Water Treatment Plants

About Water Treatment

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Many substances dissolve in water since it is considered to be a universal solvent, Because of this, water in nature and in use is rarely pure and some of its properties may vary slightly from those of the pure substance.

Water Treatment Process can be categorized as

- **Domestic Water Treatment**

- **Industrial Water Treatment**

Like many substances, it can take numerous forms that are broadly categorized by **PHASES** or say different types of Water forms.

(The liquid phase is the most common known as"**water**." The solid phase of water is known as ice and commonly takes the structure of hard,amalgamated crystals, such as ice cubes, or loosely accumulated granular crystals, like snow. The gaseous phase of water is known as **water vapor (or steam)**, and is characterized by water assuming the configuration of a transparent cloud. The fourth state of water, that of a supercritical fluid, is much less common than the other three and only rarely occurs in nature. When water achieves a specific critical temperature and a specific critical pressure (647•K and 22.064• MPa), liquid and gas phase merge to one homogenous fluid phase, with properties of both gas and liquid. it almost never occurs naturally. One example of naturally occurring supercritical water is in the hottest parts of deep water hydrothermal vents, in which water is heated to the critical temperature by scalding volcanic plumes and achieves the critical pressure because of the crushing weight of the ocean at the extreme depths at which the vents are located.

An important feature of water is its **polar nature**. The water molecule forms an angle, with hydrogen atoms at the tips and oxygen at the vertex. Since oxygen has a higher electro negativity than hydrogen, the side of the molecule with the oxygen atom has a partial negative charge. An object with such a charge difference is called a dipole. The charge differences cause water molecules to be attracted to each other (the relatively positive areas being attracted to the relatively negative areas) and to other polar molecules

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Water has a high surface tension of 72.8 mN/m at room temperature This can be seen when small quantities of water are placed onto a sorption-free (non-adsorbent and non-absorbent) surface, such as polyethylene or Teflon, and the water stays together as drops, air trapped in surface disturbances forms bubbles, Due to an interplay of the forces of adhesion and surface tension, water exhibits capillary action whereby water rises into a narrow tube against the force of gravity.

Chemically, water is amphoteric: it can act as either an acid or a base in chemical reactions, When reacting with a stronger acid, water acts as a base; when reacting with a stronger base, it acts as an acid.

Pure water has the concentration of **hydroxide ions (OH^-) equal to that of the hydronium (H_3O^+)** or **hydrogen (H^+) ions**, which gives pH of 7 at 298 K. In practice, pure water is very difficult to produce. As cloud droplets form in the atmosphere and as raindrops fall through the air minor amounts of CO_2 are absorbed and thus most rain is slightly acidic. If high amounts of nitrogen and sulfur oxides are present in the air, they too will dissolve into the cloud and rain drops producing acid rain. Several isotopes of both hydrogen and oxygen exist, giving rise to several known isotopologues of water. Hydrogen occurs naturally in three isotopes. A second, stable isotope, deuterium (chemical symbol D or ^2H), has an additional neutron. Deuterium oxide, D_2O, is also known as heavy water because of its higher density. It is used in nuclear reactors as a neutron moderator. The third isotope, tritium, has 1 proton and 2 neutrons, and is radioactive, decaying with a half-life of 4500 days. T_2O exists in nature only in minute quantities, being produced primarily via cosmic ray-induced nuclear reactions in the atmosphere. Water with one deuterium atom HDO occurs naturally in ordinary water

The most notable physical differences between H_2O and D_2O, other than the simple difference in specific mass, involve properties that are affected by hydrogen bonding, such as freezing and boiling, and other kinetic effects. The difference in boiling points allows the isotopologues to be separated.

Consumption of pure isolated D_2O may affect biochemical processes - ingestion of large amounts impairs kidney and central nervous system function. Small quantities can be consumed without any ill-effects, and even very large amounts of heavy water must be consumed for any toxicity to become apparent.

This gives us the spectrum and scope of water in its various forms and the need for water treatment arises depending upon the usage and application.

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Domestic Water Treatment

The domestic Water Treatments involves treatment for potable or drinking purpose. Taste. Odor. Hardness. Contamination. These are four of the most common reasons why people install water treatment systems in their home.

An activated carbon filter removes many volatile organic chemicals, some pesticides, radon gas, hydrogen sulfide, and mercury. It also reduces odor, color, and taste problems (such as residual chlorine). Water is filtered through carbon granules that trap contaminants. But infrequently maintained filters can result in higher concentrations of contaminants and can serve as a breeding ground for bacteria.

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Distillation removes radium, odor, off-tastes, heavy metals, some pesticides, nitrate, fluoride, and salt. Units with volatile gas vents can remove some volatile organic chemicals as well. With distillation, water is evaporated, leaving impurities behind. The steam is then cooled and becomes distilled water. But the distillation process is slow and consumes a lot of energy, making it expensive. It also consumes large amounts of water if the coolant used in the distillation process is water. Distilled water can corrode materials such as iron and copper in plumbing systems.

Reverse osmosis removes inorganic minerals such as radium, sulfate, calcium, magnesium, potassium, nitrate, fluoride, boron, and phosphorous. It also helps to remove salts, certain detergents, volatile organic contaminants, some pesticides, and taste- and odor-producing chemicals. Water is filtered through a membrane that has passages smaller than the contaminant molecules. Under-the-sink installations are costly and take up a lot of space. In addition, reverse osmosis is slow and wasteful of water, and filter replacement is costly. Some microorganisms may be small enough to pass through the reverse osmosis membrane and colonize the holding tank.

Cation or anion exchange (water softening) removes barium; radium; and taste, color, and odor-producing chemicals. It will remove dissolved iron and manganese when they are present in low concentrations. Also, anion exchange units will remove nitrate and fluoride, but cation exchange units will not. The water softening process works by passing hard water through resin beads. Magnesium and calcium ions in the water exchange places with sodium ions on the beads, softening the water. People with hypertension or high blood pressure should consult their doctor about personal health risks associated with drinking softened water because of the added sodium Mechanical filtration removes dirt, sediment, loose scale, and insoluble iron and manganese (flakes that have not dissolved). The water is cleared by sand, filter paper, compressed glass wool, or other straining material. Mechanical filtration does not do much to remove harmful, dissolved chemicals.

Chlorination removes bacteria; other microbiological contaminants; and some taste-, odor-, and color-producing chemicals. Also, it removes hydrogen sulfide and dissolved iron and manganese when followed by mechanical filtration or an activated carbon filter. During chlorination, a pump feeds chlorine into the water. Chlorine has a residual effect, which means it works for a while after being added to the water. But if the system is not operated properly, it is expensive and possibly toxic. Also, chlorination byproducts may be harmful.

Ultraviolet radiation removes bacteria and other microbiological contaminants. Water passes a special light bulb where ultraviolet radiation kills contaminants. However, this system may not work effectively in cloudy water or when the water flow is too fast. Also, unless the unit is equipped with a special meter, it is hard to know whether the system is doing the job.

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UV units do not have a residual effect, as chlorination does Ozonation removes bacteria; other microbiological contaminants; some pesticides; and some taste-, odor-, and color-producing chemicals. It also removes hydrogen sulfide and dissolved iron and manganese when followed by mechanical filtration or an activated carbon filter. With ozonation, water is exposed to ozone gas, which destroys microorganisms. Equipment to generate ozone is expensive, and ozonation does not have a residual effect, as chlorination does.

An oxidizing filter (greensand filter or zeolite filter) removes iron, manganese, and hydrogen sulfide. In addition, it removes some taste-, odor-, and color-producing chemicals. Contaminants are removed through filtering and chemical reactions. But the system needs to be regenerated by pouring potassium permanganate into it. Potassium permanganate can pose a hazard to eyes and skin during handling, so always wear gloves.

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Industrial Water Treatment

Industrial Water Treatment can be classified into the following categories

- Boiler water treatment
- Cooling water treatment
- Wastewater treatment

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A boiler is a closed vessel in which water or other fluid is heated. The heated or vaporized fluid exits the boiler for use in various processes or heating applications Boilers can be classified into the following configurations

a.**"Pot boiler"** or **"Haycock boiler"**: a primitive "kettle" where a fire heats a partially-filled water container from below.

b.**Fire-tube boiler**. Here, water partially fills a boiler barrel with a small volume left above to accommodate the steam

c. **Water-tube boiler.** In this type,the water tubes are arranged inside a furnace in a number of possible configurations: often the water tubes connect large drums, the lower ones containing water and the upper ones, steam and water; in other cases, such as a monotube boiler, water is circulated by a pump through a succession of coils

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Cooling water treatment :

Cooling towers are heat removal devices used to transfer process waste heat to the atmosphere. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature or rely solely on air to cool the working fluid to near the dry-bulb air temperature. Common applications include cooling the circulating water used in oil refineries, chemical plants, power stations and building cooling.

An HVAC cooling tower is a subcategory rejecting heat from a chiller

Industrial cooling towers can be used to remove heat from various sources such as machinery or heated process material. The primary use of large, industrial cooling towers is to remove the heat absorbed in the circulating cooling water systems

With respect to drawing air through the tower, there are three types of cooling towers:

- **Natural draft**, which utilizes buoyancy via a tall chimney. Warm, moist air naturally rises due to the density differential to the dry, cooler outside air. Warm moist air is less dense than drier air at the same pressure. This moist air buoyancy produces a current of air through the tower.

- **Mechanical draft**, which uses power driven fan motors to force or draw air through the tower.
o Induced draft: A mechanical draft tower with a fan at the discharge which pulls air through tower. The fan induces hot moist air out the discharge. This produces low entering and high exiting air velocities, reducing the possibility of recirculation in which discharged air flows back into the air intake. This fan/fill arrangement is also known as draw-through. (see Image 2, 3)

- **Forced draft:** A mechanical draft tower with a blower type fan at the intake. The fan forces air into the tower, creating high entering and low exiting air velocities. The low exiting velocity is much more susceptible to recirculation. With the fan on the air intake, the fan is more susceptible to complications due to freezing conditions. Another disadvantage is that a forced draft design typically requires more motor horsepower than an equivalent induced draft design. The forced draft benefit is its ability to work with high static pressure. They can be installed in more confined spaces and even in some indoor situations. Fan assisted natural draft. A hybrid type that appears like a natural draft though airflow is assisted by a fan.

Hyperboloid (a.k.a. hyperbolic) cooling towers (Image 1) have become the design standard Hyperbolic structures have a negative Gaussian curvature, meaning they curve inward rather than outward or being straight. As doubly ruled surfaces, they can be made with a lattice of straight beams, hence are easier to build and, all else equal, stronger than curved surfaces that do not have a ruling and must instead be built with curved beams.

Wastewater treatment :

Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources.

The composition of wastewater varies widely. This is a partial list of what it may contain:

- Water (> 95%) which is often added during flushing to carry waste down a drain;
- Pathogens such as bacteria, viruses, prions and parasitic worms;
- Non-pathogenic bacteria (> 100,000 / ml for sewage);
- Organic particles such as faeces, hairs, food, vomit, paper fibers, plant material, humus, etc.;
- Soluble organic material such as urea, fruit sugars, soluble proteins, drugs, pharmaceuticals, etc.;
- Inorganic particles such as sand, grit, metal particles, ceramics, etc.;
- Soluble inorganic material such as ammonia, road-salt, sea-salt, cyanide, hydrogen sulfide, thiocyanates, thiosulfates, etc.;
- Animals such as protozoa, insects, arthropods, small fish, etc.;
- Macro-solids such as sanitary napkins, nappies/diapers, condoms, needles, children's toys, dead animals or plants, body parts, etc.;
- Gases such as hydrogen sulfide, carbon dioxide, methane, etc.;
- Emulsions such as paints, adhesives, mayonnaise, hair colorants, emulsified oils, etc.;
- Toxins such as pesticides, poisons, herbicides, etc.

Industrial water treatment seeks to manage four main problem areas: scaling, corrosion, microbiological activity and disposal of residual wastewater.

Boilers do not have many problems with microbes as the high temperatures prevents their growth.

Scaling occurs when the chemistry and temperature conditions are such that the dissolved mineral salts in the water are caused to precipitate and form solid deposits. These can be mobile, like a fine silt, or can build up in layers on the metal surfaces of the systems. Scale is a problem because it insulates and heat exchange becomes less efficient as the scale thickens, which wastes energy. Scale also narrows pipe widths and therefore increases the energy used in pumping the water through the pipes.

Corrosion occurs when the parent metal oxidises (as iron rusts, for example) and gradually the integrity of the plant equipment is compromised. The corrosion products can cause similar problems to scale, but corrosion can also lead to leaks, which in a pressurised system can lead to catastrophic failures.

Microbes can thrive in untreated cooling water, which is warm and sometimes full of organic nutrients, as wet cooling towers are very efficient air scrubbers. Dust, flies, grass, fungal spores and so on collect in the water and create a sort of "microbial soup" if not treated with biocides. Most outbreaks of the deadly Legionnaires' Disease have been traced to unmanaged cooling towers, and the UK has had stringent Health & Safety guidelines concerning cooling tower operations for many years as have had governmental agencies in other countries

Disposal of residual wastewaters[1] from an industrial plant is a difficult and costly problem. Most petroleum refineries, chemical and petrochemical plants [2] have onsite facilities to treat their wastewaters so that the pollutant concentrations in the treated wastewater comply with the local and/or national regulations regarding disposal of wastewaters into community treatment plants or into rivers, lakes or oceans.

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