Environmental Biotechnology
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Lecture – 12
Microbial Ecology and Environmental Biotechnology - Part B (Contd.,)

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Welcome to the next lecture on Microbial Ecology and Environmental Biotechnology and we are discussing about the environmental biotechnology the service role of microbial ecology. And in this particular lecture we are going to talk more about the how the science and the engineering or application sites of the environmental biotechnology is providing the idea of science pools and basically the technology which is pulling a science is pushing it.

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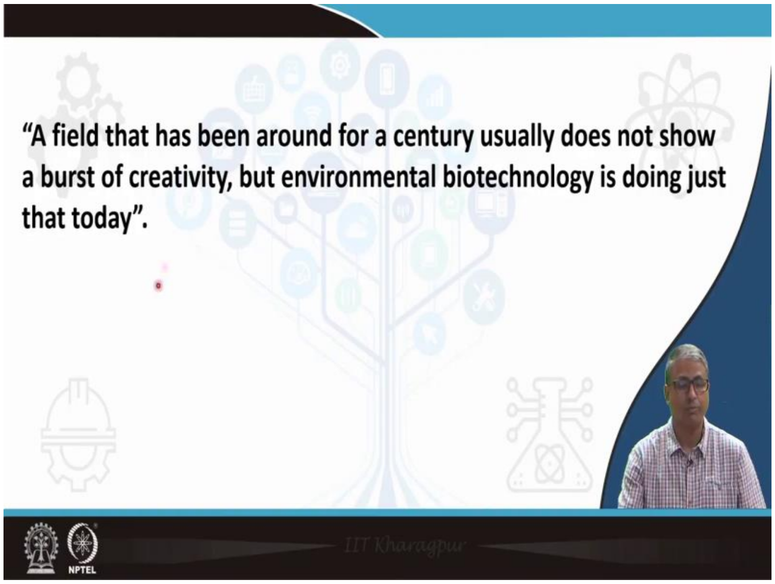

Now it is actually a field that has been around for a century the applications of these environmental biotechnology processes what we see but it does not show a burst of creativity. But environmental biotechnology is doing just that today.

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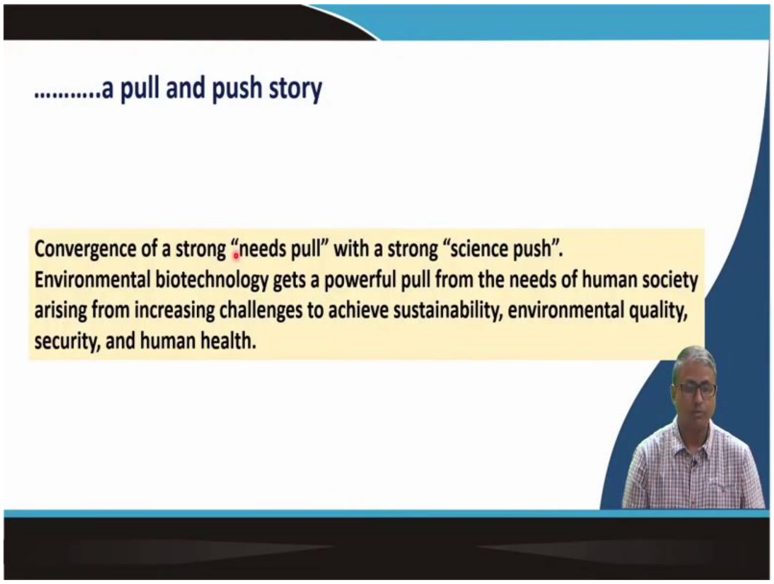

Now because it is a convergence of strong need pull and a strong science push and that is actually called a pull and a push story. N

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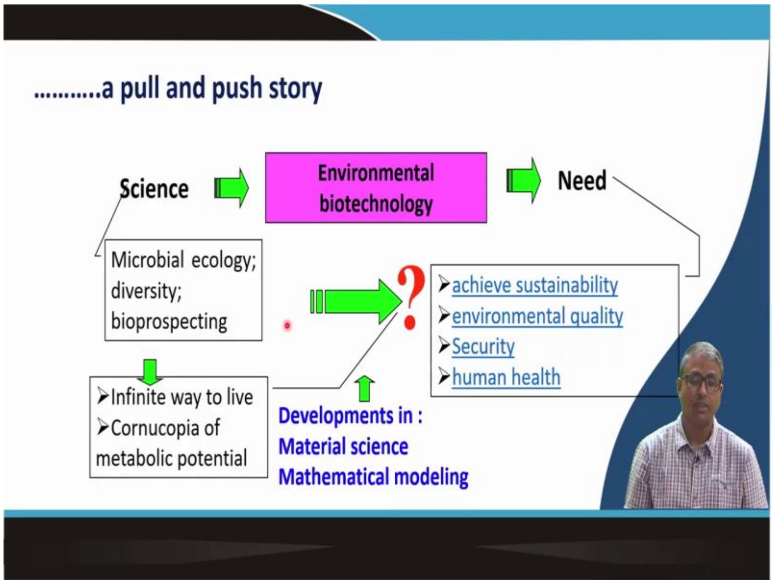

Now what actually happens that environmental biotechnology is tied up with two things on the one hand it is the need a number of requirements number of applications number of domains which are seeking help from environmental biotechnology. So, it is basically need based and on the other hand. The science is actually providing the inputs or rather we sometimes called it is the push that is that is getting from the science side.

And when we when look into the needs that which are which are being actually catered or provided by the environmental biotechnology these are can be very well categorized as to achieve the sustainability, environmental quality, security and also human health. And as we have already discussed that the science part of this is the microbial ecology which basically embodies the diversity and also the bio prospecting part.

Now as we try to link between these two that the science how this microbial ecology the science of microbial ecology is going to push the application aspects how it will help us to get the required things with respect to sustainability environmental quality security etcetera. So, that remains a big question that how are we going to get the required things required goals fulfilled from the basic understanding of microbial ecology.

So, one of the clues that we have is the natural microorganisms which are the basic part of the microbial communities living within any kind of natural ecosystem they have the infinite way to live. They have not only the infinite way of live they also have a huge diversity of their metabolic abilities which are encoded by their by their genomes. So, they are they are quite stable metabolic properties.

And with the course of evolution these properties are very well stabilized well controlled within the microbial systems. Now in recent time application of this knowledge of microbial ecology through the presence of diverse organisms or the diverse functions their metabolic abilities into the successful deployment towards achieving the goals of different environmental biotechnology applications.

This has been further supported by the developments in material science mathematical modelling and other aspects including the chemical engineering and chemical sciences physical sciences also.

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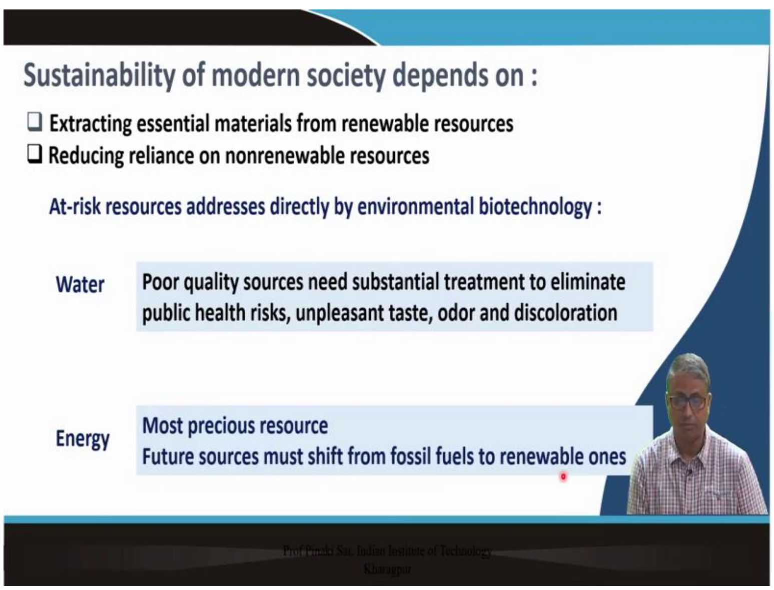

Sustainability of modern society depends on extracting the essential materials from renewable resources and also reducing the reliance on non renewable resources. Now at the top of the at risk resources which are addressed directly by environmental biotechnology are the water and energy. These are the two items or areas which are which requires maximum attention from the environmental biotechnology site.

So, with respect to water what we are observing that most of our water resources are contaminated particularly with respect to the portable water or the water which is suitable for human consumption. Now whether it is ground water or it is surface water our rivers our lakes and ponds and also the ground water are often contaminated it may be contaminated by different pesticides or different heavy metals like urine arsenic or sometimes with radionuclides also we have been reporting fluoride pollution in many parts of the globe we observed.

So, poor quality sources of water need substantial treatment before they are available for the public use to eliminate the public health risk, unpleasant taste, odour and discoloration it. And it is not only for public health risk it is also for the animal health and the plant health risk also. As has been observed with respect to particularly arsenic contaminated groundwater that the groundwater arsenic was is a problem.

But now the arsenic has moved into the crops the paddy crops and they are now migrating into the other parts of the food chains. So, addressing those type of issues or that type of issue will be one of the priority areas that is managing the quality of the water. How environmental biotechnology can work towards offering the best quality of water which is devoid of the pollutants or the void of the toxic compounds which are otherwise making the water of poor quality.

The next one is the energy with respect to energy it is the most precious resource and all the future resources must shift from fossil fuels to the renewable one. So, environmental biotechnology emphasizes that how best we can we can harness the energy in a renewable manner from and which will offer us to switch from fossil fuel based technologies towards this renewable yet very, very effective fuel sources.

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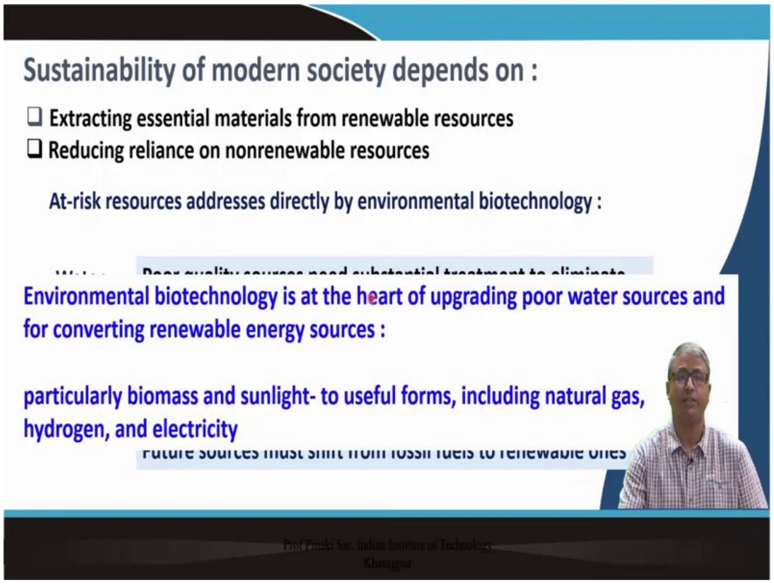

Now in this context environmental biotechnology is at the heart of upgrading the poor water sources through offering a number of treatment technologies and also converting the renewable energy sources particularly the biomass and sunlight to useful form including the natural gas hydrogen and electricity.

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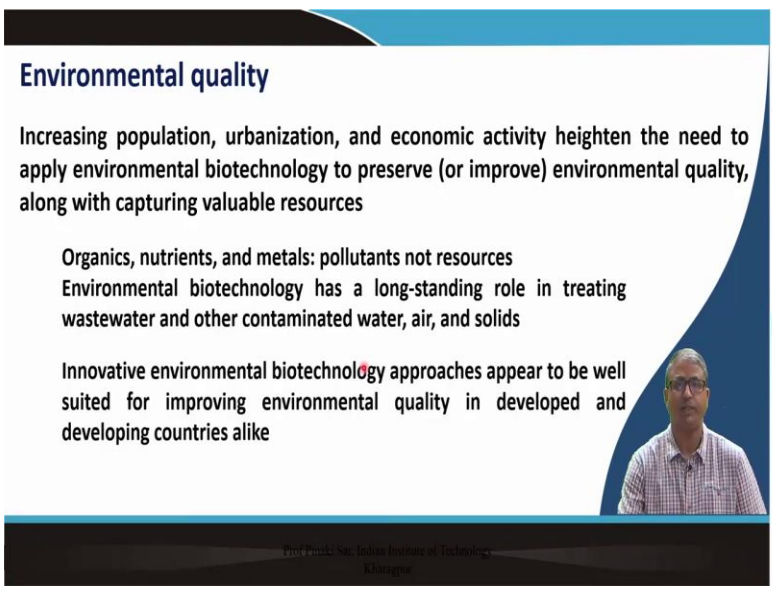

Now the next one is the environmental quality. So, after the top priority top ranked water and energy the next one is the environmental quality. Now increasing the increasing population urbanization economic activity heighten the need to apply environmental biotechnology to preserve or improve environmental quality along with capturing valuable resources. So, with all our activities more amount of pollution more widespread pollution more widespread contamination and deterioration of the environment is happening.

Now environmental biotechnology aims to control that combat that and restore the environment. At the same time restoring the environment and recovering the quality of the environment or maintaining the environmental quality it also aims to capture the valuable resources out of this. Particularly if we look at the contaminants or the pollutants which are often present in our environment like the organics different type of organic compounds nutrients like nitrate phosphates etcetera and metals including the heavy metals and radionuclides.

These are pollutants they are not resources but as we have we have learned that sometimes these organics and the nutrients can be utilized by microbial processes through environmental biotechnology systems into useful forms or resources. Like carbon can be converted to lipids or the polyphosphates bodies can be synthesized which will be of immense use. So, environmental biotechnology has a long standing role in treating the wastewater and other contaminated water air and solids.

Now these knowledge’s that the we have the knowledge base that the wastewater treatment technologies are already in place. Now how we improve that in order to like we have done with nutrient removal biological nutrient removal or microbially enhanced nutrient removal. Similarly technologies are being are being available made available. So, that these resources can be recovered as much as possible including the different pressures and other important metals for their reuse.

So, innovative environmental biotechnology approach our approaches appear to be well suited for improving the environment and quality in developed and developing countries alike.

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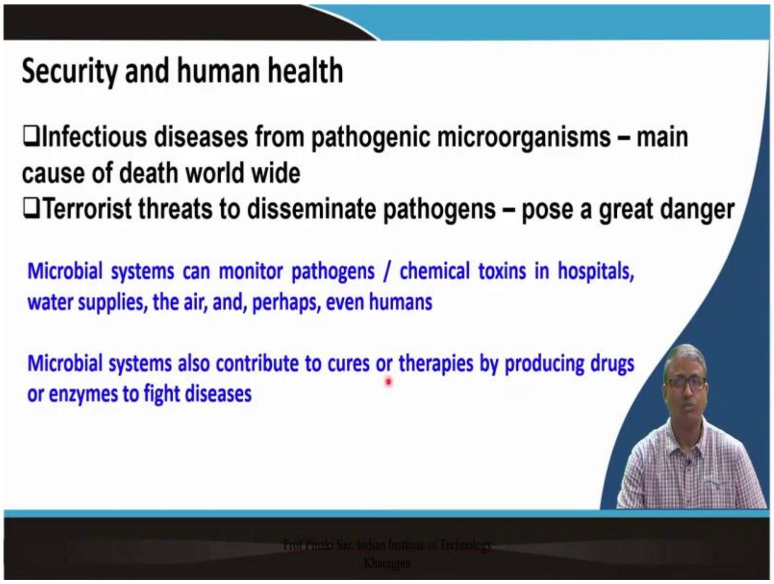

The third is security and human health. Infectious diseases from pathogenic microorganism are the main cause of death worldwide. Terrorist threats to disseminate pathogen also pose a great danger. Now microbial systems can monitor the pathogens as I have I have mentioning earlier through to different type of sensing devices. So, they can be used to sense pathogen monitor the presence of pathogen or even the chemical compounds chemical toxins in hospitals, water supplies, the airports premises and other public places and even within the human.

So, excellent monitoring and sensing devices are being developed based on microbial techniques. Microbial system can also contribute to cures or to offer therapies by providing drugs or enzymes or molecules to fight different diseases.

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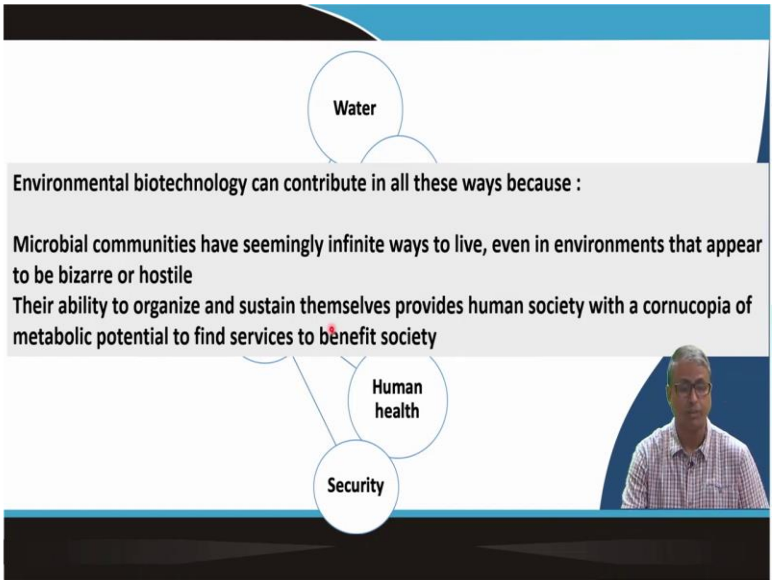

So, essentially the environmental biotechnology is not only restricted to its original idea of pollution abutment but it is directly connected to providing the or connected to the manage managing the water resources providing the energy or in the in the energy sector maintaining the environmental quality and as well as human health and security. So, environmental biotechnology can contribute in all these ways all the 5 points that that have been mentioned.

Because the microbial communities which are actually taken as a kind of a central part of all these processes whether it is a treatment of water or harnessing the energy or detecting the pathogens or other things. So, it is actually the microbial communities which are is the center piece and microbial communities are being explored or exploited for the achieving these goals.

So, because microbial communities have infinite ways of leave even in environment that appears to be very hostile very extreme they are capable of withstanding that. They can withstand the extreme desiccation, extreme other stresses including the ionizing radiation and also they are able to organize and sustain themselves which can provide the human society with a concopia of microbial potential or metabolic potential to find services to benefit society.

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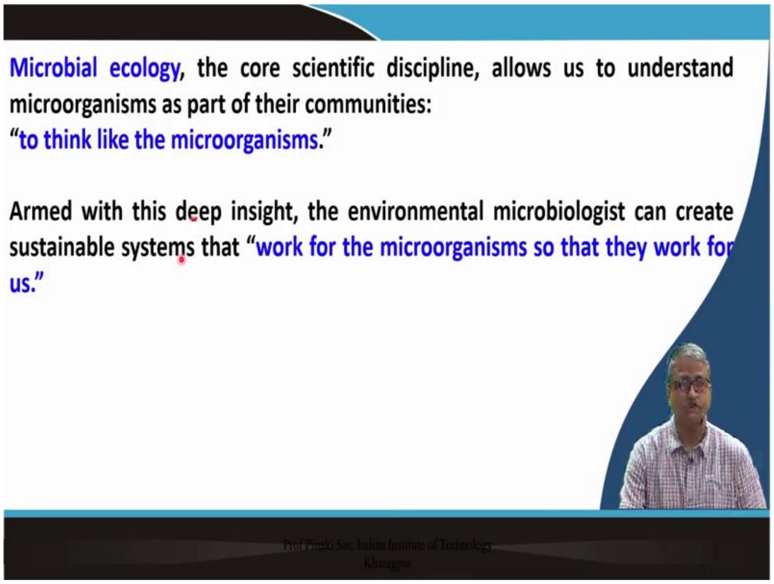

Now microbial ecology the core scientific discipline allows us to understand microorganism as part of their community. So, that is basically the science part where we have been trying to investigate and understand the microbial function and how they work. And basically in that aspect we try to highlight a point to think like the microorganisms that allows us to understand that how can we think like microorganisms because there are.

So, many species together it is very challenging it is very difficult to think like the microorganisms because we do not know always all the species present there and what are their metabolic abilities and how they can function within that. However if we can arm ourselves with that kind of deep insights the environmental microbiologist can create sustainable system that work for the microorganisms. So, that they work for us

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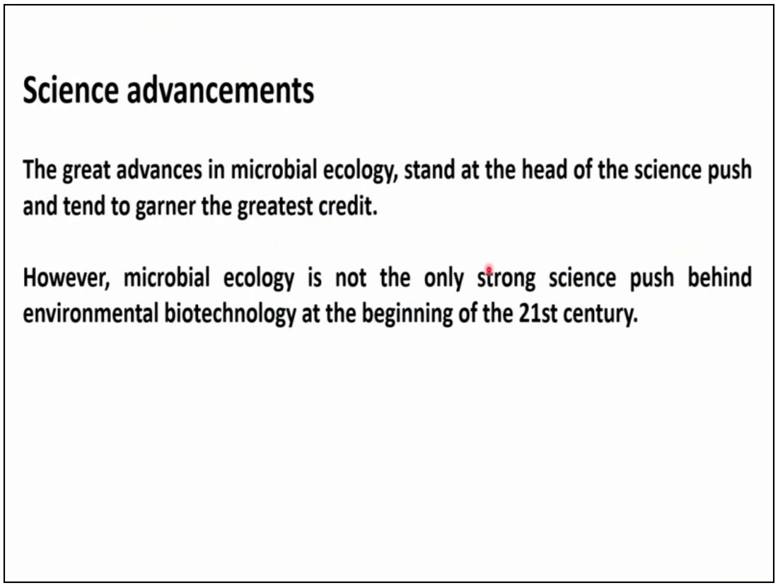

Now in continuation to this we have noticed a large number of scientific advancements. So, we know that one of the great at great advances in microbial ecology is always there and that actually stand at the head of the science push and tend to garner the greatest credit. However there are many other fields of sciences two particular aspects I am going to highlight over here.

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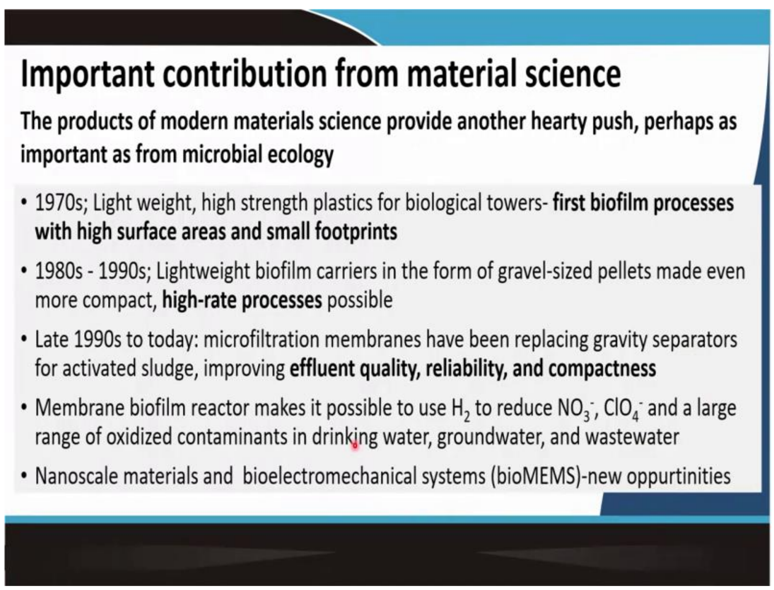

And the one of them is the advancement or the contribution made from the material sciences towards environmental biotechnology application. The products of the modern material science provide another hearty push towards achieving the goals of the environmental biotechnology perhaps as important as from microbial ecology. Microbial ecology has done outstanding advancement with respect to, it is the tools the method approaches and also its understanding.

But at the; same time when we try to apply these microorganisms in large scale structure large scale systems. We need to borrow or need to depend or need to rely on many things one of them is the material science. Because on which the microbes might be might be growing. So, as we know possibly that during 1970s light weight high strength plastics for biological towers where were developed and utilized and it is a kind of a fast biofilm processes with high surface areas and small fruit prints were available during 1980s to 1990s lightweight biofilm carrier in the form of gravel sized pellets.

So, small pellets made even more compact high rate processes are possible. During late 90's to till today we observed that micro filtration membrane have been replacing the gravity separator for activated sludge system, improving the fluid quality reliability and compactness. And in the recent time also we see that the membrane biofilm reactor makes it possible to use hydrogen to reduce nitrate or chlorate and a large range of oxidized contaminants in drinking water ground water and waste water.

And finally nano scale materials and bio electrochemical systems are offering us multiple new opportunities.

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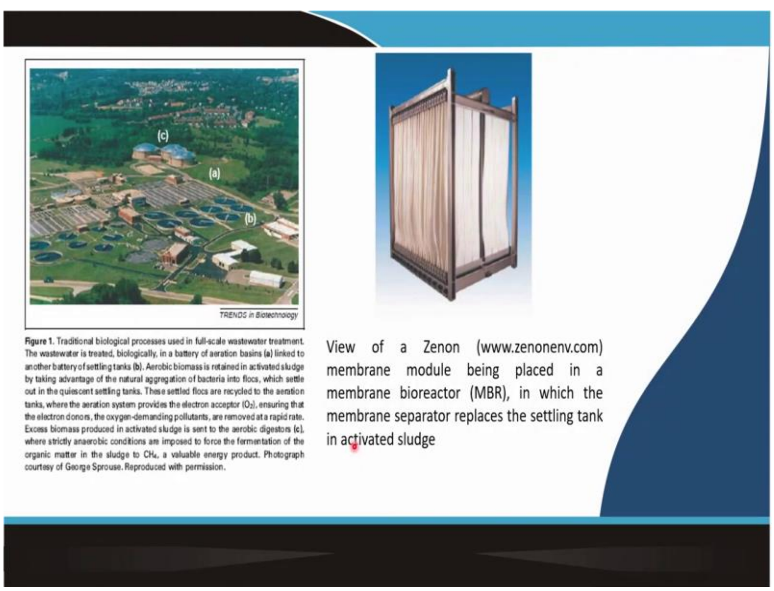

So, here we can see that two photographs. So, one on the left is a basically a traditional biological processes used in the full scale wastewater treatment. You can see that there are multiple setups as we have been discussing on them that the aeration tank settling tank and anaerobic digester. But on the right panel we have the view of a particular membrane module being placed in a membrane bioreactor that is called MBR in which the membrane separator places the settling tank and also in activated sludge.

So, the entire process of waste water treatment or that is a significant part of the waste water treatment can be accommodated within this kind of membrane bioreactors.

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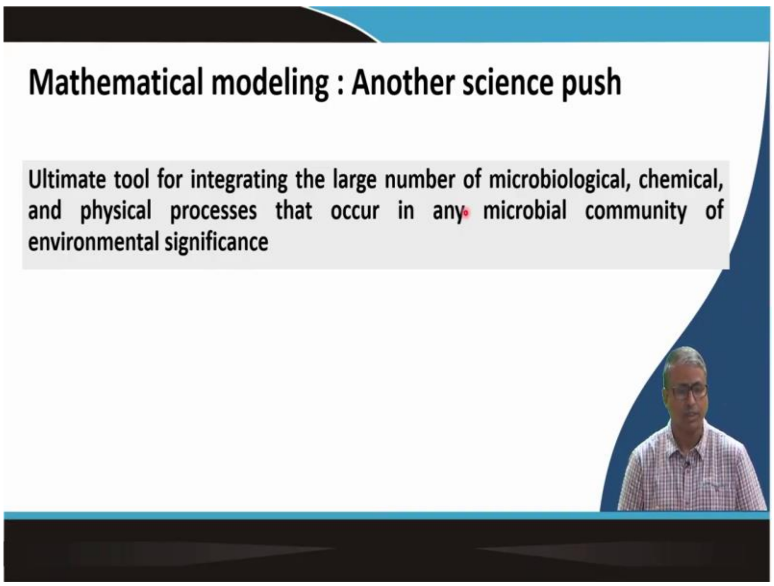

And there are many more examples in within this within this material science contribution in environmental biotechnology. The next science push is from the mathematical modeling. Now ultimate tool for integrating the large number of microbiological chemical and physical processes that occur in any microbial community of environmental significance rely on mathematical modeling. Because we are working with as I said large number of microorganisms are there they are working together.

We have the contaminants and along with the contaminants different nutrients and other parameters and there are physical processes. So, how they all interact and control the process in order to understand that mathematical modeling has come into a big way.

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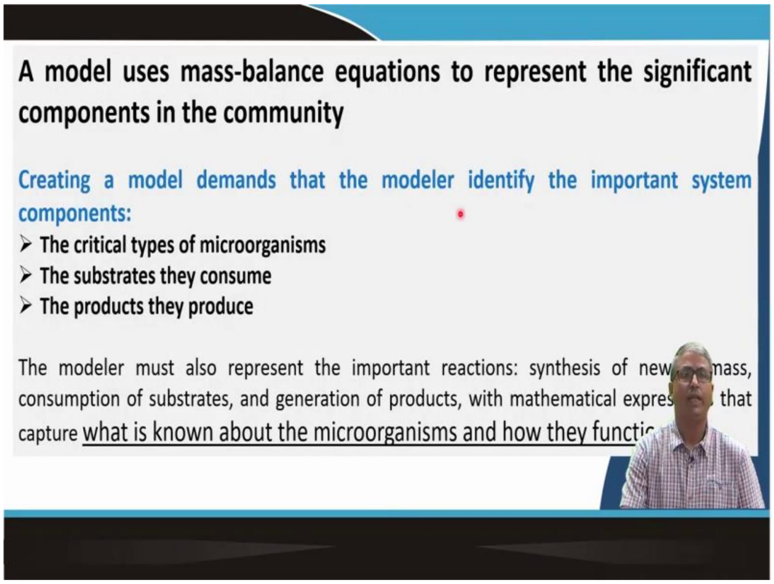

Now a model uses mass balance equations to represent the significant components in the community and these processes are significantly well defined. However creating a model demands that the modeler identify the important system components which include the critical type of microorganisms critical in the sense for a given process for example we are trying to convert carbon dioxide into lipid using a microbial community.

So, or we are trying to produce electricity within a wastewater treatment is the system using microorganisms. So, what are the critical type of microorganisms involved in either converting the carbon dioxide into lipid molecule or transferring the electrons so, that the energy or the electricity can be generated from the carbon compound or the electron donor. The substrates that they consume the products they produce.

So, these are all to be determined experimentally and for that we need advanced analytical methods and advanced tools of the molecular microbial ecology because the types of microorganisms can only be determined to the best possible extent when we use the advanced molecular tools. So, a modeler who is developing a model or try to develop a model for a particular environmental system where microbial communities are involved they need to understand that the critical types of microorganisms need to be identified.

Now the next is the point that they also represent the important reactions like synthesis of new biomass these are the category of reactions synthesis of new biomass consumption of the substrate and the generation of the products these are also happening. So, the modeler must also represent these components. So, modeler can modeler should identify the parameters like the type of microorganism rather the critical type of microorganism the substrate they consume the product they produce but also the kind of reactions happening within the system.

And then that would actually help us to capture what is known about the microorganisms and how they function with respect to a particular system which is expected to be incorporated for or utilized for environmental biotechnology application.

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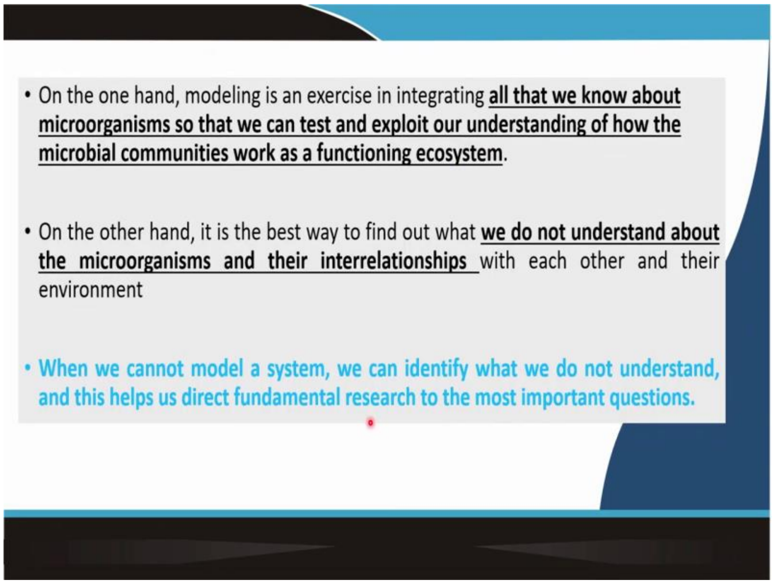

So, on the one hand modeling or mathematical modeling rather is an exercise in integrating all that we know about microorganisms. So, that we can test and exploit our understanding of how the microbial communities work as a functioning ecosystem. So, be it a wastewater treatment or a biological nutrient removal system or generating energy out of a system. So, modelling process is an exercise where we integrate all the components that we know.

Like identifying the microorganism identifying the substrate they use identifying the electron donor they use identifying the electron acceptor they use and also the kind of reactions they undergo. However on the other hand it is the best way to find out what we do not understand about the microorganisms and their inter relationship. Because modeling is done based on the information or inputs that we provide.

But it also provides us the opportunity to identify or understand that what we perhaps do not know about the microorganism particularly the relationship between one organism to the other and with one group organism or the group of organism to its surrounding physical or chemical environment. And finally when we cannot model a system we can identify what we do not understand and this helps us direct fundamental research to most important questions.

This is one of the main message out of this entire mathematical modeling concept that often we are able to model something but when we say that in a practical situation that we are unable to the model and predict the performance of the entire system.

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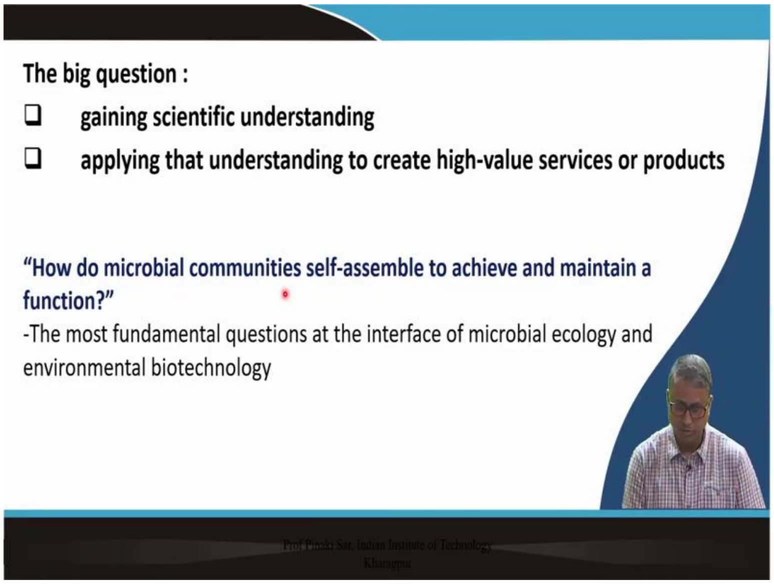

So, the most fundamental question appears. Now whether the goal is gaining a scientific understanding about the microbial process they are the mass balance their mathematical modeling parameter etcetera or applying that understanding to create a high value service or products the most fundamental questions are at the interface of microbial ecology and environmental biotechnology particularly when we think about that exploiting the microbial resources for environmental services this part remains a big question with a big question mark.

Now the big question is about the gaining scientific understanding and also applying that understanding to create the high value services or product with this respect the most fundamental question at the interface of the microbial ecology and environmental biotechnology remains how do microbial communities self assemble to achieve and maintain a function. So, no matter whether we are applying microbial ecology tools to understand them or we are using materials to to grow and to effectively utilize their potential their metabolic function.

Or we are using different mathematical models to understand and then predict their function. With all our efforts we need to answer this fundamental question that how do microbial communities self assembled to achieve and maintain a function within a given environmental biotechnology context.

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So, for this part of my lecture the following references are to be used. The microbial ecology to manage processes in environmental biotechnology by Bruce Rietman and A Vista for Microbial Ecology and Environmental Biotechnology.

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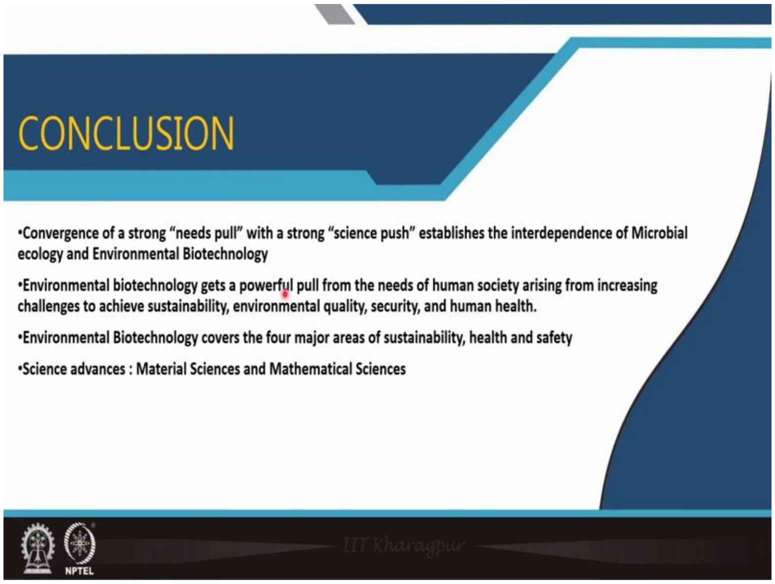

In conclusion convergence of a strong needs pool with a strong science boost establishes the interdependence of microbial ecology and environmental biotechnology. Environmental biotechnology gets a powerful pull from the needs of human society arising from increasing challenges to achieve sustainability, environmental quality, security and human health environmental biotechnology covers the four major areas of sustainability health and safety.

And it is basically the scientific advances which are being continuously made not only on microbial ecology side but also from the material science and mathematical sciences those are also discussed, thank you.