Drinking Water Disinfection and Water Quality Assessment Technologies

Introduction:

"Water As A Human Right" Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity. **"Water is the essence of life".** Without water, human beings cannot live for more than a few days. It plays a vital role in nearly every function of the body, protecting the immune system – the body's natural defences – and helping remove waste matter.

Source - https://www2.ohchr.org/english/issues/water/docs/Right_to_Water.pdf

Source - https://www.cdc.gov/healthywater/drinking/public/water_sources.html

Drinking water, also known as **potable water**, is water that is safe to drink or use for food preparation. The amount of drinking water required to maintain good health varies, and depends on physical activity level, age, health-related issues, and environmental conditions. According to the World Health Organization's 2017 report, *safe* drinking-water is water that **"does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages"**. A safely managed drinking water service is "one located on premises, available when needed and free from contamination.

Source - https://en.wikipedia.org/wiki/Drinking_water

Drinking Water Standards Of BIS:

According to the Central Ground Water Board, BIS (IS_10500 and revised module IS 10500:2012) has specifications in Uniform Drinking Water Quality Monitoring Protocol. This standard has two limits i.e. acceptable limits and permissible limits in the absence of an alternate source. If any parameter exceeds the limit, the water is considered unfit for human consumption. In broad terms, if the water is bacteriology contaminated (E-coli and viruses etc), or if chemical contamination exceeds maximum permissible limits, the BIS considers that water unfit for drinking.

According to BIS 1500-2012 the acceptable limit of bacteria and other major contamination are as follows:

Test parameter	Acceptable limit	Permissible limit (In the absence of alternate source of water)
pH value	6.5-8.5	No relaxation
Turbidity	1	5
Total hardness as CaCo3, mg/l, Max	200	600
E.coli presence/absence	Shall not be detectable in any 100ml sample	Shall not be detectable in any 100ml sample
Total iron as Fe, mg/l, Max	0.3	No relaxation
Taste	Agreeable	Agreeable
Odour	Agreeable	Agreeable

Sources –

https://www.indiawaterportal.org/sites/default/files/2020-11/indian_standard_for_drinking_water_as_per_bis_specifications_2010.pdf

https://www.kent.co.in/blog/safe-drinking-water-guidelines-in-india/

https://www.lenntech.com/applications/drinking/standards/drinking-water-standards.htm

https://www.lenntech.com/applications/drinking/standards/who-s-drinking-water-standards.htm

https://www.lenntech.com/applications/drinking/standards/eu-s-drinking-water-standards.htm

Drinking Water Regulation :

The Environmental Protection Agency (EPA) sets standards and regulations for many different contaminants in public drinking water, including disease-causing germs and chemicals. Read the information below to learn more about EPA's drinking water regulations.

Source – **https://www.cdc.gov/healthywater/drinking/public/regulations.html**

1. **The Safe Drinking Water Act** - (SDWA) was passed by Congress in 1974, with amendments added in 1986 and 1996, to protect our drinking water. Under the SDWA, EPA sets the standards for drinking water quality and monitors states, local authorities, and water suppliers who enforce those standards.

   Source – **https://www.epa.gov/laws-regulations/summary-safe-drinking-water-act**

2. **National Primary Drinking Water Regulations -** National Primary Drinking Water Regulations (NPDWR) are standards and treatment techniques that public water systems must follow. These regulations protect public health by limiting contaminant levels in drinking water.

   Source–**https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations**

3. **National Secondary Drinking Water Regulations -** National Secondary Drinking Water Regulations (NSDWR) are guidelines to help public water systems manage their drinking water for issues not related to health, such as taste, color, and smell. Water systems are **not** required to follow these water quality standard for the 15 contaminants listed.

   Water Quality Standards:

   Source–**https://www.epa.gov/sdwa/secondary-drinking-water-standards-guidance-nuisance-chemicals**

4. **Unregulated Contaminants -**
   It may require regulation in the future. EPA must publish this list of contaminants—called the "Contaminant Candidate List," or CCL—every five years and decide whether to regulate at least five or more of the contaminants on the list (called "Regulatory Determinations").
   Source–https://www.epa.gov/ccl/basic-information-ccl-and-regulatory-determination

5. **Bottled Water Regulations -** The SDWA does **not** apply to bottled water. Bottled water is regulated by the U.S. Food and Drug Administration not EPA.
   - **Regulates The Safety Of Bottled Water:**

Source–https://www.fda.gov/food/buy-store-serve-safe-food/fda-regulates-safety-bottled-water-beverages-including-flavored-water-and-nutrient-added-water

6. **National & State Water Policies –**The policy recommended the implementation of a new approach to the governance of water resources, which would include –
    - River-basin or sub-river basin as a unit of planning
    - Integrated and interdisciplinary approach to project planning
    - Consideration of the human, environmental, and ecological cost in project planning
    - Regulation of groundwater extraction
    - Conjunctive use of surface and groundwater
    - First priority to drinking uses
    - Farmers' participation in irrigation management
    - Water tariff covering the operation, maintenance cost and partial capital cost

    Source–http://www.swaniti.com/wp-content/uploads/2017/10/Water-Resources-Regulation-in-India.pdf

Water Quality Association:

They include explanations of health effects, treatment method comparisons, discussion on regulations, and reference lists to dig up even more information at your leisure. All Water Quality Association sheets are given :

https://www.wqa.org/programs-services/technical-guidance/technical-fact-sheets

- Aluminum -

https://www.wqa.org/Portals/0/Technical/Technical%20Fact%20Sheets/2014_Aluminum.pdf

- Ammonia –

https://www.wqa.org/Portals/0/Technical/Technical%20Fact%20Sheets/2014_Ammonia.pdf

- Arsenic -

https://www.wqa.org/Portals/0/Technical/Technical%20Fact%20Sheets/2014_Arsenic.pdf

- Barium –

https://www.wqa.org/Portals/0/Technical/Technical%20Fact%20Sheets/2016_Barium.pdf **etc.**

The Disinfection Of Drinking Water :

- Water disinfection means the removal, deactivation or killing of pathogenic microorganisms. Microorganisms are destroyed or deactivated, resulting in termination of growth and reproduction. When microorganisms are not removed from drinking water, drinking water usage will cause people to fall ill. **Source**–**https://www.lenntech.com/processes/disinfection/what-is-water-disinfection.htm#ixzz6hLx2XoPc**
  https://www.epa.ie/pubs/advice/drinkingwater/Disinfection2_web.pdf

- The goal of disinfection of public water supplies is the elimination of the pathogens that are responsible for waterborne diseases. The transmission of diseases such as typhoid and paratyphoid fevers, cholera, salmonellosis, and shigellosis can be controlled with treatments that substantially reduce the total number of viable microorganisms in the water.

  Source–**https://www.ncbi.nlm.nih.gov/books/NBK234590/**

Methods of Drinking Water Disinfection -

The method employed disinfection is only one of the requirements of a potable water supply system. Disinfection requirements and efficacy are often highly interrelated with other water supply and treatment operations. A complete system of potable water supply operations may be considered in three general phases: collection, treatment, and distribution, Chlorination.

Source–**https://www.ncbi.nlm.nih.gov/books/NBK217999/**

General Aspects of Disinfection -

The use of chlorination as presented in examples in the following pages does not imply that it is necessarily the method of choice. Rather, this method has been studied more thoroughly than other methods.

- Raw Water Quality
- Disinfectant Demand
- Physical and Chemical Treatments

The indicator microorganism, as defined in *Drinking Water and Health* (National Academy of Sciences, 1977), is a "microorganism whose presence is evidence that pollution (associated with fecal contamination from man or other warm-blooded animals) has occurred.

Source–**https://www.ncbi.nlm.nih.gov/books/NBK234590/**

Necessity Of Drinking Water Disinfection:

The larger part of pathogenic microorganisms is removed from water during the primary water purification steps. However, water disinfection is still necessary in order to prevent drinking water from being harmful to our health.

- Microorganisms
- Types of pathogenic microorganisms (Bacteria, Viruses)
- The odds of infection
- Secretion and sewer water

Source–**https://www.lenntech.com/processes/disinfection/necessity/necessity-drinking-water-disinfection.htm**

Disease And Risk:

Wide range of diseases which may include:

- those due to ingestion of water contaminated by micro-organisms and chemicals such as diarrhoea, arsenicosis or fluorosis
- diseases like schistosomiasis which have part of their lifecycle in water;
- diseases like soil-transmitted helminthiasis resulting from poor sanitation and hygiene;

Unsafe drinking-water and poor sanitation and hygiene can present significant health risks by exposing populations to various microbial, chemical, and other hazards.
Source–**https://www.who.int/water_sanitation_health/diseases-risks/en/**

https://www.who.int/water_sanitation_health/diseases-risks/diseases/en/

Integration of Drinking Water Disinfection Within Overall Treatment:

Many water treatment works abstracting from surface waters, such as rivers and reservoirs, have long adopted the ‘multi-barrier’ approach to water treatment, where a number of treatment processes are employed to provide treatment and disinfection. Failure of an upstream process such as clarification or filtration may mean that the chlorination stage will not be able to achieve disinfection. Both chemical coagulation based treatment followed by rapid gravity filtration and slow sand filtration can provide

effective removal of protozoan pathogens, bacteria and, sometimes to a lesser extent, viruses.

Source–**https://www.epa.ie/pubs/advice/drinkingwater/Disinfection2_web.pdf**

https://www.arviatechnology.com/drinking-water-treatment/#:~:text=The%20treatment%20process%20for%20drinking,a%20safe%20quality%20for%20consumption.

The treatment process for drinking water varies according to the type and quality of the raw water. Common treatment methods include:

- Aeration,
- Flocculation,
- Sedimentation,
- Filtration, and
- Disinfection to ensure water is of a safe quality for consumption.

Challenges Of Drinking Water Disinfection:

Drinking water chlorination has contributed to a dramatic decline in waterborne disease rates and increased life expectancy. Most water systems are meeting these new standards by controlling the amount of natural organic matter prior to disinfection, while ensuring that microbial protection remains the top priority.

Source–**https://waterandhealth.org/safe-drinking-water/wp/#challenge-of-disinfection-byproducts**

Water Quality Assessment:

Water quality assessment is the overall process of evaluation of the physical, chemical and biological nature of the water, whereas water quality monitoring is the collection of the relevant information.

https://www.who.int/water_sanitation_health/resourcesquality/wqachapter2.pdf?ua=1

Objectives of Water Quality Assessments –

https://www.obwb.ca/newsite/wp-content/uploads/osoyoos_wqo_2012.pdf

Implementation Of Water Quality Assessment Programs-
http://www.ijstm.com/images/short_pdf/1489116666_P1130-1139.pdf

Water Quality Assessment Technologies :

Water treatment plants use technologies to produce water that is safe both chemically and biologically, and that is appealing in terms of colour, odour and taste. Some of the prevalent water purification & treatment technologies are listed below –

- Capacitive Deionization (CDI) is a technology where ions are removed from water by passing it through a spacer channel with porous electrodes on each side
- Ozonation is a chemical water treatment technique based on the infusion of ozone into water
- Ultraviolet technology uses Ultraviolet light, just like sunlight, to kill micro-organisms present in the water
- Reverse Osmosis (RO) is a technology that removes a large majority of contaminants by pushing the water under pressure through a semi-permeable membrane
- TERAFIL is a burnt red clay porous media used for filtration & treatment of raw water into clean drinking water, developed Council of Scientific & Industrial Research (CSIR), Bhubaneshwar
- OS- Community scale Arsenic Filter is an organic arsenic filter, developed by IIT Kharagpur
- Filtration methods that may include rapid/ slow sand filters remove dirt, rust, silt, dust and other particulate matter from water
- Solar water purification systems

Compendium of innovative technologies on rural drinking water -

http://www.indiaenvironmentportal.org.in/content/406082/compendium-of-innovative-technologies-on-rural-drinking-water-sanitation/
https://www.indiawaterportal.org/topics/technology

New and Emerging Drinking Water Treatment Technologies –

https://www.nap.edu/read/9595/chapter/13

https://www.goodnet.org/articles/7-new-technologies-that-create-clean-water-for-thirsty-world

Summary and Conclusions:

Disinfection is unquestionably the most important step in the treatment of water for drinking-water supplies. The microbial quality of drinking-water should not be compromised because of concern over the potential long-term effects of disinfectants

https://www.greenfacts.org/en/water-disinfectants/l-3/water-disinfectants-99.htm#:~:text=6.-,Conclusions,water%20for%20drinking%2Dwater%20supplies.&text=The%20risk%20of%20illness%20and,risks%20from%20disinfectants%20and%20DBPs.

Contamination of drinking-water by microbial pathogens can cause disease outbreaks and contribute to background rates of disease. There are many treatment options for eliminating pathogens from drinking-water

https://www.who.int/water_sanitation_health/water-quality/guidelines/en/watreatpathexec.pdf?ua=1