CHAPTER II. WATER HYGIENE

2.1. WATER - ECHOLOGICAL FACTOR

Acces to adequate quantities of a safe and reliable water supply is the most fundamental requirement of human life. Without adequate water, human existence is imposible.

When water supplies are limited or otherwise compromised sustainable development of agriculture or industry is not tenable.

History records the rise and fall of civilisations because of changes in their water supply.

Wars have been fought over acces to water. In some areas of the world - the Midle East, the Indian subcontinent, and in Africa - future conflict over the ownership and distribution of water supplies seems inevitable.

Because of the finite quantity of potable water available, the unequal distribution of water over the earth's surface, and its vulnerability to contamination by natural chemicals and minerals, pathogens, and antropogenic biological and chemical wastes, water may be the most threatened resource on the planet.

The Resolution of the United States Water Conference in 1981 declared that acces to a sufficient and safe water supply is a right of all peoples:

"All peoples, whatever their stage of development and their social and economic conditions, have the right to access to drinking water in quantities and of quality equal to their basic needs."

Whether such a declaration is feasible or enforceable is uncertain.

However, without active commitment to the protection of earth's finite water supply, the goal of the world-wide acces to ample, safe water cannot be achieved.

Unfortunately, in many developed and developing areas of the world, commitment to "clean water" is not universal.

Individual countries have legislated rules and regulations to protect portions of their potable water. Some regions of the world have begun to cooperate in the cleanup of mutually critical sources of water. None of the less, the NIMBY syndrome is still rampart in water resource development and control.

Although slow progress has been made in the remediation of local pollution problems associated with human endeavor, transborder and supranational water pollution problems continue to exist on every continent. In Europe, the contamination of the Rhine River basin by anthropogenic wastes, and in South America, pollution of the Amazon River and its outfall are similar issues of concern.

2.1.1. HUMAN DRINKING - WATER REQUIREMENTS

Human drinking - water requirements are well-defined.

Studies in the temperate conditions have demonstrated that aclimatized adults consume approximately 2 l of water per day.

Under more extreme conditions, such as desert environments or under heavy work, human water consumption and water loss may rise precipitously.

According to Weitzman and Kleeman, the average aclimatized 70 Kg human, living in a temperate climate and at rest, consumes 800-1000 ml of water per day as water in food, and generates 300-400 ml of water from oxidation of food.

One to 2 l per day are consumed as liquid some of which may reasonable be expected to tap water.

To balance this intake, 800-900 ml of water are insensibly lost in exhaled air and approximately 200 ml of water are lost in the feces and 1-2 l of urine are produced per day. Thus, a balance at 2100-3400 ml of water intake and output is normal.

Under desert conditions and heavy work, an extreme increase in the water intake is to be expected.

The physiologists of the Israeli army have estimated that a fit, aclimatized young soldier marching in the desert at noon, and carrying a 25 Kg pack may sweat 3l/hour. In heavy military operations in the desert, the israeli defence forces allocate 18 l of water or more per day for each soldier for drinking and light hygiene purposes.

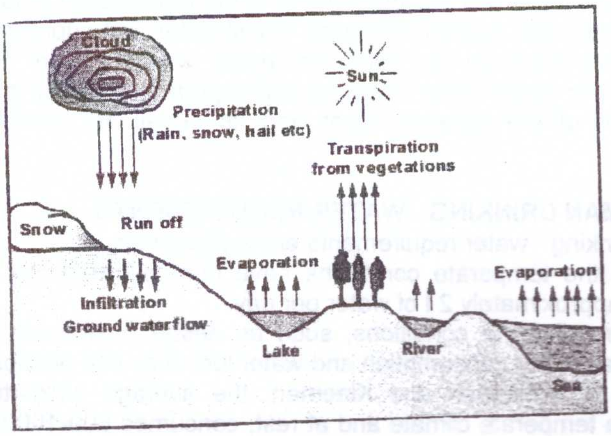
Daily water doses are assumed to be 2 liters per adult. Adjustments are made for age and size of children. Regrettably, no adjustment is made for environmental conditions under which the subjects live. Estimates of toxicity from the ingestion of water-borne chemicals are often incorrect.

2.1.2. THE WATER CYCLE AND SOURCES OF HUMAN DRINKING WATER

The earth's water is constantly in a cycle of evaporation and precipitation. Once deposited on the earth's surface, water may run off, be impounded, or percolate through various layers of soil, sand and rock to become free flowing water or confined water.

Deep aquifers are often confined. They do not participate in the evaporation and precipitation cycle unless thee confining zone above them has been penetrated and fluids extracted from them.

Evaporation from saline water sources, the oceans, and large salt marshes also contributes to the total airborne water vapor that may eventually precipitate to the earth's surface. The process of evaporation and precipitation has the potential to cleanse water of organic and inorganic contaminants, as does percolation of water through sand and soil and the action of humic bacteria and other mechanisms.



Water cycle

2.2. WATER POLLUTION

2.2.1. CHEMICAL WATER POLLUTION

Chemical pollution of water is a worldwide problem.

Freshwater resources all over the world are threatened not only by over exploitation and poor management but also by ecological degradation. The main source of freshwater pollution can be attributed to discharge of untreated waste, dumping of industrial efluent, and run-off from agricultural fields. Industrial growth, urbanization and the increasing use of synthetic organic substances have serious and adverse impacts on freshwater bodies. It is a generally accepted fact that the developed countries suffer from problems of chemical discharge into the water sources mainly groundwater, while developing countries suffer from problems of agricultural run-off in water sources.

2.2.1.1. POLLUTANTS IN DRINKING WATER

Chemicals in water can be both naturally occuring or introduced by human interference and can have serious health effects.

- ARSENIC. Arsenic occurs naturally or is possibly aggrevated by over powering aquifers and by phosphorus from fertilizers. High concentration of arsenic in water can have an adverse effect on health. Arsenic poisoning through water can cause liver and nervous system damage, vascular diseases and also skin cancer.
- LEAD. Pipes, fittings, solder, and the service connections of some household plumbing systems contain lead that pollutes the drinking water sources.
  Lead is hazardous to health as it accumulates in the body and affects the central nervous system. Children and pregnant women are most at risk.
- MERCURY. In Minamata, Japan, inorganic mercury was used in the industrial production of acetaldehyde. It was discharged into the nearby bay as waste water and was ingested by organisms in the bottom sediment. Fish and other creatures in the sea were soon polluted and eventually residents of this area who consumed the fish suffered from methyl mercury intoxication, later known as the Minamata disease. Even after the emission of mercury stopped, the bottom sediment of the polluted water contained high levels of this mercury.
- FLUORIDE. Fluoride in the water is essential for protection against dental caries and weakening of the bones, but higher levels can have an adverse effect on health. In India, high fluoride content is found naturally in the waters in Rajasthan.
  Excess fluorides can cause yellowing of the teeth and damage to the spinal cord and other crippling diseases.
- PESTICIDES. Run-off from farms, backyards, and golf courses contain pesticides such as DDT that in turn pollute the water. Leechate from landfill sites is another major polluting source. Its effects on the ecosystems and health are endocrine and reproductive damage in wildlife. Groundwater is susceptible to pollution, as pesticides are mobile in the soil. It is a matter of concern as these chemicals are persistent in the soil and water.
  The organophosphates and the carbonates present in pesticides affect and damage the nervous system and can cause cancer. Some of pesticides

contain carcinogens that exceed recommended levels. They contain chlorides that cause reproductive and endocrinal damage.

- NITRATES. The nitrates come mainly from the fertilizer that is added to the fields. Excessive use of fertilizers cause nitrate pollution of groundwater, with the result that nitrate levels in drinking water is far above the safety levels recommended. Good agricultural practices can help in reducing the amount of nitrates in the soil and thereby lower its content in the water.
  Drinking water that gets polluted with nitrates can prove fatal especially to infants that drink formula milks as it restrict the amount of oxygen that reaches the brain causing the "blue baby" syndrome. It is also linked to digestive tract cancers. It causes algae to bloom resulting in eutrophication in surface water.
- PETROCHEMICALS. Petrochemicals contaminate the groundwater from underground petroleum storage tanks. Benzene and other petrochemicals can cause cancer even at low exposure levels.
- CHLORINATED SOLVENTS. Metal and plastic effluents, fabric cleaning, electronic and aircraft manufacturing are often discharged and pollute water. There are linked to reproduction and to some cancers.
- OTHER HEAVY METALS. These pollutants come from mining waste and tailings, landfills, or hazardous waste dumps. They cause damage to the nervous system and the kidney, and other metabolic disruptions.
- SALTS. It makes the fresh water unusable for drinking and irrigation purposes.

In addition to the dosage of water that is ingested daily, humans are exposed to water vapor, aerosols, and mists of a water on a continuous basis. While this exposure to atmospheric water vapor and aerosols may contribute little to the water balance of the exposed humans, soluble organics and inorganics in this inhaled water may substantially increase the dose of toxic material that is absorbed through the respiratory system. In addition, water that is on the skin may contain dissolved material that can penetrate the epidermis and dermis and thus be absorbed.

Dermally absorbed organics may also contribute significantly to the total dose of toxic substances where humans use water contaminated with partially soluble organic materials such as halogenated hydrocarbons for all ordinary domestic purposes, consumption, cooking, and hygiene, one third of the absorbed dose of toxic materials comes from water vapor and aerosol, and one third from dermal contact.

In view of those observations, assesment of human water-borne exposure to toxic materials must be very carefully evaluated for environmental conditions and work loads and for the utilisation of water for purposes other than consumption by the population under study.

Soluble organics that may escape the soil/sand adsorbtion process or that may be resistant to bacterial degradation may be evaporated with water, separately and at different rates, only to redissolve in the water/air mass.

While much of this organic load is the result of industrial and agricultural activity, a very significant portion may be volatile halomethanes of several different structures produced in finished drinking water that has been chemically disinfected with chlorine - or bromine based disinfection systems. The most proeminent of these halomethanes, a proved animal and probable human carcinogen.

Other closely related halo-organic species also occur in finished water disinfection processes. Bromomethanes, chloramines and other closely related chemicals have been identified in finished disinfected water.

Airborne particulate matter, which is produced by the combustion of fossil fuels, may carry high loads of oxides of sulfur. These sulfur compounds are either adsorbed to the particulate's core or are dissolved in the aerosols that oxidative combustion produces.

Acid particulate contribute an acid load to atmospheric water, which may become acid precipitation. Since these acidic materials are quite stable in water, they progressively acidify the surface and groundwater into which they are mixed.

Smokes, aerosols, mists, and vapors may all contribute organic materials and inorganic substances of varying toxicologic significance to the air.

In the vicinity of some coal-fired power plants and some other solid or beneficiated fuel-fired facilities, alkaline fly ash is deposited, which produces paradoxical alkalinization of the soil and adjacent surface and groundwaters.

Much of the particulate-bound load is partially water-soluble. It will reprecipitate to the earth's surface as atmospheric conditions change and rain falls.

Oxynitrogenated organics, partially-soluble polynuclear organics and metallo-organics may participate in the evaporation/precipitation cycle to pollute surface and subsurface waters.

2.2.1.2. SIGNIFICANT POLLUTANT SOURCES AND INPUT TO SURFACE AND GROUNDWATER SOURCES

Surface waters and groundwater are particularly vulnerable to pollution by the direct influence of anthropogenic wastes.

Agricultural chemicals, industrial chemicals, mining wastes, septic tank and landfill leakage, and direct sewage discharge to surface or groundwater may pollute drinking water resources.

Small scale inputs of agricultural chemicals from domestic lawn and garden care with herbicides can pollute large quantities of drinking water.

Halogenated solvents, paints and varnishes, carburetor cleaners, and gasoline may become troublesome if released to the groundwater or surface waters in quantities below those which are regulated and reportable. These chemicals are a significant source of local and regional surface and groundwater pollution.

However, smaller scale backyard and garage pollution sources may be equally dangerous.

In recent years, massive-scale dumping of agricultural and industrial chemicals has been greatly reduced.

The right to discharge materials into the environment is granted under a permitting process that is administered by state. The permits that are granted specify the quantities of pollutants that may be discharged, and the time of discharge.

They also establish the monitoring and other activities that must be carried out to assure compliance with the permit.

They help to assure that a responsible standard is applied uniformly to all who discharge hazardous materials and who contaminated water resources, soil, or air.

SPECIFIC SOURCES OF WATER POLLUTANTS

DOMESTIC SEWAGE

Domestic sewage refers to waste water that is discarded from households. Also referred to as sanitary sewage, such water contains a wide variety of dissolved and suspended impurities.

It amounts a very small fraction of the sewage by weight. But it is large by volume and contains impurities such as organic materials and plant nutrient that tend to rot. The main organic materials are food and vegetable waste, plant nutrient come from chemical soaps, washing powders, etc. Domestic sewage is also very likely to contain disease-causing microbes. Thus, disposal of domestic waste water is a significant technical problem.

Today, many people dump their garbage into streams, lakes, rivers, and seas, thus making water bodies the final resting place of cans, bottles, plastics, and other household products. The various substances that we use for keeping our houses clean add to water pollution as they contain harmfull chemicals. In the past, people mostly used soaps made from animal and vegetable fat for all types of washing. But most of today's cleaning products are synthetic detergents and come from the petrochemical industry. Most detergents and washing powders contain phosphates, which are used to soften the water among other things. These and other chemicals contained in washing powders affect the health of all forms of life in the water.

PULP AND PAPER INDUSTRY

This industry discharges large quantities of toxic persistent and complex organics directly into surface waters, albeit which fully permitted facilities that generally operate close to or within their permitted limits. In adition to abiotic acids, lignins, and other organic extracts, chlorine-based pulp bleaching plants discharge tetrachlorodibenzoparadioxin (2,3,7,8 TCDD) and its congeners.

These highly persistent organics are transferred to silt, sediment, and biota.

From the silt, toxics are transferred to fish in the stream ecosystem.

The pollutants, may be concentrated many-fold within the fish before they are consumed by humans or animals.

Bioconcentrations of toxins that are present in very low concentrations in water supplies from which humans daw agricultural or drinking water, or which are used for subsistence, commercial, or sport fishing is a major cause of water pollutant derived risk of disease to humans.

PETROCHEMICAL EXPLORATION, REFINING AND DISTRIBUTION

Both surface pollution and ground-water pollution occcur as a result of losses and spills in petrochemical extraction, refining, distribution, and utilization.

Control of production and distribution wastes has improved in the petrochemical industry.

Current regulations prohibit the disposal of oily wastes to groundwater or surface water sources or the placement of these materials in landfill or municipal-controlled solid waste sites. Impoundment and cleanup purification and treatment of oily and sour water wastes are required before these materials may be released to sewage systems. However, past practices and current breaches of operating rules in the petrochemicals industry continue to contribute significant levels of hydrocarbons to the drinking water supplies of residents who use well water that collected in the vicinity of these operating units.

LAND FARMING AND SLUDGE APLICATIONS

The practice of land farming or sludge disposal from industrial and municipal waste plants continues to be common.

In the petrochemicals industry, contaminated sludge is applied to unpolluted soil.

This sludge is exposed to environmental conditions that promotes the movement of these materials from the sludge to groundwater.

Sludge frequently contains dioxins and related products, metals, and other persistent toxins.

Land farming practices are permitted by the EPA because of their potential for soil beneficiation.

However, the wisdom of land farming as a waste disposal method for sludge, which contains persistently toxic, partially soluble organics, metals, and long-term toxicity, even a quite low concentrations, remains questionable.

DEEP WELL INJECTION OF TOXIC MATERIALS

This process of injection on materials into the deepest saline water resources was acceptable for many years.

The consequences of the injection have never been fully evaluated.

MINING AND MINERALS PRODUCTION

On a global basis, mining and minerals production and the processing and fabrication on the final metalic products is one of the largest sources of water pollutants.

Exploitation of mineral resources results in the transfer of large volumes of metals from relatively protected deep mineral deposits to surface areas.

Natural migration and solvation of metals from mineral deposits to drinking water can result in human poisoning.

This process is responsible for areas of endemic blackfoot disease due to arsenic in well water in Taiwan.

Extraction of the minerals of interest and preparation of the economic product introduces large volumes of metals and the chemicals used to extract them to the surface and groundwater resources.

Not only does the direct extraction of metals produce water pollutants, acid mine drainage also contributes significantly to water pollution in the downstream areas.

Lead, zinc, cooper, nickel, vanadium, manganese and iron componds at toxic concentrations have been demonstrated in surface and groundwater adjacent to and downstream from mines and mineral extraction facilities.

Drinking water wells in mining areas of highly mineralized areas should be tested for metal content as well as for extraction chemicals such as phosphates, nitrates, and cyanides because these materials readily enter the water table from leaky extraction facilities.

Other mining-associated materials that have been identified in surface and groundwater sources for drinking water include polychlorinated biphenyls and sulfuric acid.

In the Balkan states, Balkan nephropathy has been identified and associated with mineral nitrogen, which probable arises in the course of mineral extraction. Studies of nitrite water pollution in the former Yugoslavia and its associated interstitial nephritis have raised concerns about the effect of these compounds on renal health.

Itai-Itai, or "ouch-ouch" cadmium-induced systemic disease, occurred in Japan as a result of the pollution of estuarine waters that provided most of the dietary fish to a large population.

RADIONUCLIDES

Radioactive minerals extraction used during Cold War military activities and for the purposes of fueling nuclear power plants has lead to surface and groundwater contamination with radionuclides. These radioactive materials include radium, uranium, and their decay products.

The water may release radon gas.

In a number of areas, water has been significantly contaminated with tritium and alpha emitters as a result of these activities.

In some localities, these elevated concentrations of water-borne radionuclides are believed to be responsible for elevated childhood leukemia rates.

Natural radioactivity also leads to contamination of groundwater and drinking water sources. Drinking water contaminated by naturally radioactive derivatives of the uranium and thorium decay series accounts only for a very small portion of the total annual dose of radiation for most humans. In some situations, the risk of leukemia and other cancers is elevated for those who live above, or drink from, groundwater sources that contain higher than normal radionuclide decay products. The products include radon and thoron.

HIGH TECHNOLOGY INDUSTRY

High technology industries such as semiconductor manufacturing plants, which are now proliferating in both the developed and developing areas of the world, are water intensive. Each facilities have included large quantities of halogenated organics such as trichloroethylene, trichloroethane, perchloroethylene, and carbon tetrachloride.

Many complex organics are used as photoactive agents in photoresists.

Metals and metalloids such as arsenic, selenium, beryllium, cadmium, and lead are also in use in these plants.

All semiconductor facilities have plating sections where cyanides and metalic plating solutions containing hexavalent chromium and other carcinogenic metals are in use.

Groundwater and drinking water pollution from high technology industries has occurred in areas where groundwater sources are important contributors to drinking water supplies.

The current situation is worrisome because the majority of the chemicals that have been leaked by these plants are of the same general type as the halohydrocarbons produced in the disinfection of drinking water.

Thus, the concern about long-term carcinogenic and other effects from disinfectant chemical residues, which at this time are inevitably present in community water supplies, is accentuated by the consumption of this high technology chemical cocktail.

The greatest concern must be directed towards bladder and colon cancer, which are increased in communities where there is long-term consumption of water with elevated concentrations of halo-hydrocarbons.

Since it appears that water disinfection technology is not sufficiently developed to permit abandonment of the chlorination procedures currently in use, the added burden of halo-hydrocarbons in the drinking water supply from industrial sources is very worrisome.

POWER PLANTS AND COOLING TOWERS

In Eastern and Central Europe, every large and many smaller industrial facilities have their own on-site power generation facility.

Each of these facilities must treat its water to prevent corosion of the cooling towers and the arrest growth of bacteria, such as the Legionella genus and fungi in the cooling water. For many years, the principal materials used to prevent cooling tower corrosion where hexavalent chromium componds. Organic mercurials were the rule for cooling tower biocides.

Local conditions are so variable that there is substantial risk that carcinogenic chromium will be distributed in the drinking water, along with organic mercurial biocides and other substances from cooling system chemicals from any such use and disposal practice.

AGRICULTURAL CHEMICALS

Agriculture is the largest user of water resources around the world. It is also the industry with most direct acces to surface and groundwater resources.

Agricultural chemicals have the greatest potential to produce serious water pollution problems.

In the past 50 years, the development of a chemically intensive agricultural pattern in every country has led to the pollution water supplies with many evanescent and persistent chemicals of considerable acute and chronic toxicity.

The Minamata Bay ecosystem in Japan was contaminated with industrial mercury runoff in the 1950s. Consumption of mercury-contaminated fish from this region resulted in many children being born with neurological birth defects.

Other materials have similar widespread distribution. Chlorophenols, fluorinated compounds, chlorothalonil, dinoseb, metribuzin, linuron and monuron, glyphosate, and others have all been identified in public and private drinking water supplies.

In many parts of the world, dibromochloropropane (DBCP) contamination of ground water has occurred as result of the direct injection of this carcinogenic compound into the soil for the control of nematodes in bananas, pineapples and sugar beets.

DBCP causes male sterility in agricultural and manufacturing workers who make or apply this material.

Pollution of surface and groundwater with nitrates used as fertilisers lead to serious and even fatal acute illness in children who consumed this water in infant formula.

In addition, these nitrates are the substrat for further biological alteration to nitrosamines, which are carcinogenic.