Water Pollution and Thermal Pollution

- Causes, effects and control measures of Water Pollution and Thermal Pollution.

Water

- Fresh water is required in day-to-day life for various purposes like domestic, agricultural, power generation, industrial, forestry, fisheries, navigation and recreational activities.
- We require pure potable water free from unwanted and undesirable impurities.

Water Resources

Type of water source	Percentage of total water
Oceans and Salt Lakes	97.41
Fresh water	
• Ice Caps and Glaciars	1.984
• Ground water	0.592
• Lakes	0.007
• Rivers	0.0001

Qualities of Potable Water

Potable Water should be

- Colourless and odourless .
- Free from suspended particulate matter and turbidity.
- Must not contain disease causing bacteria etc.
- Free from toxic materials.
- Low hardness.
- Cool and fresh.

Water Pollution

- Water becomes polluted after utilization for different purposes.
- Water pollution may be defined as presence of unwanted and undesirable impurities which may be organic, inorganic or biological, resulting in the deterioration of the quality of water by change in physical, chemical and biological characteristics of water and making it unfit for use.

Indications of Water Pollution

- Bad taste and/or presence of odour and colour.
- Excessive growth of aquatic weeds in ponds/ rivers.
- Presence of pathogens due to contamination from sewer.
- Turbidity in water.
- Dead animals floating on water in river, lake, etc.
- Oil and grease floating on water.

Water Pollution due to Domestic Garbage

Water Pollution due to Sewage disposal

Water Pollution due to Industrial Effluents

Water Pollution due to Garbage

https://givingcompass.org/article/whos-to-blame-for-ocean-pollution/

Water Pollution due to Garbage

https://www.needpix.com/photo/1083944/water-polluted-plastic-garbage-bottle-environment-texture

Major Global Issues Related To Water Pollution

- Lack of pathogen free potable water
- Disposal of domestic or industrial effluents in water bodies
- Sewage, disease-causing agents, sediment pollution, inorganic plant and algal nutrients, organic compounds, inorganic chemicals, radioactive substances, and thermal pollution

Type of Water Pollutants

Disease-causing agents

- Bacteria, viruses, protozoa and parasitic worms that usually enter into water from domestic sewage and animal wastes.

Oxygen depleting wastes

- Organic wastes, which require a large quantity of oxygen for their bacterial decomposition. Large amount of bacteria consume these wastes resulting in the depletion of dissolved oxygen gas in water.

Type of Water Pollutants

Inorganic nutrients

- Water soluble nitrate and phosphate cause too much growth of algae and other aquatic plants. The dead plants require a large quantity of oxygen for their decomposition, reducing the amount of dissolved oxygen in water, and thereby killing fish and other aquatic animals.

Water-soluble inorganic chemicals

- Presence of acids, salts, and compounds of toxic metals such as lead and mercury can make water unfit for drinking, harm fish and other aquatic life, decrease crop yields.

Type of Water Pollutants

Organic chemicals

- Presence of detergents, cleaning solvents, plastics, pesticides, oil, gasoline etc. in water affect human health and harm aquatic animals.

Suspended matter or sediment

- Fine particles of soil and other solid inorganic and organic materials which remain suspended in water are the largest source of water pollution. Suspended particulate matter reduces the visibility in water, suppresses photosynthesis by aquatic plants, and disturbs aquatic ecosystem.

Type of Water Pollutants

Radioactive substances

- Presence of radioactive substances in water makes it harmful for consumption by human beings and other living organisms.

Waste Heat

- Thermal or nuclear power plants discharge a large quantity of heated water into the nearby water bodies, which results in an increase in its temperature. This increase in water temperature results in the reduction in the dissolved oxygen content and severely affects the aquatic ecosystem as many species cannot survive in such water.

Sources of Water Pollution

The major sources of surface and ground water pollution in India are:

- Industrial effluents
- Domestic sewage
- Fertilizer and pesticide run-offs from agricultural fields
- Leaching from mining or waste disposal sites

Point and Non-point Sources

- Point sources release pollutants at definite locations through pipes, channels, or sewers into water bodies.
- Industrial units, sewage treatment plants off-shore oil wells are some examples.

Non-point Sources

Non-point sources are big land areas that discharge pollutants into surface and underground water over a large area.

Agricultural-runoffs and seepage into the ground from fields, construction areas, mining runoff , roadways and acid rain are some examples.

Ground water pollution

About 0.6% of the total water available on earth is ground water. Its total amount much higher than surface water.

Ground water is less susceptible to pollution as various contaminants get removed during its passage through soil. However, there are a number of sources of ground water pollution.

Septic tanks, industrial effluents (textile, chemical, tanneries), and mining etc. are main source of ground water pollution.

Contaminated ground water is also found naturally in some regions where it contains arsenic and fluoride etc.

Sewage

Wastewater from drains or sewers is released into water bodies. Sewer includes human wastes, soaps, and detergents

It causes serious environmental problems:

Enrichment of a body of water by high levels of plant and algal nutrients (nitrogen and phosphorus)

Increase in Biological Oxygen Demand (BOD) i.e. the amount of oxygen needed by microorganisms to decompose biological wastes

As BOD increases Dissolve Oxygen (DO) decreases

Municipal Sewage Treatment

Primary treatment

Removing suspended and floating particles by mechanical processes

Secondary treatment

Treating wastewater biologically to decompose suspended organic material; reduces BOD

Municipal Sewage Treatment

Sewage Sludge

Solids remaining after primary and secondary sewage treatment has been completed

Tertiary treatment

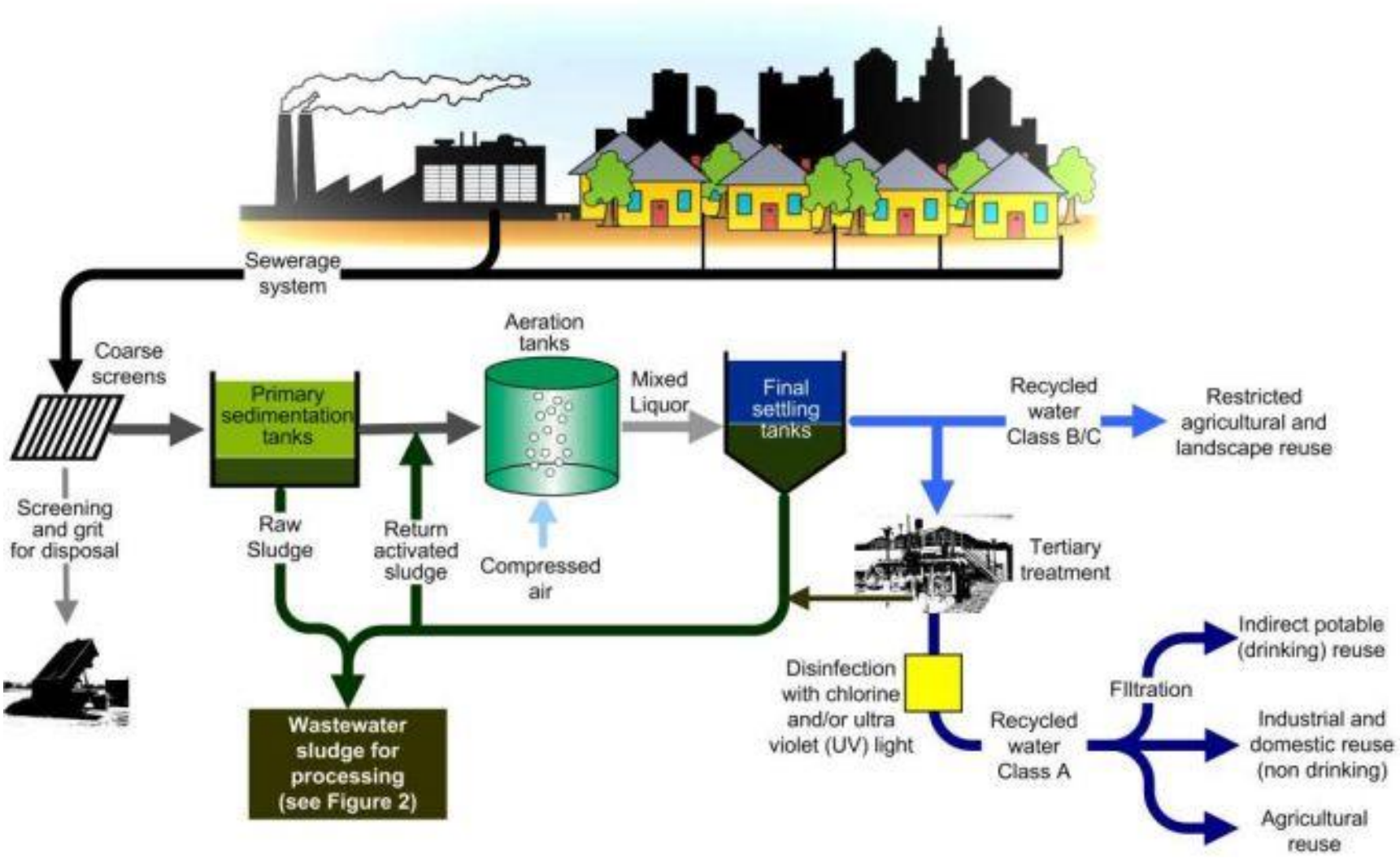
Advanced wastewater treatment methods that are sometimes employed after primary and secondary treatments

Reduce phosphorus and nitrogen

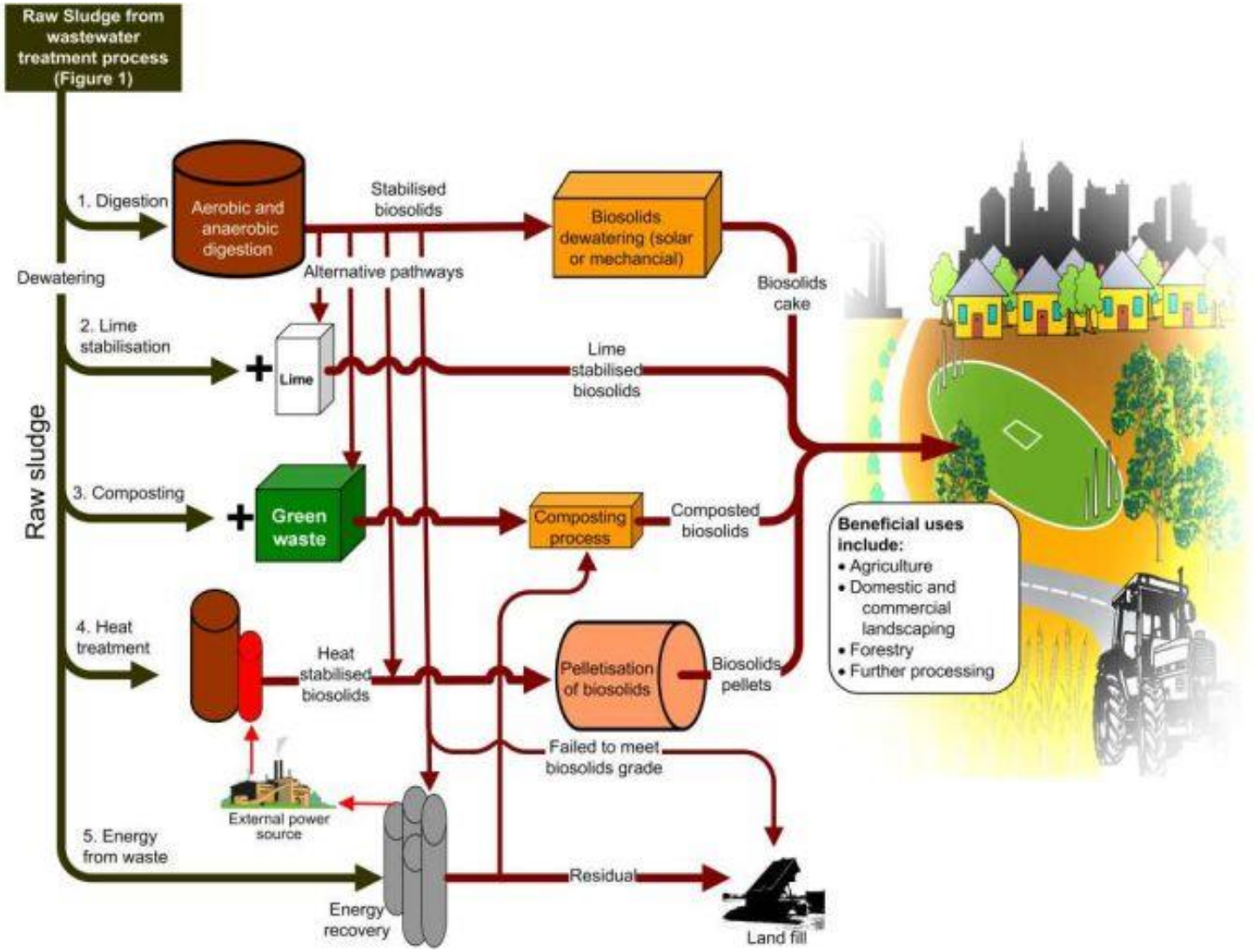
Sewage Treatment Plant

https://news.wisc.edu/bacteria-may-supercharge-the-future-of-wastewater-treatment/

Sewage Treatment Overview



Sewage Treatment



http://butane.chem.uiuc.edu/pshapley/Environmental/L35/1.html

Industrial Wastes in Water

Different industries generate different pollutants

Food processing plants generate effluents with high BOD

Paper mills generate effluents with high BOD and toxic compounds

Inorganic Plant and Algal Nutrients

Water soluble compounds containing nitrate, Phosphate and Ammonium ions.

Human sources: Sewage, manure and runoff of agricultural and urban fertilizers.

Effects

Cause excessive growth of algae and other aquatic plants, which die, decay, and deplete dissolved oxygen in water thereby killing fish

Presence of nitrates in drinking water lower the oxygen carrying capacity of the blood and can kill children and infants.

Eutrophication

- Sewage and agricultural run-off provide plant nutrients in water giving rise to the biological process know as eutrophication. Large input of fertilizer and nutrients from these sources leads to enormous growth of aquatic weeds which gradually cover the entire water-body.
- This aquatic ecosystem gets destroyed as the water body loses its D.O. and the fish cannot survive under such conditions.

Eutrophication

Eutrophication of Lakes

https://www.flickr.com/photos/48722974@N07/4464986156

Eutrophication

https://www.flickr.com/photos/33406492@N06/5052332517

Disease-causing Agents

Bacteria, Viruses, Protozoa, and parasitic worms.

Sources

Human and animal wastes

Effects: Variety of diseases like Typhoid, Jaundice, Dysentery, Amoebiasis, Polio (Infantile Paralysis), Trachoma (Eye Infection), Cholera etc.

Sediment Pollution

Excessive amounts of suspended soil particles

Comes from erosion of agricultural lands, forest soils exposed by logging, degraded river banks, overgrazed lands, strip mines, and construction sites

Problems

Reduces light penetration

Covers aquatic animals and plants

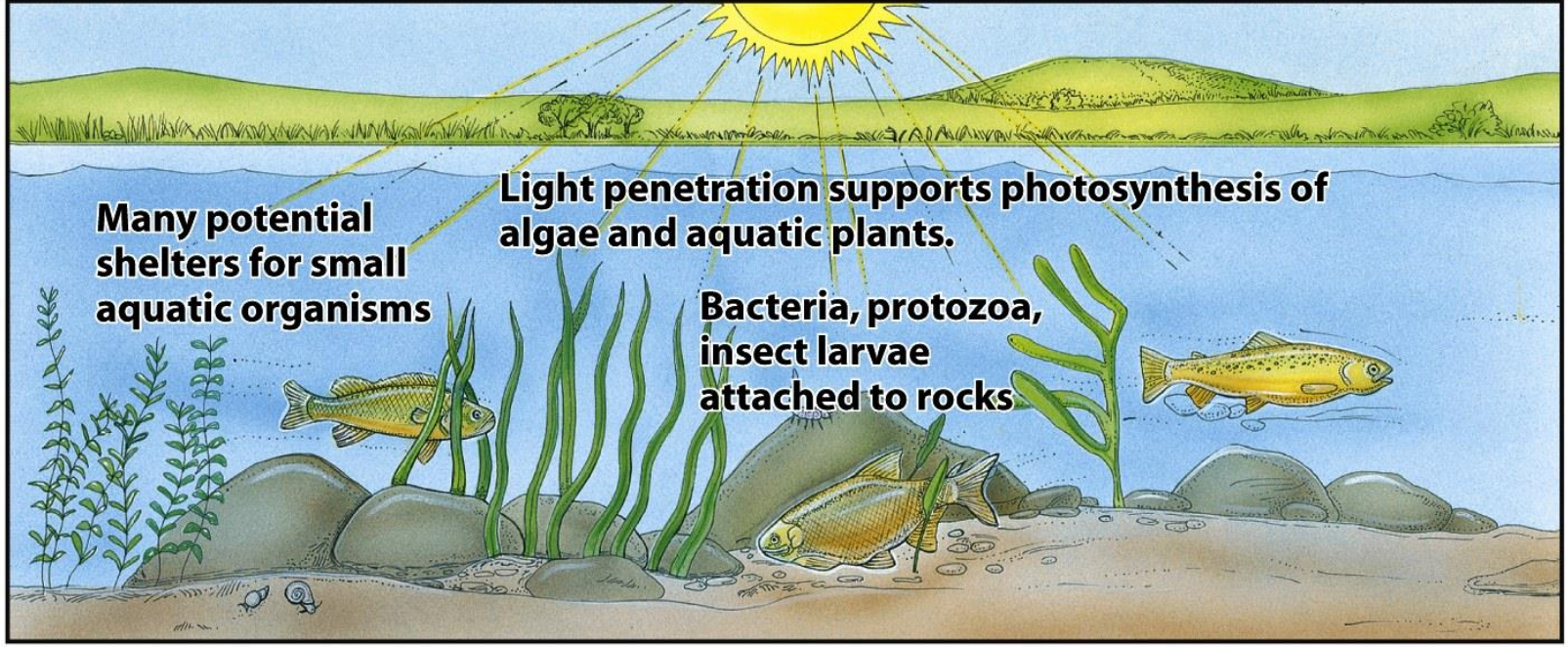
Carries insoluble toxins into waterways

Clogs and fills lakes, artificial reservoirs, stream channels and harbours.

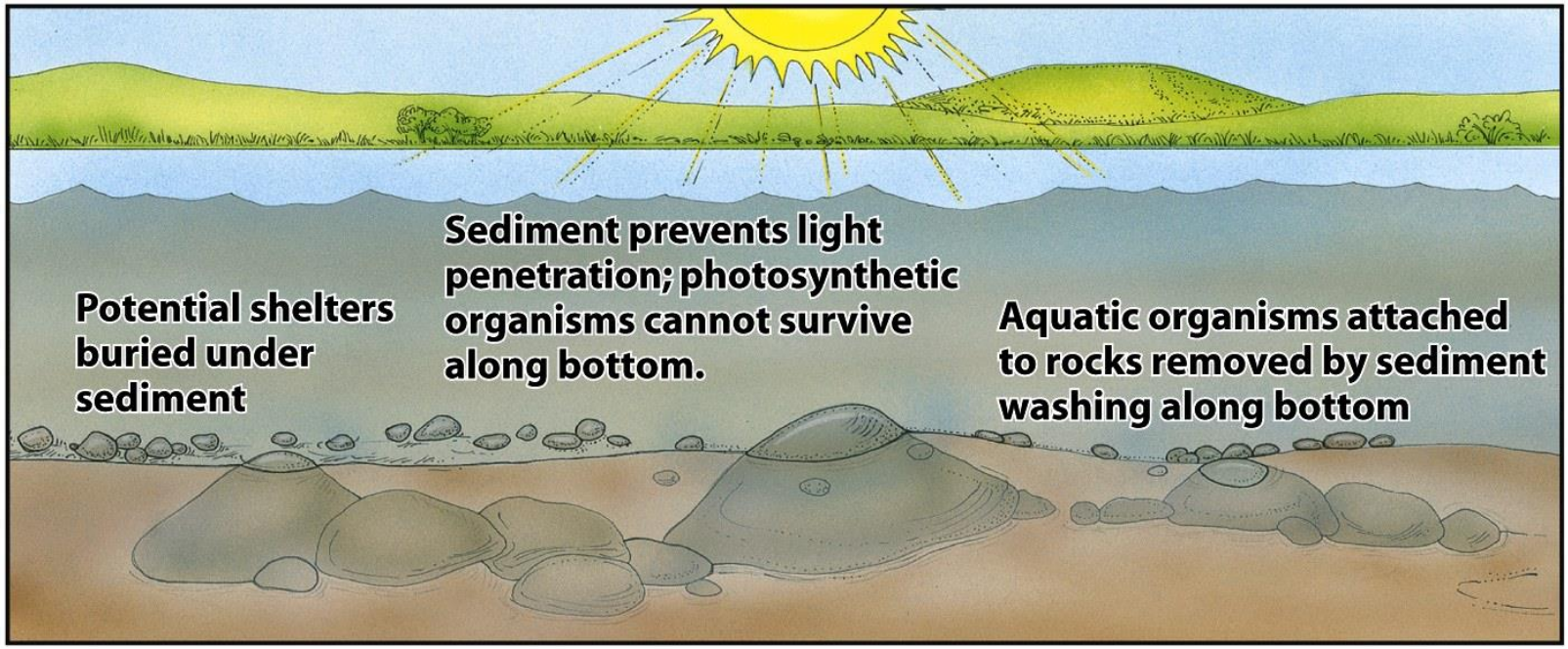
Disruption of aquatic food chain

Sediment Pollution

https://www.waterprotectionnetwork.org/2017/12/protecting-environment-age-trump-environmental-laws-failed-us-can/100_8521-sediment-pollution-flooded-wetland/



Stream ecosystem with low level of sediment



Same stream with high level of sediment

Garbage

The urban wastes consisting of garbage and rubbish materials like plastics, glasses, metallic cans, fibres, paper, rubbers, street sweepings, fuel residues, leaves, containers, abandoned vehicles and other discarded manufactured products.

Urban domestic wastes though disposed off separately from industrial wastes, can still be dangerous. This happens because they are not easily degraded.

Organic Compounds

Oil, Gasoline, Plastics, Pesticides, Cleaning solvents and Detergents.

Human Sources: Industrial effluents, household cleansers and surface runoff from farms.

Effects

Can threaten human health by causing nervous system damage and some cancers.

Harm fish and wildlife.

Inorganic Chemicals

Contaminants that contain elements other than carbon

Examples: acids, salts, and heavy metals

Do not degrade easily

Lead: Found in old paint, industrial pollutants, leaded gasoline

Mercury: Mercury bioaccumulates in the muscles of top predators of the open ocean

Radioactive Compounds

Contain atoms of unstable isotopes that spontaneously emit radiation

- Mining,
- Processing radioactive materials
- Nuclear power plants
- Natural sources

Radioactive isotopes of Iodine, Radon, Uranium, Cesium and Thorium

Effects: Genetic mutations, birth defects and certain cancers.

Purification of Drinking Water

Chlorination

Chlorine kills disease causing organisms

Chlorine byproducts are linked to numerous cancers, miscarriages and birth defects

Fluoridation

Prevents tooth decay

Linked to cancer, kidney disease

Municipal Sewage Treatment

Primary treatment

Removing suspended and floating particles by mechanical processes

Secondary treatment

Treating wastewater biologically to decompose suspended organic material; reduces BOD

Municipal Sewage Treatment

Sewage Sludge

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Tertiary treatment

Advanced wastewater treatment methods that are sometimes employed after primary and secondary treatments

Reduce phosphorus and nitrogen

Control measures of water pollution

Scientific techniques should be adopted for environmental regulation of rivers, ponds or streams

Recycling operations must be encouraged as it helps prevent disposal of wastes into natural waters.

Planting of more trees as they are capable of reducing sulphur dioxide and nitric oxide.

Strict laws should be enacted by state or central government

Control measures of water pollution

No waste (treated, partially treated or untreated) should be discharged into any natural water body. Industries should develop closed loop water supply schemes and domestic sewage should be treated by organic methods.

Public awareness must be created regarding adverse effects of water pollution.

Laws, standards and practices should be established to prevent water pollution based on current requirements and technological advancements.

Thermal Pollution

Occurs when heated water produced during industrial processes is discharged into a natural water body resulting in the increase in the average temperature of water

Human sources: Water cooling of electric power plants and some types of industrial plants. Almost half of whole water withdrawn in United States each year is for cooling electric power plants.

Effects of Thermal Pollution

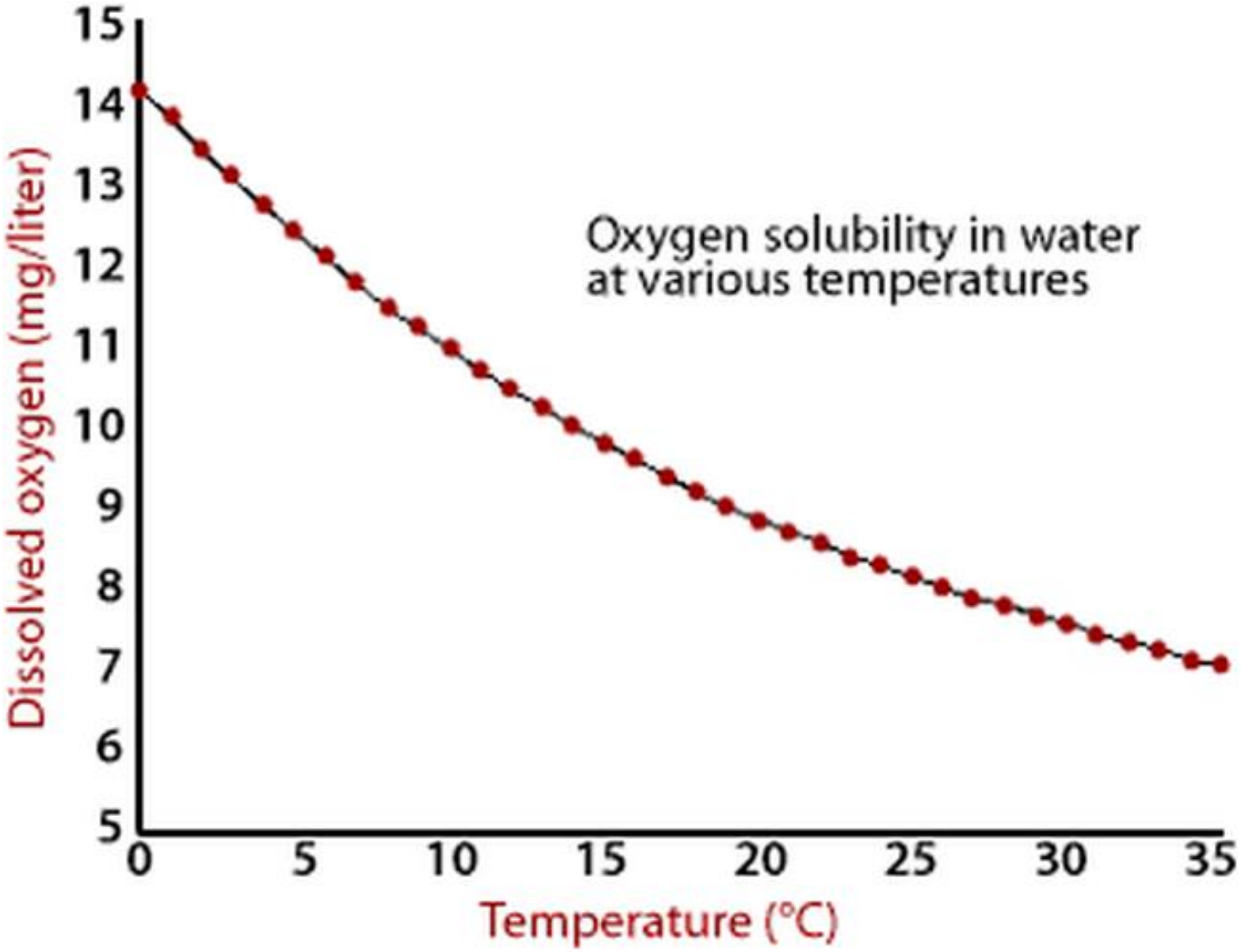
Warm water holds less DO than cold water

Low dissolved oxygen levels make aquatic organisms more vulnerable to disease, parasites and toxic chemicals.

Temperature affects reproductive cycles, digestion rates, and respiration rates

When a power plant starts or shuts down for repair, fish and other organisms adapted to a particular temperature range, can be killed by an abrupt temperature change known as thermal shock.

Thermal Pollution



http://www.cotf.edu/ete/modules/waterq3/WQassess3f.html

Control of Thermal Pollution

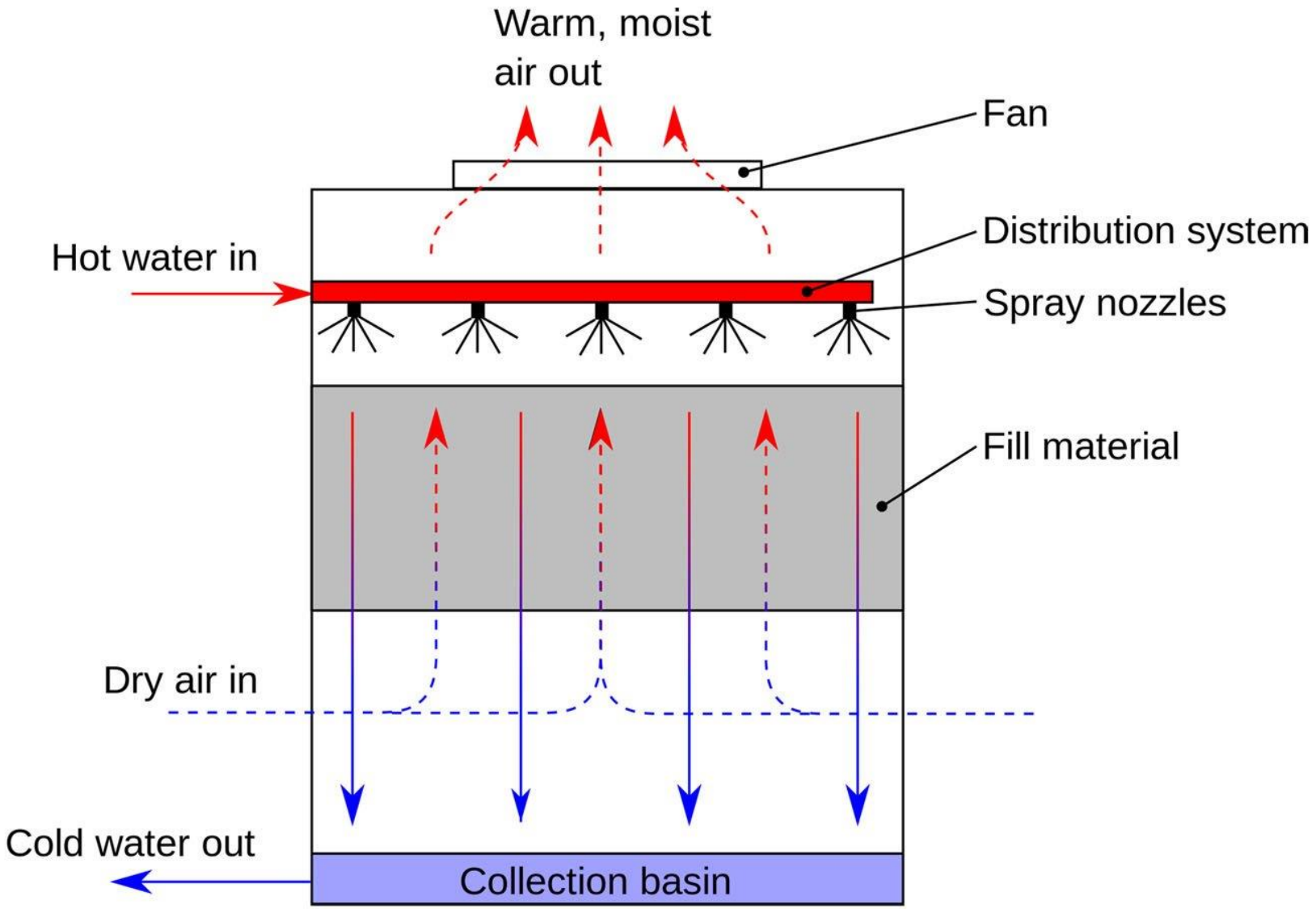
The following methods can be employed for control of thermal pollution:

- Cooling ponds
- Spray Ponds
- Cooling towers

Control of Thermal Pollution

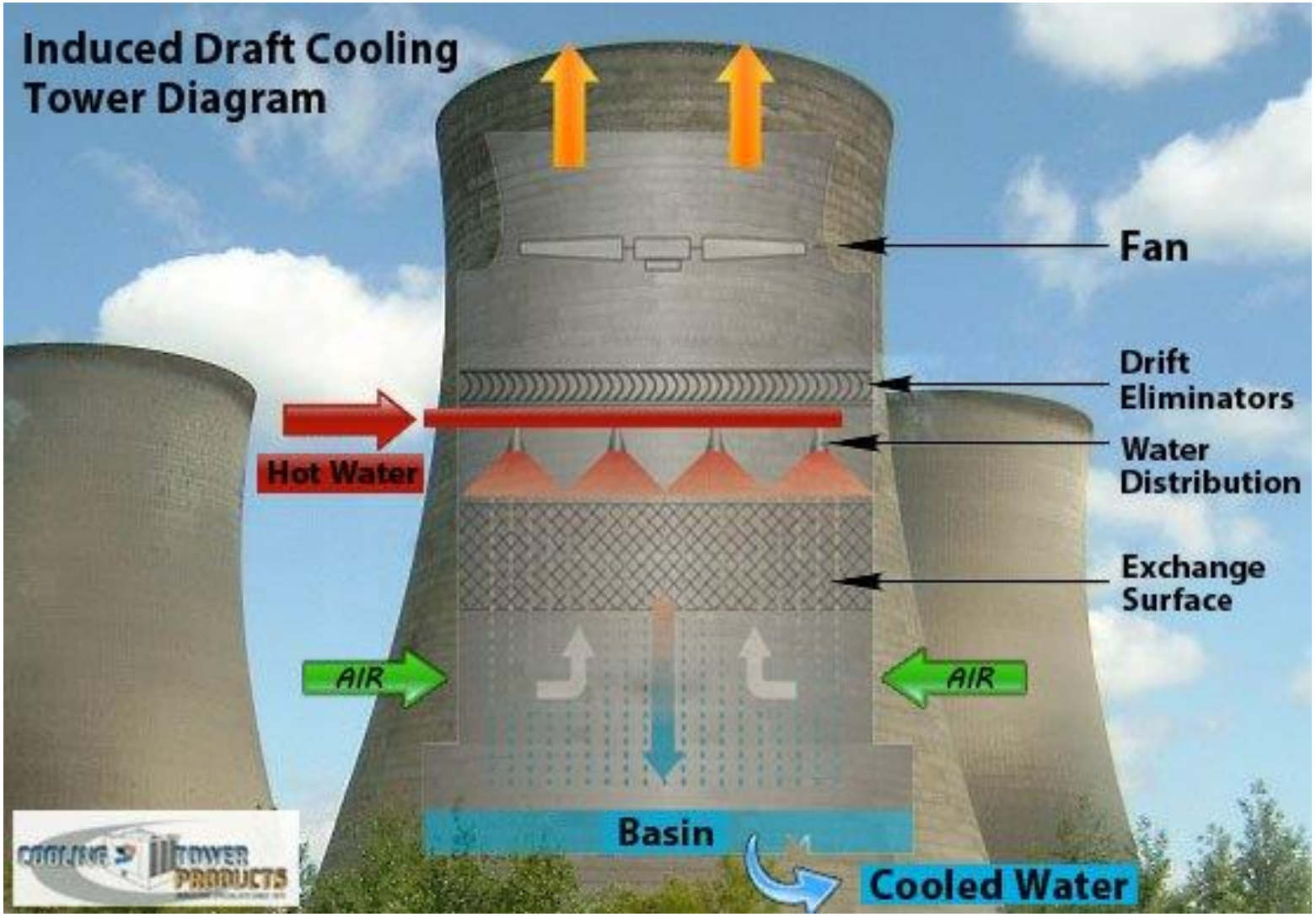
https://www.nlcindia.com/new_website/index.htm

How Cooling Towers Work



https://www.coolingtowerproducts.com/blog/how-cooling-towers-work-diagram-pictures-2015.htm

How cooling tower works

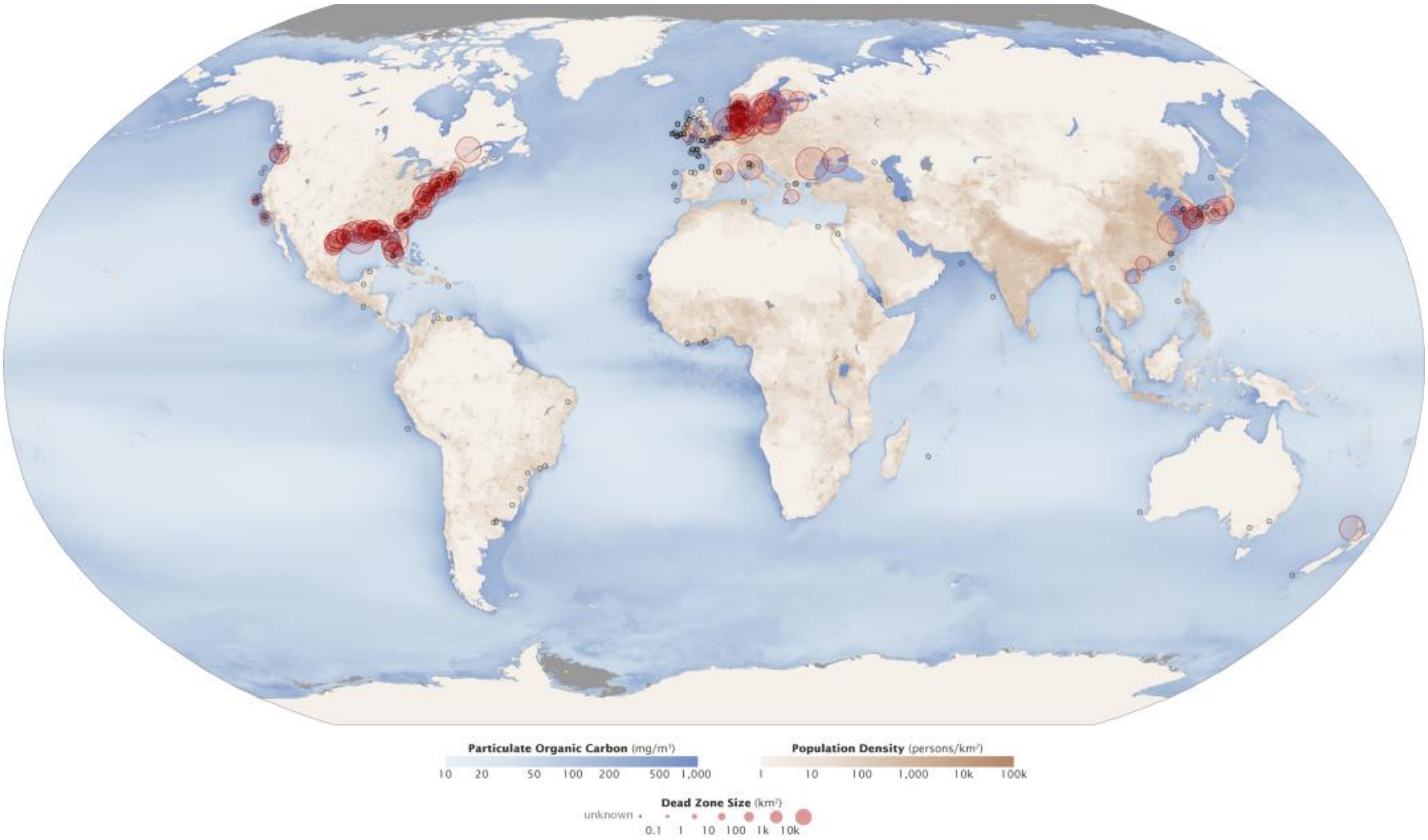


https://www.coolingtowerproducts.com/blog/how-cooling-towers-work-diagram-pictures-2015.htm

Suffocated Aquatic Zones

https://www.downtoearth.org.in/coverage/environment/dying-oceans-50679

Aquatic Dead Zones



https://earthobservatory.nasa.gov/images/44677/aquatic-dead-zones

Physical Characteristics of Water

1. Turbidity of Water

The turbidity is measured by a turbidity rod or by a turbidity meter with optical observations and is expressed as the amount of suspended matter in mg/l or parts per million (ppm). For water, ppm and mg/l are approximately equal. The standard unit is that which is produced by one milligram of finely divided silica (fuller's earth) in one litre of distilled water.

Turbidity Meters

Turbidity Rod: The turbidity can be easily measured in the field with the help of a turbidity rod. It consists of an aluminium rod which is graduated as to give turbidity directly in silica units (mg/l) Turbidimeter. The turbidity can be easily measured in the laboratory with the help of a instruments called turbidity meter.

2. Colour

The presence of colour in water is not objectionable from health point of view, but may spoil the colour of the clothes being washed. The standard unit of colour is that which is produced by one milligram of platinum cobalt dissolved in one litre of distilled water. For public supplies, the colour number on cobalt scale should not exceed 20 and should be preferably less than 10. Colour determined by an instrument is known as **tintometer.**

Taste and Odour

The extent of taste or odour present in a particular sample of water is measured by a term called **odour intensity**, which is related with the **threshold odour** or **threshold odour number.** Water to be tested is therefore gradually diluted with odour free water, and the mixture at which the detection of odour by human observation is just lost, is determined. The number of times the sample is diluted represents the threshold odour number. For public supplies, the water should generally free from odour, i.e. the threshold number should be 1 and should never exceed 3.

For potable water, temperature of about about 10 degree celcius is desirable. It should not be more than 25 degree celceius.

5. Specific Conductivity

The total amount of dissolved salts present in water can be easily estimated by measuring the specific conductivity of water.

pH value of Water

$$pH = -\log[H^+] = \log\left[\frac{1}{H^+}\right]$$

If H^+ concentration increases, pH decreases and then it will be acidic. If H^+ concentration decreases, pH increases and then it will be alkaline $[H^+][OH^-] = 10^{-14}$

pH + pOH = 14 if the pH of water is more than 7, it will be alkaline and if it is less than 7, it will be acidic. The alkalinity is caused by the presence of bicarbonate of calcium and magnesium or by the carbonates of hydroxides of sodium, potassium, calcium and magnesium. Some, but not all of the compounds that cause alkalinity also cause hardness. **pH Measurement:** the pH value of water can be measured quickly and automatically with the help of a **Potentiometer.** The pH can also be measured by indicators as given below:

3. Hardness of Water

Hard waters are undesirable because they may lead to greater soap consumption, scaling of boilers, causing corrosion and incrustation of pipes, making food tasteless etc. **Temporary Hardness**: If bicarbonates and carbonates of calcium and magnesium are present in water, the water is render hard temporarily as this hardness can be removed to some extent by simple boiling or to full extent by adding lime to water. Such a hardness is known as temporary hardness or carbonate hardness. **Permanent Hardness:** If sulphates, chlorides and nitrates of calcium or magnesium are present in water, they can not be removed at al by simple boiling and therefore, such water require special treatment for softening. Such a hardness is known as permanent hardness or non-carbonate hardness. It is caused by sulphates,

- chlorides, nitrates of Ca and Mg. **Carbonate hardness** = Total hardness or Alkalinity (which ever is less) Non-carbonate hardness = Total hardness – Alkalinity
- Carbonate hardness is equal to the total hardness or alkalinity which ever is less
- Non-carbonate hardness is the total hardness in excess of the alkalinity. If the alkalinity is equal to or greater than the total hardness, there is no non-carbonate hardness.
- One French degree of hardness is equal to 10mg/l of $CaCO_3$.
- One British degree of hardness is equal to a hardness of 14.25mg/l.

•Water with hardness upto 75 ppm are considered soft and above 200 ppm are considered hard and in between is considered as moderately hard.
•Underground waters are generally harder than surface waters.
•The prescribed hardness limit for public supplies range between 75 to 115 ppm.

4. Chloride Content

The chloride content of treated water to be supplied to the public should not exceed a value of about 250 ppm. The chloride content of water can be measured by titrating the water with standard silver nitrate solution using potassium chromate as indicator.

(5) Nitrogen Content

The presence of nitrogen in water may occur in one or more of the following reasons:

1.Free ammonia: It indicates very first stage of decomposition of organic matter. It should not exceed 0.15mg/l

1.Albuminous or Organic Matter: It indicates the quantity of nitrogen present in water before the decomposition of organic molten has started. It should not exceed 0.3mg/l

2.Nitrites: Not fully oxidized organic matter in water.

3.Nitrates: It indicates fully oxidized organic matter in water (representing old pollution).

•Nitrites is highly dangerous and therefore the permissible amount of nitrites in water should be nil.

•Ammonia nitrogen + organic nitrogen = kjeldahl nitrogen

•Nitrates in water is not harmful. However the presence of too much of nitrates in water may adversely affect the health of infants causing a disease called **methemoglobinemia** commonly called **blue baby disease.**

•The nitrate concentration in domestic water supplies is limited to 45 mg/l.

. Metal and other chemical substances in water:

Iron – 0.3ppm, excess of these cause discolouration of clothes. Manganese – 0.05ppm Copper – 1.3ppm Sulphate – 250 ppm Fluoride – 1.5 ppm, excess of this effects human lungs and other respiratory organs. Fluoride concentration of less than 0.8 – 1.0 ppm cause dental cavity (tooth decay). If fluoride concentration is greater than 1.5ppm, causing spotting and discolouration of teeth (a disease called fluorosis).

7. Dissolved gases

Oxygen gas is generally absorbed by water from the atmosphere but it being consumed by unstable organic matter for their oxidation. Hence, if the oxygen present in water is found o be less than its saturation level, it indicates presence of organic matter and consequently making the waters

Biological Oxygen Demand (BOD):

The extent of organic matter present in water sample can be estimated by supplying oxygen to this sample and finding the oxygen consumed by the organic matter present in water. This oxygen demand is known as Biological oxygen demand (BOD). It is not practically possible to determine ultimate oxygen demand. Hence, BOD of water during the first five days at 20 ^{0}C is generally taken as the standard demand. $BOD_5 = BOD \text{ of } 5 \text{ days}$

Loss of oxygen in mg/l x dilution factor. The BOD of safe drinking water must be nil.