Environmental Science

Environment, Ecosystem and Bio-diversity

Lecture 8

Ecosystem

Now moving onto **the concept of Ecosystem** and what exactly this encompasses. An Ecosystem is a biological environment which consists of pretty much all living organisms. So you have both biotic components as well as abiotic components. So you have the living organisms and the non-living but which support the living organisms like air, soil, water, sunlight, with which the organisms have a constant interaction with. So all of these components together encompass the system of an eco system.

Concept of An Ecosystem:- Eco means Habitat. System refers to any complex set of interconnected components or processes forming a whole. Philips Encyclopedia in 2005 defines this as it includes all organic life in a given area along with soil, water and as well as other inorganic components of their habitat and all the ecological interactions that take place within and between the organic and the inorganic. So all of these steps involved encompass the Ecosystem and the processes or the phenomenon it is.

If you look at the whole area of the ecosystem in our planet, you obviously have the sun. You have something called the producers that is the producers are nothing but the plants which produce food. The Consumers include the initial circle of herbivores as well as man, and then you have the decomposers. From the producers also you can have an interaction with the decomposers that is when plants and other

organisms decompose into the soil, the soil will pretty much decompose it and that decompost that is there in the soil is what helps the plant grow. So they have a very intrinsic relationship. The consumers which are other animals and human beings, we come in as a middle link between the producers and the decomposers. So even decomposers help the consumers live, as well as once the consumers also die, as well as they become a part of the soil, they to become part of the decomposing level. So these 3 main interactions are primary in any eco system and this is the basis of any ecosystem in the world.

If you look at ecosystem it is basically a **spatial functional structure**. The space could either be geographically large or small. So if you look at the largest ecosystem it is obviously the planet and the smallest ecosystem or a microcosm nothing but just a handful of soil and moss which is sealed in a jar. So if you keep that for a few days in sunlight or even in shade you will see the moss growing. You will see some worms coming in. **So for an organism or ecosystem to exist**, it is sufficient to have pretty much **of moisture, some amount of nutrition, and some amount of sunlight**. So All these 3 components is enough for an ecosystem to survive.

Like we just discussed the ecosystem consists of **2 main branches**, you have biotic factors and Abiotic factors. So your **biotic factors** encompass **sunlight, temperature, precipitation, water or moisture, soil or chemical content.** Your **Abiotic factors** include **primary producers, herbivorous, Carnivorous**, **Omnivorous and Detritivorous**. So all of these are your Abiotic components within the ecosystem. So there is obviously a constant co relation between the biotic and the Abiotic. They cannot exist by themselves; there is obviously a kind of

symbiotic relationship between both of them. They are interdependent and can never mutually exist as mutually exclusive anticipatory beings.

Moving onto what exactly is **an Ecological Pyramid**. The number, biomass and energy of organisms gradually decreases from the producer to that of the consumer level. This loss of energy or decreasing form of energy is represented by a pyramid called an ecological pyramid. So it is **basically a graphic representation of number, biomass and energy of the successive trophic levels of any ecosystem.**

So we'll see the **Different kinds of pyramids** that you have. We have pyramid of number. pyramid of biomass, and pyramid of energy.

Pyramid of number if you look at it for some examples that you have. You have the primary producer, the grass. Then you have the grasshopper and frog Is the final consumer. So the number if you look at it is gradually decreasing. The amount of grass that is available versus the amount of grasshoppers and finally the number of frogs. If you look at a co relative relationship between these 3 components, obviously the grass is much more in number than frogs. Similarly now reverse way we go. Parasites, herbivore bird, and tree. Parasites are much more in number. The herbivore birds which fed on the parasites are next and then finally trees. Then similarly you have snakes, their relation to birds and then trees.

The **pyramid of number**:-The number of individuals at each tropic level decreases from the producer level to the consumer level like we just saw. In any ecosystem the number of producers is far high. The number of herbivores is lesser than that of the producers. Similarly the number of carnivores is even lesser than that of the herbivores. That's pretty

much like the law of nature, and if there is any detrimental activity that happens to disturb this is what we'll see as the later part of the lecture were we'll go onto seeing the aspects of what happens if the pyramid is displaced or misplaced.

Moving onto **the pyramid of Biomass**:- Bio-mass refers to the total weight of living matter per unit area. So in an ecosystem the biomass decreases from the producer level to the consumer level. If you look at the pyramid of Bio-mass, Again at the base of the pyramid at the maximum you have the trees and grasses. Then you have the herbivores like deer, which feeds on the trees and grasses. And then you have the lion which actually feeds on the deer. So again if you look at the water body or the aquatic system, you have the Kingfisher bird which feeds on the big fishes and then you have the small fishes and the phytoplankton. So Phytoplankton is basically any kind of plant life that you see on a water body.

The pyramid of energy:- The energy flows in an ecosystem from the producer level to that of a consumer level. At each trophic level, 80% to 90% of the energy is pretty much lost . Hence the amount of energy decreases from producer level to consumer level. So if you look at the pyramid of energy, sun is first, directly is absorbed by plants for producing their food. So you have trees, herbs and shrubs. Then you have herbivores like rabbit, deer, which feed on them. They don't accept the sunlight as a direct form. Their energy is further lost, and then you have carnivores which actually feed on the herbivores. And then you have the omnivores which usually ends up being man and that is the least form of energy that you see at the top of the pyramid. 10.54

According to **the 2nd law of Thermodynamics**, the energy is never transferred from one object or organism to the next with 100% efficiency. There is definitely some amount of energy that is lost to the environment. It could be in the form of gases, air, or it could be in the form of water anything that is lost. If you look at another example, energy pyramid actually shows the amount of energy that moves from one level to the other, that is how much is there in the producer level. And in between the producer and the final consumer how many trophic levels are there in that ecosystem. Those many number of times there is a difference in the energy level. Now if you look into **the Dynamics of an Ecosystem**:- The various components of the ecosystem constitute an interacting system. So there is no factor or component of the ecosystem that can just be by itself. There is a constant activity or correlation between different components within the same ecosystem. They are connected by energy, nutrients, and minerals. The nutrients and minerals circulate and then re circulate between Abiotic and biotic factors and this happens many number of times. This re circulation and inter connection is not a one way street or neither a one process. It is a multiple time occurring process, multi level occurring process. Whereas the flow of energy is one way, once used by the ecosystem, it is then lost. So the continuous survival of the eco system depends on the flow of energy, circulation of nutrients, and minerals in the ecosystem.

Functions of an Ecosystem

If you look at the **dynamics or functions of an ecosystem** it includes the following. The 1st primarily being **energy**, then **Primary Production**. Secondly you have the **Secondary production** after the formation of energy. 4th the **food chain, Trophic levels** within the food chain, **Food Webs, Energy Flow** within the Food Webs; **Ecological pyramids** which

define these food Webs, and **Bio chemicals cycles** which actually describe what is happening in the above mentioned processes.

Now if you look at the **concept of energy** , it is the ability to do any kind of work. The main source of energy for an ecosystem is the radiant energy or light energy that is derived from the sun or solar energy. So this light energy is then converted into chemical energy in the form of sugar which is basically done by plants in the process of photosynthesis. But plants utilize about 0.02% of the sun's light energy that is reaching the earth. Plants use most of the energy they make up for themselves and then consumers get this energy from the plants, which is the level of producers.

Then **Primary Production**.;- The amount of light energy converted into chemical energy by plants, in a given period of time, per unit area is called primary productivity.

Then **secondary production** is the energy, that is not produced by these producers, that can be passed onto organisms, that those organisms cannot make up their own energy, which is pretty much all herbivores or all animals. Animals are incapable of making up their own food like the way plants do in the process of photosynthesis. Herbivores are completely dependent on plants for their nutrition. So that is the secondary production.

Then you have the producers, which are directly consumed by the herbivores that are eaten by the primary carnivores that, in turn are then eaten, by the secondary carnivores. So now we have the producers that are the plants, then you have the primary herbivores which consume the producers or the plants. Then you have carnivores' again two categories. The primary carnivores which consume the

herbivores, next you have the secondary carnivores that consume the primary carnivores. So the consumers store some amount of energy in their tissues. This energy stored by the consumers is called secondary production. Only about 10- 20 % of the primary production is converted into secondary production.

So **a Food Chain**. Now this will help us understand how the ecosystem goes about working. This tells us what is eaten, by what, in any ecosystem. So if you look at an example of a food chain. Many insects feed on nectars which is gathered from different kinds of flowers. Then that insect is eaten by the frog. Then the frog is eaten by the heron, which is a bird. The producers form the food for the herbivores. The herbivores form the food for the carnivores. And the sequence goes like producers, herbivores and carnivores. And carnivores if you look at it a little more complex food chain can be further categorized as primary carnivore and secondary carnivore. So this chain of food production or food consumption , however you look at it, is referred to as food chain.

Now **Trophic level** which is a main component of the food chain. Each food chain contains many steps like producers, herbivores, primary carnivores and so on. So each step of this food chain is referred to as a trophic level. The number of trophic levels in a food chain is usually restricted to 4 or 5. But very often the chains are much more complicated, with many more trophic levels. Because for understanding of the human beings, it is easier to have it in a limits of 4 to 5, because if it goes beyond that, to understand the loss of energy, when we are talking about just 5% and 10% of energy loss and consumption, it is very difficult to replicate this, to many other levels. So trophic level is basically **the position that one organism occupies in the food chain, or a group of organisms in a community that occupy the same position in**

the food chain. So it is possible to classify this, where you can, in two categories, you have the producers or the autotrophes that is, they manufacture their own food by simple inorganic substances. So that is the role of plants which are the primary producers. Then you have consumers or hectrotrophes, which is, feed on autotrophies or other hectotrophes to obtain energy. So this encompasses herbivores, carnivores, omnivores, detrivores or decomposers, that within the consumers, there is a feeding hierarchy or a which is very important. So this feeding hierarchy decides which organism is stronger, which is greater in number and which is lesser in number.

So like we've just discussed we have the first trophic level, the producer, the herbivore is the second trophic level and you can directly go to the third trophic level here which is the tiger. But usually if tiger is considered a secondary carnivore, in between you could have either a fox or a jackal which will come as a primary carnivore and then the tiger comes as the secondary carnivore at the 4^{th} trophic level. Like we just discussed again. You have trophic level 1 the producer, herbivore which is the primary consumer, and 3^{rd} is the secondary consumer or the primary carnivore and trophic level 4 is the tertiary consumer and the secondary carnivore. So autotrophes are the most important because they are the only ones that are capable of producing their own food and giving out energy and cleaning the air at the same time. So plants occupy a very important role in the eco system.

Now moving onto the next complex form, from food chains, **is Food Webs**. In an ecosystem the various food chains are interconnected with each other to form a network which is called a food web. This is because each organism may obtain food from more than one trophic level. In other words one organism forms food for more than one

organism of a higher trophic level. For a simple example you can just take man himself. Man is a herbivore, he is a carnivore as well as an omnivore. In a way we go to different levels of a trophic level for our energy consumption. We go directly to the primary consumer, we go the producers, and we rarely go to the secondary carnivore. That as man in the food pyramid; we are pretty much attacking every trophic level to contain our appetite.

Energy Flow

If you look at the **solar energy flow**, primary energy we discussed is solar energy or light energy. But that gets transferred and it gets trapped by green plants and that gets converted to chemical energy, and that is stored as carbohydrates. This entire process is referred to as photosynthesis. Apart of this chemical energy is used up by the green plants themselves. The major portion of the energy is consumed in the form of food by consumers at different trophic levels. For example if it is potato, it is in the root, if it going to be spinach it is in the leaves. So depending on the kind of vegetable or fruit we are talking about the energy gets stored in different places and in different forms. So there is an energy flow through the biotic components within an ecosystem.

The transfer of energy from one trophic level to another is called **energy flow**. This flow of energy is unidirectional. That is it can only flow from the producer level to the consumer level and never in the reverse direction. And the main reason for that to happen is obvious because only plants are the ones that can produce energy and store this. Other animals can only be food for the next level of chain and cannot produce food by themselves. So once this energy is used it can only be used once in the eco system. It cannot be returned in the direct

form, it can only be converted, so it is unidirectional like we discussed. Energy from the sun is consumed; it is released as heat into the soil. Then you have the first trophic level, the producers or the plants. Again you have second trophic level, the primary consumers, and the herbivores. The secondary consumers, the tertiary consumers, and decomposers in this case which is mushrooms, fungi, algae and all of that. But there is a generation of heat at every level that you see and that is a by- product of this process. The minerals that circulate and re-circulate many times in the eco system. A large amount of energy is lost at each trophic level. It's estimated that about 80% to 90% of the energy is lost, when it is transferred from one trophic level to another. Now when you have a loss of energy again that is in form of heat into the soil and again it could be in the release of carbon dioxide, release of oxygen depending on the organism.

If you look at this flow chart over here, the sun the primary source, plants the producers, they release heat. Then that is food for consumers as well as the decomposers. Then you have an inorganic nutrient pool in the soil that feeds, gives food for the producers, which is basically nutrients in the soil. Again the decomposers provide for the nutrients in the food. So you can see how complex this is in a way at the same time it is a very simple process, in terms of having only few players in the field. The consumers could be, many in number but as such you have only two main categories.

The **functioning of the system,** you have an input of energy. The system works, it could be any number of levels in the trophic levels. Then you have an output and the feedback could be in the form of heat which could either be used again in the system of input.

Then you have the **homeostasis mechanism**. This is basically were you have, you have a pretty much a tendency to take away from the set point. Set point is your beginning. Then you have may be some deficiency, then you have a positive feedback and then death or collapse of that organism. If there is a certain kind of deficiency which does not receive any feedback, then the negative feedback goes onto the set point where it can get readjusted and start the process once again.

Looking at the **ecological cycle** again you can see there is a generation of heat, at every level as well as the plants being the very most important part. As the gradual plants cover is reducing, there is nothing we can do to produce our own food. There is no amount of solar energy that man can directly absorb or any animal on earth that can absorb.

Now if you look at **the 3 main biotic components**- plants, algae and cynobacteria are **the producers**. They are able to create food using sunlight energy. They are also referred to as photoautotrophes.

Then you have **consumers.** They obtain energy by eating other organisms. They do not possess chlorophyll and they cannot do the process of photosynthesis. They are referred to as heterotrophes. They could either be herbivores or carnivores.

Then you have **decomposers** which is bacteria and fungi. They obtain food through the breakdown of any dead organic matter. They create humic material and are very important in recycling nutrients back to the soil. Some bacteria are very important, because some kind of bacteria are producers, because they use a similar process of photosynthesis, which uses energy from oxidation reactions, but rather than sunlight. So the process of photosynthesis happens at the level of

bacteria and algae. But it does not remain the same because they derive the energy from a different source. If it is only from the sun it can be referred to as photosynthesis.

Now Properties of an ecological system;- So you have **networks** which kind of show us there is an **interdependence** , there is **diversity, and complexity**. **Boundaries** which show there are **limits and sca**le. **Cycles** which show the processes of **recycling of resources** as well as **partnerships, symbiotic relationships. Flows** through which **energy and resources** can be transferred, **Development, succession and co-evolution; Dynamic balance that is self organization, flexibility, stability and finally sustainability.**

These are **series of open system components** were you have a direct input and output and this is an open system. It keeps going on where you have a particular output. That output becomes input for the next trophic level and so on. This is an example of an open system.

Now if you look at **an open system** What are the features of it?:- It actually process inputs and produces outputs. The amount of output produced is directly related to the amount of input that is received.

Now moving onto a **complex system**. Complex systems are composed of many interconnected and interacting subunits. They are capable of adaptation and self organization. So if you look at open systems all living organism are open systems. That is the basic cell that you have is an open system because there is a constant requirement for food from outside and then it eliminates the waste. It gives out heat as it carries on any chemical process like respiration in most cases.

If you look at **biological systems** there is a **hierarchical system. You have genetic systems, cell systems, organ systems, organismic systems, population systems and ecosystems** which is the final system that encompasses all these systems.

If you look at the **dynamics of any ecosystem**, you have the inputs,. It could be energy, gases, inorganic matter, water, organisms. Subsystems you have are plant, animals and microbes. And then the end outputs you have is energy, nutrients, gases and other inorganic matter. So the subsystem is something that can be simplified but it is actually a very complex system. Because the relationship between plants animals and microbes as we just saw in all these parts of the lecture is very complex and can be multilevel , multi functional as well as multi dependent. But we are going to study the earth as a one single system where the entire ecosystem is the earth as such. So again the solar energy is the most important. That is the focus of the input. Then you have the entire earth as the ecosystem which encompasses all living beings, inorganic beings, herbivores, carnivores, decomposers everything. And then the output is heat radiated back into space.

Moving onto the **functional aspects**. If you look at the main bio system, here you have photosynthesis, herbivory, carnivory and decomposition. So those are the functional aspects of the bio system.

Then you have the **energy flow within an ecosystem**. Photosynthesis and respiration is the most important energy flow processes within the energy system of the ecosystem. Input remains the same , solar energy and the exit energy is degraded waste energy which is usually absorbed by the soil.

Now moving onto **energy flow in any kind of ecosystem**. At any trophic level, there is 90% loss of energy. It could be any activity or respiration. Only 10 % of the energy is transferred and it's a one way flow. So you have nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, and phosphorous. They move in circular patterns. You have hydro logical cycles, nitrogen cycle, carbon cycle and phosphorous cycles.