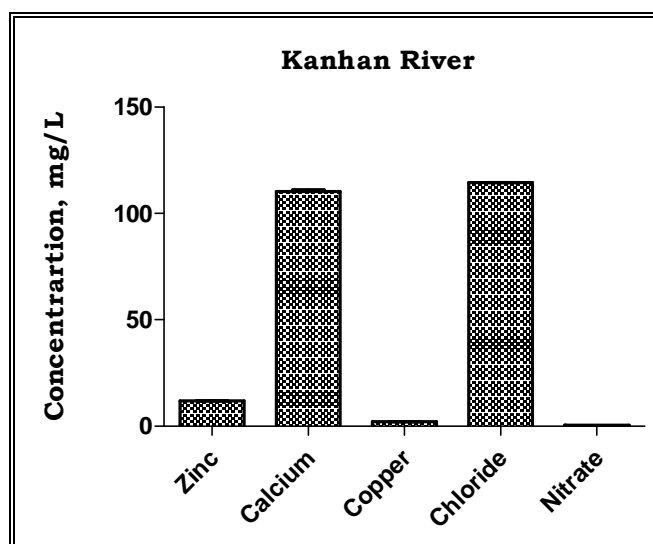


Fig. 3 Concentration of trace elements in Kanhan River

DISCUSSION

The present study designed for quantitative estimation of some essential trace elements from the natural sources like well, bore well and river, of different regions like Kamptee (21.2275°N, 79.1901°E), Kanhan (21.2297°N, 79.2381°E), Parsheoni (21.3757°N, 79.1520°E) and Nagpur (21.1412°N, 79.1260°E). For the study, water samples were collected from natural sources which includes well, bore-well and river from specified regions and evaluated as per Bureau of Indian Standards for determination of essential trace elements which includes calcium, zinc, copper, chloride and nitrate. In context to human health these trace elements are important and inadequate daily consumption can impair health, these can be fulfilled by parallel consumption of water.

Calcium provides structure, strength to the skeleton and also provides rigidity to bones, inadequate calcium intake results in diseases like osteoporosis, osteomalacia, nephrolithiasis (kidney stone), hypertension & stroke, coronary artery disease, insulin resistance and obesity. The acceptable safe limits of calcium in drinking water according to WHO is 75-200 mg/L [21]. United state institute of medicine established the dietary reference index and adequate intake of calcium in different age group as shown in (Table no.2)

Table. No.2 Dietary reference index (DRI) and Adequate intake (AI) of Calcium in different age group

Age	Calcium intake (mg/day)
0-6 months	210
6-12 months	270
1-3 years	500
4-8 years	800
9-13 years	1300
14-18 years	1300
19-50 years	1000

According to this the paediatric population up-to age 1 year can be excluded because of breast feeding but from the age of 2 to 50 the daily requirement varies from 500 to 1300 mg/day. As food and/or dairy products are primary source but adequate intake can be fulfilled only by consumption of water and extra supplement as on requirement. Study finding suggest that population residing in Kanhan and Parsheoni region and consuming water from well requires less amount of water to fulfil daily requirement and are less prone to diseases like Osteoporosis, Osteomalacia, Nephrolithiasis (kidney stone), hypertension & stroke, coronary artery disease, insulin resistance etc. as compare to the population residing in Kamptee and Nagpur region. Concentration of calcium is high in well of Kanhan and Parsheoni regions (150.965 ± 3.546 & 146.685 ± 16.924 mg/L respect.) than bore well (104.872 ± 7.162 & 113.598 ± 2.153 mg/L respect.) (As shown in Table No.1). It may be because of geographical distribution of calcium at different depth of earth.

Zinc plays important role in first line defence (Immunity), taste sensation, secretion of gastric enzymes and wound healing. Lingamaneni P [6] discussed that Zinc is essential for proper growth, normal spermatogenesis, wound healing, taste sensation and secretion of gastric enzymes and inadequate Zinc intake is associated with retardation of growth in children, coronary artery disease, poor wound healing, high blood cholesterol, low blood sugar level and diarrhoea in paediatrics. The acceptable safe limits of Zinc content in drinking water according to WHO is 5-15 mg/L. [21]

Table. No.3: List of adequate intake of Zinc in different group of population

Category	Zinc intake (mg/day)
Infants	5
Pre-adolescent children	10
Adult Women	12
Adult Men	15

Daily requirement of zinc varies in different age groups from (5 to 15 mg/day) (Table no.8) as food is a primary source but adequate intake can be fulfilled only by consumption of water and extra supplement as on requirement. Study finding suggest that concentration of zinc is high in water fetched from well of Nagpur and Parsheoni regions (19.428 ± 3.015 & 18.297 ± 2.010 mg/L respect.) than bore well (15.842 ± 1.245 & 9.117 ± 0.435 mg/L respect.) (As shown in Table No.1). Therefore population residing in Nagpur and Parsheoni region requires less amount of water to fulfil daily requirement of zinc in addition to food and supplement they consumed and are less prone to coronary artery disease and have good immunity.

Inadequate chloride intake results in muscle weakness, loss of appetite, irritability, and dehydration and without chloride, and the human body would be unable to maintain fluids in blood vessels, conduct nerve transmissions, move muscles, or maintain proper kidney function. The acceptable safe limits of Chloride in drinking water according to WHO is 250-1000 mg/L and daily adequate intake of chloride is 750-900 mg/day.

Study finding suggest that population residing in Kamptee and Kanhan region and consuming water from well requires less water to fulfill the daily requirement of chloride as compared to population residing in Nagpur and Parsheoni regions and they are less prone to chloride deficiency symptoms like muscle weakness, loss of appetite, irritability and dehydration. Concentration of chloride is high in well of Kamptee and Kanhan regions (114.915 ± 10.219 & 103.333 ± 0.371 mg/L respect.) than bore well (32.505 ± 1.556 & 114.915 ± 10.219 mg/L respect.) (As shown in Table No.1) and it may be due to chlorination of well.

Copper Plays important role in wound healing, treating osteoarthritis and osteoporosis, proper growth, utilization of iron, enzymatic reactions and RBC formation and inadequate copper intake results in abnormal bone formation with skeletal fragility, osteoporosis, joint pain and arthritis. The acceptable safe limit of copper content in drinking water according to WHO is 0.05 – 1.5 mg/L [21] and daily adequate intake of copper is 1-5 mg/day.

In all specified regions concentration of copper is high in well of Parsheoni and Nagpur regions (15.683 ± 0.600 & 9.040 ± 0.633 mg/L respect.) than bore well (2.348 ± 0.302 & 5.498 ± 0.536 mg/L respect.) (As shown in Table No.1). So population residing in Parsheoni and Nagpur region requires less amount of water to fulfil daily requirement of copper in addition to consumption of food and are less prone to diseases like skeletal fragility, osteoporosis, joint pain and arthritis.

Primary health hazard with nitrate in drinking water occurs when nitrate is transformed to nitrite in digestive system. The nitrite oxidizes the iron (Fe^{2+} to Fe^{3+}) in haemoglobin of red blood cells to form methemoglobin, which lacks the oxygen carrying ability of haemoglobin. This creates the condition known as methemoglobinemia also referred to as "blue baby syndrome"[48], in which blood lacks the ability to carry sufficient oxygen to the individual body cells causing the veins and skin to appear blue. The acceptable safe limits of nitrate content in drinking water according to WHO is 0 - 50 mg/L [21] and daily adequate intake is 43-131 mg/day. In water samples of all the regions and in river, the nitrate concentration was found in a range of 0.3 - 0.4 mg/L (As shown in Table No.1) but the daily adequate intake of nitrate is very high and can't be fulfilled by the water consumption alone, Therefore the food source like vegetables, meat and fish is a major source to fulfil the daily requirement of nitrate.

According to current USEPA recommendations water is considered safe for drinking, if it contains less than one colony per 100 ml of water. The occurrence of coliforms detected in water is a direct measurement of deleterious effects of pollution to human health causing typhoid, dysentery, cholera etc. Bacteriological testing of water samples showed that in the all the water samples of well and bore well of all four regions i.e. Kamptee, Kanhan, Parsheoni and Nagpur as well as in Kanhan river, there was too numerous count (TNC) of coliform bacteria, except in sample no. 1, 2, 3, 4 and 6 of well of Parsheoni region, the most probable number of coliform bacteria in these water samples were found 10, 8, 28, 7 and 6 respectively. Therefore according to current USEPA recommendations water from specified regions was not fit and safe for drinking purpose according to microbial testing suggested but water purification plant can resolve the problem related to microbial contamination.

CONCLUSION

Quantitative estimation of some essential trace elements like Calcium, Zinc, Chloride, Copper and Nitrate from Natural sources like river, well and bore well of different regions of Kamptee, Kanhan, Parsheoni and Nagpur showed that concentration of essential trace elements like Calcium, Zinc, Chloride, Copper and Nitrate is high in well than in bore-well of all the four regions and from this we can conclude that well is a better source of essential trace elements to fulfill the daily requirement of essential trace elements than bore-well and microbiological examination showed that none of the water samples of all four regions are safe or fit for drinking purpose requires purification by means of membrane filtration, RO, UV etc. and other purification processes.

Further it has been concluded from the study that the population residing in specified region requires parallel consumption food and dairy products and other supplementary products to fulfil the adequate intake of essential trace elements.

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