

Mineralization of purified drinking water

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Abstract - Water purification is the process of removing undesirable substances from water. Various techniques and technologies are adopted for water purification such as reverse osmosis, sediment filtration, activated carbon filters, and UV technique. All these methods have proved to be very effective in removing TDS and disease causing pathogens. There are several purifiers of different brands who guarantee 99.99% purified water. But this is actually a pure marketing technique for which we humans have fallen prey. Along with complete removal of suspended solids, wastes and other TDS, natural minerals available in the water are also removed during the purification process. Natural constituents of water comprise calcium ion and magnesium ions basically which are vital for diet supplement intake, metabolic activity and stay healthy. RO purification of water along with removal of micro contaminants increases the pH of water, makes it demineralized whose consumption on daily basis is not appreciable. Mineral rich resin beds can be incorporated in purifiers which can restore the lost or removed water minerals before available to drink and also balance the pH. Hence mineralized water with sufficient minerals fit for drinking would be obtained which is vital for each and every human beings metabolic activity and healthy body. People will no longer have to consume waterless water indeed which our purifying brands are actually providing.

Key Words: Mineralization, calcium ion, magnesium ion, RO, TDS, mineral rich resin bed, mineralized water

1. INTRODUCTION

Drinking water is also known as potable water. It is the water that is safe for drinking and cook food. Water is an inevitable part of human life. Human should consume at least two to three litres of water daily for proper functioning of the body especially the metabolic activities.

Not only food are regarded as source of nutrient but water also because it also contains necessary minerals in them like calcium, magnesium etc. consumption of these minerals through water are vital for a human body. However these minerals are lost when they are subjected to purification process.

The use of water purifiers is increasing day by day due to lack of availability of pure water. Nowadays water is getting contaminated from its source itself due to the carelessness of human being. Pollution is a prime cause of water contamination. In order to get rid of the unwanted

substances and microorganisms, people are relying on water purifiers to get purified drinking water.

The purifiers available in market adopt several techniques to make them free from contamination. RO or reverse osmosis is one such technique which is common in all purifiers which uses a semi-permeable membrane to filter out all the contaminants. Along with the removal of unwanted substances, the vital minerals present in the water are also removed due to the tiny pore size of the membrane. As a result the water from the purifiers is mere clear liquid devoid of essential minerals. Human are consuming actually water less water from the purifiers which can just only quench the thirst but cannot provide necessary supplements to the human body in taking them. Consumption of this kind of water creates several issues such as dehydration, lack of nutrients etc.

Hence it is important to take necessary step as a remedy or to avoid such condition. Therefore purified water has to be mineralized to incorporate all the necessary minerals previously present in water before available for drinking.

1.1 Water purifiers

Water purifiers are the devices which are used to filter and purify drinking water in order to make them free from impurities, contaminants and microorganisms. They adopt several techniques to purify the water which are RO or reverse osmosis, ultra-filtration and nano-filtration techniques.

RO is a process used to purify water which employs semi permeable membrane of pore size ranging approximately 0.0001 micron. It removes almost all the dissolved salts, impurities and purifies water to an extent of 99%. Due to the very small pore size of the membrane even the vital dissolved minerals are being removed. The matter present in water greater than the pore size retains over the membrane whereas the water passes through the membrane.

Nano-filtration is also a purification or filtration technique which adopts membranes with nano pore sizes for filtration. Pore size ranges from 1 to 10 nm, which is just larger than that of RO pore size. In nano-filtration water is actually being softened by retaining minerals such as Ca^{2+} , Mg^{2+} .

Ultra-filtration is a technique where water and low molecular weight constituents present in water passes through the membrane. Whereas the particles greater than that of pore size retains over the membrane. The pore size of the membrane of ultra-filtration ranges 0.1 to 0.01 microns.

Table -1: comparison of RO, UF and NF

Reverse Osmosis	Ultrafiltration	Nano-filtration
Uses electricity	Does not use electricity	Uses electricity
Membrane based	Membrane based	Hollow fiber
Pore dia= 0.0001 micron	Pore dia=0.01 micron	Pore dia=0.001 micron
Minerals not retained	Minerals are retained	Minerals are retained
90% hardness of water removed	Not ideal for hard water	Removes up to 60% hardness of water
A lot of water gets wasted	No water is wasted	Little water is wasted

A conventional water purifier consists of the following parts: A sediment pre filter, carbon pre filter, RO membrane and post carbon filter.

Sediment pre filter acts like a sieve to remove large particles present in water to prevent clogging of RO membrane. Carbon filter is used to remove taste, odour and chlorine too.

RO membrane removes rest of the constituents present in water including vital minerals present in water. It also removes 95% of the TDS.

Post carbon filter is the last most component of the purifier which gives a final touch of purification to the water emerging out of the purifier.

TDS or Total Dissolved Solids is the measure of the all dissolved constituents (organic and inorganic) present in water. It is measured using a TDS meter. When TDS increases, the taste of water began to change and it becomes unfit for use. The acceptable TDS ranges are given below.

Table -2: Quality of water based on TDS level

TDS Level in parts per million(ppm)	Palatability Quotient
Between 50-150	Excellent for drinking
150-250	Good
250-300	Fair
300-500	acceptable
Above 500	Unacceptable

Not all drinking water needs RO process for purification. The purifier and purification technique should be selected based on the TDS of the drinking water.

Table -3: Types of purifier process based on TDS level

TDS Level	Type of water purifier
TDS < 300	UF +UV
900 >TDS > 300	NF + UV
TDS >900	RO

2. METHODOLOGY

Since RO process along with the removal of contaminants and pathogens removes the vital mineral constituents of the drinking water, demineralization of the water occurs. Demineralization refers to the process of removing mineral contents in water. Water naturally contains dissolved mineral. These minerals are being removed along with the contaminants when the water is passed through RO membrane.

Consumption of demineralized water just quenches the thirst, but is not capable to provide the sufficient minerals and hydration to the body. RO purified water is waterless water. Health experts have reported that the longer you drink demineralized waters, the more you are at risk of developing multiple mineral deficiencies and placing your body into an acidic state.

The RO water turns out be acidic on purification. Acidic water is not favourable for human consumption. Human have to consume water of pH ranging 6.5 to 8.5.

Hence in order to overcome the demineralization and acidic problem, the RO purified water could be passed through selective ion membranes of Ca^{2+} and Mg^{2+} in order to restore the calcium and magnesium levels back to the drinking water to restore them to make the water mineralized. When the minerals are incorporated to the water the pH of the water turns slight alkaline which is desirable. Hence passing of water at the final stage at end of all process in the purifier helps to mineralize the water.

Figure given below is the flow diagram of the proposed water purifier which is capable to mineralize the demineralized purified drinking water.

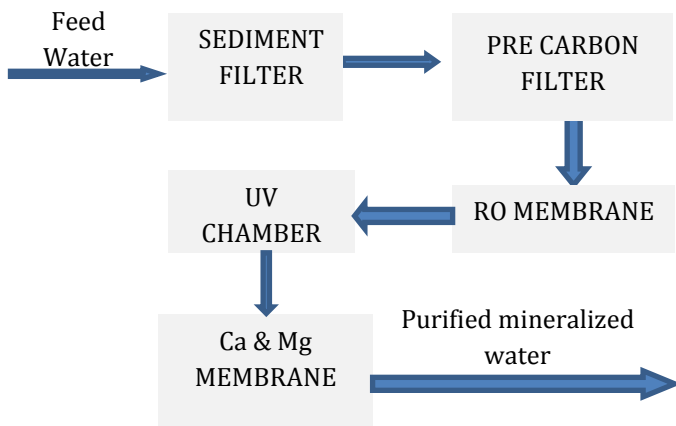


Fig -1: Flow diagram

Following steps were carried out.

1. Water sample collection
2. Test for pH
3. TDS evaluation
4. Test for minerals

Water samples were collected from two different sources. And the sample sources are well and bore well. Most of the bore well water possesses hardness. The water sample collected from bore well did not possess much hardness.

Test for pH are carried out at two stages: before purification and after purification. pH was tested using pH meter. Test for pH is also carried after purification. It is carried out with and without proposed membranes. Test without membrane is carried out to check the presence of Ca and Mg in the purified water to ensure that the minerals are lost during purification. Test for pH after purification is done to prove that the lost minerals can be incorporated into the purified demineralized water if the water is passed through Ca and Mg membranes.

TDS of the samples were valuated using TDS meter .TDS evaluation was done before and after purification. TDS evaluation is a mandatory step to determine the loss of minerals. TDS of our tap water should be checked prior to make decision regarding purchase of a water purifier. TDS of our tap water decides which purification process is required for the purifier.

Test for minerals like Ca²⁺ and Mg²⁺ were carried out at laboratory. Test for minerals were also carried at two stages, before and after purification.

Test for minerals before purification was carried out to detect the presence of natural minerals present in water. Meanwhile test after purification without membranes are carried out to point out the loss of vital minerals from

drinking water due to adaption of purification processes like reverse osmosis which is not needed for all drinking water.

In the test for calcium ions, two ml of water sample is treated with aqueous sodium hydroxide solution. If calcium ions are present a white precipitate would be formed. Add excess aqueous sodium hydroxide solution. If there is no change in the precipitate formed it indicates the presence of calcium otherwise not.

To another two ml of the sample solution add aqueous ammonia solution. If it exhibits no change, it indicates the presence of calcium ions.

In the test of magnesium ions, to few ml of the sample solution add few drops of ammonium hydroxide solution. If white precipitate is formed it indicates the presence of magnesium ions. In order to confirm ammonium carbonate solution is added to few ml of the sample solutions. If white precipitate is formed slowly presence of magnesium ions is confirmed.

3. RESULTS AND DISCUSSION

Various laboratory tests are carried out on different water samples and were repeated before and after purification to understand the variation in parameters like TDS, pH, presence of Ca²⁺ ions and Mg²⁺ ions.

The results for various tests are:

3.1 Test for pH

The below results were obtained when test for pH is carried out on various water samples. It is very clear that purification process makes water acidic which is not good for human health.

Table -3: PH results

Before purification	
Sample 1	7.5
Sample 2	5.5
After purification without membranes	
Sample 1	5.5
Sample 2	4.5
After purification with membranes	
Sample 1	7.5
Sample 2	7

4.2 Test of TDS evaluation

From the below test results it is clear that vital minerals are lost during purification process. And these minerals are incorporated back into the water after installation of mineral membranes in the purifier.

Table -4: TDS results

Before purification	
Sample 1	250
Sample 2	650
After purification without membranes	
Sample 1	200
Sample 2	450
After purification with membranes	
Sample 1	Sample 1
Sample 2	Sample 2

4.3 Test for Ca and Mg ions

In the case of test performed for presence of Ca ion, the result before purification is as:

Sample 1: presence of Ca shown

Sample 2: presence of Ca shown

In the case of purification without membranes, the results were:

Sample 1: absence of Ca ion

Sample 2: absence of Ca ion

When the test was carried after purification with membranes the results were as:

Sample 1: presence of Ca ion

Sample 2: presence of Ca ion

In the case of test performed for presence of Mg ion, the result before purification is as:

Sample 1: presence of Mg shown

Sample 2: presence of Mg shown

In the case of purification without membranes, the results were:

Sample 1: absence of Mg ion

Sample 2: absence of Mg ion

When the test was carried after purification with membranes the results were as:

Sample 1: presence of Mg ion

Sample 2: presence of Mg ion

From the above tests it is easy to conclude that all the necessary vital minerals like Ca and Mg are being removed during the purification process in purifiers especially when reverse osmosis process is adopted. The lost minerals can be incorporated when the demineralized purified water is passed through Ca and Mg membranes. The water passing through these membranes will absorb the minerals which help to restore the lost minerals.

4. CONCLUSION

Water purifiers have become a vital part in our daily life. Over dependence on purifiers is mainly due to the over contamination of our water sources by various means especially due to human activities. In order to make the water fit for drinking, it has to be purified. Water purifiers available in markets employ several methods to purify water. Reverse osmosis process is a common method adopted to eliminate contaminants and impurities. It has an efficiency of 90%. Other techniques used for purification are nano-filtration and ultra-filtration technique along with ultra violet radiation disinfection.

But along with removal of contaminants and impurities, necessary minerals present in water also get eliminated. This is due to the tiny pore size of the membranes used for RO technique. Due to the removal of vital minerals, we obtain demineralized water as an output of purifier. This is undesirable because demineralized water has no benefit on health and at the same time causes dehydration issues.

In order to overcome this obstacle, the purifier can be installed with ion membranes that can incorporate lost calcium and magnesium ions to the water so that the output of purifier would be alkaline mineralized water which not only quenches the thirst but also provide sufficient minerals and hydration to human body.

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