

Water Purifiers *for* *Drinking Water*



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Water Purifiers for Drinking Water

Water is important for hydration and, consequently, for life. It is also essential in food preparation and cooking, sanitation and hygiene and for different uses. The safe drinking water must be free from all hazardous materials and contaminant. Nature has provided enough drinking water resources for living organisms through rain, springs, rivers, lakes/ponds and subsurface resources. However, due to non availability of safe drinking water at all places and limited drinking water supply, people started opting commercial products for treating their water supply at domestic and community level without knowing much about its technologies adopted in these commercial products and assuming that the treated water from these products are a symbol for high purity potable water. Different chemicals such as pesticides, disinfection by product are the subject of interest while some other constituents are out of focus. There are certain elements which play an important role in human health, representing essential elements for human body activities. Calcium and magnesium are major representatives of these types of constituents.

With more and more citizens becoming aware of the hazards of drinking contaminated water from anthropogenic sources, the demand for effective water purifiers is growing enormously. The majority of intestinal disorders and infections are caused by water borne micro organisms. As a result, the number of consumers looking for reliable purification options is increasing not only in the metros but also in the towns and even in rural areas across India. The water supplies may contain both biological and chemical contaminants. Biologically contaminated water contains microbes such as viruses, which may result in minor to serious infections, and bacteria that lead to stomach disorders. Common causes of chemical contamination are inadequate treatment of industrial/municipal waste and pesticide/fertilizer overuse in the fields. If chemically contaminated water is used regularly it could lead to serious long term ailments.

Boiling is one of the oldest and proven methods for purifying water by killing most of the microorganisms. Filtration process is being used since old time by Jains as their religious preachers advise use of cotton cloth filter for removing germs from water. Candle water filters are still used in many households across India. How does one choose from the plethora of technologies and brands now available in India? Which water purification system would be best for you? The common parameters of selection are degree of purification, maintenance

cost and product price. Different technologies deliver differing degrees of purity.

The National Green Tribunal (NGT) on May 28, 2019, instructed the Union Ministry of Environment, Forest and Climate Change (MoEF & CC) to notify prohibiting the use of drinking water processed through RO systems in areas where the amount of total dissolved solids (TDS) was less than 500 mg/L. The purpose of this brochure is to create public awareness on these water purification technologies for choosing the best for their safe drinking water needs.

Drinking Water Specifications

The Bureau of Indian Standards (BIS) has laid down the standard specifications for drinking water (BIS, 2012). In order to enable the users, exercise their discretion towards water quality criteria, the maximum permissible limit has been prescribed especially where no alternate sources are available. The important water quality characteristics for drinking purpose as laid down in BIS Standard are given in Table 1.

Water Purifiers

Different types of domestic water purifiers based on different techniques are available in market. Water purifiers range from simple water filters to advanced purifiers using membrane technology for water filtration followed by disinfection with UV lamp filters. Here we will discuss the common water purification methods used for filtering domestic water.

Candle Filter

Water purifiers with candle type filter have a simple operating mechanism. The candle has very minute pores, generally less than 3 μm . Any particle which has the size larger than the pores gets blocked out and cannot pass on to the clean side. The candle filter is suitable for removing the suspended solids. It does not require any electricity for operation. However, these filters are not suitable for the removal of soluble contaminants like arsenic, fluoride, etc. as well as the bacteria and so water still needs to be boiled before consumption. Also the candle needs to be cleaned up frequently for effective operations. In addition, filtration of drinking water through these candle filters require time, due to which mechanized water purification systems have become more popular and are often considered more reliable.

Table 1. Drinking Water Specifications (BIS, IS: 10500, 2012)

S. No	Characteristics	Acceptable limit	Permissible limit
1.	Colour, Hazen units, Max	5	15
2.	Odour	Agreeable	Agreeable
3.	Taste	Agreeable	Agreeable
4.	Turbidity, NTU, Max	1	5
5.	pH value	6.5 to 8.5	-
6.	Total hardness (CaCO ₃), mg/L, Max	200	600
7.	Iron (as Fe), mg/L, Max	0.3	-
8.	Chlorides, mg/L, Max	250	1000
9.	Free residual chlorine, mg/L, Min	0.2	-
10.	Dissolved solids, mg/L, Max	500	2000
11.	Calcium, mg/L, Max	75	200
12.	Magnesium, mg/L, Max	30	100
13.	Copper, mg/L, Max	0.05	1.5
14.	Manganese, mg/L, Max	0.1	0.3
15.	Sulphate, mg/L, Max	200	400
16.	Nitrate (as NO ₃), mg/L, Max	45	-
17.	Fluoride, mg/L, Max	1.0	1.5
18.	Phenolic compounds, mg/L, Max	0.001	0.002
19.	Mercury, mg/L, Max	0.001	-
20.	Cadmium, mg/L, Max	0.003	-
21.	Selenium, mg/L, Max	0.01	-
22.	Total arsenic (as As), mg/L, Max	0.01	0.05
23.	Cyanide, mg/L, Max	0.05	-
24.	Lead, mg/L, Max	0.01	-
25.	Nickel, mg/L, Max	0.02	-
26.	Anionic detergents	0.2	1.0
27.	Total chromium (as Cr), mg/L, Max	0.05	-
28.	PAH, mg/L, Max	0.0005	-
29.	Mineral oil, mg/L, Max	0.5	-
30.	Total alkalinity, mg/L, Max	200	600
31.	Aluminium, mg/L, Max	0.03	0.2
32.	Boron, mg/L, Max	0.5	1.0

Pesticide Residue Limit (µg/L)		
33.	Alachlor	20
34.	Atrazine	2
35.	Aldrin/Dieldrin	0.03
36.	Alpha HCH	0.01
37.	Beta HCH	0.04
38.	Butachlor	125
39.	Chlorpyrifos	30
40.	Delta HCH	0.04
41.	2,4-Dichlorophenoxyacetic acid	30
42.	DDT (o,p and p,p -Isomers of DDT, DDE and DDD)	1
43.	Endosulfan (alpha, beta and sulphate)	0.4
44.	Ethion	3
45.	Gamma- HCH (Lindane)	2
46.	Isoproturon	9
47.	Malathion	190
49.	Methyl parathion	0.3
50.	Monocrotophos	1
51.	Phorate	2

Activated carbon filter

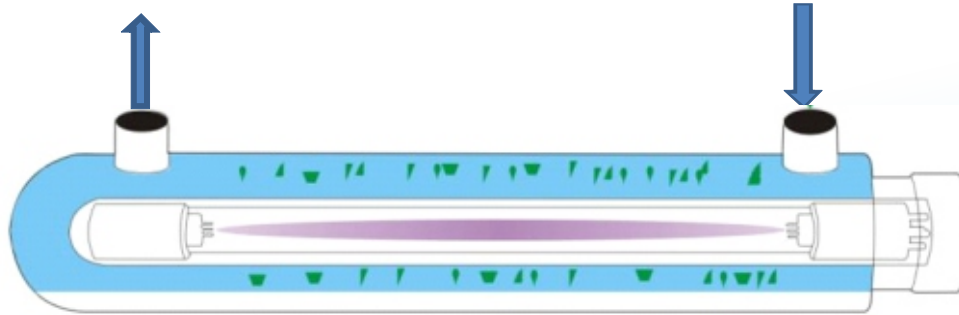
This water filter uses activated carbon filters for purification process. The carbon filters can remove chemicals like chlorine, pesticides and impurities to a great extent. The filtration changes the taste and odour of water. It does not require electricity for operation. But it is also not very effective in removing microbes from water. In addition, the conventional carbon filters are a breeding ground for the microbes and therefore, nano-silver coated carbon is now being used by most of the commercial filter suppliers.

UV purification or e-boiling

UV (Ultra Violet) water purification uses ultra-violet light to inactivate all germs, bacteria, microbes, cysts, etc. in water. Ultraviolet water purification is a simple but effective process that destroys around 99.99% of the harmful organisms in water. There is a tiny mercury lamp inside the purifier that produces short wave UV radiations. These radiations irradiate the water and penetrate the cells of bacteria and viruses, destroying their ability to reproduce. The microbes and organisms fail to multiply and eventually die. This purification

Disinfected water free from bacteria & viruses

Infected water containing bacteria & viruses

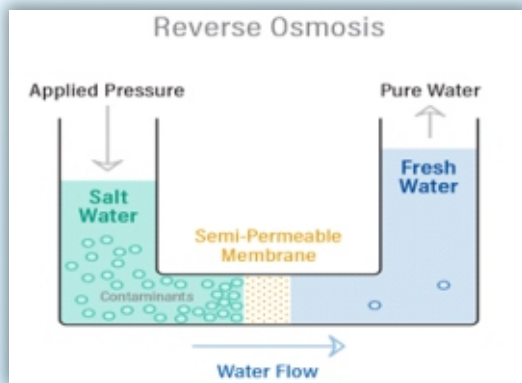


UV Purifier

method only inactivates the germs but the bodies of the inactivated germs remain in the water. Separate filters are required to remove the germs physically. UV water purification is usually done in conjunction with other forms of filtration such as reverse osmosis or activated carbon filters.

RO purification

Reverse osmosis (RO) is the most widely used water purification method. RO uses membrane technology to remove dissolved salts, impurities and germs from water. The semipermeable membrane (SPM) separates germs and dissolved chemicals from water.



In reverse osmosis, an external excess pressure is applied and the larger particles or the impurities are retained on the pressurized side of the membrane and the pure water is allowed to pass through. The RO membrane has a pore size range of 0.0001-0.001 μm that allows only water to pass through it leaving behind all the harmful chemical, dissolved salts and microbes suspended in water. Thus, the ions and particles larger than the pore size of RO membranes are removed from the water

UF purification

UF (Ultra-filtration) purification method uses membrane

similar to RO membranes but with bigger pores (0.01-0.1 μm). UF membrane acts as a physical barrier to all colloidal impurities including most pathogenic organisms and turbidity but fail to remove the dissolved solids and salts. Ultra-filtration membrane based water purifiers should be preferred to RO based purifiers when the water to be treated is having TDS less than 500 mg/L.

A Typical RO System

A typical RO system consists of i) a Sediment Pre-filter to remove sediment and dust particle by a micro-filter (usually 5 microns), ii) Activated Carbon filter for removing chlorine and odour by trapping organic compounds and other volatile substances, iii) RO/UF membrane removes dissolved particles, ions and some minerals and sometimes are fitted with extra cartridges (TDS Controller) which add back minerals thus making it potable, iv) UV Filter that kills harmful bacteria and virus in the water, v) Post Carbon filter, which further enhances the taste of the water and removes any odour if present, vi) Storage Tank to store the final treated water.



Typical RO System

Comparison of different purifiers is given in Table 2:

Table 2. Comparison of different purifiers

S. No	Name of the purifier	Function
1.	Candle filter	Can remove particles size larger than 3 µm.
2.	Activated carbon filter	Can remove chlorine, pesticides and impurities
3.	UV purification or e-boiling	Can inactivate all germs, bacteria, microbes, cysts, etc. in water.
4.	RO purification	Can remove dissolved salts, impurities and germs from water.
5.	UF purification	Can remove pathogenic organisms and turbidity but fail to remove the dissolved solids and salts.

Water Purifier Market in India

There is a big market of water purifier in India and a long list of vendors exists. Major vendors include Eureka Forbes, Zero-B, Aquagaurd, Kent, Havells, Tataswach, Livpure, Pureit, Philips, Hindustan Unilever, Whirlpool, Bluestar, AO Smith etc. Prices range from Rs.2500 to Rs. 50000 depending upon the technology used for purification. Domestic water purifiers available in the market usually use chemical disinfection, ultraviolet disinfection, media/cartridge filtration, reverse osmosis and a combination of these technologies. There is much confusion about these filters and most often the general public is misguided by the vendor claims. As a result, RO based water purifiers have mushroomed in the market as people think that only RO based purifier ensures safe drinking water, which is true to some extent but RO purifiers are not advisable for all types of waters.

In the present brochure, the function of RO, its merits and demerits and its need of hour have been discussed by analyzing the sample collected from inlet, outlet and reject from different brands of RO available in the market.

Performance Evaluation of Different RO Purifiers

Water samples were collected from Inlet, Outlet and Reject from three RO purifier of different brand and analysed for physico-chemical parameters on Ion Chromatograph and the results are summarised in Table 3. From the analysis, it is evident that the TDS of treated water from the purifier reduced to less than 50 mg/L i.e. 10% of Inlet to the RO Purifier in first two case I and II and in case III, the TDS reduced to 112 mg/L i.e. 20% of Inlet to the Purifier.

Table 3. Results of Physico-chemical Analysis of Water from Different RO Purifiers

Case I - RO Purifier: Brand 1				
SNo	Parameters	Inlet	Outlet	Reject
1.	pH	7.3	6.0	7.5
2.	EC (µS/cm)	948	69	1221
3.	TDS (mg/L)	607	44	781
4.	Alkalinity (mg/L)	403	36	534
5.	Hardness (mg/L)	378	22	503
6.	Sodium (mg/L)	43	9.4	55
7.	Potassium (mg/L)	6.1	2.5	8.5
8.	Calcium (mg/L)	104	6.1	140
9.	Magnesium (mg/L)	28.6	1.7	37.3
10.	Chloride (mg/L)	41.3	6.9	57.6
11.	Sulphate (mg/L)	17.9	1.0	22.9
12.	Nitrate (mg/L)	0.08	0.05	0.6
13.	Fluoride (mg/L)	0.40	0.36	1.64

Case II - RO Purifier: Brand 2				
S. No.	Parameters	Inlet	Outlet	Reject
1.	pH	8.3	7.5	8.3
2.	EC (µS/cm)	482	63	620
3.	TDS (mg/L)	309	40	397
4.	Alkalinity (mg/L)	270	95	344
5.	Hardness (mg/L)	188	59	214
6.	Sodium (mg/L)	39.6	13.5	45.5
7.	Potassium (mg/L)	3.1	1.1	3.8
8.	Calcium (mg/L)	46.7	14.6	51.9
9.	Magnesium (mg/L)	17.5	5.4	20.6
10.	Chloride (mg/L)	0.92	0.84	1.7
11.	Sulphate (mg/L)	2.9	1.1	3.3
12.	Nitrate (mg/L)	0.09	0.01	0.9
13.	Fluoride (mg/L)	0.21	0.07	0.23

Case III - RO Purifier: Brand 3				
S. No.	Parameters	Inlet	Outlet	Reject
1.	pH	8.0	7.3	7.8
2.	EC (µS/cm)	830	175	1027
3.	TDS (mg/L)	531	112	664
4.	Alkalinity (mg/L)	447	105	555
5.	Hardness (mg/L)	370	60	416
6.	Sodium (mg/L)	43.8	14.1	46.0
7.	Potassium (mg/L)	4.3	1.2	4.1
8.	Calcium (mg/L)	91.8	17.1	102.9
9.	Magnesium (mg/L)	34.3	4.3	38.7
10.	Chloride (mg/L)	4.6	1.2	4.2
11.	Sulphate (mg/L)	9.2	0.25	10.5
12.	Nitrate (mg/L)	0.06	0.01	0.14
13.	Fluoride (mg/L)	0.08	0.04	0.25

Total dissolved solid (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in water. A cartridge (micron) filter generally removes particles that are more than 0.45 microns in size. The contaminants left after filtration are dissolved ions and molecules. Moderate to high TDS in water not only changes the taste of water but also poses a lot of health hazards. One of the important factors that one needs to consider when looking for a water purifier is the TDS level. Depending on the TDS level, the configuration and need for a RO membrane in a water purifier should be decided. However, TDS is always not the driving factor but other contaminants also play a critical role. The principal constituents of TDS are usually calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate, Silica, and nitrate. BIS (2012) has prescribed the acceptable limit of TDS as 500 mg/L and maximum permissible limit as 2000 mg/L in absence of an alternate source for drinking purpose.

Calcium and magnesium are essential minerals supplemented through drinking water. As per BIS (2012), acceptable limit of calcium and magnesium has been prescribed as 75 mg/L and 30 mg/L respectively while maximum permissible limit as 200 mg/L and 100 mg/L respectively for drinking purpose. Enamel in teeth contains calcium, magnesium, and phosphate compounds and therefore the low level of these constituents will make teeth susceptible to decay induced by acid-producing bacteria. Magnesium deficiency linked to cause several medical issues, such as high blood pressure, irregular heartbeat and diseases, the blood vessels and pre-eclampsia in pregnant women and diabetes type II and osteoporosis.

Advantage of RO Purifiers

- RO Purifier is advisable in the areas where the quality of water is hard and it has high TDS.
- RO Purifier can remove bacteria, viruses, Fluoride, Iron, Arsenic or other metals and pesticide residues.

Disadvantage of RO Purifiers

- The main drawback of RO is that it alters the taste of water by reducing its TDS and essential minerals.
- Calcium and magnesium levels are also reduced after passing through RO Purifier to such level, which are not acceptable. Researchers have published and reported the effect of low intake of calcium and magnesium of human health and activities. They also reported the effect of low calcium and magnesium concentration in the water for the people who drink very soft water. There are certain brands of RO which claim to retain the essential minerals in water.

- The semipermeable membrane requires regular care and maintenance. Further, it requires electricity to operate and increase the operating cost.
- In most of the RO based domestic water purifiers, for every unit of raw water, only about 25% is obtained as treated water and 75% is wasted as reject.
- However, few brands like Zero-B, Kent, AO Smith etc. are coming up with innovative ideas for high recovery products with recovery up to 70%. NGT also asked the ministry to lay down a requirement for RO systems manufacturers that the recovery of treated water is at least 60 per cent and not more than 40 per cent should go as waste. Gradually, the recovery rate should be enhanced to 75 per cent. Therefore, use of RO Purifier is not justified from water conservation point of view also as huge quantity of water is wasted in this process.
- The results of analysis of reject water from RO Purifier indicate that TDS and other constituents also increased compared to Inlet water. If the reject water containing high TDS and higher values of other constituents is disposed on the surface soil, it enters into subsurface soil by infiltration and also pollutes the ground water.

RECOMMENDATIONS

- Physico-chemical analysis of water from different RO purifiers reveals that TDS and essential minerals, calcium and magnesium of water are reduced after passing through RO Purifier, i.e. RO treatment gives demineralized water.
- There is a need of RO purifier mostly in hard water from some surface sources and many groundwater sources.
- RO generates lot of waste water which can be collected and used for plants, gardening, non soap washing such as floor cleaning, car washing etc.
- For most of the surface water sources, a combination of candle, activated carbon and UV filter is enough.

When we should go for RO Purifiers

RO Purifier is helpful in those areas where TDS level is more than 500 mg/L or some specific water pollution problem viz; Fluoride, Iron, Arsenic or other metal problems and pesticide contamination have been detected. RO water can be used for drinking purpose if it has automatic TDS controller/Mineral Stabilizer system, which will supplement all essential minerals.

When we should not go for RO Purifiers

RO Purifier is not highly recommended in those areas where TDS level is equal to or less than 500 mg/L until unless there is some specific water pollution problem, viz., Fluoride, Iron, Arsenic or other metal problems and pesticide contamination.

Frequently Asked Questions (FAQ) about Water Quality

S. No.	Question	Answer
1.	What is physical characteristic of drinking water?	Drinking water should be colourless, odourless and tasteless.
2.	What is hardness and how to remove from water?	Water's hardness is determined by the concentration of multivalent cations in the water. Common cations found in hard water include calcium and magnesium. Hardness may be of two types: Temporary hardness and Permanent hardness. Temporary hardness is a type of water hardness caused by the presence of dissolved bicarbonate minerals (calcium bicarbonate & magnesium bicarbonate) and can be removed just boiling of water while Permanent hardness caused by the presence of calcium sulphate/calcium chloride and / or magnesium sulphate / magnesium chloride in the water (mineral content) and is generally difficult to remove just by boiling but can be removed using a water softener, or ion exchange column.
3.	How to remove the colour and smell from water?	If coloured water is passed through charcoal powder, colour and smell are removed.
4.	What is cause behind water having light yellow colour?	If water is light yellow in colour then there may be possibility of iron problem or bacterial contamination in the water. Bacterial contamination can be removed to some extent just by boiling.
5.	What is cause if water turns light yellow in colour after drawing it from underground and keeping in open?	If water turns light yellow in colour after drawing from underground and keeping in open, there is a possibility of iron problem because iron gives yellow colour after it is exposed to air.
6.	What is alkaline water?	Normal drinking water generally has a neutral pH of 7. Alkaline water typically has a pH of 8 or 9. Alkaline water must also contain alkaline minerals and negative oxidation reduction potential (ORP). ORP is the ability of water to act as a pro- or antioxidant. Alkaline water may occur naturally passing over the rocks or may be produced artificially through the process of electrolysis
7.	What is recommended pH level of drinking water?	As per BIS (2012), IS:10500 for drinking purpose, pH level of drinking water should be between 6.5 and 8.5.
8.	What is carbonated water?	Carbonated water is water containing dissolved carbon dioxide gas, either artificially injected under pressure or occurring due to natural geological processes



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