Pollution

Pollution is the introduction of contaminants(pollutant) into the natural environment that cause adverse change to the environment.

Pollutant: A pollutant is a waste material that pollutes air, water, or soil. Three factors determine the severity of a pollutant: its chemical nature, the concentration and the persistence.

The common types of pollution include:

Water pollution,
air pollution,
Soil pollution,
Light pollution, and
Noise pollution.

Water pollution

Water pollution is the **pollution** of bodies of **water**, such as lakes, rivers, seas, the oceans, as well as groundwater with any foreign substances, thereby decreasing the quality of water and would pose a great environmental hazard.

Causes of water pollution

1. Domestic waste and sewage – release of kitchen wastes, human faces, urine, plastics bags and bottle, and organic substances into the canals and rivers pollute water sources.
2. Industrial waters: - water get polluted by wastes of industries like paper, leather, textile. Soap, distilleries and oil refineries. They release acids, alkalis cyanides, hazardous metals insecticides, pesticides.
3. Runoff water from land and fields- water washed down from residential and industrial area contains heavy metals, oil, grease, harmful bacteria, viruses pollute water.
4. Oil industry: -Oil spills during its transportation, extraction and washing of automobile run- off to rivers and pollute them.
5. Agriculture discharge: -Animal manure, pesticides, insecticides, fertilizers all cause water pollution.
6. Bacteria, virus and aquatic plants: -effluents form hospitals, medical lab and the presence of dead bodies of animal and plants in water bodies contaminate the water and cause water pollution.
7. Radioactive experiment/ explosion: -discharging the contaminated water from the atomic explosion and experiment sites cause water pollution.
8. Religious means: - things immersed in water after performance of religious rites and activities result in polluting water.

Effect of water pollution

1:- disposal of domestic sewage into rivers and lakes causes the spread of water-borne disease like dysenteries, cholera, typhoid , amebiasis, diarrhea, hookworm infection and several Bactria and viruses infections.

2- consuming the water containing toxic substances like heavy metals, radioactive metals, fungicides, pesticides and other organic and inorganic materials cause life threatening diseases like hepatitis, polio, typhoid, cancer, thyroids.

3- Excessive addition of chemical fertilizer containing nitrates and phosphates in agriculture leads to depletion of oxygen in water, thereby increasing BOD of water. Which leads to death of aquatic life.

4:-Excessive nitrates in drinking water reduce the oxygen carrying capacity of hemoglobin, thereby causing suffocation and injuries to respiratory and vascular system.

5- water pollution causes scarcity of quality drinking water.

Control of water pollution

Water pollution can be reduced by using the following techniques.

1:- stabilization of ecosystem- it involves reduction of the waste at source, burying the organic wastes, fish management and proper use of water.

2- by suitable treatment of waste water before its discharge into the river, ocean and lakes, through aeration, filtration or activated sludge treatment.

3:- by using sewage water for irrigation purpose as it contains all the nutrients the plants needed.

4- by using the special techniques like adsorption, ion-exchange, electrodialysis, reverse osmosis etc to remove the toxic chemicals form the contaminated water.

5- by diluting the waste waters before their discharge into water bodies to decrease the pollution load in the waste water.

Dissolve oxygen -DO

Dissolved oxygen (DO) is the actual amount of oxygen available in dissolved form in the water. The decrease in the oxygen supply in the water has a negative effect on the fish and other aquatic life. Fish kills and an invasion and growth of certain types of weeds can cause dramatic changes in a stream or other body of water.

Biological oxygen demand-BOD

Biological oxygen demand (BOD) is the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic (oxygen is present) conditions at a specified temperature.

BOD is used, often in wastewater-treatment plants, as an index of the degree of organic pollution in water.

A BOD level of 1-2 ppm is considered very good. There will not be much organic waste present in the water supply. A water supply with a BOD level of 3-5 ppm is considered moderately clean. An average sewage has a BOD of 100 to 150mg/lt. Therefore, a low BOD is an indicator of good quality water, while a high BOD indicates polluted water.

BOD determination

For the BOD determination, the diluted sewage solution with known volume is incubated in a closed bottle at $20^{O}C$ for 5 days. After this, oxygen content in original diluted water and incubated water is determined . The difference between two gives BOD of water sample.

Chemical oxygen demand(COD)

Organic matter in waste water is often assessed in terms of oxygen required to completely oxidize the organic matter into CO2 and H2O and other oxidized species.

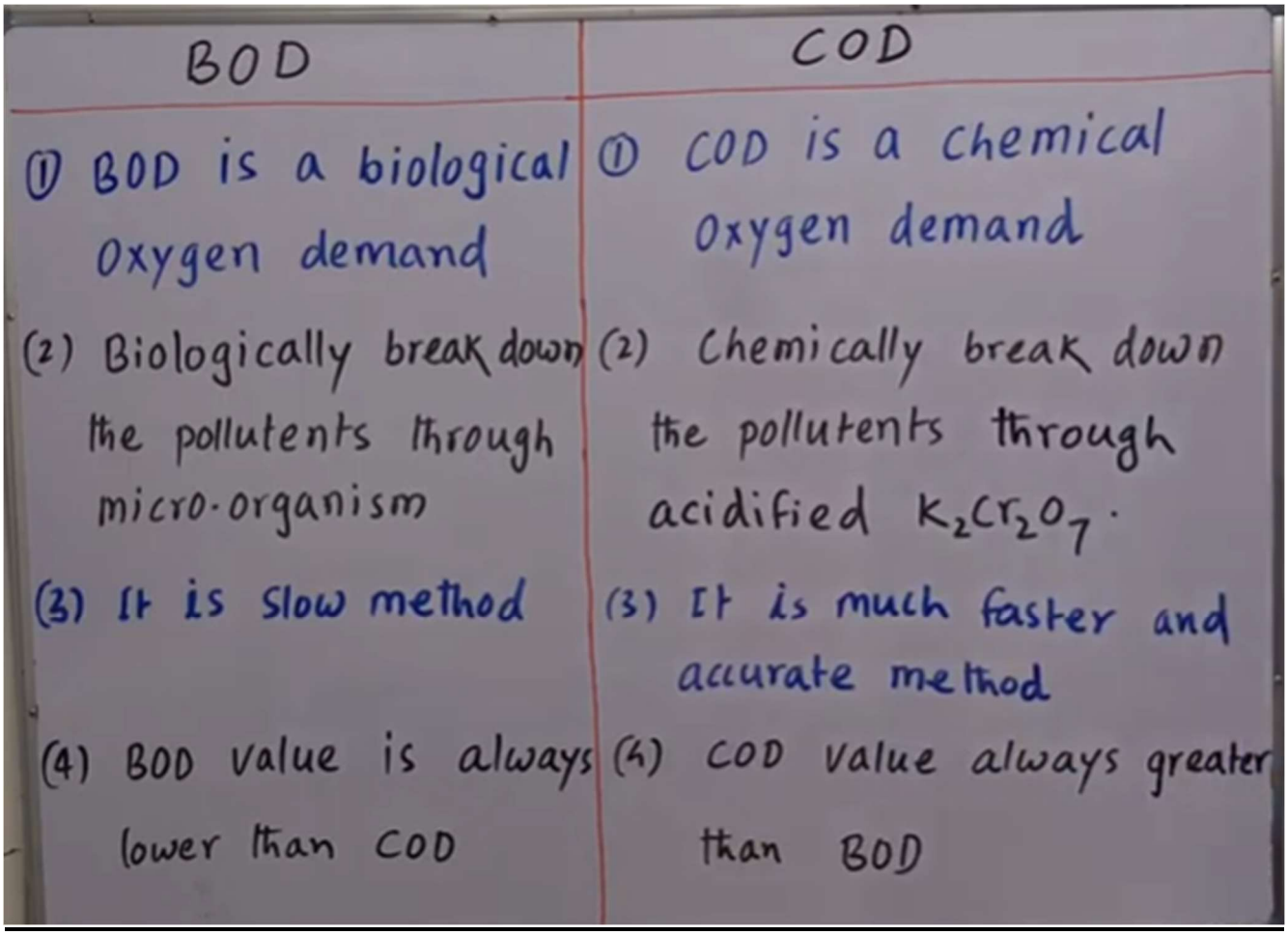
Chemical oxygen demand (COD) is the amount oxygen required to oxidized the Organic matter present in the water waster by strong oxidizing agents mimicking the bacterial action inside the water. It is an indicator of magnitude of contamination in waste water.

Similar to BOD, it provides an index to assess the effect discharged wastewater will have on the receiving environment. ... The COD test is often used as an alternate to BOD due to shorter length of testing time.

COD determination

- A known volume of (250mL) of the water sample is mixed with standard 5mL K2Cr2O7(1N) and 20mL dil. H2SO4 in presence of a little Ag2SO4 catalyst and reflux for 90 minutes.
- The unreacted K2Cr2O7 is then titrated against standard Mohr' salt solution using ferroin indicator.
- Green to reddish brown colour represents the end point.
- The oxygen equivalent of K_2C2O7 consumed is taken as a measure of the COD.
- 1mL of 1N K2Cr2O7=0.008g oxygen.
- Mohr’s Salt=Ammonium iron(II) sulfate; (NH4)2Fe(SO4)2(H2O)6

Difference between BOD and COD



BOD	COD
(1) BOD is a biological Oxygen demand	(1) COD is a chemical Oxygen demand
(2) Biologically break down the pollutents through micro-organism	(2) Chemically break down the pollutents through acidified $K_2Cr_2O_7$.
(3) It is slow method	(3) It is much faster and accurate method
(4) BOD value is always lower than COD	(4) COD value always greater than BOD

Questions

- Define water pollution. Mention and explain the causes and effect of water pollution. What can be done to control it?
- Define water pollution. Discuss briefly about its sources, effects and control methods.
- `write short notes on
    - i) biological oxygen demand(BOD)
    - Ii) Chemical oxygen demand(COD)
    - Iii) difference between COD and BOD

Air pollution

Air pollution is the contamination of the indoor or outdoor air by a range of gasses and solids that modify its natural characteristics. Common air pollutants include;

- Carbon Monoxide

- Sulphur dioxides
- Nitrogen Oxides(NOx).
- Carbon Dioxide
- Black carbon
- Ammonia
- **Suspended Particulate Matter**
- Radioactive Pollutants

Sources of Air pollution

1. Household and agriculture burning: Use of biomass fuel for domestic energy needs such as cooking;
2. Motor vehicles: Heavy traffic on roads, vehicles not complying to pollution norms;
3. Industrial facilities and power plant: Thermal (coal-based) power plants and other factories emitting polluting smoke;
4. Uncontrolled construction or demolition sites;
5. Forest fires: Bursting fire crackers; Burning waste from houses, hospitals, electronic waste, crop residues, etc.
6. Volcanic eruption
7. Radioactive materials
8. Pollen grains

Air pollution and its impact on human health

Short-term exposure to polluted air is likely to cause acute health reactions such as irritation to the eyes, nose, and throat, coughing, wheezing and increased frequency of acute lower respiratory infections deep in the lungs.

More prolonged and continued exposure to either high or lower levels of air pollution can also lead to

1. an increased risk of respiratory infections, exacerbation of asthma, bronchitis
2. cardiovascular problem h by hardening the arteries and increase the risk of heart attack and strokes lung cancer and premature death.
3. has been linked to miscarriages during pregnancy as well as premature birth, autism spectrum disorder and asthma in children.
4. mental health conditions and degenerative brain diseases such as Alzheimer's disease, Parkinson's disease and schizophrenia.

Effect of air pollution

The effects of air pollution are alarming. They are known to create ;

1. Respiratory and heart problems along with Cancer. Children in areas exposed to air pollutants are said to commonly suffer from pneumonia and asthma.
2. Global warming With increased temperatures worldwide, increase in sea levels and melting of ice from colder regions and icebergs, displacement and loss of habitat .
3. Acid rain can cause great damage to human, animals, and crops.
4. Eutrophication; where a high amount of nitrogen present in some pollutants gets developed on sea's surface and turns itself into algae and adversely affect fish, plants and animal species.
5. Effect on wildlife; toxic chemicals present in the air can force wildlife species to move to a new place and change their habitat.
6. Depletion of the ozone layer will allow to emit harmful rays back on earth and can cause skin and eye related problems. UV rays also have the capability to affect crops.
7. Smog: Smog is the deadly combination of Smoke and Fog. is extremely harmful to humans and the entire environment. It can lead to diseases such as cold, flu, irritation of the eye, asthma and in the long term even lung cancer
8. Air pollution kills 3,450,000 people a year

Control of air pollution

Some of the measures that can be adopted to control air pollution are:

1. Use public mode of transportation to save energy and money. Check out options for carpooling to work or school
2. Conserve energy by reducing the number of fossil fuels to be burned to produce electricity.
3. Apply the concept of Reduce, Reuse and Recycle. Reuse them for some other purpose. For e.g. you can use old jars to store cereals or pulses.
4. Emphasis on clean energy resources solar, wind and geothermal
5. Use energy efficient devices at the domestic level or at the industrial level as incomplete combustion causes air pollution.
6. Ensure that houses, schools, restaurants and playgrounds are not located on busy streets
7. Plant trees along busy streets as they remove particulates, carbon dioxide and absorb noise
8. Emission rates should be restricted to permissible levels by each and every industry

Questions

1. Define Air pollution. Discuss its sources, causes and effect to human health and ways to control it.

2. Kathmandu is considered as one of the very polluted cities in Asia. Discuss its causes, effect to human health and ways to control it.

Ozone/Ozone layer

The ozone layer is a natural layer of ozone (O_3)gas in the upper atmosphere that protects humans and other living things from harmful ultraviolet (UV) radiation from the sun. The ozone layer filters out most of the sun's harmful UV radiation and is therefore crucial to life on Earth.

Importance of Ozone layer

- The sun rays consist of UV, Visible, and infrared radiations. Ozone absorbs some of the higher energy UV rays from the sun in the same way a cloud absorbs and reflect some of the visible light. The parts of the UV light absorbed or reflected is very harsh on the eyes and skin of humans.
- Without the layer of ozone in the atmosphere, it would be very difficult for anything to survive on the surface. Plants cannot live and grow in heavy ultraviolet radiation, nor can the plankton that serve as food for most of the ocean life. The ozone layer acts as a shield to absorb the UV rays, and keep them from doing gradual damage at the Earth's surface.

How Ozone layer is formed?

Ozone is formed in the atmosphere when energetic ultraviolet (UV) radiation dissociates molecules of oxygen, O_2, into separate oxygen atoms. This free oxygen atoms can recombine to form oxygen molecules forming ozone.

$$O_2 + UV \Rightarrow O + O$$
$$2O + 2O_2 \Rightarrow 2O_3$$
$$\text{Net Reaction: } 3O_2 + UV \Rightarrow 2O_3$$

How Ozone layer is depleted

Ozone depletion is a gradual thinning of Earth's **ozone layer** in the upper atmosphere caused by the release of chemical compounds containing gaseous chlorine or bromine from wide range of industrial and consumer applications. The thinning is most pronounced in the polar regions, especially over Antarctica.

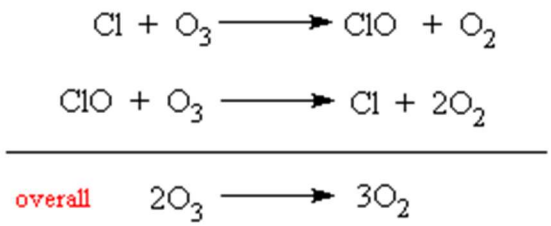
The gases responsible for these ozone depletion (Ozone holes) are chlorofluorocarbons (CFCs), Halons, carbon tetrachloride, methyl chloroform and methyl bromide. Emissions of greenhouse gases can affect the depletion of the ozone layer through atmospheric interaction.

The destruction is mostly caused by chlorofluorocarbons (CFC)

$$CFCl_3 \xrightarrow{\text{UV radiation}} CFCl_2 + Cl$$

$$CF_2Cl_2 \xrightarrow{\text{UV radiation}} CF_2Cl + Cl$$

It is the atomic chlorine that does the damage, since it can react with ozone (O_3) to form oxygen.



CFCs have many uses in industry mainly in refrigerators, air conditioners and fire extinguishers., and methyl bromide is a pesticide. Halons, are used in fire extinguishers and agriculture. Thus, UV radiation plays a crucial role in the both formation and destruction of ozone.

Similarly, Emission of Nitric oxide by high flying supersonic aircraft, nuclear explosion and various chemical/photochemical reaction in the cause chemical reactions that break down **ozone** molecules, reducing **ozone's** ultraviolet radiation-absorbing capacity.

$$NO(g) + O_3(g) === NO_2(g) + O_2(g)$$

Ozone layer depletion and its effect

When the ozone layer gets depleted the harmful UVB radiation reaches the surface of the earth and have

1- Effect on the skin: increased exposure to sunlight containing UV radiation risk fatal form of skin cancer.

2- Effects on the eyes: UV-B radiation can damage several parts of the eye, including the lens, the cornea, and the membrane covering the eye (conjunctiva). "Snow blindness"

3- Effects on the immune system UV affects our ability to fight disease. Recent research has shown that some viruses can be activated by increased exposure to UV.

4- Effects on the environment Excessive UV-B inhibits the growth processes of almost all green plants. UV-B causes cancer in domestic animals similar to those observed in humans.

How can we protect the ozone layer?

The ozone layer depletion can be minimized/controlled by;

1. avoiding the consumption of gases dangerous to the ozone layer, like CFCs (chlorofluorocarbons), halogenated hydrocarbon, methyl bromide and nitrous oxide.
2. Minimizing the use of cars and instead using bicycle, walking Or carpooling with others to decrease the use of cars in order to pollute less and save.
3. not using cleaning products that are harmful to the environment and to us. Replace these dangerous substances with non-toxic products such as vinegar or bicarbonate.

4. Buying local products to avoid consuming the food that has traveled long distances. As the more distance traveled, the more nitrous oxide is produced during the transportation of that product.
5. Maintaining air conditioners, as their malfunctions cause CFC to escape into the atmosphere.

Question what is Ozon layer depletion? Mention the main causes of it. Explain the consequences of Ozone layer depletion. What should be done to control it?

Greenhouse effect

The greenhouse effect is the problem caused by increased quantities of **gases** mainly carbon dioxide, in the air. These **gases** trap the heat from the sun, and cause a gradual rise in the temperature of the Earth's atmosphere.

The natural greenhouse effect exists due to the balance of the major types of greenhouse gases and keep the planet warm enough to sustain life. without these gases, the Earth would be too cold for humans, plants and other creatures to live. However, when abnormally high levels of these gases accumulate in the air, more heat starts getting trapped and leads to the enhancement of the greenhouse effect.

The principal gases in the atmosphere enhancing greenhouse effect are:

1. Carbon dioxide (CO_2): burning of fossil fuels, deforestation, industrialization;
2. Methane (CH_4) created by humans during fossil fuel production and use, livestock and rice farming, as well as landfills.
3. Nitrous oxide (N_2O): caused by the use of synthetic fertilizers for agriculture, fossil fuel combustion and livestock manure management.
4. Fluorinated gases: come from refrigeration, cooling and manufacturing applications.

Que. Define green house effect? How human activities are responsible for increasing greenhouse effect?

5 marks

Que. Write short note of Greenhouse effect -5

Global warming

Global warming is the gradual heating of Earth's surface, oceans and atmosphere.

The ozone layer presents in the upper atmosphere absorbs most of the UV radiation and allows visible and infrared radiation to pass through the CO_2 layer in the earth. This infrared radiation has heating effect on the atmosphere on the earth. Consequently, if large amount of CO_2 is present in the atmosphere, it causes continuous trapping of infrared rays and greater heating up of the earth's atmosphere thereby leading to an overall increase in global temperatures and global warming.

The earth's rising temperatures are fueling longer and hotter heat waves, more frequent droughts, heavier rainfall, and more powerful hurricanes.

Effect of global warming

Because of global warming many damaging environmental, economic, and health consequences are likely to occur if current trends continue.

1- ***Desertification: changing water cycle and rainfall pattern shift*** cause water shortages. this makes areas that are already dry even drier degrading lands into desert. This process is called desertification

2- Increased melting of snow and ice Melting glaciers, early snowmelt, and severe droughts will cause more dramatic water shortages and increase the risk of wildfires around the world.

3- Sea level rise Rising sea levels through thermal expansion and glacier melting will lead to coastal flooding and loss of habitat, loss of arable land which could drive many plant and animal species to extinction.

4. Stronger hurricanes and cyclones The earth's ocean temperatures are getting warmer—which means that tropical storms can pick up more energy.

Extreme heat waves have caused tens of thousands of deaths around the world in recent years.

5. *Allergies, asthma, and infectious disease* outbreaks will become more common due to increased growth of pollen-producing ragweed, higher levels of air pollution, and the spread of conditions favorable to pathogens and mosquitoes.

Control measures of global warming

9. Apply the concept of Reduce, Reuse and Recycle. Reuse them for some other purpose. For e.g. you can use old jars to store cereals or pulses.
10. Use public mode of transportation to save energy and money. Check out options for carpooling to work or school
11. Conserve energy by reducing the number of fossil fuels to be burned to produce electricity.
12. Emphasis on clean energy resources solar, wind and geothermal
13. Use energy efficient devices at the domestic level or at the industrial level to minimize the production of greenhouse gases.
14. Plant trees as much as possible as they absorb carbon dioxide and give off oxygen .
15. Restrict the emission rates to permissible levels by each and every industry.

Questions: what are the greenhouse gases? How these gases are responsible for global warming? Explain the effect of global warming and how it can be controlled?

Acid Rain

Acid rain is a **rain** or any other form of **precipitation** that is unusually **acidic**, meaning that it has elevated levels of hydrogen ions (low pH). It can have harmful effects on plants, aquatic animals and infrastructure.

Acid rain is caused by a chemical reaction that begins when compounds like sulfur dioxide and nitrogen oxides are released into the air. These substances can rise very high into the atmosphere, where they mix and react with **water**, oxygen, and other chemicals to form more acidic pollutants, known as acid rain.

Effect of Acid Rain

- **Acid rain** has many ecological **effects**, especially on lakes, streams, wetlands, and other aquatic environments. **Acid rain** makes such waters more **acidic**, which results in more aluminum absorption from soil, which is carried into lakes and streams.
- Acid rain affects nearly everything. Plants, soil, trees, buildings and even statues can be transformed by the precipitation.
- Acid rain has been found to be very hard on trees. It weakens them by washing away the protective film on leaves, and it stunts growth.
- Acid rain can also change the composition of soil and bodies of water, making them uninhabitable for local animals and plants.
- Most fish species can't survive a water pH of below 5. When the pH becomes a 4, the lake is considered dead.
- It can additionally deteriorate limestone and marble buildings and monuments, like gravestones.

Questions:

1.Write short notes on Acid rain.

2.Mention the effect of acid rain.

Soil pollution/land pollution

Soil pollution is the addition of some chemical substances in an indefinite proportion to the soil system, thereby changing the fertility of soil. The polluted soil produces inferior quality of crop and that too in reduced quantity.

Sources of soil pollution

1 domestic wastes and industrial wastes dumped on land.

2. dumping of wastes from coal mining and ores.

3. excessive usage of fertilizers, pesticides and insecticides.

4. chemical and radioactive waste discharged from hospitals, research center and industry

5. soil erosion, deforestation and defective agricultural means.

6- improper dumping by oil refineries and vehicle workshop.

Therefore, human activities are responsible for the majority of the soil pollution.

Effect of soil pollution

1. Inferior quality of crop and its reduced quantity
2. Loss of habitat and Negative Impact on Ecosystem and Biodiversity

3. loss of soil structure and nutrient degradation
4. Harmful Effect on Human Health
5. Water Sources Contamination

Control of soil pollution

Soil pollution can be controlled by

1. using sanitary landfills
2. Forestation
3. wise management of hazardous solid and liquid waste including toxic chemicals and hospital dispose.
4. Proper treatment of industrial and sewage wastes before disposal on land

Therefore, it is very important to educate people around you the importance of environment if they are not aware.

Question: what is soil pollution? Mention its causes and effect. Also write its controlling measures.

Hard water

Hard water is water that has high mineral content (in contrast with "soft water"). Hard water is formed when water percolates through deposits of limestone, chalk or gypsum, which are largely made up of calcium and magnesium carbonates, bicarbonates and sulfates.

Hardness of water/Causes of hardness

The presence of salt of calcium or magnesium in water which forms a scum with soap and prevents the formation of a leather is known as hardness of water.

Additional contributors to the hardness of the water include aluminium(Al^{3+}), iron (Fe^{2+}), strontium (Sr^{2+}), zinc (Zn^{2+}), manganese (Mn^{2+}) and other ions. However, their concentrations are usually significantly lower than the concentration of calcium and magnesium. Specially chlorides, sulphates and bicarbonates of Calcium and magnesium in the water gives an adequate hardness measure.

What are the effects of water hardness?

1. Hard water might cause scale deposition in water distribution and irrigation systems.
2. It reduces the efficiency of heat exchangers.
3. Water hardness might cause corrosion.
4. Might cause scaling in membrane filtration systems.
5. In addition, calcium and magnesium react with soap to form soap scum. Hard water will increase the consumption of soap, as soap will not create foam.

Does water hardness have any positive effects?

Yes, in adequate concentrations, calcium and magnesium have a positive effect on human health and also on plants. They both are essential nutrients and their deficiency might cause health problems, so in drinking water and irrigation water, a certain level of hardness is favorable.

Types of hardness

There are two types of hardness – temporary hardness and permanent hardness.

Temporary hardness – also called 'Carbonate hardness'. This type of hardness is due to presence of carbonates and bicarbonates of calcium and magnesium in the water. Heating the water or reacting it with lime removes this hardness. CO_2 is released as gas and precipitates of insoluble calcium carbonate and/or magnesium hydroxide are formed.

By boiling;

$Ca(HCO_3)_2 \rightarrow CaCO_3\downarrow + CO_2\uparrow + H_2O.$

$Mg(HCO_3)_2 \rightarrow Mg(OH)_2\downarrow + 2CO_2 \uparrow + H2O$

By adding lime;

$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + H_2O.$

$Mg(HCO_3)_2 + Mg(OH)_2 \rightarrow 2Mg(OH)_2\downarrow + H_2O$

Permanent hardness: It is also referred to as 'non-carbonate hardness and is the hardness due to the presence of sulfates, chlorides and nitrates of Calcium and magnesium. For example, calcium sulfate, magnesium chloride etc.

Removal of permanent hardness is removed by ion exchange method using Zeolite or by treating with Na_2CO_3.

$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + NaCl$

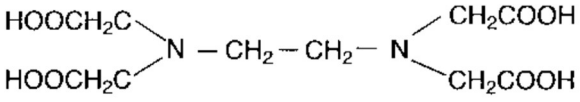
$MgSO_4 + Na_2CO_3 \rightarrow MgCO_3 + Na_2SO_4$

$CaCl_2 + Na_2Z \rightarrow CaZ + 2NaCl$

Sodium Zeolite

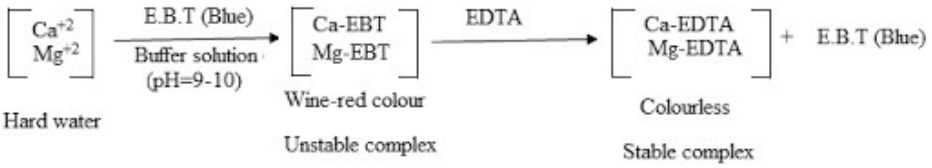
How Hardness of water is measured

The hardness of water is not a pollution parameter but indicates water quality. It is measured by performing complexometric titrations on water sample provided from the sources. An EDTA (ethylenediamine tetra-acetic acid) solution is used as a titrant on account of its powerful complexing actions, which will form complexes with Calcium or magnesium ions in the water.



Standard EDTA

A buffer solution of pH10 and Eriochrome Black-T indicator is added into the water sample before titrating against standard EDTA solution. The colour change from wine red to clear blue indicate the end point of the titration and corresponds to the total hardness of water.



For permanent hardness, water sample is boiled gently for half an hour and titrated against standard EDTA as before when it cools down. The difference between total hardness and permanent hardness corresponds to the temporary hardness in the water sample

The most common unit for expressing the level of hardness in the water is ppm(mg/L).The concentrations of calcium and magnesium are expressed as equivalent of $CaCO_3$.

Calculation;

The concentration of Calcium and magnesium is calculated by considering 1 Mole of EDTA is equal to the 1 Mole of $CaCO_3$.

The following formula can be used to calculate hardness, when the concentrations of calcium and magnesium in the water are known:

The molar mass of $CaCO_3$ is 100 g/mol, thus

$MCaCO_3/MCa=100/40=2.5$

$MCaCO_3/MMg=100/24.3=4.1$

Thus, we can express the total hardness of water as

$[CaCO_3] = 2.5[Ca^{2+}] + 4.1[Mg^{2+}]$

Example
For example, water with 30 ppm Calcium and 3 ppm magnesium will have hardness of:

$[CaCO_3]=2.5 \times 30$ mg/mL$+ 4.1 \times 3$ mg/L $= 75$ mg/L $+ 12$ mg/L$= 87$ mg/L $CaCO_3$

Questions: 1.what is hard water? How it is measured in a laboratory?

2. define hardness of water. What are the causes of hardness of water? How it can be measured in a laboratory?

Alkalinity of water

Alkalinity of water is a measure of the ability of the water body to neutralize acids and bases and thus maintain a fairly stable pH level". Alkalinity is not a chemical in water, but, rather, it is a property of water that is dependent on the presence of certain chemicals in the water, such as bicarbonates, carbonates, and hydroxides.

Measurement of alkalinity of water

The type and extent of alkalinity present in the water sample is measured volumetrically by titrating it against standard HCl in two steps. In the first step, the titration is conducted until the pH is lowered to 8.2, the point at which phenolphthalein indicator turns from pink to colorless. This value corresponds to the points for conversion of carbonate to bicarbonate ion (equation 1 and 2) represented by P. The second phase of titration is conducted until the pH is lowered to 4.5, corresponds to methyl orange end point, which corresponds to the equivalence points for the conversion of bicarbonate ion to carbonic acid (equation 3) represented as M.

The reaction taking place is represented by the following equations,

$$OH^- + H^+ \rightarrow H_2O \quad .....(1)$$

$$CO_3^{--} + H^+ \rightarrow HCO_3^- \quad .....(2)$$

$$HCO_3^- + H^+ \rightarrow H_2CO_3 \rightarrow H_2O + CO_2 \quad ..(3)$$

Sample observation

Alkalinity Relationships

Result of P/M or P/T Alkalinity Test*	Hydrate Alkalinity (OH) Equals:	Carbonate Alkalinity (CO_3) Equals:	Bicarbonate Alkalinity (HCO_3) Equals:
P = 0	0	0	M
P = M	M	0	0
P = ½ M	0	M	0
P < ½ M	0	2P	M–2P
P > ½ M	2P–M	2(M–P)	0

*Note: Because the endpoints for methyl orange and total alkalinity indicator are nearly identical (pH 4.6 and pH 4.5, respectively) the industry uses both indicators interchangeably for reading total alkalinity. **Therefore, the values for M and T can be interchanged in the table above.**

Calculation

1. Phenolphthalein end point P, = Acid consumed until P end point,

So, Normality of water Np = N_1V_1 x N_2 V_2= N strength of x mL of Acid consumed/volume of water sample taken.

Therefore, Strength of $CaCO_3$= Np x 50(gm equivalent weight of $CaCO_3$, g/L)

2. Methyl Orange end point T, =total acid consumed

So, Normality of water NM = N1V1 x N_2 V_2= strength of acid x total mL of Acid consumed/volume of water sample taken.

Therefore, Strength of of HCO_3^- = NM x 61(gm equivalent weight of $CaCO_3$).

The types of alkalinities present in the samples are calculated using the equations given in the following table and the results are tabulated.

Alkalinity with respect to carbonates and bicarbonates is generally expressed as parts per million(ppm) in terms of $CaCO_3$ or on degree Clark.

Questions.

Define alkalinity of water. How it is measured in laboratory?

Que. Calculate the type of alkalinity and total alkalinity present in water in ppm.

Given, Volume of water sample=100mL

Strength of HCl used =N/50

Amount of HCl consumed until Phenolphthalein end point(P)=18mL

Total Amount of HCl consumed until methyl orange end point(T)=41mL

Solution,

1. Phenolphthalein end point P, = 18mL

So, Normality of water Np = N_1V1 x N_2 V_2= 0.02 x 18 /100=0.0036N

.

Therefore, Strength of water in terms of $CaCO_3$= Np(0.0036) x 50(gm equivalent weight of $CaCO_3$, g/L)=0.18g/L.

2. Methyl Orange end point T, =total acid consumed=41mL, 1/2 T=20.5mL

So, Normality of water NT = N_1V_1 x N_2 V_2= strength of acid(0.22)x total mL of Acid consumed(41)/volume of water sample taken(100)=0.0082N

Therefore, Strength of water in terms of $CaCO_3$= NT(0.0082) x 50(gm equivalent weight of $CaCO_3$)=0.41g/L

Since P<1/2T, the alkalinity of water sample is due to CO_3^{--} and HCO_3^- and not OH^- ions.

Alkalinity due to CO_3^{--} ions= 2(P)=2 x 180 mg/L=360mg/L=360ppm

Alkalinity due to HCO_3^- ions (T)= 2(P)=410-360=50mg/L=50ppm

And total alkalinity in terms of $CaCO_3$= 360+ 50= 410ppm