GENERAL CHARACTERISTICS OF WATER

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Summary

Water is among the abundantly available substances in nature, covering 75 per cent of the earth's surface. It is also an essential ingredient of animal and plant life due to its unique physical, chemical and biological properties. Natural water is never completely pure. During precipitation water passes over and through the ground, acquiring a wide variety of dissolved or suspended impurities that profoundly affect its usefulness. Chemical properties of water refer to the properties of aqueous solutions of a variety of substances, namely those found as impurities in natural water, added to water during treatment, picked up during the flow of water through pipes and conduits, and added to water by manifold uses that convert it to household, municipal, or industrial waste water.

The substances of interest range from dissolved gases through numerous inorganic materials to the complex organic compounds that impart color to natural waters, which are characteristic of sewage and other waterborne waste.

Water treatment is carried out to produce water for potable use, domestic use (washing utensils, clothes, etc.) and industrial use, i.e. cooling towers, steam production in boilers, and water fit for pharmaceutical and electronic industries, etc. Water is treated either to remove harmful substances from polluted water completely or partially to prevent deterioration of the ground water supply.
From energetic viewpoint water is a valuable resource. From biological viewpoint, water is a main life support to all known living systems. However, some living systems are pollutants or life-threatening with respect to other living systems.

1. Pure Water

The anomalous properties of pure water are as follows.

(a) The high specific heat of water prevents extreme ranges in temperature and heat transfer by water movements is very large. Water tends to maintain uniform body temperature.
(b) A high latent heat of fusion results in a large thermostatic effect at freezing point during absorption or release of heat.
(c) A high latent heat of evaporation results in a large thermostatic effect at boiling point temperature. It is extremely important in heat and water transfer within the atmosphere.
(d) Fresh water and dilute seawater have a maximum density at temperatures above the freezing point. The maximum density of normal seawater is at the freezing point.
(e) Highest surface tension is important in cell physiology as it controls certain surface phenomena and the formation and behavior of droplets.
(f) The dissolving power of water has obvious implications in both physical and biological phenomena.

A high dielectric constant of water is important in the behavior of inorganic dissolved substances because of the resulting high dissociation. Water is a neutral substance, yet it produces both $H^+$ and $OH^-$ ions due to its very small dissociation. Water is largely transparent to sunlight. The absorption of radiant energy in water is large in infrared and ultraviolet regions. In the visible portion of the energy spectrum there is relatively little selective absorption by water. Hence, water is colorless in small amounts. The characteristic absorption of radiant energy by water is important in physical and biological phenomena.

The high heat conductivity of liquid water is important on a small scale such as in living cells. Water has low viscosity at comparable temperatures, hence it readily equalizes pressure differences. The maximum density of freshwater is $1 \text{ g cm}^{-3}$ at $3.98^\circ \text{C}$ and seawater has a maximum density at its freezing point, i.e. $-1.9^\circ \text{C}$. Light can travel a maximum of a few hundred meters through water. Sound can travel thousands of kilometers through water. Water is essential to life.

2. Natural Waters

Natural waters acquire their characteristics due to dissolution as well as chemical reactions with different materials they come into contact with during the hydrological cycle. Dissolved mineral matter in the natural waters comes from the crust materials of the earth, which the water disintegrates and dissolves by weathering. The interaction of carbon dioxide in the atmosphere with the mineral rocks also determines the composition of the water. Eighty per cent of water analyses indicate dissolved silica concentrations
ranging from \(10^{-3.8}\) to \(10^{-3.2}\) M, while the range of \([H^+]\) is generally from \(10^{-6.5}\) to \(10^{-8.5}\) M.

In order to understand how natural waters obtain their compositions, it is necessary to study the processes involved in the weathering of rocks and in the formation of soils. Moreover, the biosphere is also important in weathering phenomena because living matter increases the carbon dioxide content as a result of respiration. The organic matter thus produced in the biosphere serves as a reducing agent to form organic solutes which can complex with cations and contribute to their mobility.

**Water Quality Characteristics (Reynolds, Richards, 1995)**

**Biological Characteristics Microorganisms**

**Bacteria**
- Viruses
- Protozoa
- Coliform bacteria (indicate human waste)
- Helminths
- Fungi, algae

**Physical Characteristics taste, odor, color**

**Total solids (dissolved and suspended)**
- Turbidity
- Color (apparent and true)
- Taste & odor (organic compounds in surface water; dissolved gases in ground water)
- Temperature

**Chemical Characteristics Natural or Manmade**

**pH**
- Anions & cations (dissolved solids)
- Alkalinity (HCO\(_3\)-, CO\(_3\)\(_2\)+, OH-system)
- Hardness (Ca\(_2\)+, Mg\(_2\)+)
- Dissolved gases (O\(_2\), CO\(_2\), H\(_2\)S, NH\(_3\), N\(_2\), CH\(_4\)...)
- Priority pollutants (organic and inorganic)

**Microbial Contamination Is Of Major Concern For Water (Faust, Aly, 1998)**

- Protozoans
  - Amoeba, cryptosporidium, giardia, ...
- Bacteria
  - Salmonella, typhus, cholera, shigella, ...
- Viruses
  - Polio, hepatitis A, meningitis, encephalitis, ...
• Helminths
  – Guinea worm, hookworm, roundworm,…

Disinfection of water

• Chlorination
  – Highly effective for bacteria, and effective for viruses
  – Not effective for protozoa
  – Inexpensive, very common

• Ozonation
  – Highly effective

• Ultraviolet radiation
  – Effective for low turbidity

• Boiling
  – Complete sterilization possible

• Principal transmission is by human waste
• Principal purification technique is chlorination, especially for bacteria.

Disinfection of water (Twort, Rathnayaka, Brandt, 5th edition, 2000)

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Physical characteristics

• Color is due to dissolved (true color) or colloidal (apparent color) material…iron, manganese, clay,…
• Taste/odor…typically treated by aeration (to release dissolved gas from ground water) or activated carbon (to remove organics from surface water)
• Suspended solids include silt, clay, algae, colloids, bacteria...remove by settling, filtration, or flocculation
• Turbidity interferes with passage of light, usually as the result of colloidal material

**EPA Primary Standards for ~130 chemicals (WHO, 2006.)**

• Toxic metals—Arsenic, lead, mercury, cadmium, chromium,…
• Organic compounds—insecticides, herbicides, PCBs, petrochemicals, PAH, benzene, halogenated hydrocarbons,…very long list
• Radionuclides—mainly natural alpha emitter
• Secondary standards for taste, odor, appearance: Cl-, SO42-, pH, color, odor, iron, manganese, copper, zinc, foaming agents
• Nitrate or nitrite—fertilizer by product
• Fluorine—damages teeth and bones at high concentrations

**Bibliography and Suggestions for further study**


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General Characteristics of Water

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