# Water Quality and Standards

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# Importance of Water

To function properly, man needs at least 8 glasses of water daily.

Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation.

Approximately 70% of freshwater is consumed by agriculture.

Different bodies of water provide livelihood and economic security to different countries.

# Water Quality

Water quality is the physical, chemical, biological, and aesthetic characteristics of water which determines its fitness for a variety of uses and for protecting the health and integrity of aquatic ecosystems.

Another general perception of *water quality* is that of a simple property that tells whether water is polluted or not.

Water quality depends on the local geology and ecosystem, as well as human uses such as sewage dispersion, industrial pollution, use of water bodies as a heat sink, and overuse (which may lower the level of the water).

# SOURCES OF WATER

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# WATER QUALITY CLASSIFICATION

# Water Resource

Surface Water is:

- 97% saltwater (oceans and seas)
- 2.4% glaciers and polar ice caps
- 0.6% other land surface water such as rivers, lakes, and ponds

Ground Water – all water that saturates the tiny spaces between alluvial material (sands, gravel, silt, clay) or the crevices or fractures in rocks. This includes the aeration zone, aquifers, saturation zones, capillary water, and water-bearing rocks.

A very small amount of the Earth's water is contained within water towers, biological bodies, manufactured products, and food stores.

# Human Consumption or Drinking-Water - Parameters

- Alkalinity
- Color of water
- pH
- Taste and odor
- Dissolved metals and salts (sodium, chloride, potassium, calcium, manganese, magnesium)
- Microorganisms such as fecal coliform bacteria (*Escherichia coli*), Cryptosporidium, and Giardia lamblia
- Dissolved metals and metalloids (lead, mercury, arsenic, etc.)
- Dissolved organics: colored dissolved organic matter (CDOM), dissolved organic carbon (DOC)
- Radon
- Heavy metals

# Environmental Water Quality

Also called **ambient water quality,** pertains to water bodies such as lakes, rivers, and oceans.

Ambient water quality standards vary significantly due to different environmental conditions, ecosystems, and intended human uses.

Toxic substances and high populations of certain microorganisms can present a health hazard for non-drinking purposes such as irrigation, swimming, fishing, rafting, boating, and industrial uses. These conditions may also affect wildlife which use the water for drinking or as a habitat. Modern water quality laws general specify protection of fishable/swimmable use and antidegradation of current conditions.

# Environmental Water Quality

Environmental advocates express desires to return water bodies to pristine, or pre-industrial conditions.

Current environmental laws focus of the designation of uses and therefore allow for some water contamination as long as the particular type of contamination is not harmful to the designated uses.

Given the landscape changes in the watersheds of many freshwater bodies, returning to pristine conditions would be a significant challenge. In these cases, environmental scientists focus on achieving goals for maintaining populations of endangered species and protecting human health.

# Environmental Water Quality – Parameters

- **Physical Properties**
  Color, odor, temperature, solids (residues), turbidity, oil content, and grease content.

- **Chemical Properties**
  - pH
  - Conductivity
  - Dissolved oxygen (DO)
  - Nitrate
  - Orthophosphate
  - Chemical oxygen demand (COD)
  - Biochemical oxygen demand (BOD)
  - Pesticides

- **Biological Properties**
  Bacteriological parameters: coliforms, fecal coliforms, specific pathogens, and viruses.

# COMPONENTS OF WATER QUALITY

(microbial, biological, chemical, and physical aspects)

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# MEASUREMENTS

# Components of Water Quality

Microbial Aspect

Drinking water should not include microorganisms that are known to be pathogenic.

It should also not contain bacteria that would indicate excremental pollution, the primary indicator of which are coliform bacteria that are present in the feces of warm-blooded organisms.

Chlorine is the usual disinfectant, as it is readily available and inexpensive. Unfortunately, it is not fully effective, as currently used, against all organisms.

# Components of Water Quality

## Biological Aspect

Parasitic protozoa and helminths are also indicators of water quality. Species of protozoa can be introduced into water supply through human or animal fecal contamination.

Most common among the pathogenic protozoans are *Entamoeba* and *Giardia*.

Coliforms are not appropriate direct indicators because of the greater resistance of these protozoans to inactivation by disinfection.

A single mature larva or fertilized egg of parasitic roundworms and flatworms can cause infection when transmitted to humans through drinking water.

# Components of Water Quality

## Chemical Aspect

Chemical contamination of water sources may be due to certain industries and agricultural practices, or from natural sources.

When toxic chemicals are present in drinking water, there is the potential that they may cause either acute or chronic health effects.

Chronic health effects are more common than acute effects because the level of chemicals in drinking water are seldom high enough to cause acute health effects.

# Components of Water Quality

## Physical Aspect

The turbidity, color, taste, and odor of water can be monitored.

Turbidity should always be low, especially where disinfection is practiced. High turbidity can inhibit the effects of disinfection against microorganisms and enable bacterial growth.

Drinking water should be colorless, since coloration may be due to the presence of colored organic matter.

Organic substances also cause water odor, though odors may result from many factors, including biological activity and industrial pollution.

Taste problems relating to water could be indicators of changes in water sources or treatment process. Inorganic compounds such as Mg, Ca, Na, Cu, Fe, and Zn are generally detected by the taste of water.

# Water Quality Measurement

The complexity of water quality as a subject is reflected in the many types of measurements of water quality indicators. Some measurements that can be made on-site are temperature, pH, dissolved oxygen, and conductivity.

More complex measurements that must be made in a laboratory setting require a water sample to be collected, preserved, and analyzed at another location (e.g., microbiological tests).

# Measurement:pH

- pH, or the "potential of hydrogen", is a measure of the concentration of hydrogen ions in the water.
- This measurement indicates the acidity or alkalinity of the water. On the pH scale of 0 - 14, a reading of 7 is considered to be "neutral." Readings below 7 indicate acidic conditions, while readings above 7 indicate the water is alkaline or basic.
- Naturally occurring fresh waters have a pH range between 6.5 and 8.5. The pH of the water is important because it affects the solubility and availability of nutrients, and how they can be utilized by aquatic organisms.
- The main significance of pH in domestic water supplies relates to its effects on water treatment.

# Measurement of pH

The pH of a water does not have direct health consequences except at extremes:

- pH <4.0, severe danger of health effects due to dissolved toxic metal ions are expected. Water tastes sour.

-At pH 4.0 – 6.0, toxic effects associated with dissolved metals, including lead, are likely to occur. Water tastes slightly sour.

-At target water quality range of 6.0 to 9.0, no significant effects on health are expected.

-At pH 9.0 – 11.0, the probability of toxic effects associated with deprotonated species increases sharply. Water tastes bitter.

- At pH>11.0 – severe danger of health effects due to deprotonated species. Water tastes soapy.

Treatment option would be the addition of an acid or an alkali

# Measurement # 2 Dissolved Oxygen (DO)

- Dissolved oxygen is the amount of oxygen dissolved in water, measured in milligrams per liter (mg/L).
- This component in water is critical to the survival of various aquatic life in streams, such as fish.
- The ability of water to hold oxygen in solution is inversely proportional to the temperature of the water. For example, the cooler the water temperature, the more dissolved oxygen it can hold.
- Common standard for water is that DO is at 8.0 mg/L
- The Philippines standard is 5 mg/L

# Measurement #3
# Biological Oxygen Demand (BOD)

- Biological Oxygen Demand is a measure of how much oxygen is used by microorganisms in the aerobic oxidation, or breakdown of organic matter in the streams.
- Usually, the higher the amount of organic material found in the stream, the more oxygen is used for aerobic oxidation.
- This depletes the amount of dissolved oxygen available to other aquatic life. This measurement is obtained over a period of five days, and is expressed in mg/L.
- Philippines standard for BOD in water is not more than 5 mg/L

# Surface Water Class A and Coastal and Marine Water Class SB

| DO mg/L | | BOD mg/L | |
|---|---|---|---|
| Satisfactory (S) | >5 | Satisfactory (S) | <5 |
| Marginal (M) | 5 | Marginal (M) | 5 |
| Unsatisfactory (U) | <5 | Unsatisfactory (U) | >5 |
| Minimum Requirement | 5 | Minimum Requirement | 5 |

# Measurement #4
# Temperature

- Temperature is a measure of how cool or how warm the water is, expressed in degrees Celsius (C).
- Temperature is a critical water quality parameter, since it directly influences the amount of dissolved oxygen that is available to aquatic organisms.
- Water temperature that exceeds 18°C (for Class A Waters) has a deleterious effect on several fish species in streams.
- Salmonids, for example, prefer waters of approximately 12 to 14 degrees Celsius.

# Measurement #5 Conductivity

- Conductivity is the ability of the water to conduct an electrical current, and is an indirect measure of the ion concentration.
- The more ions present, such as that of carbonate, bicarbonate, chloride, suphate, nitrate, Na, K, Ca, and Mg, the more electricity can be conducted by the water.
- This measurement is expressed in microsiemens per centimeter (uS/cm) at 25°C. The target water quality range is 0 – 70.

# Measurement #6
# Total Dissolved Solids (TDS)

- Total dissolved solids is a measure of the amount of particulate solids that are in solution.
- This is an indicator of nonpoint source pollution problems associated with various land use practices.
- The TDS concentration is directly proportional to the electrical conductivity of water.
- Since conductivity is much easier to measure than TDS, it is routinely used as an estimate of the TDS concentration.
- TDS is expressed in (mg/L) with target water quality range of 0 – 450 mg/L.

# Measurement #7 Turbidity

- Turbidity is a measure of the clarity of the water.
- It is the amount of solids suspended in the water.
- It can be in the form of minerals or organic matter.
- It is a measure of the light scattering properties of water, thus an increase in the amount of suspended solid particles in the water may be visually described as cloudiness or muddiness.
- Turbidity is measured in Nephelometric Turbidity Units (NTU).
- Standard is 5 NTU's

# Measurement #8
# Fecal Coliform Bacteria

- Fecal coliform bacteria are microscopic organisms that live in the intestines of all warm blooded animals, and in animal wastes or feces eliminated from the intestinal tract.
- Fecal coliform bacteria may indicate the presence of disease-carrying organisms which live in the same environment as the fecal coliform bacteria.
- The measurement is expressed as the number of organisms per 100 mL sample of water (#/100mL).
- Standard Fecal Coliform Bacteria is 100 organisms per 100 mL

# Environmental Water Quality – Biological Assessment

Biological monitoring metrics have been developed in many places, and one widely used measure is the presence and abundance of members of the insect orders Ephemerontera (Mayfly), Plecoptera (Stonefly) and Trichoptera (Caddisfly)

Generally, within a region, the greater the number of taxa from these orders, the better the water quality.

Without the laboratory scale analysis, an individual can use this biological indicator to get a general reading of water quality (such as the benthic macro-invertebrate indicator key).


# SOURCES OF CONTAMINATION

# Sources of Contamination

Construction and mining sites, disturbed land areas, streambank erosion and alterations, cultivated farmland

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Fertilizer on agricultural, residential, commercial and recreational lawns, animal wastes, effluent from aquaculture facilities, leaky sewers and septic tanks, atmospheric deposition, municipal wastewater

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Pesticide applications, disinfectants (chlorine), automobile fluids, accidental spills, illegal dumping, urban stormwater runoff, industrial effluent

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Wastewater effluent, organic matter, leaking sewers and septic tanks, animal waste

# Sources of Contamination

Failing septic tanks, animal waste, runoff from livestock operations, wildlife, improperly disinfected wastewater effluent

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Salt applications to snow and ice

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Leaky automobiles, industrial areas, illegal dumping

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Hydrological modifications that influence the amount of fresh or saline waters entering a system

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Heated landscape areas, runoff from impervious areas, tree removal along streams, wet detention ponds

# Sources of Point and Nonpoint Pollution

## POINT SOURCES

- Wastewater effluent, both municipal and industrial
- Runoff and leachate from waste disposal sites
- Runoff and infiltration from animal feed lots
- Runoff from mines, oil fields, and unsewered industrial sites
- Storm sewer outfalls from cities with a population of greater than 100,000
- Runoff from construction sites larger than two hectares
- Overflows of combined storm and sanitary sewers

## NONPOINT SOURCES

- Runoff from agriculture (including return flow from irrigated agriculture)
- Runoff from pasture and range
- Urban runoff from unsewered areas and sewered areas with a population of less than 100,000
- Septic leachate and runoff from failed septic systems
- Runoff from construction sites smaller than two hectares
- Runoff from abandoned mines
- Atmospheric deposition over a water surface
- Activities on land that generate contaminants, such as logging, wetland conversion, construction and development of land or waterways

# MEANS OF TREATMENT

# Means of Treatment

**Coagulation** – the separation or precipitation of particles in a dispersed state from a suspension resulting from their growth. This may result from the addition of an electrolyte (coagulant), prolonged heating, or from a condensation reaction between a solvent and solute.

**Flocculation** – the addition of chemical reagents (flocculants) to bring small particles together in flocs through the process of coagulation, aggregation, or biochemical reaction of fine suspended particles.

**Ion exchange** – the interchange of ions of like charge, usually on a solid medium and is used in water treatment, such as water softening.

# Means of Treatment

**Ozonation** – disinfection using ozone.

**Reverse Osmosis** – a technique in the desalination of water in which pressure is applied to the surface of the saline solution, forcing pure water to pass through a semi-permeable membrane which prevents passage of other ions.

**Distillation** – the process of producing gas or vapor from a liquid by heating the liquid in a vessel and then collecting and condensing the vapors into liquids.

**Electodialysis** – the process of selective diffusion through a membrane conducted with the aid of an electromotive force applied to electrodes on both sides of the membrane.

# Means of Treatment

**Disinfections** – to kill living organisms (ex. chlorination, ozonation, use of potassium permanganate, UV light, or silver ions.

**Filtrations/ultra-filtrations** – ex. A bed of sand or pulverized coal, or through a matrix of fibrous material supported on a perforated core.

**Adsorption** – ex. using activated alumina, activated carbon or activated carbon (GAC).

**Aeration** – a process of exposing water to air by dividing the water into small drops, by forcing air through the water, or by combination of both. It is used to add oxygen to water and to remove CO2, hydrogen sulfide, and taste-producing gases or vapors .

**Boiling** – to kill some bacteria.

# WATER QUALITY MANAGEMENT

# Water Quality Management

Water quality management is the planning for the protection of a water's quality

- for various beneficial use,

- for the provision of adequate wastewater collection, treatment, and disposal of municipalities and industries, and

- for activities that might create water quality problems, and regulating and enforcing programs to accomplish the planning goals, and law and regulations dealing with the water pollution control.

# Water Quality Management

The United Nations, in its recent examination of global water scarcity (1997) identified water quality as one of the key concerns in Asia in the next century. This concern is based on the fact that water quality degradation is so severe in many Asian countries that it is placing serious constraints on economic growth. It continues to be a serious problem for human health and it is causing widespread negative environmental effects.