FINAL EXAMINATION

ATTEMPT ALL THE QUESTIONS (OUT OF 70 MARKS)

1. What do you understand by the following terms? (20 Marks)

    a. **Water cycle** – The water cycle, also known as the hydrologic cycle or the hydrological cycle, describes the continuous movement of water on, above and below the surface of the Earth. The mass of water on Earth remains fairly constant over time but the partitioning of the water into the major reservoirs of ice, fresh water, saline water and atmospheric water is variable depending on a wide range of climatic variables. The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, surface runoff, and subsurface flow. In doing so, the water goes through different forms: liquid, solid (ice) and vapor.
    b. **Sublimation** This is the conversion between the solid and the gaseous phases of matter, with no intermediate liquid stage. In the water cycle, sublimation is most often used to describe the process of snow and ice changing into water vapor in the air without first melting into water.
    c. **Water quality –** This describes the condition of the water, including chemical, physical, and biological and aesthetic (appearance and smell) characteristics, usually with respect to its suitability for a particular purpose such as drinking or swimming
    d. **Turbidity -** Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates including algae. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Turbidity is considered as a good measure of the quality of water.
    e. **Salinity -** the quality or degree of being saline. Salinity is the saltiness or amount of salt dissolved in a body of water, called saline water. Salinity is an important factor in determining many aspects of the chemistry of natural waters and of biological processes within it, and is a thermodynamic state variable that, along with temperature and pressure, governs physical characteristics like the density and heat capacity of the water.

2. What is the difference between Point Source Pollution and non-point source pollution? (10 Marks)

   Point sources release pollutants from discrete conveyances, such as a discharge pipe, and are regulated by water governing agencies. The main point source dischargers are factories and sewage treatment plants, which release treated wastewater. **Nonpoint Source Pollution** is a combination of pollutants from a large area rather than from specific identifiable sources such as discharge pipes. Runoff is generally associated with nonpoint source pollution, as water is emptied into streams or rivers after accumulating contaminants from sources like gardens, parking lots or construction sites.

3. Discuss FIVE ways used to measure and monitor the quality of water and encourage a clean and healthy ecosystem (20 Marks)

   1. Colored or chromophoric dissolved organic matter (CDOM)

   Coloured or chromophoric dissolved organic matter occurs naturally in water bodies. This organic matter absorbs the ultraviolet light and decomposes to release tannin, an organic pollutant that causes the water to turn murky. Moreover, tannin contributes to reducing the pH (acidic) of the water and depleting the oxygen levels. A portion of the CDOM fluoresces and is referred to as fluorescent dissolved organic matter (FDOM) further making the water look cloudy. CDOM/ levels can be measured using electrical optical sensors that use fluorometers and sapphire lens. These sensors gauge the light availability in water bodies depending on the water level and indicate the concentration of dissolved organic matter.

   2. Chlorophyll Fluorescence Analysis

   When the surface water in ponds and lakes is rich in minerals, namely phosphorus and nitrogen, algae flourish. Disproportionate growth of algae leads to oxygen depletion and increased levels of nitrogen and phosphorus which can be toxic to the flora and fauna. Chlorophyll fluorescence, measured using algae measurement tool, indicates the percentage of wet-chemical chlorophyll and active chlorophyll in the water sample under illumination. This is an effective method to keep a check on the excessive algal growth and monitor the water quality.

3. Conductivity, Salinity, and total dissolved solid Monitoring

The conductivity of a water body is an early indicator of the water quality. Conductivity affects the salinity and total dissolved solids content, which in turn affects the concentration of oxygen in the water. Certain ecological (temperature, excessive rainfall, and increased organic matter content) and man-made (pollution) factors can increase or decrease the water bodies' conductivity, severely impacting the water quality. For instance, an oil spill or increased levels of organic substances in an ocean can decrease its conductivity, indicating water pollution. Conductivity, salinity, and total dissolved solids content meters analyze the water quality by measuring the specific electrical conductance of electrolytes dissolved in the water. Though each of these instruments measures a separate parameter, the results are correlated and indicative of pollution.

4. Recording the Water Temperature

Temperature is a crucial factor that affects the other water quality parameters such as, the rate of photosynthesis and metabolism, the dissolved gas concentrations, the conductivity and salinity, the pH, and the water density amongst other factors. For instance, ammonia at a high pH is toxic to plants and aquatic animals, however, a sudden change in temperature can double the impact. Several devices such as thermometers, thermistors, thermocouples, and digital temperature sensors are used to obtain temperature readings at varying depths, time, and locations.

5. Measuring the Dissolved Oxygen Levels

The dissolved oxygen (DO) is a measure of the amount of oxygen available to the flora and fauna and is reported as percent saturation or mg/L. The oxygen levels in water go down owing to the decomposition of organic material such as dead plants and animals and human wastes. A dissolved oxygen level of less than 6 mg/L can be harmful to the ecosystem of water bodies. The dissolved oxygen concentration can be measured using the electrochemical or optical sensor, the colorimetric method, the Winkler titration method, and the optical dissolved oxygen sensors.

6. pH and carbonate hardness Testing

An increasing pH level is dangerous to the ecosystem of the water body. A safe pH range for a pond or a lake is between 6.0 to 8.0; however, certain factors such as overgrowth of algae and pollution alter the pH of the water and increase the

levels of toxic ammonia. pH can be tested using water test kits that are color-coded and offer a wide range of pH measurement. These kits work best to give you an idea of the pH range the water falls into. However, for accurate pH measurements, electronic pH sensors offer measurement values up to two decimal points. The carbonate hardness (a measure of carbonate and bicarbonate levels) is another factor that needs to be monitored as it significantly impacts the pH of the water. Therefore, to readjust the pH, you may often have to stabilize the water carbonate hardness.

7. Assessing the Turbidity, total suspended solids and Clarity

The solar radiation provides light, heat, and energy to all living being on earth. Low or high levels of ultraviolet radiations can halt the photosynthetic process, causing permanent damage to the aquatic ecosystem. Suspended solids, decaying vegetation, and other dissolved coloured material cause the water to appear cloudy and murky, impacting the penetration of sunlight on water and the aquatic life. A sudden increase in the turbidity and the total suspended solids (TSS) is an indicator of soil erosion and point-source pollution adding heavy metals and effluents into the water.

4. Discuss the Water Recycling process in detail. (20 Marks)
   All water is recycled and reused as a part of natural water processes such as the hydrologic cycle. This are some of the different processes that lead to movements and phase changes in water.
   i. Precipitation - Condensed water vapor that falls to the Earth's surface. Most precipitation occurs as rain, but also includes snow, hail, fog drip, graupel, and sleet.
   ii. Subduction & Mineral hydration Sea water seeps into the oceanic lithosphere through fractures and pores, and reacts with minerals in the crust and mantle to form hydrous minerals (such as serpentine) that store water in their crystal structures. Water is transported into the deep mantle via hydrous minerals in subducting slabs. During subduction, a series of minerals in these slabs such as serpentine can be stable at different pressures within the slab geotherms, and may transport significant amount of water into the Earth's interior. As plates sink and heat up, released fluids can trigger seismicity and induce melting within the subducted plate and in the overlying mantle wedge. This type of melting selectively concentrates volatiles and transports them into the overlying plate. If an eruption occurs, the cycle then returns the volatiles into the oceans and atmosphere
   iii. Canopy interception- The precipitation that is intercepted by plant foliage eventually evaporates back to the atmosphere rather than falling to the ground.
   iv. Snow melt - The runoff produced by melting snow.

v. Runoff - The variety of ways by which water moves across the land. This includes both surface runoff and channel runoff. As it flows, the water may seep into the ground, evaporate into the air, become stored in lakes or reservoirs, or be extracted for agricultural or other human uses.
vi. Infiltration - The flow of water from the ground surface into the ground. Once infiltrated, the water becomes soil moisture or groundwater. A recent global study using water stable isotopes, however, shows that not all soil moisture is equally available for groundwater recharge or for plant transpiration.
vii. Subsurface flow - The flow of water underground, in the vadose zone and aquifers. Subsurface water may return to the surface (e.g., as a spring or by being pumped) or eventually seep into the oceans. Water returns to the land surface at lower elevation than where it infiltrated, under the force of gravity or gravity induced pressures. Groundwater tends to move slowly and is replenished slowly, so it can remain in aquifers for thousands of years.
viii. Evaporation - The transformation of water from liquid to gas phases as it moves from the ground or bodies of water into the overlying atmosphere. The source of energy for evaporation is primarily solar radiation. Evaporation often implicitly includes transpiration from plants, though together they are specifically referred to as evapotranspiration.
ix. Sublimation - The state change directly from solid water (snow or ice) to water vapor by passing the liquid state.
x. Deposition - This refers to changing of water vapor directly to ice.
xi. Advection - The movement of water through the atmosphere. Without advection, water that evaporated over the oceans could not precipitate over land.
xii. Condensation - The transformation of water vapor to liquid water droplets in the air, creating clouds and fog.
xiii. Transpiration - The release of water vapor from plants and soil into the air.
xiv. Percolation - Water flows vertically through the soil and rocks under the influence of gravity.
xv. Plate tectonics - Water enters the mantle via subduction of oceanic crust. Water returns to the surface via volcanism.