Chapter-two

Water and Health

What is water?

- **Chemistry:** Pure water consists of two atoms of hydrogen & one oxygen = H20 (distilled water?? Rain Water??).
  - It is impossible for water to exist in such form in nature. Water contains some kind of impurities.
  - Physical characteristics: odourless, colourless, tasteless, liquid, about density 1.0 g/cm3.

What is water?

- **Dissolve oxygen (DO):** clear fresh water at 25C0 contains 9-10ppm (mg/L)of oxygen; threshold for aquatic life is 4.0ppm;
- **Biochemical oxygen demand (BOD):** the amount of dissolved oxygen consumed by aquatic microorganisms. Typical fresh natural water contains 1-2ppm; treated water: 10-20ppm; Sewage; >200ppm (Little Akaki river in AA has about 400ppm).

What is water?

- **Chemical oxidation demand (COD):** the amount of oxygen needed for the decomposition of both organic and non-organic matter.
- **Both BOD & COD**:- measures the strength of water pollution.

Importance of water

- Physiological needs: 70% of our body by weight;
- To maintain this level a healthy man will require 2.0-2.5 litres per day
- Water intake balance: 2-2.5L intake (1.5L drink, 0.6-1.0L food, 0.3-0.4L body oxidation); equal loss (1.5L urine, 0.4-0.6L sweat, 0.35-0.4L breathing, 0.1-0.14L faeces;
- generally half of intake is lost by skin and lung, and half of it by urine and faeces);

Importance of water

- Domestic use: cleaning, washing, swimming, livestock watering
- Recreational purposes: swimming, boating, fishing,(lakes Langano, Ziway, etc.)
- Other uses: agriculture, transportation, power production, industrial use, etc.
- Lack of safe and adequate water is still a major problem globally and nationally

Importance of water

- In emergency situations such as in refuge camps, a minimum supply of five liters of safe water is needed per day for each person to secure the most elementary needs for survival - two to three liters of water for drinking and cooking and the remaining two liters for washing and cleaning.

Importance of water

- In the post-emergency phase, a daily ration of 20 liters per person per day has proven necessary to avoid the transmission of major water borne-disease.

Technical terms in water supply

- **Raw water**: untreated water from suspicious sources such as river, lake or from unprotected wells and springs.
- **Potable water**: which is safe, clean and whole some for human consumption
- **Hard water**: water which contains excessive amount of dissolved minerals, usually salts of calcium and magnesium

Technical terms in water supply

- **Contaminated water**:- water which may contain harmful microorganisms or toxic chemicals which make it unfit for use.
- **Palatable water**:- water which is pleasant to drink
- **Safe water:-** It is water that does not contain harmful chemical substances, or microorganisms in concentration that could cause illness in any form (WHO).
  - Drinking water must be physically, microbiologically, and chemically safe.

Current water issues

- Vulnerability of surface water to drought and diversion of rivers for agricultural and urban use.
- Declining ground water levels due to failure to replenish, compaction of aquifers and salt water intrusion.
- Surface water pollution from nonpoint sources
- Ground water pollution
- Increasing competition for water supplies

Occurrence and sources of water

- 72%of earth's surface is covered by water, of which
- 97.2% ocean (Contains 35mg/l salt) ,
- 2% in frozen state,
- Only 0.8% exists as available fresh water.
- Sources of drinking water: **Surface** (river, lakes, ponds, dams); **Ground water**(springs and wells); **Rain water.**

Impurities of water

1. Suspended impurities: e.g. Microorganisms, suspended solids(cause color taste and turbidity), algae (cause color taste and turbidity)
2. Dissolved impurities: e.g. gases(CO_2, H_2S) , minerals (Salts of Ca, Mg, Salts of Na. K, Salts of heavy metals: Pb, As, Cr, Nitrates, Fluorides etc) plant dyes

Health effects of impurities

- Infection
- Turbidity, taste, colour, odour
- Acidity, photosynthesis
- Hardness
- Alkalinity
- Toxicity
- Methaemoglobnamia
- Dental caries or mottling

Hardness of water_

- Causes: Temporary hardness: Ca (HCO3)2, Mg (HCO3)2; permanent: Cl; SO4-2, CO3- of Ca, Mg, Fe, Mn.
- Adverse effects: loss of soap & detergents; effects to kidney; scale formation on boiling; disturbance of GI tract (MgSO4,), decreases life fabrics;
- Methods of softening:
  - Temporary hardness: boiling and use of hydrated lime, Ca (OH)2 in large scale.
  - Permanent: use of soda ash (Na2CO3) and ion exchange method

Health importance of drinking water supply

1. Toxicity: excess chemicals above the standard causes a health risk of acute and sub acute toxicity: example Pb≤0.05mg/l, Hg≤0.001mg/l, etc. of WHO standard.

Health importance of drinking water supply

2. Water related diseases:

- Diseases associated with water can be broadly classified in to 5 epidemiological groups. These include:
- Water borne: when the pathogene is in the water and consumed (cholera, typhoid, giardiasis, etc)
- Water washed: when the water is inadequate (conjunctivitis, scabies, trachoma)

Health importance of drinking water supply

- Water based (contact): the pathogen spends part of its life cycle in aquatic animals. (schistosomiasis, guinea worm).
- Water-insect related: the pathogen carrying insect is breeding near the water and bite near it (yellow fever a viral, by Mosquito Aedes Egypti, malaria by Anopheles mosquito, dengue fever viral by Aedes mosquitoes, filariasis helminthic by mosquitoes Aedes, Culex, and Mansonia, onchocerciasis bacteria by black fly).

Health importance of drinking water supply

- ***Excess or shortage of chemical constituents:***
- Elements occur due to the geological formation or water gets contaminated through discharges or infiltration of organic compounds and pesticides used in agriculture. E.g. dental fluorosis, dental caries etc

Health importance of drinking water supply

- 20-30 diseases different etiologies are transmitted through water;
- Adequate water can decrease diarrhea by 25%; Water quality alone by 16%, both by 37% (some studies);
- Improved latrine provision decreases diarrhea by 20% (some studies)
- Water supply, latrine provisions, and hygiene education decrease diarrhea significantly.

Objective of drinking water supply

- To supply safe and wholesome water: this means:

1) microbiological safety;
2) removal of excessive and undesired chemicals;
3) addition of essential chemicals;
4) removal of impurities that interfere with water colour, taste, and odour;

- Adequate supply for all purposes: cooking, washing, personal hygiene,

Sources of Water

- Ground water-wells, springs...
- Surface water-rivers, streams, lakes, ponds, sea...
- Rain water-the purest source provided that it is collected from clean surface

Ground water

1. Definition: “Ground water is that portion of the rainfall water which has percolated into the earth until it reaches an impermeable stratum”
2. Advantages: likely to free from contamination and pollution; does not need treatment plants if properly protected (a protected well, spring); can be accessed for individuals where it is abundant,dependable year round.(Ziway, etc);

Ground water

Disadvantage:

- May contain excessive dissolved minerals
- May need pumping

Well protection

- Site selection: the well should be sited at least 15 metres (preferably 30 meters) away and upward from any potential underground contamination;

Well protection

- With in the well: 1) fencing (at about 10m radius in rural);

2) a 3m from the surface water tight internal wall lining; The casing should also extended for a minimum of 60cm above the surrounding ground level, and

3) water proof concrete platform about one mater square should be constructed on the ground surface at the top of the well, overlapping the casing and graded off.

Well protection

4) Cover: the well should be closed (sealed) while the water being drawn with a pump or drawn with a fixed bucket and rope system (windlass);
5) a raised well apron of at least one meter radius and height of >50cm;
6) Diversion ditch **:** a surface runoff drainage channel of at least 10 meters length with a soak away pit/trench or plant irrigation.

Spring protection

- Definition: Ground water issued at favorable water table.
- Need of sanitary survey: adequacy, topography, hydrology, and potential source of contamination;
- Structure: eye of spring; protection box; collection box; delivery or in take pipe, over flow pipe with a screen; water gradient; diversion ditch; fencing;

Surface water supply

1. Occurrence: fresh water – river, lakes, ponds;
2. Characteristics:

- Physical: less naturally dissolved minerals; has dissolved oxygen: 8-12 ppm;
- Pollution: likely to be polluted by industrial & municipal effluents affecting the water physical, biological and chemical characteristics;

Surface water supply

- Self purification: sedimentation, dilution, oxidation, photosynthesis, plankton;
- Un polluted water has aquatic animals; animals like worms, snails, etc in its bank;
- BOD (biological oxidation demand): amount of oxygen needed for aerobic microorganisms to decompose organic matter. A water with no organic has 0 ppm; fresh surface water – 2-5ppm; domestic sewage->100ppm (Addis Ababa Akaki river – 400ppm; treated sewage-10-20ppm.

Surface water supply

- Dissolved oxygen (DO): fresh surface water has 8-12ppm; An oxygen sensitive fish can not survive <4ppm (critical level)

Surface water treatment

- It is the process of removing all those substances whether biological , chemical or physical which is potentially dangerous or undesirable in water supplies for human and domestic use.

The main objectives of water treatment

- To remove pathogenic organisms and consequently prevent water-born diseases
- To remove substances which impart color, taste, or odor to the water.
- To remove excess or undesirable chemicals or minerals from the water
- To regulate essential elements or chemicals which may be in excess or lacking in a certain water supply system
- To remove excess or undesirable dissolved gases

The process flow

2.1 Water intake: the source can be a dam, river, lake. There are sanitary zones

restricted and controlled (supervised) to prevent the water pollution.

2.2. Aeration: removal of H_2S, CO_2,

oxidation of iron, manganese,

The process flow

2.3. Pre chlorination and pre limation: use of chlorine and Ca (OH)2 for killing microbes, odour control and pH adjustment;

2.4. Coagulation and Sedimentation: to remove mainly suspended matters; reduction of microbes; use of aluminium sulfate, ferrous and ferric sulphates, synthetic flocculants;

The process flow

2.5. Filtration: to remove suspended, colloidal matters; removal of microbes; use of slow and rapid sand filter beds;

2.6. Disinfection: mainly use of chlorination to remove pathogenic microorganisms;

2.7. Distribution.

Rain water

- Rain water is reasonably clean and safe for drinking if properly collected from clean catchment (roof) surfaces
- . It is the main source of water in arid and semi arid areas like Somalia, Afar, some areas of Wello.

Rain water

- Rain water can be harvested in storage tanks (roof catchment), dams and ponds by surface catchment.
- The mean annual rainfall amount in mm, the catchment surface area, the water consumption amount, and the seasonal pattern of rainfall is necessary to design the required catchment and amount of water needed for the dry season when there is no rainfall.

Treatment of water in small scale

1. Definition: Water supply at village, community, and house hold level at affordable cost to meet safe water.

2. Rural community water supply (underground water source): Well and springs protection;

3. community and Household level water treatment (surface water source):

3.1. Contamination and pollution control: restriction of activities by zoning of surface water; safe handling of fetched water;

Treatment of water in small scale

3.2. Water suspended matters be removed or highly reduced on storage in big container for 34 days to decrease the turbidity at least by 50%; or use of a barrel filter with 30cm sand thickness;

3.3. filtration using a home made barrel sand filter with 60cm sand thickness and 20cm gravel thickness;

3.4. Use of Moringa crushed seeds for tubidity improvement; 150-200mg/l; about 30 seeds per 40 litres; only effective within 24 hours after coagulation.

Treatment of water in small scale

3.5. Water can be disinfected:

- Chlorine solution: three drops of 1% chlorine solution per liter of clear water, six drops per liter of turbid water;
- Chlorine tablets: halazone: used as per instruction (example halazone tablets containing four mg. of p-carbixybenzenesulphondichloroamide used as one tablet per clear water, two tablet per highly contaminated water for 30 minutes exposure time)

Treatment of water in small scale

- Iodine solution: two drops of 2% Iodine tincture per liter of clear water; iodine tablet
- Use of direct sunlight radiation: SODIS technique: a five hours sunlight radiation of one litre of water contained in half blackened and half transparent plastic or glass bottle;
- Boiling for 5 minutes;

Treatment of water in small scale

4. Raine water: in arid areas: harvesting rain water into storage tanks, ponds or dams (example Tigrai, Somali, and Afar Regions);

Water quality control and surveillance

1. Definition: Characteristics or attributes of water, good or bad, that are related to acceptability for drinking. Water safety in terms of physical, chemical, and biological acceptability.

Types of water surveillance:

- Sanitary survey: topography, hydrology, and epidemiological assessment. Its aim is to detect any possible source of contamination, detect any leakages; confirm the integrity of the water system; identify if the system is protected as required

Types of water surveillance:

- . It is done during site selection, during construction works, during epidemics, after heavy flooding and heavy rainfall; during sample taking.

Laboratory surveillance

- sampling, laboratory test for chemical, biological, and physical tests.
- The most usual routine test include: organoleptical, residual chlorine (if treated) and faecal coliform (E.Coli) determination.
- Residual chlorine in a chlorinated water – 0.2-0.5ppm;
- No E.coli be detected using either memberane or multiple dilution method.

Bacteriological analysis indicators: guide line for repeated analysis

- 95% of water samples should not contain any coliform organisms in 100ml through out any one year provided:
- No sample should contain more than 10 coliform organisms per 100ml.
- Coliform organisms should not be detected in 100ml of any two consecutive samples.
- No sample should contain E.coli per 100ml

Bacteriological analysis: requirements

- Both pathogenic and non pathogenic organisms may exist in water;
- There should be both technically and economically feasible to detect one of them;
- Coliforms are chosen as an indicator:
- Co-exist with pathogens in water and sewage;

Bacteriological analysis: requirements

- Their number is proportional to the extent of pollution;
- Present in greater numbers than pathogens;
- No after growth in water;
- Greater survival than pathogens;

Bacteriological analysis: requirements

- Absent in unpolluted water;
- Easy and fast to detect in lab;
- Harmless to animal and human;
- Good indicator of faecal contamination from animals and humans.

Coliform groups:

- Grows well in lactose broth and endo agar at 35-37C0 in 24 hours; biochemically: lactose broth fermenting with acid and gas formation; it is gram negative bacilli, aerobic; rod shaped, non spore forming;