**Nalanda Open University**

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**E-CONTENT 6**

for

Part-I Examination, 2020

**SHORT DESCRIPTION OF THE SUGGESTED TOPICS**

**THEORY PAPER**

**REMAINING TOPICS OF PAPER – III**

**(ENVIRONMENTAL CHEMISTRY)**

1. **Bio monitoring – Meaning and importance. Bio-indicators – Bio-indicator groups and examples.**

**Meaning of Bio-monitoring:**

Bio-monitoring is a scientific technique for assessing human exposure to natural and synthetic chemicals, based on sampling and analysis of individual’s tissues and fluids. While blood, urine, breast milk and expelled air are most commonly measured, hair, nails, fat, bone and other tissues may also we sampled and analyzed. The technique takes advantage of the knowledge that chemicals that have entered the human body leave markers reflecting their exposure. The marker may be the chemical itself. It may also be a breakdown product of the chemical or some change in the body that is a result of the action of the chemical on individual. For example, alterations in the levels of certain enzymes or other proteins may serve as markers so might the modification of normal body process, such as the transfer of oxygen to tissues. Thus, bio-monitoring is considered to be a valuable source of pollution information.

**Importance of Bio-monitoring:**

Perhaps the most important strength of bio-monitoring is that it is the only technique that can provide a direct measure of the exposure of human individuals and population. In addition to being a direct measure, bio-monitoring has the advantage that it integrates, or adds together exposures from multiple sources, e.g. air, water and food, to provide a reflection of total exposure. Thus, it is a measure of total exposure by all routes and from all sources.

Bio-monitoring provides exposure information that can be used in a number of ways. These date help in understanding which chemicals are in the environment and the relative levels of each, how these levels change over time, and which sectors of the population may have unusually high exposures to particular compounds. As a result to this understanding, it may be possible to assess the effectiveness of steps taken to reduce exposures, to identify new research that is needed and to help physicians diagnose and treat patients who may have had unusually high exposures to particular substances.

**Bio-indicators: An introduction**

Bio-indicators are defined as the animals or plants which accumulate pollutants in their tissues and organs in direct relation to the environmental levels. Thus bio-indicators are species which are used to monitor the health of environment or ecosystem. They are any biological species or group of species whose function, population or status can reveal the qualitative status of the environment. Bio-indicators can tell us about the cumulative effects of different pollutants in the ecosystem and about how long a problem may have been present, which physical and chemical testing cannot. One important advantage is that scientists need to observe only the single (or a small group of) indicating species to check on the environment rather than monitor the whole community.

**Bio-indicators Groups:**

For preparing for this topic it is suggested to consult the following study materials.

1. Studylearning material of NOU, Patna: Part I, Paper III
2. Study learning material of NOU, Patna : Part II Paper XI, Environmental Toxicology
3. Environmental Biology: by P.D. Sharma

Others resource materials may also be consulted.

1. **Soil: Definition, Different components of Soil, Physical and Chemical properties of Soil.**

**Soil: An Introduction:**

Soil is the top most layer of the earth’s surface which is a mixture of minerals, organic matters, air, water and organisms, that together support life. Soil is formed from rocks through the process of wear and tear.

Soil is an essential natural resource. Life on the planet earth is directly dependent upon soil because without soil there will be no vegetation and no food for animals and human beings. We get food, clothing and building materials, medicines and several other useful things from the crops and plants grown in the soil. Soil is the home for a number of microorganisms that decomposes dead and decayed plants and animals and produce nutrients and humus, which make the soil fertile. Soil is porous in nature and acts as facilitator for percolation of rainwater to underground aquifer for our use. The water retained by the soil (called soil water or soil moisture) is utilized by plants for their growth.

**Different Components of Soil:**

Soil consists of four major components - minerals, organic matter, moisture and air, all of which are thoroughly mixed with each other in the soil. The percentage composition of the soil is as given below:

Minerals: 45-50%

Organic matter (living as well as non-living): 5% (approx)

Soil Moisture: 5-10%

Soil Air: 40% (approx)

**Inorganic Components of Soil:**

It has been mentioned above, soil is formed from rocks through the process of wear and tear. In soil the minerals from the rocks, which constitute 45-50% of the soil weight, are present as particles of different size. Soil particles vary greatly in size, and soil scientists classify soil particle into sand, silt and clay. Based on their size, soil particles have been put under the following class:

**Class name of soil particles Size (diameter) of soil particle (mm)**

1. Coarse Sand 2.0 - 0.2
2. Fine Sand 0.2 -0.02
3. Silt 0.02 – 0.002
4. Clay Less than 0.002 mm

**NOTE:-**

1. For short description of soil particles
2. For organic components of soil, and
3. For physical and chemical properties of soil.

**It is advised to consult the following study materials.**

1. Studylearning material (SLM) Part I, Paper III provided by NOU, Patna
2. Environmental Biology: by P.D. Sharma

Other resource materials may also be consulted as per the availability and need.

1. **(a). Acidic Soil : How is this soil formed? Reclamation of acidic soil for agriculture.**

**Acidic Soil:**

Acidic soils are those having their pH value (level) less than 7. pH value of such soils are usually less than 5.5 for most of the year. They are associated with a number of toxicities as well as deficiencies and other plant restricting conditions. Therefore, understanding soil acidity (pH < 7) and soil basicity (pH > 7) is essential for proper management of soil pH and optimum soil and crop productivity.

**Reasons for acidic soil formation:**

Following are the important reasons for acidic soil formation:

1. In the regions of high rainfall, soils are acidic in their reaction because of the facts that soluble basic salts such as those of Ca, Mg, K and Na are leached away by drainage water and insoluble acidic residue composed chiefly of oxides and silicates of iron, silicon, aluminum etc. are left which accumulate in pretty high amount. These salts are acidic in nature, hence soils are acidic. Other causes which produce acidity in the soil are the following.
2. Continuous removal of lime and other base elements by crops and accumulation of acids contained in the manures.
3. Application of acid forming fertilizers in the soil. These fertilizers include nitrogenous fertilizers (especially NH4-N sources) and phosphetic fertilizers.
4. Microbial Action: Soil contains a number of types of microbes which are responsible for nitrification and decomposition of organic matter in soil. In the process of such microbial actions acids are formed which make soil acidic.
5. Carbon dioxide: CO2 of atmosphere as well as of soil dissolves in water to form carbonic acid (H2CO3) which when percolates down the soil profile degrades carbonates and primary minerals present in the soil and make the soil acidic.
6. Other sources of soil acidity include:

Formation of soil from rock and soil organic matter or humus which contains reactive carboxylic and phenolic groups that behaves as weak acids.

**Note:** For

1. Effect of acidity on plants and
2. Reclamation of Acid Soil.

It is suggested to mainly consult Study Learning Materials (SLM) of Environmental Science Part I, Part III provided by N.O.U. Patna. Other resource materials may also be consulted if so needed.

**(b). Alkaline Soil: How is this soil formed? Reclamation of alkaline soil for agriculture.**

**Alkali or Alkaline Soil, Saline Soil and Saline Alkali Soil:**

Alkali or Alkaline soils are clay soils with high pH (pH > 8.5), poor soil structure and a low infiltration capacity. Alkali soils owe their unfavorable physico-chemical properties mainly to the dominating presence of Sodium carbonate, which causes the soil to swell and difficult to clarify/settle.

**Saline Soil:**

A saline soil is a non-sodic soil containing sufficient salt to adversely affect the growth of most crop and plants. It has a lower limit of electrical conductivity of the saturated extract being 4 decisiemens/meter which is equivalent to a value of 4 mmhos/cm (at 250C). The soil has exchangeable sodium percentage less than 15 % and pH< 8.5.

**Saline Alkali soil:**

Saline alkali soil is a salt affected soil with a content of exchangeable sodium percentage (ESP) greater than 15%, with much soluble salts. The soil has a pH value usually more than 8.5 and the electrical conductivity of the saturated extract more than 4 mmhos/cm (at 250C).

**Non-Saline Alkali Soil:**

When soluble salts (from saline alkali soils) are removed by leaching as a result of increase in rainfall or continued irrigation, it gives rise to non-saline alkali soils (with only Na - clay in the soil colloids). At 25C the electrical conductivity of the saturated extract of the soil is less than 4 mmhos/cm, exchangeable sodium percentage (ESP) is greater than 15% and pH value is between 8.5 and 10.

**NOTE:** For

1. Important causes for formation of Saline and Alkali soils.
2. Effect of Alkalinity and Salinity on plants, and
3. Reclamation of Saline and Alkali soils

It is suggested to consult mainly study learning material (SLM) of Environmental Science, Part I, Part III provided by NOU Patna. Other resource materials may also be consulted it so needed.

1. **Essential Plants Nutrients: Their role in nutrition and their deficiency symptoms in plants (Emphasis on deficiency symptoms of Nitrogen, Potassium, Phosphorous, Zinc and Iron).**

**Essential Plant Nutrients:**

Chemical elements and compounds necessary for plant growth and plant metabolism are called Essential Plant Nutrients. In the absence of these nutrients plants are unable to complete a normal life cycle. The total essential plant nutrients include sixteen (16) different elements. Some of these essentials nutrients are consumed by plants in larger quantities and have, therefore, been given the name macronutrients. Macronutrients include Carbon (C), Hydrogen (H), Oxygen (O) Nitrogen (N) Phosphorus (P) Sulphur (S) Calcium (Ca) Magnesium (Mg) Potassium (K). Of these macronutrients carbon, hydrogen, oxygen and nitrogen contribute to over 95% of a plant’s entire biomass on a dry matter weight basis. Other essential nutrients are required by plants in smaller quantities and have therefore been given the name micronutrients. Micronutrients include Iron (Fe), Boron (B), Chlorine (Cl), Manganese (Mn), Zinc (Zn), Copper (Cu) and Molybdenum (Mo). Of these essential plant nutrients carbon, hydrogen and oxygen are absorbed from the air whereas the other nutrients including nitrogen are obtained from the soil (exception include some parasitic or carnivorous plants). These elements stay beneath soil as salts, so plants consume these elements as ions.

Most soil conditions across the world can provide plants adapted to that climate and soil with sufficient nutrition for a complete life cycle without the addition of nutrients as fertilizer. However, if the soil is cropped it is necessary to artificially modify soil fertility through the addition of fertilizer to promote vigorous growth and increase or sustain yield. This is done because even with adequate water and light, nutrient deficiency can limit growth and crop yield.

**Role of nutrient elements and their deficiency symptoms:**

Let us take up them individually as regarding their source, role as nutrient and deficiency systems.

1. **Carbon:** Carbon forms the backbone of most plant biomolecules including proteins, starches and cellulose. Carbon is fixed through photosynthesis. In photosynthesis chlorophyll bearing. Plants synthesize carbohydrate molecules form carbon dioxide of air and water in presence of sunlight. A part of the carbohydrate (i.e. energy source) so produced in plants is utilized by the plants as food for their own metabolic activities (as respiration and growth i.e. tissue building).
2. **Oxygen:** Oxygen is a component of many organic and inorganic molecules within the plant, and is acquired in many forms. Those include O2 and CO2 (mainly from the air via leaves), and H2O, NO3 - , H2PO4- and SO4-- (mainly from the soil water via roots). Plants produce oxygen gas (O2) along with glucose during photosynthesis.

6CO2 + 6H2O C6H12O6 + 6O2

Plants in turn, require this Oxygen (O2) to undergo aerobic cellular respiration and break down this glucose to produce ATP.

1. **Hydrogen:** It is obtained almost entirely from water. Hydrogen is necessary for building sugars and building the plant. Hydrogen ions are imperative for a protein gradient to help drive the electron transport chain in photosynthesis and for respiration.
2. **Nitrogen:** Nitrogen is a major constituent of several of the most important plant substances. For example, Nitrogen compounds comprise 40% to 50% of the dry matter of protoplasm, and it is a constituent of amino acids, the building block of proteins. It is also an essential constituent of chlorophyll.

**Deficiency symptoms:** Nitrogen deficiency most often results in stunted growth, slow growth and chlorosis. Nitrogen deficient plants also exhibit a purple appearance on the stems, petioles and underside of leaves from an accumulation of anthocyanin pigments.

1. **Phosphorous:** Like Nitrogen, Phosphorous is involved with many vital plant processes. Plants need phosphorous for normal development and timely maturity. Phosphorous is noted for its role in capturing and converting the sun’s energy into useful plant compounds. The structure of both DNA and RNA are linked together by phosphorous bonds. Phosphorous is a vital component of ATP, which is of immediate use in all processes that require energy with the cells. Phosphorous can also be used to modify the activity of various enzymes by phosphorylation and is used for cell signaling.

**Deficiency Symptoms:** Phosphorous deficiency in plants is characterized by an intense green coloration or reddening in leaves due to lack of chlorophyll. If the plant is experiencing high phosphorous deficiencies the leaves may become denatured and show signs of death. Occasionally the leaves may appear purple from an accumulation of anthocyanin. Because phosphorus is a mobile nutrient, older leaves show the first signs of deficiency.

1. **Potassium:** Unlike other major elements, Potassium does not enter into the composition of any of the important plant constituents involves in metabolism, but it does occur in all parts of plant in substantial amount. Potassium is outstanding among the nutrient elements for its mobility within the plant tissue. Process involving potassium include the formation of carbohydrates and proteins, the regulation of internal plant moisture, as a catalyst and condensing agent of complex substances, as an accelerator of enzyme action, and as contributor to Photosynthesis, especially under low light intensity. Potassium regulates water loss form the leaves and increases drought tolerance. Potassium helps in fruits coloration, shape and also increases its brix. Hence quality fruits are produced in potassium rich- soils.

**Deficiency Symptoms:** Potassium deficiency may cause interveinal Chlorosis. When potassium is moderately deficient, the effects first appear in the older tissues and from there progress towards the growing points and die-back commonly occurs. Potassium deficiency may result in higher risk of pathogens within Chlorosis, brown spotting and higher chances of damage from frost and heat.

1. **Sulphur:** Sulphur is a structural component of some amino acids and vitamins and is essential for chloroplast growth and function. It is found in iron-sulphur complexes of the Nitrogen (N2) fixation by legumes and the conversion of Nitrate into amino acids and then into protein.

**Deficiency Symptoms:** In plants, Sulphur cannot be mobilized from older leaves for new growth, so deficiency symptoms are seen in the youngest tissues first. Symptoms of deficiency include yellowing of leaves and stunted growth.

1. **Zinc:** Zinc is required in a large number of enzymes and plays an essential role in DNA transcription.

**Deficiency Symptoms:** A typical symptom of Zinc deficiency is the stunted growth of leaves, commonly known as “little leaf” and is caused by the oxidative degradation of the growth hormone Auxin.

1. **Copper:** Copper is important for photosynthesis. It indirectly influences chlorophyll formation and controls respiration system. It is involved in many enzyme processes; is necessary for proper photosynthesis, is involved in the manufacture of lignin (cell walls) and involved in grain production.

**Deficiency Symptoms:** Symptoms of Copper deficiency include chlorosis.

1. **Iron:** Iron is a constituent of several enzymes and some pigments. It assists in nitrate and sulphate reduction and in energy production within the planet. Although Iron is not a structural part of chlorophyll but is very much essential for its synthesis.

**Deficiency Symptoms:** As iron is immobile in plants and therefore deficiency symptoms appear first on the youngest leaves. Iron deficiency can result in interveinal chlorosis which involves yellowing between the veins of the youngest leaves.

**Note:** For role of the remaining six nutrients eg. Ca, Mg, Mn, Mo, B and Cl Study Learning Material (SLM) provided by NOU, Patna may be consulted. Other available resource materials may also be consulted. Answer may be shortened as per the demand of the question to be answered.

1. **Toxic Chemicals in Biosphere: Common method of classification of toxic chemicals. Meaning of Threshold Limiting Value (TLV): Threshold Limiting Value of some common toxic metals.**

**Toxic Chemicals in Biosphere:**

According to the recent estimates there are more than 8 million substances (chemicals) presently known to be present in the biosphere of which 60,000 to 70,000 chemicals are commonly used. Of these chemicals, some are toxic (i.e. poisonous) and the rest are non-toxic.

A toxic chemical (toxicant) may be defined as an agent that causes an adverse effect or response in a biological system, seriously damaging its structure or function causing death in many cases. According to National Institute for Occupational Safety and Health, Wasington, U.S.A, a toxicant may be defined as “Substance which demonstrates the potential to induce cancer, produce long term disease or bodily injury, affects health adversely, produce acute discomfort or endangers the life of man and animals through exposer via the respiratory tract, skin, eyes, mouths or the other routes”.

Toxic chemicals enter into the biosphere may be due to natural causes or through anthropogenic activities. However, most of the toxic chemicals are introduced into the biosphere through human activities - deliberately or accidentally - impairing the quality of environment and making it unfavorable for organizations.

Toxicants in various sections of the environment may precisely be placed and studied under the following headings:

1. Toxicants in air.
2. Toxicants in water.
3. Toxicants contaminating food.
4. Toxicants associated with radiation pollution etc.

**Classification of Toxic chemicals:**

One common method of classification of toxic chemicals is as follows:

1. Toxic metallic elements including heavy metals.
2. Toxic non-metallic elements and their compounds.
3. Toxic organic compounds.

Another method of classification of toxic chemicals is as mentioned above i.e.

1. Toxicants in air
2. Toxicants in water
3. Toxicants contaminating food and
4. Toxicants associated with radiation pollution etc.

Still another and more convincing method of classification of toxicants is on the basis of organ system affected. From the human health view point and the organ system affected, the toxicants may be of the following types:

1. Environmental Carcinogens
2. Cardio toxicants
3. Immunotoxicants
4. Tetratogens
5. Occupationally inhaled toxicants
6. Hepatotoxicants and
7. Muteric agents

**Note :** For detailed description of different class of toxic chemicals in the environment (i.e. biosphere)it is advised to consult the following study/resource materials:

1. Study Learning Materials (SLM), Nalanda Open University, Patna, Part I, Paper III
2. Study Learning Materials (SLM), Nalanda Open University, Patna, Part II, Paper XI (Environmental Toxicology)
3. Environmental Chemistry, A.K.De

**Threshold Limiting Value (TLV):**

TLV is a scale on which toxicity of toxicant is expressed. The Threshold Limit Value of a toxicant (or a chemical substance) is a level (i.e. concentration of the toxicant) to which an individual/worker can be exposed day after day for a working lifetime without adverse effects of the toxicant/chemical substance on the individual /worker. It takes into account the exposure of a worker/an individual exposed up to 7-8 hours per day during the working period of 40 hours a week. TLV is a term coined by American Conference of Governmental Industrial Hygienists (ACGIH). TLVs issued by the ACGIH are the most widely accepted occupational exposure limits both in the United States and most other countries. The concept of Threshold Limit Dose is of basic importance because it implies that there is No Observed Adverse Effect Level (NOAEL). The NOAEL is important for sitting exposure limits.

**Threshold Limiting Value (TLV) of some Common Toxic Metals:**

**Toxic Metal/Metal Compound TLV (in microgram per meter3, µg/m-3)**

1. Zinc (Zn) 500
2. Zinc oxide (ZnO) 5000
3. Mercury (Hg) 10
4. Lead (Pb) 200
5. Tetraethyl lead [(C2H5)4Pb] 75
6. Arsenic (As) 500
7. Manganese (Mn) 5000
8. Nickel (Ni) 1000
9. Nickel carbonyl [ Ni(CO)4] 7
10. Copper (Cu) 100
11. Platinum (Pt) 2
12. Uranium 200