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# Original Research

## Does crystal clear water clear the minerals away? –A Cross Sectional Study

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***ABSTRACT*:**
**Objectives:** Water is a vital for every function in the body and is an important source of mineral intake. The consumption of mineral water has greatly increased in the past decade. Studies have shown the effect of various minerals on dental health. Water is a rich source of all these minerals. The aim of the study was to estimate the levels of various minerals from different sources of drinking water. **Design:** Drinking water was collected from various sources which included Kaveri tap water, bore well water, water purified using activated carbon filter, water purified using reverse osmosis and two commercially available mineral bottled water. The above samples were sent to water testing certified company to check the levels of various minerals and other parameters using IS 3025. The results were subjected to statistical analysis. **Results:** The commercially available bottled water, water purified through reverse osmosis contained significantly lesser amount of minerals when compared to other samples. **Conclusion**: The children consuming only bottled water may have significantly lower levels of mineral (fluoride) ingestion.
**Key words**: fluoride, mineral water, minerals

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## INTRODUCTION

The consumption of mineral water has been increasing of late for reasons such as taste, smell and purity. The very concept of mineral water was first defined by the International Balneological Congress at Nauheim, Germany in 1911 as -water containing at least 1000mg of dissolved mineral constituents per liter. Over the years this definition of mineral water was changed many times and today the acceptable level had fallen to 200mg/l. [1]

Minerals are an important part of drinking water and have both direct and indirect health significance. They are essential for the normal maintenance of the body. The commonly found minerals in water include calcium, sodium, potassium, copper, manganese, iron, fluoride and magnesium. Water borne minerals are in ionic form and are easily absorbed by the gastrointestinal tract, it has been suggested that drinking water may be an important source of mineral intake.[2-4]

Minerals like calcium and magnesium are abundant in drinking water and have important physiological functions and an unsuitable intake of these minerals may increase the likelihood of the disease.[5.]Along with calcium, fluoride has beneficial effects on prevention of dental caries due to the formation of crystalline hydroxyapatite leading to more resistant enamel.

The purpose of this study was to determine the levels of some commonly found minerals like calcium, magnesium, fluoride, iron, chloride and sulphate in various sources of drinking water.

## METHODOLOGY

A convenience sample of water has been collected from various sources of drinking water. The samples included municipal tap water (Kaveri water), bore well water, water purified by activated carbon filter, water purified by reverse osmosis and two brands of commercially available mineral bottled water.

Five samples of each category containing one liter of water were sent to water testing certified company .The levels of various minerals and hardness of the water was tested using IS 3025 . The various minerals in the water that is calcium, magnesium, fluoride, iron, sulphate and chloride levels were measured and subjected to statistical analysis.

The values were subjected to Kruskalwalis test to find out whether there is significant difference between the water samples for various minerals. Mann-Whitney pair test was done to compare the difference in each mineral for the given pair of water samples.

## RESULTS

In the present study; it was noticed that the bore well water had the highest minerals followed by Kaveri, activated carbon filter, reverse osmosis and commercially available bottled water respectively. Table 1 shows mean values of minerals in various water samples. Chi square value obtained from Kruskalwallis is greater than critical value, indicating that there is significant difference between the water samples with respect to various minerals.

Table 2 shows the pair wise comparison for each mineral for all the samples and significant difference ($p<0.05$) was observed in many cases.

It was observed that bore well water had the highest mineral content among all the samples, However, the hardness of bore well water was 458 mg/l which is more than the standard limit as per IS 10500 making it unfit for drinking.

It was observed that kaveri water had more minerals when compared to activated carbon. Calcium, magnesium, chloride and sulphate were significantly higher in Kaveri water. Though, iron and fluoride was higher in Kaveri water than activated carbon it is not statistically significant. When Kaveri water is compared to commercially available drinking water and water purified by reverse osmosis there was significant increase among all the minerals. Commercially available drinking water had least amount of minerals when compared to all the samples and was statistically significant. Though the amount of fluoride, iron and sulphate was more in water purified by reverse osmosis than commercially available bottled water, it was not statistically significant.

## DISCUSSION

Mineral levels vary among different sources of water. Mineral intake from drinking water depends on the individual and the source and quantity of water that is being consumed.

Calcium intake is important at all ages. Calcium reduces the age related bone loss and hip fractures. Clinical studies support the existence of an inverse relation between calcium intake and occurrence of osteoporosis.[7-8] Adequate calcium intake has been associated with lowered risk of elevated blood pressure. Calcium also plays an important role in preventing demineralization and encourages remineralisation of hard tissues of tooth along with preservation and maintenance of health of pulp.[9]

Magnesium plays an important role in many biological functions. Epidemiological studies suggest that an inverse relation exist between magnesium intake and the occurrence of ischemic heart disease, cardiac arrhythmias and sudden death.[10-11] The major portion of $Mg^{+2}$ intake is via food ;however $Mg^{+2}$ in water is highly bioavailable and water borne $Mg^{+2}$ is absorbed approximately30% faster and better than magnesium from food.[12-13]

Iron is an essential element and deficiencies can result in impaired mental development in children and in severe cases it can cause iron deficiency anemia. Chloride is common constituent of all natural water and is required for the homeostasis. Sulphate is anti-inflammatory and anti –depressant and is required for many physiological processes.[14]

Although all foods contain traces of fluoride, water borne fluorides are generally the most important source for humans. Fluoride decreases the caries by increasing enamel's resistance to acid solubility, the ability of fluoride to remineralize the demineralized or hypomineralized enamel and antibacterial effect on plaque growth. The glycogen synthesis, acid production, production of extracellular polysaccharides necessary for plaque adhesion to tooth surface are also altered.[14] The two most important forms of fluoride on a public health level are community water fluoridation and fluoride dentifrice. The two modalities have been recommended by Center of Disease Control and Prevention (CDC) as desirable for all the individuals.[14] Water fluoridation was recognized by the CDC as one of the 10 most important overall public health achievements of the 20$^{th}$ century.[15]

In the present study, among all the samples, the bore well water contained the highest amount of minerals but the hardness of bore well water is 458 mg/l which is more than the standard limit as per IS 10500 and hence the water is not feasible for drinking. Bore well water was followed by Kaveri water, which had the second highest minerals with a hardness of 158.2 among all the samples.

| Water sample | N | calcium | Kruskalwallis test | | Mean magnesium | Kruskalwallis test | | fluoride | Kruskalwallis test | | iron | Kruskalwallis test | | chloride | Kruskalwallis test | | sulphate | Kruskalwallis test | | hardness | Kruskalwallis test | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Chi-square | P value | | Chi square | P value | | Chi square | P value | | Chi square | P value | | Chi square | P value | | Chi square | P value | | Chi square | P value |
| Kaveri | 5 | 34.6 | 28.146 | <0.05 | 11.6 | 27.879 | <0.05 | 0.06 | 27.44 | <0.05 | 0.05 | 27.814 | <0.05 | 99.44 | 27.709 | <0.05 | 10 | 28.594 | <0.05 | 158.2 | 28.27 | <0.05 |
| Borewell | 5 | 82.4 | | | 35.9 | | | 0.11 | | | 0.1 | | | 253 | | | 76.6 | | | 458 | | |
| Activated carbon | 5 | 21.4 | | | 9.38 | | | 0.05 | | | 0.04 | | | 60.36 | | | 17.6 | | | 105.8 | | |
| RO | 5 | 10.77 | | | 1.56 | | | 0.009 | | | 0.009 | | | 18.93 | | | 0.009 | | | 39.2 | | |
| Commercial 1 | 5 | 4.42 | | | 0.88 | | | 0.009 | | | 0.009 | | | 10.58 | | | 0.009 | | | 10 | | |
| Commercial 2 | 5 | 4.68 | | | 0.76 | | | 0.009 | | | 0.009 | | | 10.36 | | | 0.009 | | | 15.2 | | |

Table 1: mean values of minerals in various water samples.

| | Pairwise comparison p value (Mann-Whitney test) | calcium | P value | magnesium | P value | fluoride | P value | iron | P value | chloride | P value | sulphate | P value | hardness | P value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Kaveri | 34.6 | 0.009* | 11.6 | 0.009* | 0.06 | 0.011* | 0.05 | 0.012* | 99.44 | 0.009* | 10 | 0.008* | 158.2 | 0.009* |
| | Borewell | 82.4 | | 35.9 | | 0.11 | | 0.1 | | 253 | | 76.6 | | 458 | |
| 2 | Kaveri | 34.6 | 0.009* | 11.6 | 0.009* | 0.06 | 0.454 | 0.05 | 0.233 | 99.44 | 0.009* | 10 | 0.008* | 158.2 | 0.009* |
| | Activated carbon | 21.4 | | 9.38 | | 0.05 | | 0.04 | | 60.36 | | 17.6 | | 105.8 | |
| 3 | Kaveri | 34.6 | 0.008* | 11.6 | 0.008* | 0.06 | 0.009* | 0.05 | 0.009* | 99.44 | 0.008* | 10 | 0.009* | 158.2 | 0.008* |
| | RO | 10.77 | | 1.56 | | 0.009 | | 0.009 | | 18.93 | | 0.009 | | 39.2 | |
| 4 | Kaveri | 34.6 | 0.009* | 11.6 | 0.008* | 0.06 | 0.005* | 0.05 | 0.005* | 99.44 | 0.009* | 10 | 0.005* | 158.2 | 0.008* |
| | Commercial 1 | 4.42 | | 0.88 | | 0.009 | | 0.009 | | 10.58 | | 0.009 | | 10 | |
| 5 | Kaveri | 34.6 | 0.009* | 11.6 | 0.008* | 0.06 | 0.005* | 0.05 | 0.005* | 99.44 | 0.009* | 10 | 0.005* | 158.2 | 0.009* |
| | Commercial 2 | 4.68 | | 0.76 | | 0.009 | | 0.009 | | 10.36 | | 0.009 | | 15.2 | |
| 6 | Borewell | 82.4 | 0.009* | 35.9 | 0.009* | 0.11 | 0.016* | 0.1 | 0.009* | 253 | 0.009* | 76.6 | 0.009* | 458 | 0.009* |
| | Activated carbon | 21.4 | | 9.38 | | 0.05 | | 0.04 | | 60.36 | | 17.6 | | 105.8 | |
| 7 | Borewell | 82.4 | 0.009* | 35.9 | 0.009* | 0.11 | 0.005* | 0.1 | 0.005* | 253 | 0.009* | 76.6 | 0.005* | 458 | 0.009* |
| | RO | 10.77 | | 1.56 | | 0.009 | | 0.009 | | 18.93 | | 0.009 | | 39.2 | |
| 8 | Borewell | 82.4 | 0.009* | 35.9 | 0.009* | 0.11 | 0.005* | 0.1 | 0.005* | 253 | 0.009* | 76.6 | 0.005* | 458 | 0.008* |
| | Commercial 1 | 4.42 | | 0.88 | | 0.009 | | 0.009 | | 10.58 | | 0.009 | | 10 | |
| 9 | Borewell | 82.4 | 0.009* | 35.9 | 0.008* | 0.11 | 0.005* | 0.1 | 0.005* | 253 | 0.009* | 76.6 | 0.005* | 458 | 0.009* |
| | Commercial 2 | 4.68 | | 0.76 | | 0.009 | | 0.009 | | 10.36 | | 0.009 | | 15.2 | |
| 10 | Activated carbon | 21.4 | 0.009* | 9.38 | 0.009* | 0.05 | 0.005* | 0.04 | 0.005* | 60.36 | 0.009* | 17.6 | 0.005* | 105.8 | 0.009* |
| | RO | 10.77 | | 1.56 | | 0.09 | | 0.009 | | 18.93 | | 0.009 | | 39.2 | |
| 11 | Activated carbon | 21.4 | 0.009* | 9.38 | 0.009* | 0.05 | 0.005* | 0.04 | 0.005* | 60.36 | 0.009* | 17.6 | 0.005* | 105.8 | 0.008* |
| | Commercial 1 | 4.42 | | 0.88 | | 0.009 | | 0.009 | | 10.58 | | 0.009 | | 10 | |
| 12 | Activated carbon | 21.4 | 0.009* | 9.38 | 0.008* | 0.05 | 0.005* | 0.04 | 0.005* | 60.36 | 0.009* | 17.6 | 0.005* | 105.8 | 0.009* |
| | Commercial 2 | 4.68 | | 0.76 | | 0.009 | | 0.009 | | 10.36 | | 0.009 | | 15.2 | |
| 13 | RO | 10.77 | 0.009* | 1.56 | 0.008* | 0.009 | 1 | 0.009 | 1 | 18.93 | 0.009* | 0.009 | 1 | 39.2 | 0.008* |
| | Commercial 1 | 4.42 | | 0.88 | | 0.009 | | 0.009 | | 10.58 | | 0.009 | | 10 | |
| 14 | RO | 10.77 | 0.008* | 1.56 | 0.008* | 0.009 | 1 | 0.009 | 1 | 18.93 | 0.009* | 0.009 | 1 | 39.2 | 0.009* |
| | Commercial 2 | 4.68 | | 0.76 | | 0.009 | | 0.009 | | 10.36 | | 0.009 | | 15.2 | |
| 15 | Commercial 1 | 4.42 | 0.014* | 0.88 | | 0.009 | | 0.009 | | 10.58 | | 0.009 | | 10 | |
| | Commercial 2 | 4.68 | | 0.76 | 0.065 | 0.009 | 1 | 0.009 | 1 | 10.36 | 0.138 | 0.009 | 1 | 15.2 | 0.008* |

**Table 2:** Shows the pair wise comparison for each mineral for all the samples. *significant $p<0.05$

Kaveri water is the municipal tap water supply for the drinking needs. Before it is supplied, the water is subjected to various treatment procedures to remove soil and dirt, harmful pathogens and chemical irritants. The steps include coagulation, flocculation, sedimentation, filtration and chlorination. It was observed that bore well water was followed by Kaveri water, which had the second highest mineral content.

Kaveri water was followed by water purified by activated carbon filter with respect to minerals. It removes the contaminants from water by two methods, adsorbtion and particulate filtration. Adsorption is a process that either adsorbs or removes the substance from water. Particulate filtration excludes particles by size.[16]Few ions which may be smaller than fifty microns may not be filtered and this might be the reason for

more amounts of minerals in water purified by activated carbon filter than in water purified by reverse osmosis.

Reverse osmosis water works on the same principle as osmosis, but in the reverse direction. Reverse osmosis removes impurities by two mechanisms. One is based on resistance to passage of ions due to their electrical charge. This mechanism is responsible for removing the ionic impurities. Even the smallest molecules are rejected if they have ionic charge. The other mechanism is based on ultra filtration effect, in which the small pores of the reverse osmosis membranes act like molecular filters. As a result water is almost free of dissolved minerals.

Many bottled waters are simply tap water processed using one or more of the processes of distillation, reverse osmosis, deionization, or filtration. This leaves the water virtually devoid of both nutrients and contaminants.[17] The appeal of these waters is therefore a reduction in impurities like lead and pesticide residues, or better taste but not enhanced mineral content. Bottled processed waters contain little or no minerals. It should also be noted that unlike tap water, purified waters and water purifiers reduce or eliminate the fluoride that is added by many municipal treatment facilities to promote dental health. The bottled water which are marketed as mineral water are poor in minerals which are essential for the normal maintenance of health. [17]

In this study it was observed that commercially available mineral water and water purified with reverse osmosis had negligible amount of minerals and are significantly less when compared to Kaveri water. Hence, individuals consuming only bottled water may have lower mineral consumption which could affect the oral and general health.

## CONCLUSION

1. Bore well water contains the highest mineral content among all the water samples but hardness is more than the Indian standards for drinking water.
2. Kaveri water had significantly higher amount of minerals when compared to water purified by reverse osmosis, water purified with activated carbon and commercially available bottled water.
3. Water purified through reverse osmosis and commercially available bottled water contained least amount of minerals. Long term consumption of this water could affect the health of an individual. However further studies have to be carried out to relate the long term consumption of this water, availability of minerals and their effect on health of the individual.

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