Environmental Science

Environment, Ecosystem and Bio-Diversity

Lecture 9

Functional Attributes

If you look at the **functional attributes**, you have **Food Chains**. The sequence of feeding relationships in an ecosystem is basically called a Food Chain.

The **Trophic Structure** which is each organism in the ecosystem is assigned a feed level or a trophic level.

Then you have the **Simple Food Web Model.** Like we just discussed the food chain, and food web just changes or differs in complexity. We saw a basic food chain encompasses about maximum of about 4 to 5 levels. When it comes to a food web it could be about 3 levels but it will be simultaneous like the one we just seeing as an example. Here we are seeing **the producer is the pond grass, the herbivore is the water insects,** at the same time you have **the small fish**, and then you have**carnivore on one end which is the large fish and carnivore on the other side you have the duck. And then the top carnivore is man**. So basically if you are talking about phytoplankton, sea weeds, even sometimes the sea weeds are directly also consumed by man. So it depends on the different kinds of organisms across the ecosystem. Different kinds of food chains and food webs are in existence.

Now if you look at a **Simple Food Chain Model** we have seen, you have **the sunlight, the producer, the herbivore and the carnivore. At one end you have the heat that is being produced and at the other end** of the spectrum **you have the decomposers** and **the inter relationship between the decomposers and the producers, herbivore as well as the carnivore.**

You have **Two Types of Food Chains**. You have **the Grazing Food Chain and the Detritus Food Chain**. Now in **the grazing food chai**n it basically starts with **green plants**. That is the **primary producers** and it **culminates with carnivores**. So you have **Phytoplanktons, water fleas, small fish** and then you have the **carnivorous fish within the pond ecosystem**.

Then you have the **Detritus Food Chain**, which pretty much starts with **dead organic matter** which **detrivores and decomposers consume.** Thus grazing food chain derives its energy basically from the plant energy. And **the detritus food chain is obtained from primarily the plant bio-mass, secondary from microbial bio-mass and tertiary from carnivores**. So then the **detrivores** play a very important role in this kind of food chain, where they **actually consume the decomposed matter.**

Food Web is basically a **network of food chainswhere different type of organisms are connected at different trophic levels.** So you have many number of options of eating and being eaten at each trophic level.

So if you look at **the Significance, Why is the Food Chain very crucial**? Food chains **maintain energy flow** as well as **the nutrient cycle**. Food chains maintain **ecological balance by regulating the population** size, and they basically **biologically magnify toxicity of some chemicals**.

Carbon Cycle is very crucial. How carbon dioxide is maintained? The level of carbon dioxide is maintained. So you first have **carbon di oxide in the atmosphere**. Then it is used by the plants, organic compounds in green plants, then you have a constant relationship that is a direct relationship through photosynthesis. But then when plants go through feeding and respiration, we actually, animals and human beings give out carbon dioxide in respiration. Then when all these organic compounds decompose and die, you have carbon compounds in dead organic matter and that again goes through respiration in the decomposers. And back again if you look at the organic compounds in the green plants, they actually even, when they decompose they add on to the carbon compounds in the dead organic matter. At the same time what happens over a larger period of years, say 300,000 years later, 400,000 years later, fossilization is a process occurs and that makes , carbon gets converted into fossil fuels. Again once that happens when fossil fuels are getting consumed by man, again carbon dioxide is released into the atmosphere. So if you look at the main processes involved in this cycle, you have respiration, photosynthesis, decomposition and respiration, fossilization and combustion. So photosynthesis is the direct process and then you have fossilization that happens directly. But the time period we are talking about is pretty much impossible for us to calculate in our lifetime. We are

talking about 400,000 years, 200,000 years that kind of time frame. The rest that we are talking about respiration, decomposition, it's all within a particular time frame that can be compared. So all of these processes are very important, to ensure the carbon dioxide level in the atmosphere does not change and if at all it does change we could be aware of it. Because the only organism that consumes carbon dioxide in a positive fashion is plants. They consume the carbon dioxide and release oxygen. Human beings consume this oxygen and again release carbon di oxide. So we need to make sure that the plant to human being ratio doesn't go to an extent where the carbon dioxide in the atmosphere is no more, does not have any more place to be absorbed.

Now if you look at the **carbon dioxide that is taken up by plants during photosynthesis**, then it is also released by organisms during respiration, decomposition, fires and volcanic eruptions. Carbon dioxide is also released by automobile industries and industries. Carbon that is present in pretty much all organic molecules, moves through the food chain as one organism eats one another. So you have carbon that is returned to the biosphere in a cellular respiration process and then in photosynthesis process. So both of these are the chemical energies that are getting converted.

Next you have the **Nitrogen Cycle**. Nitrogen cycle basically you have atmospheric nitrogen as well as soil nitrate which is very important for plants to grow. So through plants, through different processes in the atmosphere, this balance is maintained between atmospheric nitrogen as well as the nitrates in the soil. The soil and the nitrates get primarily consumed by plants especially legumes, lentils and all of those crops consume a lot of nitrogen. And then again you have lightning, things like that that release nitrogen and that nitrogen gets into the soil. So you have this constant give and take that's happening within the atmosphere to maintain the nitrogen cycle.

So 78% of the volume of the troposphere and then you have the most complex cycle is , nitrogen cannot be used as is, it must be consumed by itself. It cannot be consumed by itself.It must be fixed so that certain organisms can use it , especially when we say it cannot be used by itself, we are talking about human beings and animals. Nitrogen as such cannot be consumed by us. But we have assigned certain

ways of assimilation within our body through plants, through the soil and some other system.

So how do you go about **Different Steps within this Cycle**:-**Nitrogen Fixation, Assimilation, Ammonification, Nitrification and Denitrification.**

So when you think of **Nitrogen Fixation** , it is basically atmospheric nitrogen must be processed or fixed to be used by plants. So these fixation factors occurs in lightning strikes, but most fixation is done by free living or symbiotic bacteria, which actually help in inducing this kind of nitrogen in the form of soil nitrates.

Next you have **Assimilation:-** Plants actually gets the nitrogen from the soil by absorption in their roots and then this happens through either nitrate ions or ammonium ions.

Then you have the process of **Ammonification,** where a plant or an animal dies, the animal then actually expels waste, because of decomposition. That initial form of nitrogen is completely organic. So any bacteria or fungi converts this organic nitrogen with the remains back into ammonium and this process is called ammonification or mineralization.

Then you have **Nitrification**. In nitrification the conversion of ammonium to nitrate that is soil nitrate where the plants can absorb it, is performed primarily by soil living bacteria and other nitrifying bacteria. So you have the process of nitrification, ammonification and assimilation. All of these are ways by which the free nitrogen in the air gets converted finally to a kind of nitrogen that can be assimilated by organisms.

If you look at **Denitrification,** this is basically the reduction of nitrates back into larger inert nitrogen gas completing the cycle of nitrogen. So this happens by bacterial species in anaerobic conditions. Anaerobic conditions is nothing but absence of oxygen or absence air as such. So they use nitrate as an electron acceptor in the place of oxygen during respiration. So instead of oxygen, if oxygen is there this process will not take place, so this has to be in dark conditions, pretty much under the soil where it is release as nitrogen gas and then that goes back into the atmospheric surface.

Then you have **The Water Cycle**, which is very commonly known by most people. You have a constant relationship between water and the sun where there is constant evaporation, Transpiration with respect to plants and plant surfaces. And then you have lakesother ground waters and everything that is maintained by precipitation. Precipitation could either be in the form of snow, rain, hail or whatever it is. All the atmospheric trapped moisture under certain conditions of temperature get released in the form of precipitation. So this precipitation gets collected in lakes, it could get collected as ground water, rivers, oceans, any of these water bodies. All of these gets filled, again from the surface of all these bodies, when the temperature Is right, when the sun is out , when the clouds are clear, all of this again gets transpired and evaporated and back the same cycle occurs again and again.

Now if you look at **Productivity, Primary Productivity or PP**, the gain in energy or bio-mass by producers per unit area, per unit time. Then you have **Secondary Productivity** where the gain in energy or bio-mass by hetrotrophs per unit area, per unit time. So if you actually look at this concept, this primary productivity if you look at it, its actually basically the conversion of solar energy. So it is dependent on the amount of sunlight, temperature, carbon dioxide, etc. So under these optimum conditions you will realize what is the primary productivity of that particular plant. Secondary productivity involves feeding or absorption, so that is dependent on how much food is actually available, and whatever food that is available there , how efficiently is it going to get converted into bio-mass.

Gross productivity;- **Gross Primary Productivity**- This is the total gain in energy or bio-mass by producers per unit area, per unit time, were you are not taking any loss due to respiration into account. **Secondary Productivity** in this case is again the same thing but we are not taking into consideration any loss because of respiration or defecation into account.

So then you have **Net Productivity** where in this case we are taking into account that there is obviously some loss due to respiration into that account. Then you have the **Net Secondary Productivity**, where the gain in energy or Bio-mass by hectrotrophes, per unit area, per unit time. We actually take again the loss due to respiration and defecation into that account. So the net productivity values are actually more useful to us, they give us the information about actually how much

energy or bio-mass is available from one trophic level to the next. If we actually think that this energy loss because of respiration or defecation is minimal, we are very much mistaken. The percentages that are actually conserved in terms of energy is barely 10%. We end up losing about 80% to 90%. So the net productivity value is what gives us the right consideration and more useful information about how much energy or bio-mass is finally going to be available.

Function of an Ecosystem;- Ecosystems have **simple functional attributes** which keep the component parts running together. For example- **Green leaves prepare food, roots absorb the nutrients from the soil, Herbivores feed on plant production, and in turn serves as food for carnivores. Decomposers carry out the function of breaking down the complex organic materials, into simple inorganic products which can be used by the producers**. All these functions in an ecosystem occur through delicately balanced and controlled processes. Thus the cycle goes on and on leading to a very efficient, continuous functioning of the ecosystem. So you have **food chain, food web, trophic structure; energy flow; cyclingof nutrients** like we have seen the nitrogen , carbon dioxide; **Primary and Secondary Production, and the different levels of it; Ecosystem development and regulation.**

Different Types of Ecosystem

The Different Types of Ecosystem: - So we have **Natural and Artificial**. Within the natural components which we'll be first concentrating on is **Forests, Grasslands, Aquatic and Desert.** And then in artificial we have **Terrestrial, Microbial as well as Aquatic**.

Moving onto a **Forest Ecosystem**:-**High Rainfall**- what are the characteristics of such an ecosystem? **High Rainfall; Large number of organisms and Flora; High diverse population**; When we are talking about diversity in population , within plants you will have numerous types, within flowering plants you will have numerous types, so individual species , sub-species, and sub sub-species are very diverse and different. **Stability of the ecosystemhence becomes very sensitive**. Because these typologies are very specific to one kind of environment, certain kind of environment conditions ,orcertain animals or certain plantsnearby, it is very sensitive.

The **Different types of Forests:- We have the Tropical Evergreen Forest, Tropical Deciduous Forests, Temperate Evergreen Forests, Temperate Deciduous Forests, and Taiga.**

If you look at the **Features of a Forest Ecosystem;-Forest Canopy, Forest floor and Forest Soil**. So these 3 features are the ones that can be described as what kind ofa Forest Ecosystem we are talking about. How fertile is the soil, what kind of forest soil it is,

Forest Floor refers to kinds of shrubs, plants that exists within the ground level and a couple of feet above ground level. The **Forest Canopy** is the soaring trees and the tall plants that exist and that cover the entire forest is the Canopy. So those are the 3 different levels.

Function of a Forest Ecosystem:-**Water shed protection; Atmospheric regulation; Soil erosion Control; Wind erosion control.**

Now moving onto a **Desert Ecosystem**;-**High temperatures; Intense Sunlight and Low water**; So here **Flora and Fauna are very poorly developed and very scarce**. **Organisms are Xeric adaptive**. That is they can change because of weather conditions and the heat**; Scarcely populated** in the sense there is no kind of cover that you will see over here. It does not have any kind of continuous structure.

Sand Desert, Stony Desert, Rock Desert, plateau Desert, mountain Desert and Cold Desert. So inspite of having so many **types of deserts**, one thing remains common is the scarcity in population of species. That does not make them any less useful. Usually what happens in perception wise is , desert plants and animals, animals also gain some kind of importance, but the plants are gained rarely any importance thinking that it does not require anything, what is the big deal in it, but usually the kind of cacti, and the kindof plants that grow in these areas are very crucial to maintain the level of water that is minimally there in that area. Number 2 the animals that are present within the desert. Even though the desert is described as scarcely populated by any standards, there are still certain organisms that thrive in that soil. And for those organisms to thrive in that soil it is very crucial these plantscontinue to thrive in that soil as well. So irrespective of the different types of desert, certain factors remain common.

This is a **typical sand desert**which most of us are familiar with. **The rock desert** is one which is very rocky and cliffy and even the scarcely populated plants might exist very rarely. **The stony desert** is again vast expanses but here in the stony desert you find a lot of small, sharp, piney shrubs in this area. The **plateau desert** is a common platform between a mountainous area and a desert region, where it is elevated above the sea level but because of certain conditions, it could be hidden behind a mountain, it could be in the leeway side of a valley, any of these reasons could be why a plateau desert exists. Here too the same factors contribute. The temperature could be actually quite chilly in the plateau desert, the temperature is not aplying factor. But the level of moisture, the level of water in these areas remain a poorest of quality and because of that even the scarcely populated shrubs or the plants that you see are even more widely spaced**. Mountain desert** is clear on the next stage where you do not have, its too cold, that is there can be no species or thriving organisms and the mountain desert could either be snow capped mountains like we will see now or it could just be the dry , arid mountain desert. This is the cold desert again because of temperature conditions you will not see any kind of activity on top of the surface but way below the levels of snow and ice you will have a wildly active aquatic life system. So irrespective of all these deserts you might think there is no plant life on this , this cover, this solid ice cover helps sustain a very much viable ecosystem in the aquatic world below this thick slab of ice.

Now **features of a desert Ecosystem;-Rainfall, Temperature, Soil, Light, and Plants and animals that are adaptive to live in these extreme conditions either extreme heat or extreme cold.**

Function of a desert Ecosystem:-Mineral Resource ; Solar energy Resource.

Types of Grass land Ecosystem:-So moving onto the third we have grass land ecosystem, **Tropical Grasslands, Temperate Grasslands an**d the others get classified .

Now if you look at the **Features of a Grassland Ecosystem-Temperature, Precipitation, Humidity, Topography, Unadaptive plants and animals.** Because the system, the ecosystem is so vibrant and thriving, you will not find these plants and animals ready to adapt. They for centuries have been exposed to a

similar kind of atmosphere, similar kind of growth conditions. But suddenly now because of certain human activities if things are changing, these plants and animals find it very difficult to adapt themselves.

Now **Function of a Grassland Ecosystem**:- Grasslands are obviously the main food providing sources, they are also main breeding areas, and they contribute to maximum percentage of human habitat. Now within the grassland ecosystem – **marginal rainfall; vegetation is dominated by grasses; unimproved by wild plant communities; densely populated.**

Moving onto **the Aquatic Ecosystem**;-**Low temperature and sunlight; Soil and vegetation is submerged; Flora and Fauna have adapted because of these conditions; Densely populated** in the sense under the river or the sea or whicheveraquatic system we are talking about, it is densely populated, overlapping different ecosystems it could, but one thing again is differentiated here,based on the quality of water. You will have a separate ecosystem for sea water, fresh water, river water.

So like we've just going to see **types of Aquatic Ecosystem**- we have **ocean, lotic, lentic, and wetland**.

So the **features** that distinguish all of these are **light and temperature**; the amount of sunlight permeating through the different levels of water,decideswhat kind of oxygen level is going to be in the water. Depending on that the different kinds of aquatic life forms will generate or degenerate. Again based on the amount of light that is getting into the layers of water, the temperature of the water is decided and based on that again the species and sub-species get accumulated in one particular area.

Current of the water plays a very important role. If the current is very high you will not find plants or sea weeds growing there because they get torn and ripped apart. You will find them in low current areas where they can grow peacefully and Based on these sea weeds which fishes depend for nutrition and food, those fish will migrate to areas where current is low too**.**

Chemistry over here refers to the different levels of oxygen, nitrogen, other important gases and micro nutrients within the aquatic system.

Competitive organism- competitive organism is nothing but what levels of fish or Phytoplanktons are available. What is the predator? What is the prey? How many levels of the food chains exist within one particular aquatic ecosystem.

Now the **functions of an aquatic ecosystem**:- It helps in **recycling nutrients**. It **purifies water** because of the different aquatic plants over there, even they have to prepare their own food and everything.**Responsible for proper rainfall** because the surfaces are mostly used in the water cycle that we discussed. It is from the surface of rivers, oceans and lakes, that Evaporation occurs and clouds are formed; **Attenuate floods; Recharge ground water**.

Moving onto **Bio-diversity**;- The term bio-diversity was **first coined by Walter G Rosen in 1986**. The biosphere comprises of a complex collections of innumerable organisms and this is referred to as Bio-Diversity. It doesn't just mean a mixture, a couple of organisms. It has to be different hierarchical, it has to be different types as well as sub-species. This all constitutes the vital life support for survival of human race. Biological diversity, abbreviated as bio-diversity, represents the sum total of various life forms such as unicellular fungi, protozoa, bacteria, and multi cellular organisms such as plants, fish and mammals at various biological levels including gents, habitat and ecosystem.

What is Bio-Diversity? It encompasses the variety of all life forms on earth. It is identified as the variability among living organisms and the ecological complexes of which they are apart of including diversity within and between species and ecosystem. In simple words it can be defined as variety, variability between genes, species and ecosystems. The termed Bio-Diversity was first coined in 1985, barely like 30 years back, and we have learnt so much in this particular time frame. Bio obviously refers to life and the diversity that occurs in this earth is diversity or variety of it , is bio diversity.

Now if you look at the **concepts in the different types of bio-diversity** that exists. It basically encompasses life forms on earth. When you think of life forms on earth, it actually includes aquatic. The ones that exists in air, land different forms and the essential interdependence,their different relationships between all living things. So as defined in a convention on biological diversity in 92, bio-diversity is defined as the variability among living organisms from all sources, that is

including interalia, terrestrial , marine, and other aquatic ecosystems, and the ecological complexes of which that area are part of. This includes diversity within species, between species, and of ecosystem. According to IUCM in 98, the variety and variability of species of their population, the variety of species of their life forms, and the diversity of the complex association with species, with their interaction and their ecological process which influences performance.

You have **3 different types of biodiversity**- **Diversity of species, Diversity of ecosystem and Diversity of Genes.**