

1. Water quality pollution and analysis

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1.1. Introduction

Water is a common chemical substance that is essential for the survival of all known forms of life. In typical usage, water refers only to its liquid form or state, but the substance also has a solid state (ice), and a gaseous state (water vapor or steam). Water is essential to life. Without it, the biosphere that exists on the surface of the earth wouldn't be possible. Nicknamed the "water" planet, earth is covered by one of our most precious resources. However, almost 93% is locked in the oceans, toxic to humans and many plants and animals. Our use of water is increasing rapidly with growing population, regardless of the acute shortages of both surface and underground waters in many areas of the world in general and in Ethiopia in particular.

Many experts have produced figures that clearly demonstrate that physical output and life expectancy are much increased by adequate and safe supply of water. Indeed, one of the millennium development targets under Goal 7, i.e. Environmental sustainability, is to halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation. Most of the world still does not have centralized water supply with connections to individual households.

The estimated water supply coverage for Ethiopia is 65.8 % for rural and 91.5% for urban without considering the functional condition of the facilities making the country's water supply coverage 68.5%.

- ✓ **Drinking water** is water used for domestic purposes: drinking, cooking and personal hygiene;
- ✓ **Safe drinking water** is water with microbial, chemical and physical characteristics that meet WHO guidelines or national standards on drinking water quality.
- ✓ **Access to water-supply services** is defined as the availability of at least 20 liters per person per day from an "improved" source within 1 kilometer of the user's dwelling.

- ✓ An **“improved” source** is one that is likely to provide "safe" water, such as a household connection, a borehole, etc.

An improved water supply is defined as:

- ✓ Household connection
- ✓ Public standpipe
- ✓ Borehole
- ✓ Protected dug well
- ✓ Protected spring
- ✓ Rainwater collection

Only 48% of the world's population is connected at the household level.

Wholesome water is defined as the water which containing the minerals in small quantities at required levels & free from harmful impurities. The water that is fit for drinking safe and agreeable is called **potable water**. The following are the requirements of wholesome water;

- It should be free from bacteria
- It should be colorless and sparkling(bright)
- It should be tasty, odor free and cool
- It should be free from objectionable matter
- It should not corrode pipes.
- It should have dissolved oxygen and free from carbonic acid so that it may remain fresh

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, and use of water bodies as a heat sink, and overuse (which may lower the level of the water). Water quality describes the condition of the water, including chemical, physical and biological characteristics, usually with respect to its suitability for a particular purpose such as drinking or swimming.

Absolutely pure water is never found in nature and contains number of impurities in varying amounts. The rainwater which is originally pure also absorbs various gases, dust and other impurities while falling. This water when moves on the ground further carries salt, organic and inorganic impurities. So this water before supplying to the public should be treated and purified for the safety of public health, economy and protection of various industrial processes, it is most essential for the water work engineer to thoroughly check, analyze and do the treatment of the raw water obtained the sources, before its distribution. The water supplied to the public should be strictly according to the standards laid down from time to time. 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, and use of water bodies as a heat sink, and overuse (which may lower the level of the water).

The materials found in water may be divided into living organisms and solid or dissolved organic and inorganic. Not all of these are harmful, and some may even be desirable for health, esthetic, or technical reasons. Potable water is one that is safe to drink, pleasant in taste, and suitable for domestic purposes. A contaminated water or polluted water contains suspended or dissolved materials which makes it unsuitable for its intended use. The primary objective of water treatment is to produce water which is safe and appealing for human consumption. Thus water collected from best available sources will be subjected to pass through various physical and chemical processes and unit operations. This will ensure the production of water of good physical, chemical and biological quality, and free from unpleasant taste and odour and containing nothing which might be harmful to health.

All surface water and some ground waters require treatment prior to consumption to ensure that they do not represent a health risk to the user. Health risks to consumers from poor quality water can be due to microbiological, chemical, or physical contamination. However, microbiological contamination is generally the most important to human health as this leads to infectious diseases which affect all populations groups, many of which may cause epidemics and can be fatal. Chemical contamination, with the exception of a few substances such as cyanide and nitrate,

tends to represent a more long-term health risk. An example of this is nitrate which can cause methaemoglobinaemia in babies. Substances in water which affect the clarity colour or taste of water may make water objectionable to consumers. As many microorganisms are found associated with particles in water, physical contamination may also represent a health risk as it extends microbial survival.

The following three categories are used to describe drinking water quality:

1. Physical: Physical characteristics relate to the quality of water for domestic use. They include color, turbidity, temperature, and, in particular, taste and odor.

2. Chemical: Chemical characteristics of waters are sometimes evidenced by their observed reactions, such as the comparative performance of hard and soft waters in laundering. Most often, differences are not visible. However, in some cases, such as the oxidation of iron, the reactions result in highly objectionable color.

3. Microbiological: Microbiological agents are very important in their relation to public health and may also be significant in modifying the physical and chemical characteristics of water.

Drinking-water requirements:

- ❖ The most important requirement DW must meet is that it is free of organisms and chemical substances which might be injuries to health.
- ❖ DW should be of such a composition that consumers do not question the safety of the water. This requirement implies that turbidity, colour, taste and odour should be low, and macro-organisms (e.g. worms, Asellus, aquatic and fly nymphs) should be absent.
- ❖ DW should be suitable for housekeeping, for this reason
 - The iron and manganese content should be low, because these substances colour laundry (like shirts) during washing. Iron causes a brown and manganese a black colour.
 - Hardness should be low, because water with a high hardness causes scale formation in water-heaters by precipitation of calcium carbonate. Moreover a high hardness of the water implies that a high dosage of detergent is required for washing.
- ❖ DW should not be aggressive to materials like lead, copper, asbestos cement and concrete, cast iron, galvanized steel, PVC (poly vinyl chloride) and PE (polyethylene).

Because pipes, tubes and apparatus used in distribution systems and plumbing installations may consist of these materials. Pipes, tubes and apparatus affected by water cause many problems.

- ❖ DW should be free of any disagreeable taste or odour. Consumers do not like to be supplied with water that does not have a good test and odour. Moreover DW which has any disagreeable taste or odour is unsuitable for making tea, coffee, soup, etc.

1.2 Sources of Water Pollution

In general, pollutants can be released into the environment as gases, dissolved substances or in the particulate form. Ultimately pollutants reach the aquatic environment through a variety of pathways, including the atmosphere and the soil.

Pollution may result from point sources or non-point sources. There is no clear-cut distinction between the two, because a non point source on a regional or even local scale may result from a large number of individual point sources, such as automobile exhausts. An important difference between a point and a non point source is that a point source may be collected, treated or controlled (non point sources consisting of many point sources may also be controlled provided all point sources can be identified). The major point sources of pollution to freshwaters originate from the collection and discharge of domestic wastewaters, industrial wastes or certain agricultural activities, such as animal husbandry. Most other agricultural activities, such as pesticide spraying or fertilizer application, are considered as diffuse sources. The atmospheric fall-out of pollutants also leads to diffuse pollution of the aquatic environment.

Point sources

Point source is a pollution input that can be related to a single outlet. Untreated, or inadequately treated, sewage disposal is probably still the major point source of pollution to the world's waters. Other important point sources include mines and industrial effluents. As point sources are localized, spatial profiles of the quality of the aquatic environment may be used to locate them. Some point sources are characterized by a relatively constant discharge of the polluting substances over time, such as domestic sewers, whereas others are occasional or fluctuating discharges, such as leaks and accidental spillages. A sewage treatment plant serving a fixed population delivers a continuous load of nutrients to a receiving water body. Therefore, an increase in river discharge causes greater dilution and a characteristic decrease in river concentration. This contrasts with atmospheric deposition and other diffuse sources where increased land run-off often causes increased pollutant concentrations in the receiving water system.

Non-point sources

Non point sources cannot be ascribed to a single point or a single human activity although, as pointed out above, they may be due to many individual point sources to a water body over a large area. Typical examples are:

- ✓ Agricultural run-off, including soil erosion from surface and sub-soil drainage. These processes transfer organic and inorganic soil particles, nutrients, pesticides and herbicides to adjacent water bodies.
- ✓ Urban run-off from city streets and surrounding areas (which is not channeled into a main drain or sewer). Likely contaminants include derivatives of fossil fuel combustion, bacteria, metals (particularly lead) and industrial organic pollutants, particularly PCBs.
- ✓ Pesticides and herbicides may also be derived from urban gardening, landscaping, horticulture and their regular use on railways, airfields and roadsides. In the worst circumstances pollutants from a variety of diffuse sources may be diverted into combined storm/sewer systems during storm-induced, high drainage flow conditions, where they then contribute to major point sources.
- ✓ Waste disposal sites which include municipal and industrial solid waste disposal facilities; liquid waste disposal (particularly if groundwater is impacted); dredged sediment disposal sites (both confined and open lake). Depending on the relative sizes of the disposal sites and receiving water bodies, these sources of pollution can be considered as either diffuse or point sources, as in the case of groundwater pollution.
- ✓ Other diffuse sources including waste from navigation, harbor and marina sediment pollution, and pollution from open lake resource exploitation, in particular oil and gas.

1.2.1 Main sources of water pollution

The following are the main sources of water pollution:

1. Domestic Sewage

If domestic sewage is not properly after it is produced or if the effluent received at the end of sewage treatment is not of adequate standard, there are chances of water pollution. The indiscriminate way of handling domestic sewage may lead to the pollution of underground sources of water supply such, as wells. Similarly if sewage or partly treated sewage is directly

discharged into surface waters such as rivers, the waters of such rivers get contained.

2. Industrial Wastes

If industrial wastes are thrown into water bodies without proper treatments, they are likely to pollute the watercourses. The industrial wastes may carry harmful substances such as grease, oil, explosives, highly odorous substances, etc.

3. Catchment Area

Depending upon the characteristics of catchment area, water passing such area will be accordingly contained. The advances made in agricultural activities and extensive use of fertilizers and insecticides are main factors, which may cause serious pollution of surface waters.

4. Distribution System

The water is delivered to the consumers through a distribution of pipes which are laid underground. If there are cracks in pipes or if joints are leaky, the following water gets contaminated by the surrounding substances around the pipes.

5. Oily Wastes

The discharge of oily wastes from ships and tankers using oil as fuel may lead to pollution.

6. Radioactive Wastes

The discharge of radioactive wastes from industries dealing with radioactive substance may seriously pollute the waters. It may be noted that radioactive substances may not have color, odour, turbidity or taste. They can only be detected by and measured by the use of special precise instruments.

7. Travel of Water

Depending upon the properties of ground through which water travels to reach the source of water supply; it is charged with the impurities. For instance, ground water passing through peaty land possesses brown color.

1.2.2 Water Contaminants

1.2.2.1 Disease causing organisms

Adequate and Safe drinking water is important in the control of many communicable diseases which may be transmitted by water includes diarrhea, cholera, typhoid, paratyphoid fever, Trachoma, Typhus, amoebic and bacillary dysentery. Diseases associated with inadequate and unsafe water can take a number of forms. This may be grouped accordingly in Table 1.1. Organisms which cause infection disease are normally spread through the fecal and urinary discharge of sick persons and carriers. Protection of water supplies against these agents is thus normally a matter of preventing discharge of inadequately treated wastewater into the source and provision of appropriate treatment mechanisms.

Water borne diseases are those carried by water that is contaminated with infecting agents from human or animal origin. When the water is drunk the infecting agents will be ingested and may cause disease. To control such diseases improve the quality of the water.

Table 1.1 Diseases related to deficiencies in water supply and/or sanitation

Group	Disease
○ Disease transmitted by water (Water – Borne disease)	Cholera, Typhoid, Bacillary dysentery, Giardiasis, etc
○ Disease due to lack of water (Water-Washed diseases)	Trachoma, Ascariasis, Hookworms, Typhus, etc.
○ Disease caused by infecting agents spread by contact with or ingestion of water (Water-Based diseases)	Biliharziosis (Schistosomiasis)
○ Disease transmitted by insect which live close to water (Water – related Vectors)	Malaria, Sleeping sickness

Diseases due to lack of water tend to be a serious health hazard. When people use very little water, either because there is very little available or because it is too far away to be carried home in quantity, it may be impossible to maintain a reasonable personal hygiene. Skin or eye infections are thus allowed to develop, and intestinal infections can much more easily spread

from one person to another. The prevention of water washed diseases depends on the availability of, and access to adequate supplies of safe water.

1.2.2.2 Inorganic contaminants

Inorganic contaminants include both suspended and dissolved materials. Suspended materials are undesirable for esthetic reasons, but their primary effect on quality lies in their ability to shield microorganisms from disinfectant. Dissolved inorganic which have health effects includes aluminum, arsenic, barium, cadmium, chromium, fluoride, lead, mercury, nitrate, selenium, and silver. Table 1.2 summarizes the effect of some of these and other common water contaminants.

1.2.2.3. Other common constituents of natural water

All Natural waters contain some dissolved mineral matter. The commonly encountered cations are sodium, potassium, calcium, magnesium, iron, and manganese, which are associated with the anionic species bicarbonate, carbonate, sulfate, and chloride. These contaminants do not have chronic or toxic health impacts. In fact, People are so accustomed to these impurities that distilled water tastes flat and unpleasant. The divalent cations contribute to hardness, which is sometimes defined as the ability to neutralize soap. Iron and Manganese contribute to hardness, but their more important effect results from their oxidation and subsequent precipitation. This causes metallic taste and discolored water which stain clothes, cooking utensils, and plumbing fixtures.

Sulfate in association with magnesium and sodium can have a pronounced laxative effect on people who are not accustomed to water. Chloride in high concentration can contribute a salty taste to water and is sometimes an indication of sewage contamination, since the chloride concentration increases when water is used for domestic purposes. Bicarbonate and carbonate results from the dissolution of carbonate rocks and provide a very important buffer system in natural waters. Dissolved gases in water include all those to which it is exposed. Those which are commonly encountered are nitrogen, oxygen, carbon dioxide, hydrogen sulfide, and methane. Hydrogen sulfide has a disagreeable rotten egg odor in low concentration, is poisonous in high concentration and contributes to corrosion of metals and concrete. Carbon dioxide can contribute to dissolution of subsurface minerals and corrosion of metals. Oxygen can contribute to corrosion of metals under some conditions.

Table 1.2 Suspended and Dissolved Impurities of Water

Type	Constitutes	Effect
1. Suspended impurity	a) Bacteria b) Algae, protozoa c) Silts	Some cause disease Odour, Colour, and Turbidity Murkiness, or turbidity
2. Dissolved impurity	a) Salts I. Calcium and Magnesium - Bicarbonate - Carbonate - Sulfate - chloride II. Sodium - Bicarbonate - Carbonate - Sulfate - Fluoride - chloride b. Metal and compounds - Iron oxide - Manganese - Lead - Arsenic - Barium - Cadmium - Cyanide - Boron - Selenium - Silver - Nitrate c. Gases - Oxygen - Carbon dioxide - Hydrogen sulphide	Alkalinity Alkalinity, hardness Hardness Hardness, corrosion Alkalinity, softening effect Alkalinity, softening effect Foaming in boilers Dental fluorosis or mottled enamel Taste Taste, red colour, corrosiveness, hardness Black or brown colour Cumulative poisoning Toxicity, poisoning Toxic effect on heart, nerves Toxic Fatal Affect central nervous system Highly toxic to animals, fish Discolouration of skin, eyes Blue baby conditions; infant poisoning colour; acidity Corrosiveness to metal Acidity, corrosiveness Odour, acidity, corrosiveness

1.3 water quality changes

Water quality is a term used here to express the suitability of water to sustain various uses or processes. Any particular use will have certain requirements for the physical, chemical or biological characteristics of water; for example limits on the concentrations of toxic substances for drinking water use, or restrictions on temperature and pH ranges for water supporting invertebrate communities. Consequently, water quality can be defined by a range of variables which limit water use. Although many uses have some common requirements for certain variables, each use will have its own demands and influences on water quality. Quantity and quality demands of different users will not always be compatible, and the activities of one user may restrict the activities of another, either by demanding water of a quality outside the range required by the other user or by lowering quality during use of the water. Efforts to improve or maintain a certain water quality often compromise between the

quality and quantity demands of different users. There is increasing recognition that natural ecosystems have a legitimate place in the consideration of options for water quality management. This is both for their intrinsic value and because they are sensitive indicators of changes or deterioration in overall water quality, providing a useful addition to physical, chemical and other information.

The composition of surface and underground waters is dependent on natural factors (geological, topographical, meteorological, hydrological and biological) in the drainage basin and varies with seasonal differences in runoff volumes, weather conditions and water levels. Large natural variations in water quality may, therefore, be observed even where only a single watercourse is involved. Human intervention also has significant effects on water quality. Some of these effects are the result of hydrological changes, such as the building of dams, draining of wetlands and diversion of flow. More obvious are the polluting activities, such as the discharge of domestic, industrial, urban and other wastewaters into the watercourse (whether intentional or accidental) and the spreading of chemicals on agricultural land in the drainage basin.

Water quality is affected by a wide range of natural and human influences. The most important of the natural influences are geological, hydrological and climatic, since these affect the quantity and the quality of water available. Their influence is generally greatest when available water quantities are low and maximum use must be made of the limited resource; for example, high salinity is a frequent problem in arid and coastal areas. If the financial and technical resources are available, seawater or saline groundwater can be desalinated but in many circumstances this is not feasible. Thus, although water may be available in adequate quantities, its unsuitable quality limits the uses that can be made of it. Although the natural ecosystem is in harmony with natural water quality, any significant changes to water quality will usually be disruptive to the ecosystem.

The effects of human activities on water quality are both widespread and varied in the degree to which they disrupt the ecosystem and/or restrict water use. Pollution of water by human faeces, for example, is attributable to only one source, but the reasons for this type of pollution, its impacts on water quality and the necessary remedial or preventive measures are varied. Faecal pollution may occur because there are no community facilities for waste

disposal, because collection and treatment facilities are inadequate or improperly operated, or because on-site sanitation facilities (such as latrines) drain directly into aquifers. The effects of faecal pollution vary. In developing countries intestinal disease is the main problem, while organic load and eutrophication may be of greater concern in developed countries (in the rivers into which the sewage or effluent is discharged and in the sea into which the rivers flow or sewage sludge is dumped). A single influence may, therefore, give rise to a number of water quality problems, just as a problem may have a number of contributing influences. Eutrophication results not only from point sources, such as wastewater discharges with high nutrient loads (principally nitrogen and phosphorus), but also from diffuse sources such as run-off from livestock feedlots or agricultural land fertilized with organic and inorganic fertilizers. Pollution from diffuse sources, such as agricultural runoff, or from numerous small inputs over a wide area, such as faecal pollution from unsewered settlements, is particularly difficult to control.

1.3 .1 Natural processes affecting water quality

Although degradation of water quality is almost invariably the result of human activities, certain natural phenomena can result in water quality falling below that required for particular purposes. Natural events such as torrential rainfall and hurricanes lead to excessive erosion and landslides, which in turn increase the content of suspended material in affected rivers and lakes. Seasonal overturn of the water in some lakes can bring water with little or no dissolved oxygen to the surface. Such natural events may be frequent or occasional. Permanent natural conditions in some areas may make water unfit for drinking or for specific uses, such as irrigation. Common examples of this are the salinization of surface waters through evaporation in arid and semi-arid regions and the high salt content of some groundwater under certain geological conditions. Many groundwater are naturally high in carbonates (hardness), thus necessitating their treatment before use for certain industrial applications. Groundwater in some regions contain specific ions (such as fluoride) and toxic elements (such as arsenic and selenium) in quantities that are harmful to health, while others contain elements or compounds that cause other types of problems (such as the staining of sanitary fixtures by iron and manganese). The nature and concentration of chemical elements and compounds in a freshwater system are subject to change by various types of natural process, i.e. physical, chemical, hydrological and biological.

1.3.2 Water use and water quality deterioration

Historically, the development of civilizations has led to a shift in the pattern of water use from rural/agricultural to urban/industrial, generally according to the following sequence: drinking and personal hygiene, fisheries, navigation and transport, livestock watering and agricultural irrigation, hydroelectric power, industrial production (e.g. pulp and paper, food processing), industrial cooling water (e.g. fossil fuel and nuclear power plants), recreational activities and wildlife conservation. Fortunately, the water uses with the highest demands for quantity often have the lowest demands for quality. Drinking water, by contrast, requires the highest quality water but in relatively small quantities. Increasing industrialization and the growth of large urban centers have been accompanied by increases in the pollution stress on the aquatic environment. Since ancient times, water in rivers, lakes and oceans has also been considered as a convenient receiver of wastes. This use (or abuse) conflicts with almost all other uses of water and most seriously with the use of freshwater for drinking, personal hygiene and food processing.

All water uses have impacts on the quality of the aquatic environment, including hydrological changes such as storing water in reservoirs or transferring water from one drainage area to another. Human use of water for almost all purposes results in the deterioration of water quality and generally limits the further potential use of the water.

A three-point strategy has been developed to resolve the conflicts between quality deterioration and water use as follows:

- The quality of water and of the aquatic environment is determined and water-use procedures that prevent deterioration are adopted.
- Wastes are treated before discharge to a water body in order to control pollution.
- Unsatisfactory water is treated before use in order to meet specific water quality requirements.

Human activities are the source of particulate, dissolved and volatile materials which may eventually reach water. Dissolved materials and many particulates are discharged directly to water bodies, while the particulate and volatile materials that pollute the atmosphere are picked up by rain and then deposited on land or in water.

1.3.3 Population Density and Water Quality

Human activities produce residential pollutants, primarily food waste, washing residues, hospital sewage, and household garbage. However, due to the lack of proper processing of these pollutants, most were directly discharged into the natural environment and carried by runoff into water bodies.

1.3.4 Pipe material

The pipe material is important because of its influence on water quality and its relationship to energy efficiency. For example, the release of lead will pose health risks for consumers; the release of nutrients from rubber material will promote microbial growth in the distribution system, the presence of tuberculation will make the pipes rough inside, resulting in increased pumping costs and, in some extreme cases, leakages. Worldwide, the traditional inorganic pipe materials are being replaced by organic pipe materials, even if the use of stainless steel is increasing. Iron pipes with interior cement-mortar lining and exterior plastic protection, as well as other cement-based materials, are still being installed. Although lead and asbestos cement-based material are being phased out and replaced, there are still substantial lengths being used in operational distribution systems.

1.3.5 Aging pipes.

The challenges of aging pipes:

- ✓ Aging pipes are more vulnerable to contaminants. The challenge is especially serious in developing countries where maintenance of the distribution system infrastructures is lacking due to inadequate resources. Water loss level increase in aging pipes. In cases of low or negative pressures in the pipes, the contaminated water, wastewater, and other contaminants surrounding the pipes can be drawn into the pipes through cracks. In such cases, even if measures are taken to improve water quality at the treatment plant, customers will not fully benefit from them.
- ✓ The material accumulated in a distribution system (biofilm, scaling and loose deposits) develops over time. Therefore, the older the pipes the greater the accumulation of material in the form of pipe scales, biofilm matrix and loose deposits.

- ✓ Because the long design lifespan and limited accessibility, the distribution lines consist of pipes installed at different times. As a result, it is a variegated reflection of both past and present.

1.3.6 Impact of Increased Air Temperature on Water Quality

Many studies have concluded that water temperature will increase because of global warming. A reduction in the concentrations of nutrients as a result of warmer water temperatures is due to increased air temperatures as consequences of global warming. Nutrient concentrations in rivers decline when air temperature increases. The decreases in nutrient concentrations may be a product of increased phytoplankton growth, such that more algae are utilizing more nutrients, and therefore a lower concentration of nutrients remains in the water. In addition Temperature increase may affect the portability of water, and temperature above 15°C is objectionable to drinking water. The temperature of surface waters governs to a large extent the biological species present and thereof activity. Temperature has an effect on most chemical reactions that occur in natural water systems. It also has pronounced effect on the solubility of gases in water.

1.4 Impurity of water schemes

Water that is absolutely pure is not found in nature. Water vapor in the air condenses about particles and, as it falls, absorbs dust and dissolved oxygen, carbon dioxide and other gases. At the ground surface it takes up silt and other inorganic matter. A few bacteria will enter the water from the air, but at the ground surface many more will be picked up as it runs off in streams or rivers. Small amount of the products of the decomposition of organic matters, nitrites, nitrates, ammonia, and carbon dioxide will go into solution. Surface water will retain all these impurities for an indefinite period, but that part of the rainfall which percolates into the soil will lose the suspended silt and bacteria by filtration. The products of decomposition may also be lost in the filtration process by chemical combinations or by the action of plants. This loss of impurities, however is offset by the solution of various salts which percolating water will encounter in its path, the amount and character depending upon the length of underground travel and the chemical makeup of the strata traversed.

Potable water is one that is safe to drink, pleasant to the test, and usable for domestic purposes. Contaminated water is one that contains microorganisms, chemicals, Industrial or other wastes or sewage so that it is unfit for its intended use.

Water that has no impurity is called pure water. It is important constituent of food, every cell in our body contains 90% of water. Pure water is not found under natural conditions. That water which is nearer to purity is rain water especially that which has been collected from clean surfaces and that which is stored in a tank protected from pollution or contamination. Even then rainwater may pick various kinds of impurities while falling

1.4.1 Types of impurities

1. **Organic impurities**-found from the growth and decay of animals and vegetable matters. This may include waste matter (animal, human) refuse and garbage, bacteria, microscopic plants and animals.

2. **Inorganic impurities**-found from the earth. These are minerals/nutrient and chemicals.....

1.4.2 Forms of Impurities of water

1. **Suspended impurities ($> 1 \mu\text{m}$)** these are very fine particles of insoluble matter, which float in a liquid; they do not disappear as in the case of dissolved solids. If they are allowed to stand undisturbed they may settle to the bottom.

➤ Some of these are:

a) Microorganisms ($1-10 \mu\text{m}$) as a result of pollution of surface water. Pathogens (harmful bacteria) may be present in such condition, most dangerous impurity. Pure water is a very

b) Suspended solids that include solids and clay, pesticide, insecticides that may be washed down from agricultural or industrial setup or droplet from a sprayer. Suspended solids (ferric hydroxide) generally cause taste or colour or turbidity (muddiness)

c) Algae that grow in ponds, riverbanks and in still water, causes taste, colour and turbidity important constituent of food

2. **Dissolved impurities ($< 0.001 \mu\text{m}$)**: Many solids and gasses are soluble in water. Thus, if they are put in water they disappear seemingly to become liquids, but in reality they are there dissolved. These are divided in to two: Gases (for example oxygen, CO_2 , H_2S , etc) and

Minerals/ions (Salts of Ca & Mg that causes *hardness* in water and Na & K causes *alkalinity*; other minerals such as Pb, As, Hg, Cr are *toxic* and Fluoride, cause *florosis* and *stained teeth*; Nitrate causes *Blue baby syndrome* or *Methaemoglobin anemia* in infants; Humic substance causes color and test problem Every cell in our body.

3. Colloidal impurities (0.001- 1 μm) or (0.005 – 0.2 μm): Colloidal particles (colloids) are midway in size between dissolved solids and suspended matter. Colloids are kept in suspension (stabilized) by electrostatic repulsion and hydration. Some of these are: clay, proteins, silica, microorganisms (0.03 – 0.3 μm), great variety of organic polymers, cause color and test problems. Some impurities of water cannot be seen with the naked eye but can be detected by test or odour. Some can be seen, and other can be detected only by laboratory tests. Therefore it is usually advisable to ascertain the nature and quality of impurities by taking samples at different seasons and condition to the laboratory.

