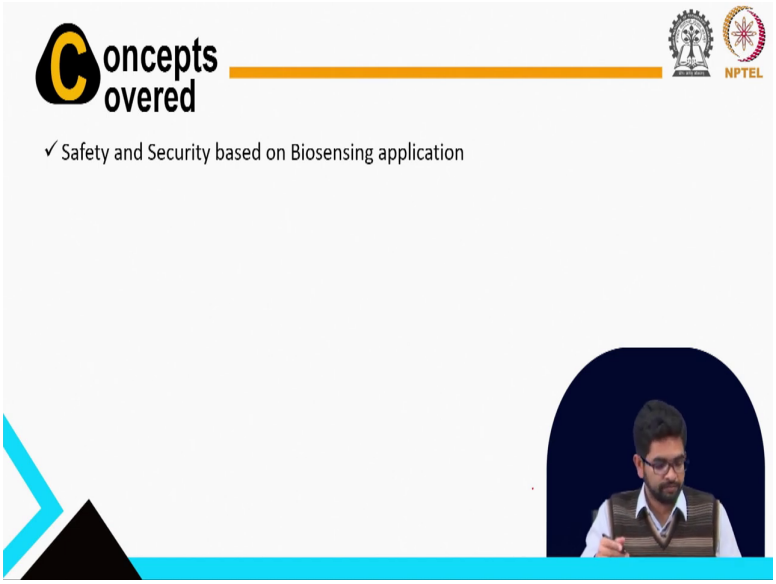
Nanobio Technology Enabled Point-of-Care Devices
Prof. Gorachand Dutta
School of Medical Science and Technology
Indian Institute of Technology, Kharagpur

Lecture - 32
Biosensors for Safety and Security

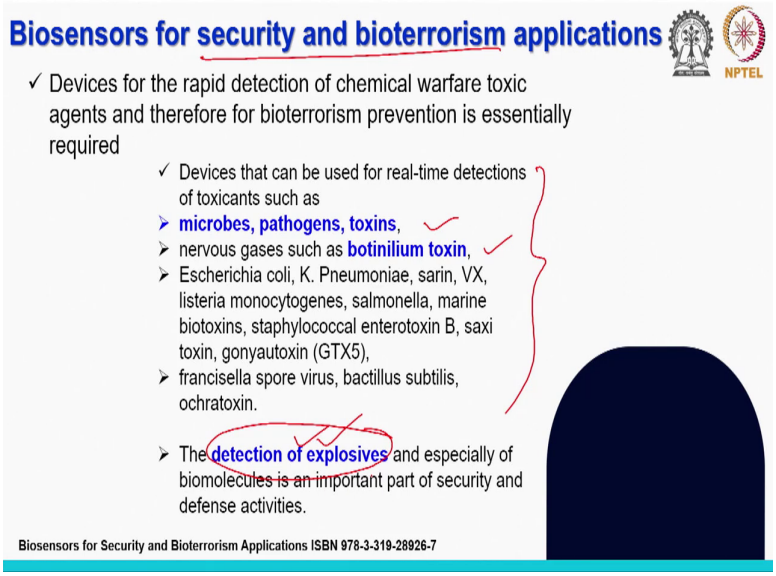
Dear students, today, I will teach you the biosensor in some different way. You see today's topic is the Biosensor for Safety and Security so, some other applications. So, now, we are very close to completions of this slavers of our subject. That is why today, I plan to show you the different application, means some other applications, not only all of the disease, some other applications for biosensor, let us see.

(Refer Slide Time: 00:57)



So, main things I will discuss today, our main concept that will I will cover is the safety and the security based on the biosensing applications. So, where we can apply the biosensing applications, not only this disease diagnosis, there is so many other application, those topic let us cover it.

(Refer Slide Time: 01:19)



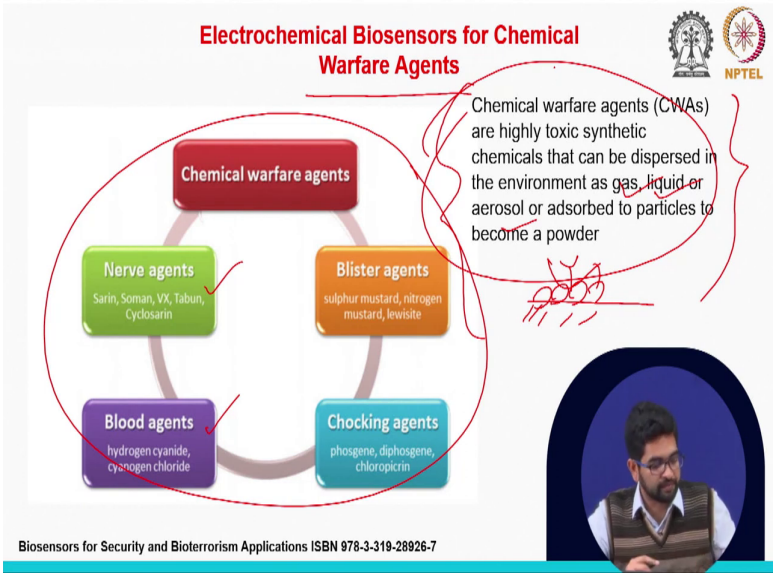
See, lots of details I already I have written in my slides, but just I want to summarize and I want to show you some a basic concept, a story where we can apply the biosensor hm. So, it can be the security and the bioterrorism applications. So, you may ask what is this? Actually, we can develop some biosensors device that can be equally useful for chemical warfare, toxic agents and therefore, the bioterrorism prevention.

See, the biosensing device that can be real time that can be useful for toxicants such as microbes, pathogen, different toxins. Also, you know, specially in the war field, we may need

this kind of sensor that can help you for preventions, for like the nervous gases, different kind of nervous gas such as means botinilium toxin, or maybe different toxins such as Escherichia coli. Those agents we can detect.

So, the main things that I think I wrote the story, you please go through this story that it can be useful different kind of the toxins that we may want to detect, during the security and a bioterrorism purpose. See, the detections of the explosives is another things and especially for the biomolecules is an important part for the security that you can detect, the different kind of explosives, ok.

(Refer Slide Time: 03:20)



So, the biosensor for the security for bioterrorism, now you understands right. So, why we need? This is really really importants. Let us show you a overview. Like electrochemical biosensor, it can be used for chemical warfare agents. You can see this full story like

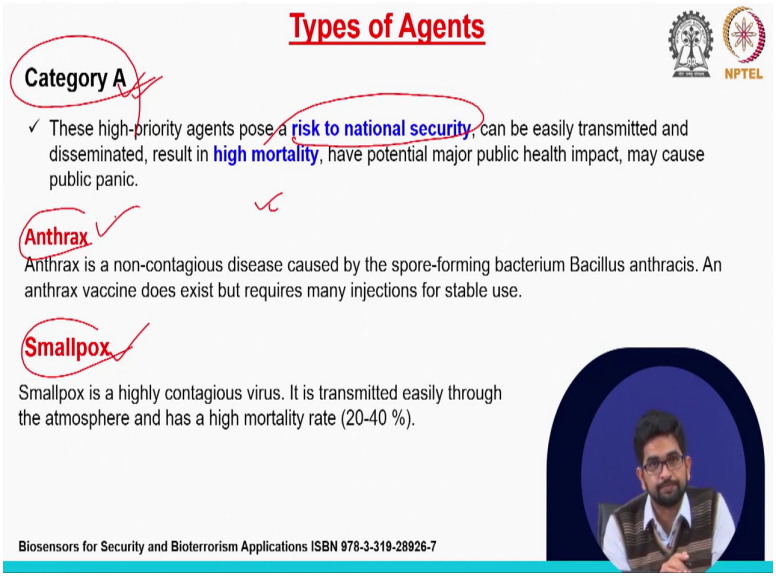
chemical warfare agents, then, I mean, the different kinds of nerve gases, blood agents like hydrogen cyanide, cyanogen chloride.

So, really need kind of some protections, ones for to know if there is this kind of agents presents or not that we definitely we should have the information's. For that, we can use some sensing device. If you see this right, see this one, you can see the chemical warfare agents are highly toxic, even the synthetic chemicals that can be dispersed in the environment as the gas, as the liquid or the aerosol.

So, it can be very much, you can say means dangerous and the war fields also. So, we should have the some biosening device. See, I already taught you the main basic mechanism. Today, I just wanted to show you the basic analyte. Like, this is the scope, I am telling you, this is the scope. Here, you can apply the biosensor technology right. The how you can develop?

Now, you can (Refer Time: 04:32) how we can develop this detections, like all the toxin agent, how we can detect? I mean, that is story you know, like just a simple sensor and like you can use some very specific nano particle that can be useful for the that is very specific toxin detections that or maybe some specific bio receptor, it can be aptamer, it can be DNA, it can be RNA, something like this. So, that story you know, but you should know the area of your interest. So, this is the one of the basic area of the interest for the biosensor.

(Refer Slide Time: 05:09)



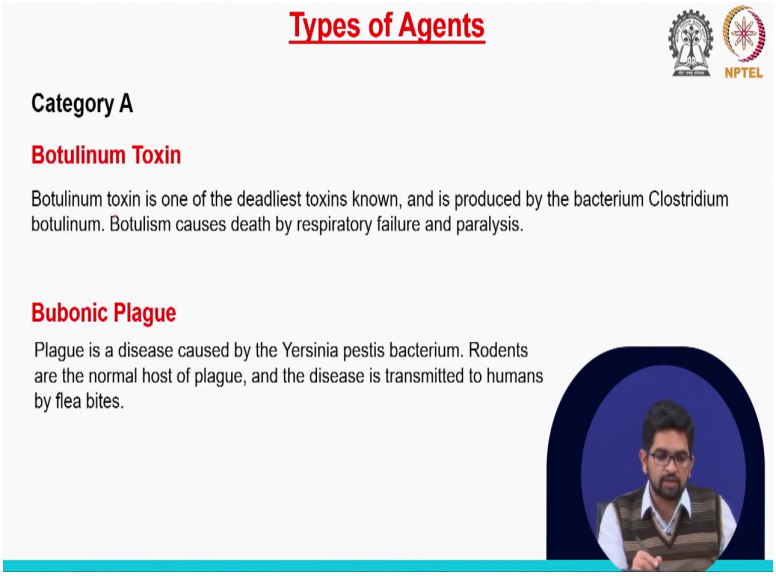
So, let us show you the story here. So, first story is the types of the agent. So, you should know like different category of these toxins present and they are very much harmful and based on their toxicity, we can categorize them A, B like this way. See, we categorize first the category A toxins, their high mortality rate they have and the risk of their highly risky, means high priority agents that was the risk of national security.

So, we should have focus this kind of toxin agent for biosensor development that I am going to tell you here kind of the anthrax smallpox, this kind of the type category A toxins, you should detect maybe you can develop some biosensors. The all the concept is same.

So, after few class also, after this class, may be as we are very close to the completions of this course, I mean I will take one more tutorial there I may ask you design kind of smallpox detections right, but you know already. But just I today I am just showing you like anthrax

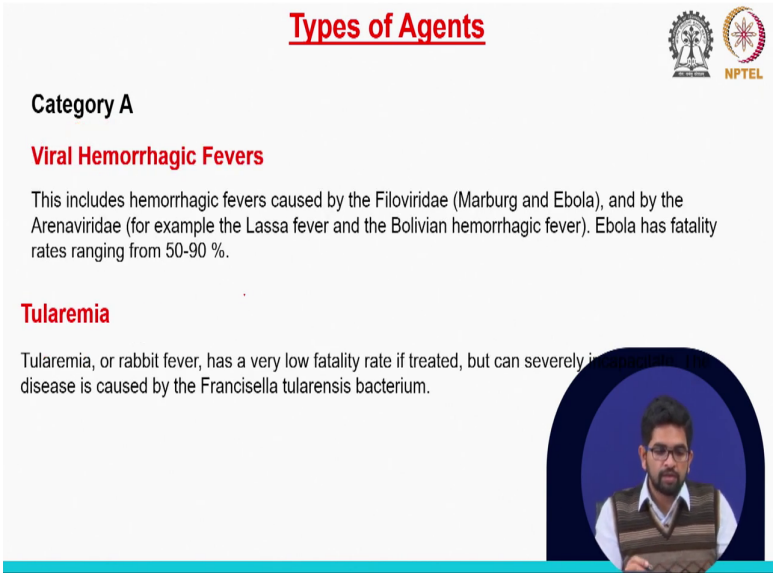
smallpox this kind of the category A agents that we can detect based on our biosensing technology, clear.

(Refer Slide Time: 06:30)



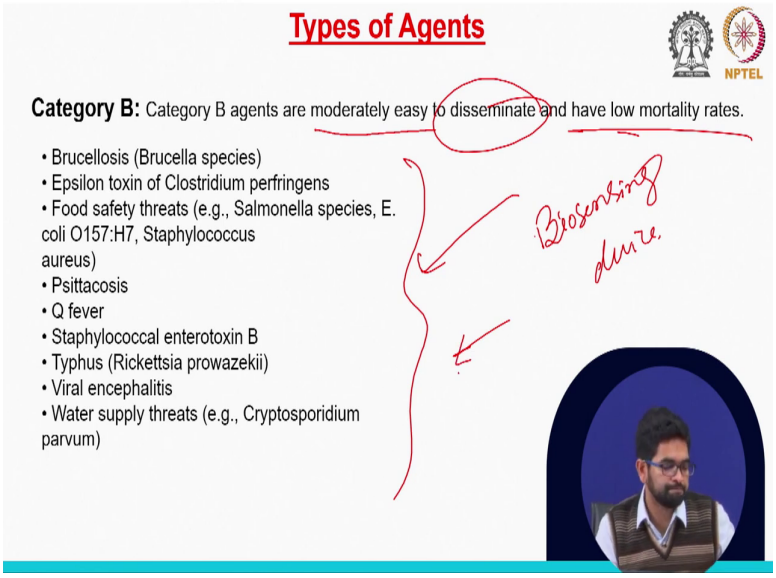
Now, come the another toxin that I told you like botulinum toxins and the bubonic plague. So, this kind of toxins also you can try to develop a sensing device ok.

(Refer Slide Time: 06:46)



Now, another some example like viral, some kind of agents like hemorrhagic fever that also can be detected. And so, there is lots of example of the category A.

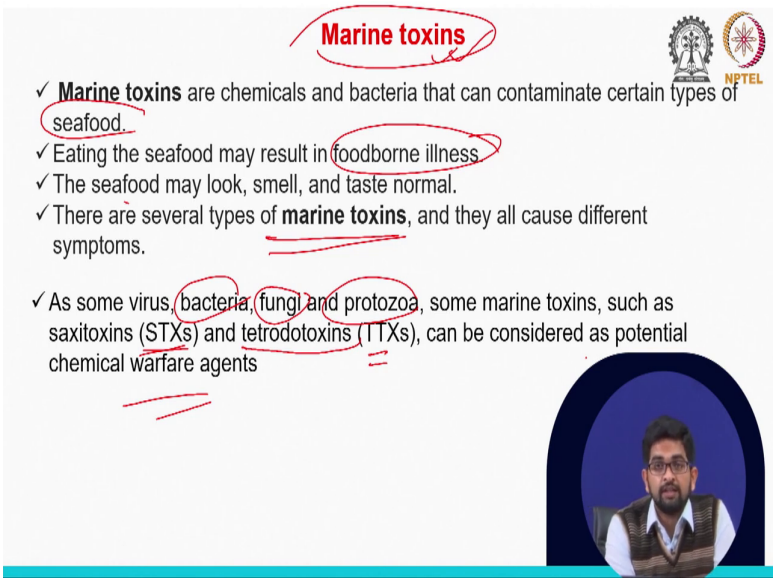
(Refer Slide Time: 07:08)



Now, let us come the category B. So, category B as they are moderately easy to disseminate and have the low mortality rate, but still, you should have the some information's where you can detect them if it is present. So, they are the kind of category B ok.

So, they are moderately and they are easy to, they are they can easily disseminate. It can spread or among the ourselves and it can be something dangerous also. So, for that also you can focus your biosensing device. So, your biosensing device you can develop here. This is the another scope you have.

(Refer Slide Time: 07:48)



Now, I am going to tell you some marine toxins I think from the name you can understands right, because or many areas not all about the world where highly depend on the seafood, we like seafoods also. So, eating the seafood may result in the different kind of foodborne illness. So, there also some scope right.

So, now see there is vast area you can think about to develop in the sensing device, one is the marine toxin, what kind of marine toxin? The seafood may they look the good, they smell good, taste good, they are very delicious you may feel bud, they may be contaminant right.

So, therefore, the several types of marine toxins and what is kind of the I mean the problem can cause in the health that also you may think. So, here I just mentioned some different kind

of the some name you may think about more in this area. So, some viruses, bacteria, fungi, protozoa.

So, this kind of some toxin when some analyte you can detect for the marine as for the marine toxins. So, the I have to mention this as saxitoxins or tetrodotoxins. So, this kind of toxin can be considered as the potential chemical warfare agents. So, those you can detect or try to develop some sensor.

(Refer Slide Time: 09:12)

So, that is done for the agents or different kind of warfare agents or different kind of marine toxin agents that you can focus ok that is one part finished today. Now, let us come to the another area. So, today I just mainly want to focus on different different areas where you can focus your biosensing technology not only for this is mainly we are very much familiar, right.

Today again you can see this slide this slide. I am going to show again some something not as usual, but something you should think development biosensing device based on like soil detection that is called soil on a chip. Say our soil we are I mean your plantations that is you are doing a soil that can be contaminant right.

We are using fertilizer we are using pesticide many chemicals we are using, but those chemicals can contaminant your soil and your drinking water also can be contaminant from the soil. Because there a during the rain. So, this means rain water can go through the soil different kind of pesticides, different kind of all the chemicals can dissolve and to come to the ponds, river and we are drinking those water right.

So, there that is why detection those analyte in the soil or in the drinking water it is equally important to make ourselves healthy right. So, whatever we are drinking we are taking food where we are cultivating. So, those places are safe for us or not right. This is a good scope for some development sensing device that is why I am saying here soil on a chip means we can detect the soil health.

This is see this is indirectly we are actually means we are checking our also health conditions because we are cultivating our foods everything on soil and if soil health good then only you also will get the better production from the soil right. See we can develop some chip that is means including the micro fluidics in you can see the integrations of the microfluidics there can be some you see here maybe you can inject some sample.

What kind of sample you can inject maybe some extract from the soil or maybe drinking water that you can inject or maybe you can extract from the plant and then this all the things come maybe there you can here maybe you can incorporate your sensor your biosensor maybe here.

Now, let us detect your sample how you will detect those technique you already know I will discuss little bit. So, I am saying that there is a scope for soil health determinations it is equally important. See, nitrate why I am saying the nitrate always because nitrate fertilizers

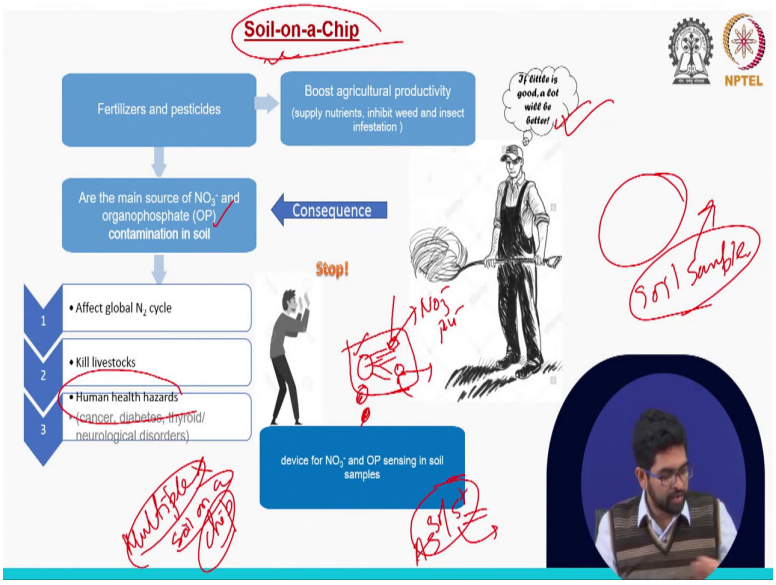
are very much important for plants the nutritions the plants they are getting main thing is the nitrate based fertilizers.

But is it good if we apply large amount of the nitrate fertilizers right, they can means plants they are getting the nutrients from this fertilizer. But if they are too much see may be it is a not I mean it is unused conditions. So, those nitrate can come to the your drinking water and it can contaminant your drinking water then there is a lots of health hazards may health problem happened because of this nitrate.

That means you know pesticide we are using different pesticide to get the very good productions for your fertilizer for your like your crops productions, but these fertilizers kind of the chemicals different chemicals right. So, you have to use in proper ratio not in a too much level.

So, we have to understands the level of the means fertilizers level of the pesticides inside the soil. So, that they should not contaminant in the drinking water or you should not enter in anyway indirectly its come to the our inside body and they can then we are we may face different issues even health problem.

(Refer Slide Time: 13:42)



So, let us show you one soil on a chip very basic concept right now like fertilizer and the pesticide right. So, then what our concept to boost our agriculture productions we are using like we are supply different nutrients different fertilizers. So, some time we are thinking if little amount you are adding to in the soil may be I getting very good productions let us add more then we will get the more production right that is we are thinking.

But no there can be some problem like this kind of nitrate organophosphate they can affect our whole global nitrogen cycle they can kill the livestock's that I told you know it can come to the rivers and also human health hazards possible like different kind of cancer, diabetes, thyroid problem, neurological disorder it may happen because of this because of this you are thinking that let us use more and more nitrate fertilizers may be you may get the better productions.

So, we will have to stop how we can stop them? No, we you should not we have to I mean give some awareness to the farmer this kind of awareness will be create what awareness means you can develop a device then like maybe you may have one nitrate another one is the pesticide or different kind of other analyte you can that you want to detect and those that can the have the human health hazards those you want to detect from the soil right. So, all the nitrate, phosphate, different pesticides.

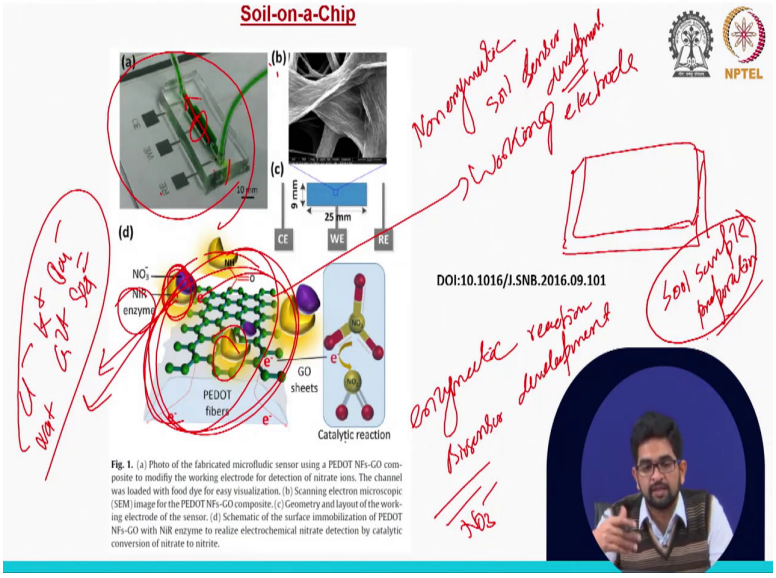
So, different different channel we can make we can make it sensor chip lab on a chip that we are saying the soil on a chip. Now, let us collect your soil sample ok. So, you should know the information's means how you have to collect the soil sample this is there is a story even how to collect.

The soil sample you have to go in I mean inside the productions area I mean here the field you have to go for certain depth or the field and collect some soil and then you can dissolve this soil and make some extractions and those extraction extracted sample you can put here on a chip.

Then detect here nitrate one or maybe here some phosphate or some others all analyte like you may need to detect also the arsenic right there is arsenic 3 plus arsenic 5 plus you may need to detect because that is also very bad contaminant for the soil right. Why? Because from the soil maybe (Refer Time: 16:34) this is anyway this is not coming from the fertilizer that I am showing the your soil may have the arsenic also in our India many places arsenic contamination is really really very very badly affected.

So, you may need to detect this arsenic also. So, you can make a soil on a chip that is why like this is kind of multiplex soil on a chip. So, what will help this one multiplex soil on a chip? It can help to detect at the same time all this analyte together so, that you can detect.

(Refer Slide Time: 17:12)



Let us show you some one soil on a chip some basic biosensing mechanism see as I mentioned that you can fabricate first your biosensor chip biosensor means this is the working area right this is working electrode means you are making a right.

You can see here this is a some chip here your working electrode different counter electrode and this is just kind of you can inject in the sample and then it will pass through the working area and your working electrode may content this means fabrication steps you have to follow right.

This is just for example; you know the basic concept that I have taught you may be they are using like Pedot or graphene oxide kind of some fabrication on the surface on that surface they immobilize the enzyme or nitrate detection this is nitrate this is the reductase on enzyme.

So, this reductase enzyme will help specifically to detect the nitrate, ok. So, this is although you may think the enzymatic reaction this is enzymatic biosensor, I mean enzymatic reaction for biosensor development. What biosensor this is for nitrate detections. So, how means just like as I told you know glucose oxidase case it will it can oxidize the glucose and selectively you can detect the glucose something like this.

Now, here we are detecting the nitrate based on this nitrogen reductase enzyme and the very important things that this enzyme is very very specific specifically if I detect the nitrate maybe your soil sample may have the so many other contaminant. See as I said told you that like our real blood samples it may contain so many different species at the same time your soil sample also contain so many different species not only nitrate it may contain like others ion phosphate they may interfere your sensing strategy sensitivity, right.

So, your specificity can be hamper. So, your detection scheme should be such a way. So, that it should detect only the nitrate not other anion. So, you have to check interference separate in the soil samples also see as like I taught you for the serum sample right different interference species present.

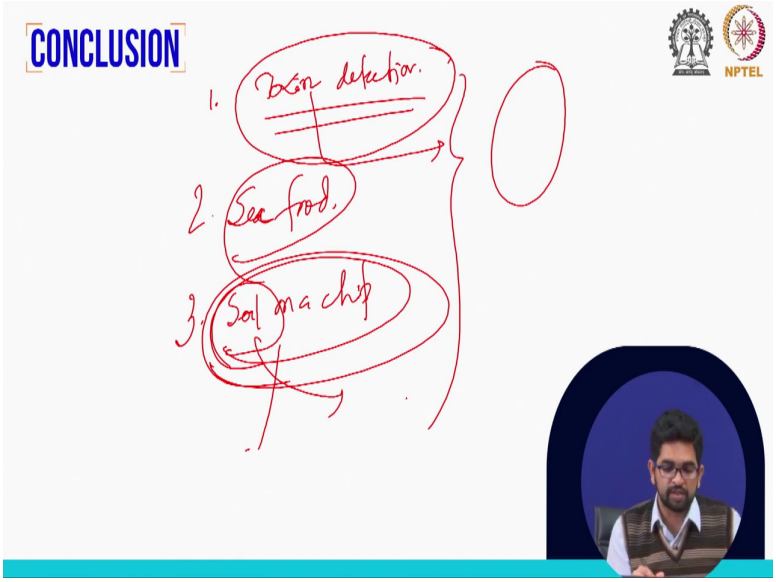
So, what the interference species can be in the in a soil? So, in this case chloride right it make want a different kind of chloride ion like sodium ion, like potassium ion, calcium ion and phosphate, sulfate. So, this all kinds of different kind of ion can be there that is why we will check for the soil on a chip kind of sensor and you are going to develop this kind of sensor.

So, you will be very much careful about the interference effect inside the soil sample ok. So, this is just a concept for soil on a chip that you can develop for the like a soil health monitoring. Just think I am saying this one for on-spot detection maybe you have to think.

This kind of device definitely you can use on-spot, but this sensor made by the enzyme you may think some non-enzymatic now this is another scope non-enzymatic soil detection soil sensor development right this is another scope like this way we can plan. Also, this kind of sensor you have to apply on-spot.

So, you should have the proper information's like how you can make your soil sample. That soil sample preparation is one of the main job for this soil on a chip you have to provide this information to the farmer. So, this is kind of the awareness you are creating for the farmer. So, that before using too much fertilizer on soil they may test the soil and they can check if there is enough nitrate already present then no need to add the more and more nitrate fertilizer something like this.

(Refer Slide Time: 21:50)



So, as for the basic all the things now I want to conclude here let us summarize on by one. See today I just taught you different different applications for the biosensor not for the hail some other application right. So, first is the bioterrorism or for like in the warfare some different toxins right different toxin detection. Let us summarize.

So, why it is really needed toxin detections because like different kind of terrorism and like different kind of terrorist attack different cases. So, you already heard about the bioterrorism right. So, it is very much dangerous different kind of also different kind of cyanide gas they also can affect our like whole population.

So, that is why this kind of development also can help our security or national security make our or necessarily more stronger ok. So, that you have the think how we can develop the different kind of sensor that can help to detect different kind of the this kind of the bioterrorism means this bioterrorism cases that all the toxin names I already told you.

Sometimes like high (Refer Time: 23:00) also can be spread all over the populations during the terrorism attack the virus also can effect like you may think that COVID also can be spread easily or some sometime like it can affect the whole population. So, you should have the proper solutions if suddenly outbreak there how you can detect this kind of viruses bacteria, protozoa. So, those you have to think.

2nd I just told you different kind of main toxins because you know the seafood, seafood were highly dependent we like the seafood, but this seafood also can be affected different kind of toxin. So, those toxins maybe you can detect and you can think about before taking those four.

Number 3 then I taught the soil on a chip. So, why I said this application for the biosensor because not only our mean not only the direct your means monitoring for your human health indirectly also our soil also can affect on your on our body right. There are so many problems may happen as I told this nitrate can affect like many way right different kind of like nerve systems can be affected.

So, those kind of nitrate (Refer Time: 24:38) different kind of chemicals may come to our human body from this soil from this water. So, we should have; that means, proper detections before drinking may be you can have the proper information should I drink or before

cultivations in a on your field area maybe you should have the proper information should I cultivate across there. I mean do I need more fertilizers more pesticides something like this.

But if some of the large area is affecting because of the and by some other some formers they do not know right means unknowingly they may be actually contaminating our water system that also you should have the proper information that is why determinations of soil health is really really important.

So, this kind of concepts I just taught you today just try to think if you can develop this kind of device, it will be also equally important for the society, ok. That is all for this today's lecture.

Thank you, thank you very much.