WATER QUALITY AND CONSERVATION - THE INDIA SCENARIO

Note from WQA India

Let's understand our basics. India is a diverse nation, both from a cultural and a geographical perspective. There is a saying: *"vaani aur paani har 100 km mein badalta hai"* which when literally translated means that in India, there is a difference in language and quality of water every 100 kms. India also has the distinction of having 16% of the world's population, and only 4% of the planet's freshwater resources. In terms of quality of water supplied to its citizens, India ranks poorly. 38 million Indians suffer from water borne diseases annually – resulting in 4, 54, 367 deaths , that too mostly infants and children.

The water Quality Association of India (WQA India) is a not for profit, dedicated to the improvement of water quality in India. An apex body of manufacturers, dealers and component suppliers of drinking water systems, WQA India has the twin objectives of improvement in standards of water purification devices, and generating awareness of water quality. In a first of its kind, WQA India has introduced a Microbiological Standard for drinking water treatment devices which denotes that a water purification device having the SEAL OF PURITY is tested to rigorous standards and is capable of removing microbiological impurities which cause dangerous waterborne diseases.

This booklet is an attempt to educate consumers about water quality, different methods of purification, the need to conserve water and emerging trends such as recycling and reuse of wastewater.

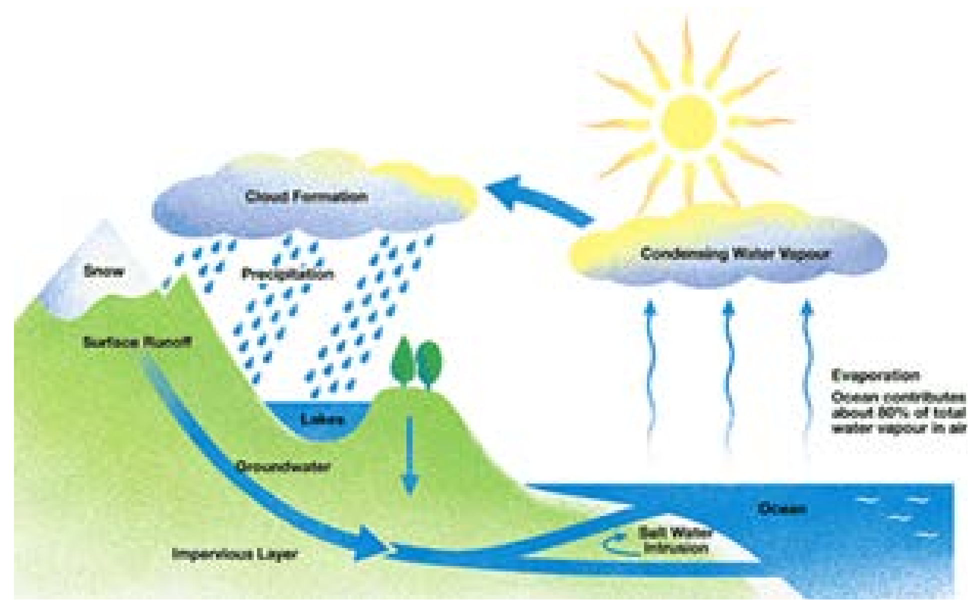
We hope that you find the information useful.

WQA India

Contents

Water Cycle

- In general over 97% of the world's water is in its oceans but sea water is not usable without extensive treatment. Water desalination is not affordable for drinking water.
- The remaining 3% which is fresh water is not evenly distributed and often inaccessible.
- Two –thirds of the world's fresh water is tied up in the polar ice caps and glaciers; the remaining one-third is in ground water, surface water, and the atmosphere and soil moisture. The only two sources of water supply available to man are ground waters- wells (open & bore) and springs, and surface water –lakes, rivers, streams and reservoirs, which is 1% of the total water available.
- The water cycle, also known as the hydrological cycle or the H2O cycle, describes the continuous movement of water on, above and below the surface of the Earth. The mass of water on Earth remains fairly constant over time but the partitioning of the water into the major reservoirs of ice, fresh water, saline water and atmospheric water is variable depending on a wide range of climatic variables.
- The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. In doing so, the water goes through different phases: liquid, solid (ice), and gas (vapor). The water cycle is also essential for the maintenance of most life and ecosystems on the planet.



The Water Cycle

Water Quality

- In providing the right water for any demand one must consider both a precise analysis of the raw water supply and the end use of the water.
- Analysis of water can show the existence and amount of sediment, color, taste and odor - (Physical Impurities), dissolved minerals gases , organic and inorganic matters - (Chemical Impurities), and microorganisms-(Microbiological Impurities).
- Whether any of these impurities could be harmful or undesirable depends on:
  - The nature and amount of the impurities
  - The tolerance permissible for each of these impurities.
  - To what use the water will be put.
- Both the quality of raw water and its end use must always be determined before it can be treated economically.
- It is almost impossible to find a source of water that will meet basic requirements for potable purposes (safe for human consumption) without requiring some form of treatment.
- Generally these requirements are that it be free of disease producing organisms, that it be colorless, clear, odorless and good tasting, that it be non-corrosive and free of objectionable gases and staining minerals, and that it be plentiful and low in cost.
- There are tremendous variations in the quality of water depending upon source, geography and season (time) of the year. In some cases there are variations in quality even on a day to day basis.
- A given quality of water that is unacceptable for one function may prove satisfactory for another.

Surface Water

- Surface water is a term that refers to sources like lakes, ponds, rivers, sea.
- Normally when water reaches the earth, it is slightly acidic, corrosive and relatively soft.
- Surface waters contain many impurities such as silt, sand and clay –which give them a muddy or cloudy appearance.
- Surface waters are relatively low in mineral content, but normally possess a high degree of physical & microbiological contamination, and may require treatment to make them potable.

Ground Water

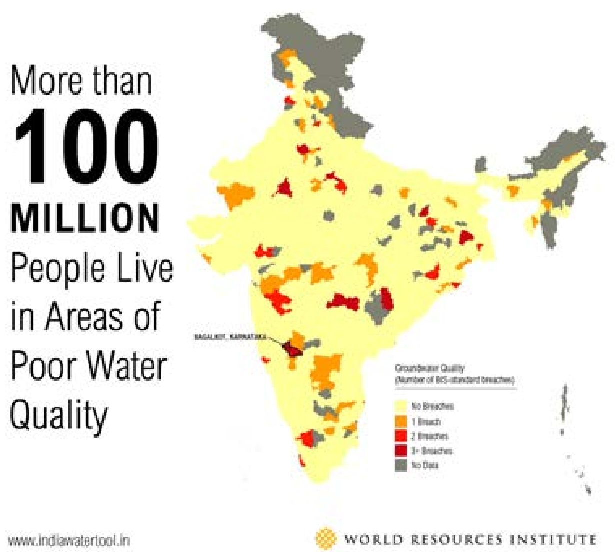
- Water must travel through various strata before becoming groundwater.
- Below the surface it moves first through the subsoil, the intermediate layer, the capillary fringe, and finally into the ground water bed.
- Ground water supplies are usually higher in mineral content than surface waters in the same area.
- The nature and kinds of impurities vary widely in different sections of the country as the rocks and sand in the soil consists of many kinds of minerals and chemical substances.
- Usually, shallow wells will not contain as high an amount of hardness and other dissolved materials as deep wells.
- Groundwater from deep wells typically contains high concentrations of dissolved minerals like Calcium, iron, etc. It is usually clear and colorless due to filtration through rock and sand. Many ground waters are contaminated with disease causing minerals like fluoride, arsenic, nitrate also.
- Springs provide another source of ground water. It's a popular belief that spring waters are clear, sparkling and absolutely pure. In reality spring waters may contain large amounts of mineral matter and often show a marked degree of turbidity.

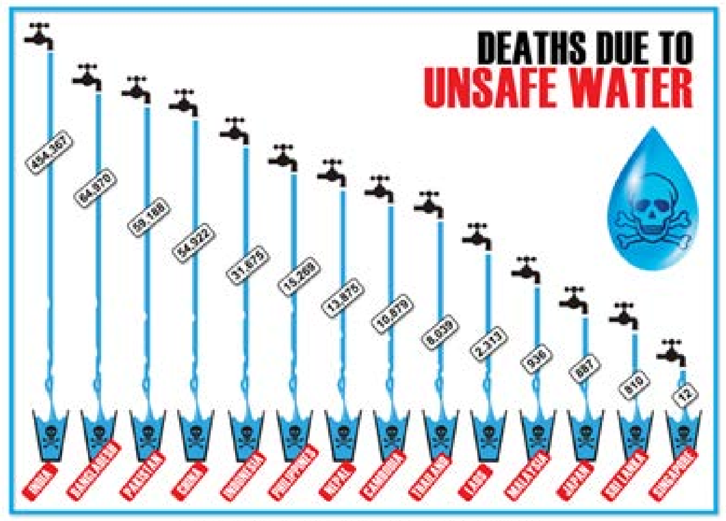
Water Quality Issues in India

- It is estimated that about 70% of India's groundwater is contaminated. Dumping of untreated sewage into water bodies which ultimately seep into surrounding areas, discharge of industrial effluents directly into the ground, and overuse of pesticides in agriculture, have been responsible for groundwater contamination. Over exploitation of ground water to meet the demands of agriculture, industry and consumption outside city limits have lowered the water tables to critically low levels. With falling water tables, contaminants and salts dissolved in water (TDS) reach high levels of concentration. Contaminants in groundwater include but are not restricted to chemical contaminants which include naturally occurring organic chemicals, salts, metals, pesticides etc. Excess fluoride, arsenic, nitrate and iron levels in groundwater which can spell disaster on the human body with long term usage are typical problems faced in some parts of our country.
- Surface waters are found in reservoirs, lakes, ponds and rivers and is essentially rain water. Surface waters are naturally soft and contain very few dissolved impurities. Here again, the problem begins with source contamination, which is the start of the problem. Discharge of sewage and industrial effluents into water bodies cause serious contamination. (It is estimated that 90% of wastewater in developing countries is discharged into rivers and water bodies without treatment.) Surface waters become the feed for treatment plants operated by civic authorities (municipalities). This water is pumped to the treatment plant. Post treatment, water is distributed via pipelines to residents within defined urban areas. Water is supplied intermittently in most cities. Ageing pipelines run parallel to sewage lines. This intermittent supply creates a vacuum in unpressurized water pipes, allowing for contaminants from the sewage lines to be sucked into the drinking water lines, many of them riddled with leaks. Most of these impurities are pathogenic (harmful) in nature, mostly bacteria and viruses which cause serious water borne diseases like typhoid, cholera, jaundice, gastroenteritis and diarrhoea especially during periods of heavy contamination (eg.in floods) leading to outbreaks of epidemics.

What Does This Mean?

What this means is that both groundwater and surface water are often contaminated beyond permissible limits. Groundwater may contain more than the permissible TDS and municipal supplies may get re-contaminated during distribution and storage. The level of microorganisms may again exceed permissible levels.

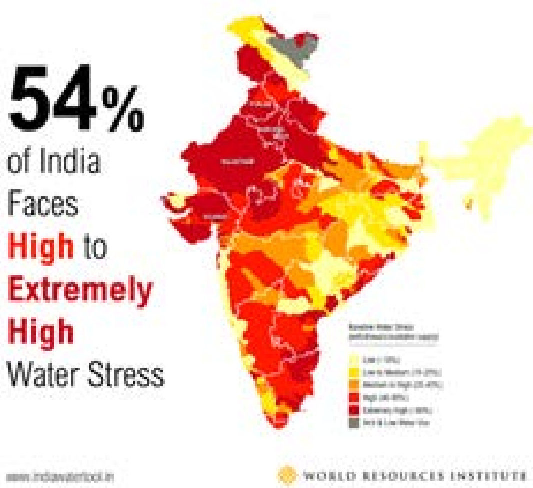




(SOURCE: WORLD HEALTH ORGANIZATION REPORT, 2010)

What Needs To Be Done?

- For protecting water bodies and groundwater, it is imperative that sewage & effluents be treated before discharge into water bodies.
- Treat water at the point of use before consumption after considering available treatment options



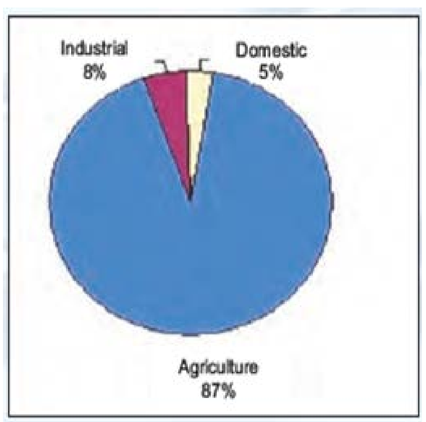


Figure 3: Water Use Pattern of India

Conservation Of Water

Even though 70% of the Earth is covered by water, only 1% is available for use. In the last 40 years, the world's population has doubled, and the demand for water has gone up 4 times. In developing countries, 8 in 9 people lack access to clean water. Going by current trends, by 2025 there will be 1.8 billion people who will be without access to this basic need. There is therefore an immediate need to conserve

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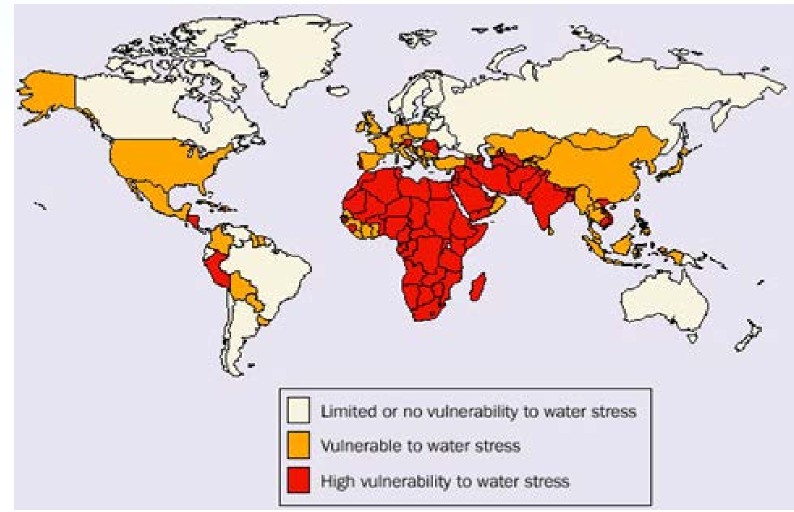
Source: Stockholm Environment Institute World map showing countries vulnerability to water stress projected for the year 2025



Methods To Conserve Water

- Rain Water Harvesting- A simple technique used for centuries to collect rain water for later usage in tanks & reservoirs.
- Drip Irrigation in agriculture sector
- Conservation of ground water by building sub surface bunds and watershed management
- Treatment, Recycle & Reuse of grey water and wastewater by appropriate treatment technologies like advanced and affordable Biological Membrane Processes
- Use of gadgets which are water saving: eg waterless urinals, efficient flush tanks, sensor controlled faucets, low flow showers
- Fixing leaks and wastage-both in domestic sector as well as in public distribution systems
- Desalination plants to convert sea water to fresh water using advanced desalination technology.

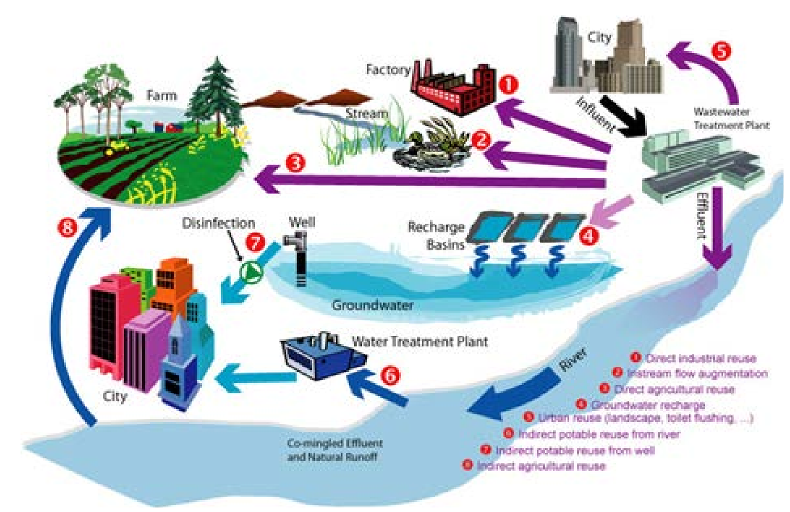


Figure: The purple arrows represent uses of recycled water (also known as grey - sullage/black – sullage water) and the blue arrows represent "new" water.

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Technologies Available For Water Purification

Filtration, Ion Exchange Membrane, Separation and Disinfection are 4 broad categories of technologies available to purify water. Within Membrane Separation process there are technologies classified as micro-filtration, ultrafiltration, nano filtration and reverse osmosis which separate contaminants by size. Under disinfection there are technologies like UV, ozonation, chlorination and advanced hydroxyl treatment.
Depending on the water quality, filtration, separation (membrane) and disinfection technologies are used together or in different combination depending upon quality of water to be treated for potable purposes.
Reverse Osmosis (RO) is an effective way to treat water with higher than permissible levels of TDS, pesticides and other chemical contaminants such as excess fluoride, arsenic and nitrate. A high TDS level is normally associated with hardness and an undesirable taste. In many cases, the main driver of RO usage is the noticeable change in taste post treatment by RO. RO treated water has a pleasant taste, akin to bottled water.
For surface water with low TDS and suspended solids, coarse filtration followed by and disinfection technologies is sufficient to make the water potable.

Popular technologies to purify drinking water at home include UV, UF, RO and Chemical Disinfection and combinations thereof based on quality of water available at source.

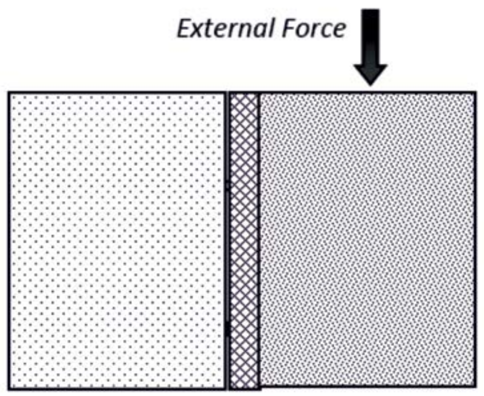
RO Technology for Water Purification

Boon for the Right Places & Bane for the Wrong Places
Any untreated/natural water is known to contain contaminants classified under Physical, Chemical and Biological categories. Physical contaminants include visible contaminants like mud/dirt, sediment or suspended materials. Chemical contaminants include naturally occurring organic chemicals, salts, metals, pesticides etc. Biological contaminants include microbes like bacteria, viruses and parasites (cysts). Physical contaminants can be removed largely using basic pre-filtration techniques commonly used in many water purifiers. Biological contaminants can be removed using various technologies like UV, Ozonation, Ultrafiltration, Biocidal resins and allied materials. However, a key challenge is removing the dissolved chemicals/solids due to its size and complex nature. While activated carbon can remove some organic chemicals and chlorine, it cannot remove heavy metals and pesticides effectively. **This is where RO enters the picture. Reverse Osmosis (RO) is a membrane separation process in which the water is passed under high pressure through a semi-permeable membrane. This process removes excess TDS (Total Dissolved Solids), chemical contaminants like Nitrate, Fluoride, Arsenic, other heavy metals & Pesticides from water to make it safe for drinking. About 20-30% of purified water is achieved and 70-80% water with high contaminant concentration is drained ('reject' or 'waste' water).

RO cannot be universally applicable for all water types due to key technology limitations. Since RO works on very tiny pore-sized membranes molecularly separating out dissolved chemical contaminants, it cannot, by design, discriminate between so-called 'good' and 'bad' chemicals. Therefore, it is essential to use RO technology only for waters where the resulting benefits exceed its limitations.

RO is a preferred technology in the following areas where safety and other benefits take precedence over water wastage:

- Water with TDS (Total Dissolved Solids) more than 500 mg/L. As per government norms, the maximum acceptable limit for TDS in potable water is 500 mg/L and for Hardness (Calcium + Magnesium), it is 200 mg/L.
- In today's world due to deterioration of fresh water sources and colossal increase in population, usage for groundwater high in dissolved solids has unfortunately become more common. Many people complain of 'heaviness' or 'salinity' in the water when TDS exceeds 500 mg/L or when hardness exceeds 200 mg/L. To make this water potable as per the government norms, and to achieve acceptable taste, RO usage is vital.
- Long-term consumption of such high TDS water can result in excess mineral agglomeration in kidneys, leading to 'kidney stones', which is an acute health issue.
- Additionally, due to anthropogenic activities, we find high levels of heavy metals like lead, arsenic and other contaminants in the input water that must be removed by RO in a household application to render safe drinking water. Other technologies (like UV or boiling or resin-based) cannot remove these heavy metals to acceptable global standards. Ion Exchange processes are used extensively for heavy metal removal (iron, arsenic, fluoride, nitrate) and also trace uranium beyond permissible limits for drinking in several ground waters.



Areas where RO benefits are marginal compared to water wastage:

- Water below 500 mg/L TDS, more specifically below 200 mg/L TDS, when subjected to RO treatment leads to potable water with very low mineral content, which could deplete essential minerals for the body in long run . However, it must be pointed out that water is not the main source of minerals or nutrients for a human being – food is. More than mineral depletion, the strongest reason why RO should be avoided in low TDS areas is to avoid waste of water as 70-80% of water is drained when RO is used. For waters between 200-500 mg/L, which can be a transition range where taste and/or health factors can influence a purchase decision, both RO and other treatment technologies can be used as individual taste preferences and household conditions also matter. Here, the responsible choice may be to avoid RO because many consumers may still find water acceptable in taste to have upto 500 mg/L TDS, unless specific medical conditions (such as diagnosis of kidney stones) exists in a household, which will necessitate use of RO even in 200-500 mg/L cases.

Thus it is essential to use RO technology in appropriate water conditions rather than use it indiscriminately. The end-consumer must be made aware of both the positives and limitations of RO technology and availability of alternate water purification processes and must be educated to use, as per their household requirements, preferences and quality of input water.

**Activated carbon blocks are generally used for odor removal. For other specific contaminants other adsorbents may be chosen as an alternate to RO.

Note:

1. Commercial water purifiers are available with membranes that give up to 65 – 70% recovery
2. Newer RO membranes with recoveries >50% are sometimes used in TDS levels under 200 to limit the problem of water wastage.

Reverse Osmosis (R.O.):

R.O. is basically using an external force, to reverse the natural phenomenon of osmosis. Based on this technology, a number of commercial filters are available to remove the TDS from water. Such systems use commercially manufactured semi-permeable membranes that are made of many synthetic materials. The pore size of such membranes is 0.001 Micron. Effective pre-treatment is required for the liquid, before it is allowed to be filtered by these membranes.

IS 10500: 2012 Standard for Drinking Water as Per Bureau of Indian Standards

PARAMETERS FOR POTABLE WATER as per IS 10500 : 2012			
Sr. No.	CHARACTERISTICS / SUBSTANCE	MAX DESIRABLE LIMIT	MAXIMUM PERMISSIBLE LIMIT IN ABSENCE OF AN ALTERNATE SOURCE
1	P.H.	6.5 to 8.5	No relaxation beyond this range (Ideal Value is 7)
2	Colour	5 Hazen Units	Beyond this colour becomes Objectionable
3	Odour	Should be unobjectionable	
4	Turbidity	1 N.T.U.	5 N.T.U. (Naphalometric Turbidity Units)
5	Total Dissolved Solids	500 Mg / Lit	Palatability decreases beyond this value. (Max 2000 ppm)
6	Iron As Fe	0.3 Mg / Lit	No relaxation
7	Chloride as Cl	250 Mg / Lit	1000 Mg / Lit
8	Free Chlorine	0.2 Mg / Lit	1 Mg / Lit
9	Alkalinity	200 Mg / Lit	600 Mg / Lit
10	Total Hardness As (Caco3)	300 Mg / Lit	600 Mg / Lit
11	Calcium as Ca	75 Mg / Lit	200 Mg / Lit
12	Nitrate as No 3	45 Mg / Lit	No relaxation
13	Sulphide (as H2S),	0.05	No relaxation
14	Sulphates as So4	200 Mg / Lit	400 Mg / Lit (provided Magnesium as Mg is not > 30
15	Manganese as Mn	0.1 Mg / Lit	0.3 Mg / Lit
16	Copper as CU	0.05 Mg / Lit	1.5 Mg / Lit
17	Fluoride as F	1 Mg / Lit	1.5 Mg / Lit
18	Magnesium as Mg	30 Mg / Lit	100 Mg / Lit
19	Zinc as Zn	5 Mg / Lit	15 Mg / Lit
20	Arsenic as As	0.01 Mg / Lit	0.05 Mg / Lit
21	Chromium (as Cr)	0.05 Mg / Lit	No relaxation
22	Cadmium (as Cd),	0.003 Mg / Lit	No relaxation
23	Lead (as Pb),	0.01	No relaxation
24	Total Coliform	Shall not be detectable in any 100 ml sample	No relaxation
25	E - Coli	Should be absent	No relaxation
These are some important parameters listed above – For all the parameters please refer to the Drinking Water Specification IS 10500 : 2012			