Water Quality Management Practices

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Lecture - 03

Emerging Concerns in Wastewater Treatment in Global Scenario

Hello everyone, welcome to this NPTEL online certification course on Water Quality Management Practices. My name is Gourav Dhar Bhowmick. I am from the Department of Agriculture and Food Engineering of Indian Institute of Technology, Kharagpur. In this particular lecture continuing to the introductory module that we are doing it for this course, I will be majorly discussing about the emerging concerns in the wastewater treatment in the global scenario. The major content will be to highlight the emerging concerns to be precise the emerging contaminants, I will be discussing about that in detail. What are the WHO recommendations? What are the major sources of this emerging contaminants? And what are the effects environmental effects of this emerging contaminants specifically focusing on PPCVs you know the full form of it majorly the pharmaceuticals and the personal care products PPCV pharmaceuticals and the personal care products and the antibiotics are the major environmental concern and the emerging contaminants that we will be discussing in details.

Other than the emerging technologies that is to be incorporated in the wastewater treatment to facilitate the you know emerging contaminant removal from the system. Considering the highlighting the emerging concerns in the wastewater treatment in global scenario to start with as I was discussing that in the last lecture if you remember we were discussing about the different type of pollutants present in the wastewater that we normally has to deal with right. Like you know majorly during using the treatment plant or any decentralized or centralized treatment units by which we can actually deal those pollutants. Recently for last couple of years and say like in a for a decade now scientists are really puzzled with the number of pollutant that number of type of pollutants that is increasing in the system.

And this different types of new pollutants this emerging pollutants or the contaminants that we call are of major concern because it requires us completely separate analysis procedure for us to understand the the the the vanity of the situation that how much of its concentration is actually severe for human health or say animal health or say for the

ecosystem. And the same times the detection procedure is tough and has to be developed day to day basis at the same times the procedures or the technologies that is actually perfect or the optimum for reducing those contaminants from the wastewater treatment line is also something new something being researched daily basis now a for the last couple of years. And all over world people are working on this emerging contaminant removal and because of its adverse effects and the the the problems that is associated with it. Majorly if you see those emerging contaminants what are they? They are nothing, but the pharmaceutical products majorly. You know the India being the one of the pharmaceutical hub of this world and surprisingly however, other than India another continent like I mean like India being in the south eastern part of this Asian continent and also the north is North America as a continent is one of the major producer of the pharmaceutical waste in this world.

Other than that this personal care products is also being nowadays blooming like anything because people started using it in a daily basis and it is the the percent number is very high I will discuss about all these things like how what is the number game in this case and the country basis or the continent basis. Other than that this some persistent and mobile chemicals or PMCs in in short we call it are also causing a huge harm to the ecosystem by actually entering to our food chain by entering to our human body through this food chain and its cause unless until we will actually focus on the development of new technology and modification or the retrofitting the existing technology in order to eliminate those PPCPs or PCMs the future is very heinous and we have to really work on it and that is the major focus of our lecture today to discuss about the what are the different type of PPCPs and the PCMs that needs to be you know focus that need that should be a research focus for hours and scientist all around the world and what are the technologies those are available to eliminate it. So, how this PPCPs and PMCs are actually causing harm it is it makes this antibiotic resistance biotic or the microbial organisms it it actually it creates an environment suitable for those kind of microorganisms to survive and they actually become antibiotic resistance resistant I would say. Other than that the microplastics the presence of microplastics is one of the major you know I would say that the cons part of this PPCPs and PMCs and majorly what they are doing this microplastics and now it is it not only increase enhance like you know somehow entering to our food chain, but also it is entering to our in a very cell you know almost in the cellular level inside the present also like I was saying in the last lecture there are research studies which where people have found out that key researchers have found key this microplastics are present in the human placenta and also there in the breast milk. It also creates the nutrient balance imbalance and so, emerging technologies and the it is energy consumption also we have to keep in mind because some of these technologies which are suitable for removing this emerging contaminants.

However, it is a energy consuming process. So, at the same times in order to reduce one harm environmental harm we can cause another kind of a harm. So, we have to optimize this procedures and this technology the uses of this technology and the the find out the best available technologies or in short we call it BAT for treating this kind of emerging contaminants and all. So, although the most of the domestic waste it does not contain the inorganic matter or say like refractic organic compounds as I was discussing the synthetic organic compound at a highly toxic matter, but they are present in the COS due to the increased use of this personal care products or the cosmetics and all. What are the effects of it? First the antiviral ah antimicrobial resistance as I was discussing that the the microbes become antibiotic ah antibiotic resistance at the same times this antimicrobial resistance it caused various type of persistent mobile chemicals to lead to ah like huge adverse effect the even human health the financial and the social cost.

Its long term environmental persistence can because it it it cannot degrade easily it takes years it takes centuries to degrade in the natural environment and it leads to a long term exposure of to the aquatic aquatic organisms and all it has the capacity to disrupt the endocrine like and we call it the endocrine disruptors. So, what it does it actually ah this kind of pharmaceuticals or the personal care products PPCBs they they they what they do they act as a endocrine disruptor in the aquatic organisms and leading to a reproductive and the development abnormalities in the ah in their in their ah life time. Other than that the metabolism disruption is also happening and because of that at the end it leads to the death of those aquatic animals and all. At the end it is not only the death of those aquatic animals, aquatic species, but also it comes to us also ah in the form of a few in the in the in the when it enters the human food chain and it actually comes to us and we it actually affects us as well. How it happens you see this pharmaceutical and antibiotics when we have this doses.

So, administration of this antibiotic to human it causes if you see in the from the left side to right side we will go. It not only ah provided to the humans, but also provided to the animals for their for is faster growth or for their disease control. It reaches then it reaches to the to the sewage line I mean like sewerage systems and all and what happens there those bacteria will become this drug resistance. So, this drug resistance one they become this drug resistance resistant they will pass to this terrestrial and the marine environment and at the end it comes to the food it comes to the food chain and it actually enters through to us through this drinking through drinking water or through the food that we are consuming on daily basis. So, this drug resistance bacteria are very dangerous it can ah it ah can actually cause us to be you know infected like infected ah with the different kind of a diseases and we can easily ah get affected and even there are instances where people even ah succumb to death because of this ah EC's the excess amount of EC's present in then also.

Another major drawback of ah this ah emerging contaminants are it is a it is majorly they are the carcinogenic almost 99 percent of them are are carcinogenic in nature. So, the moment they will enter to enter your health in enter your body it can cause drastic trauma to our system and it can ah cause ah some carcinogenic ah affect to the system. So, WHO ah recommendations on the endocrine disruptors in the ah in the wastewater if I say. So, if you see the beta estradiol or the noniphenol or the bisphenol A it is one of the major ah endocrine disruptors. This bisphenol A you can easily find it in the plastic this PET bottles that we normally ah use that the for the drinking purposes and all I mean it is possible to have a ah leach it through the single use plastics.

That is one of the major reason that people normally ah request like the scientists the policymakers they request us to not to use the single use plastics and all because once it is ah it forms in favorable environment like specially like you know ah when the temperature is higher and all and you put some hot food or any ah changes in the pH and all. So, this can leach to your food and that food once you consume it you can actually consuming a huge amount of this ah endocrine disruptors. This endocrine disruptors even in the in a in a as low as 1 micro gram per liter ah can be ah very harmful for your body. So, in general the recommendations based on the world health world health organization is to make it as low as possible. So, below then ah 0.

1 milli micro gram per liter. If you see the regional distribution is very interesting. So, here ah if you see this graph in the market share and the the the report by the statistic 2023 it is the forecast of the regional distribution of ah the global pharmaceutical market in 2023. If you see the North America 45 percent of the market is dominated by the Northern American ah countries. Then there comes the Asia Pacific, then Europe, Latin America and at the end the Middle East and the African region.

So, if you see this North American and the Asia Pacific region this the presence of ah this pharmaceutical market and it actually causes a huge ah you know impact ah to the wastewater treatment systems as well because those antibiotics and those pharmaceutical products are actually people are consuming and what happen. Nowadays you know people even for a very minute ah simile affect ah minute similar changes in their health also they become worried and they go to the go to the hospital and actually get them some checked and get a lot of medicines. Specially countries ah most of the countries like India and all it is very easy for you to get ah lot of medicines from the doctor. It is clearly not a healthy solution clearly not a healthy solution for environment at least to have so many medicines at the same go and like even if you have a very mild ah health ah abnormalities and all. So, anyway so I am not a doctor I am not a doctor of medicines.

So, I cannot suggest you all these things, but I can all at least request to reduce the consumption of medicine as much as possible and focus on having healthy ah vegetables or fruit based diet and also if possible some animal protein based diet also. It is better than ah having as a lot of medicines and all because at the end what is happening you know those medicines it actually creates a lot of noises in the wastewater that is generating out of your system out of your systems and at the same times from the water that is coming out of ah the the the unit I mean like the apartment or the building or the colony that you are staying. That water will have those ah those chemicals and those what will happen those bacteria or the microorganisms which are growing in those sewer systems ah the sewer systems what they do they will do they will consume those they will somehow have some anti micro anti drug resistance in their body. So, in that can be very dangerous actually. So, anyway so this is something that I I was thinking of discussing with you another another thing is the consumption of this pharmaceutical products it is worldwide annual per capita consumption is around 15 gram which is if you consider now the developed countries it is almost 3 to 10 times higher in the developed countries which is a lot.

So, can you imagine 50 to 150 gram of ah pharmaceuticals are being consumed per capita per year ah by countries like most of the countries in ah the Europe and USA. So, which has to which being the advanced country they can easily reduce it the consumption of all this pharmaceutical intake of this pharmaceutical products and all ok. Then I would I would not say like India is also far ah behind in this India is also in ah almost going at part. So, we also need to reduce the consumption of consumption of at least the antibiotic anti microbial product as little as possible to start with. Other than ah you see the majority of this persistent and mobile chemicals as I was discussing PMCs and the pharmaceuticals and personal care products PPCBs are coming from the industries agriculture or the household.

Household we already discussed in details that from where this households PPCBs are coming. We know from agriculture from agriculture also when the agriculture runoff is taken because of the agriculture runoff phenomena also we can actually ah it can actually contribute to a huge amount of PPCBs and the like you know PMCs especially ah in the regular water surface water bodies and all. And industries definitely the pharmaceutical industries the personal care products ah whoever ah manufacturing it those industries are also causing a huge harm. And if they are not treating their waste water in a in their ETPs effluent treatment plants it and then there before doing that if they release it into the surface water body that can cause a huge issues in the follow up systems and all ok. The ecosystem can be ah completely ah geo-paradise because of that.

So, we need to reduce the ah consumption of pharmaceutical the personal care product

as much as possible unless until it is organically built or it has a biodegradable ah chemicals there is should be whenever you buy any ah personal care products I mean like it is it can be cream it can be powder and anything you should always check it is ingredient you should always you know ah make sure that the ingredients of all this product should be environmental should not be environmentally ah harming I mean like you know it should be ah it should not be having any component or any chemicals which can cause a huge disruption in the ecosystem that you are ah relying on ok. Ah So, other than that the pharmaceutical uses also as I was discussing you try to reduce it as much as possible even if you not if you cannot you try to avoid the you know I mean like the throwing of unused ah medicines or unused ah or the whatever the excretion excretory product in the regular ah water body then better than you use the septic tank I mean like at least a centralized ah wastewater unit you treatment unit you go ahead with that rather than the I mean like decentralized one rather than going through the centralized one I am sorry. So, so that what will happen whatever the problems or whatever the hospital waste or whatever the industrial waste that you will generate which may have a higher amount of PPCBs you can actually confine it to a certain limit confine it to a certain well or certain ah septic tank discharge and all this and so, that it will not leach through it and it will not come in contact with the groundwater also you have to make sure that and also please do not throw it in the surface water body unless until you are sure about a the contamination level is ah well within the permissible limit set by that a world health organization or the central pollution control board in India or the national green tribunal tribunal NGTs ah NGT in India. How this ah this PMCs of the PPCBs are getting to the environment we already discussed that first of all the direct disposal the industrial effluent ah we if we directly dispose it and also the wastewater treatment plants also from there also through the leakage and all the sewer can actually come in contact with the surface water and gradually it goes to the sea water and all even even if it is a surface water in somewhere it can actually leach through the soil and it can reach the groundwater as well. So, and also in agriculture and all pesticides and all we when we use the sprayers that can also this spraying phenomena then it can cause also the aerosols.

Because aerosols can also ah contain this PPCBs which directly comes in contact when it directly comes in contact with any human being it can affect our body as well it can go it can go inside our body and it can accumulate ok. So, in general our target is to reduce the points like you know the as like you know to check the leakage from the treatment units treatment line ah water treatment line or wastewater treatment line reduce the direct or indirect disposal of ah this ah kind of hazardous ah emerging contaminants if it is present in your ah industry wastewater or industry waste or ah hospital waste or hospital wastewater ah try to avoid the exposure ah by this kind of chemicals by putting the mask in those ah region with the higher amount of PPCBs can be found. Try to avoid

somehow recharging the groundwater if try to ah look in look around and see that what are the possible way that ah your PPCB that you are generating out of your household or industry can reach to the groundwater you have to make a decision there and you have to somehow make sure that it will not reach to the groundwater. So, that you can ah actually treat it before that only and then you can leave it to the groundwater level. What are the emerging technologies that is ah coming up in this wastewater treatment ah scenario which can facilitate the emerging contaminant removal? To start with if I ah make it easier for you the most of this emerging contaminants you know what it is nothing, but it is a ah longer chain organic ah chemicals you know measured you know which has a very long chain.

So, how we can reduce I mean that is the reason why it it is very hard for the microbes to actually consume it. So, what you can do you can break those chain you can make it to some other byproducts which can be biodegradable I mean like. So, make it to the hardly biodegradable you have to somehow convert it into biodegradable product. So, how we can do that how we can break those chain how we can break those ah like you know because it needs some high amount of energy right. So, it is this is done by a process called advanced oxidation process there are different other processes as well.

In advanced oxidation process what is the basic funda here you are somehow generating some reactive oxygen species ROS ok. So, what is this ROS is nothing, but you know some radicals like you know say oxygen radicals say hydroxyl radicals and also this radicals what they are doing this radicals are actually having a very high oxidizing capacity. So, it will it will break the ah it will do the cell lysis or it will somehow ah reduce the you know the the higher chain I mean this chemicals to a lower chain once or somehow ah in a in a in a byproduct which can easily degradable in the later stage of the reaction. So, that is the major purpose of it ok. So, once how we can do that we can do this we can actually do this kind of job by introducing some photo catalyst.

Those photo catalyst in the presence of solar irradiation or say artificial irradiation this photo catalyst what it does it actually either release or consume absorb some amount of energy. Whatever it does and in general this because of this phenomena what is happening the energy that it actually liberated that can be useful for generating this ah radicals and this reactive oxygen free radicals or the reactive oxygen species that can actually drastically reduce the ah emerging contaminant ah presence in the wastewater. Other than that you can directly use the solar irradiation also other than that you can use the fundamentals ah like you know ozone. So, ozone ah treatment is another treatment another way by which you can actually reduce the emerging contaminant there are technologies like ah other kind of photo catalysis technologies cavitation technology another way of doing it ultrasonication technology by which actually you can create this

ROSs and actually at the end you can reduce the emerging contaminant concentration in the systems. Nowadays people are also working on the different type of ah microbial technologies.

In those microbial ah fuel cell technology we what we call what is happening you have a anodic chamber you have a cathodic chamber in the anodic chamber those microbial ah say inoculum that you are providing it with. This inoculum will consume the waste present in the I mean like the pollutant present in the wastewater and it will create some energy that energy will be like somehow we harvest it using this anode and cathode some may we will make a circuit we make a proton exchange membrane in between. I will be discussing with you in details in the I think in the 8th or 9th module about how this bio-autogramical system works. So, at the end by this kind of systems in the cathode also you can actually ah reduce the presence of ah this emerging contaminants or the PPCBs and all and there are lot of studies also regarding that is also available in the ah Google I mean like available in the ah research ah archives. As I was discussing the TiO2 based nanocomposites are also one of the very famous ones that is also nothing, but it is a photo catalyst.

Then also graphite based ah some graphene based hybrid materials are also coming up nowadays which can also act as a treat act as for treating like you know for treating this ah PPCBs and all. Other than that ah nowadays another ah kind of organic way of treating this kind of chemicals are also coming up like you know we call it ah constructed ah wetland combined with the action of plant absorption ah adsorption ah and the biodegradation by microorganisms living in the wetland. So, what is this wetland? You might have heard about the Nalban or Salt Lake area in the Kolkata ah in India. So, what is happening if you see that this is one of the finest example of how we can treat a city's wastewater using only a kind of a wetland like structure ok. So, what is happening those treatment of wastewater is being done you simply broadcast it or distribute it into the huge ah lake like structure in that lake there will be like plenty of fishes and also you right next to it you have you have a island of ah Kanandika species like that Kanandika is one of the species of this wetland plant where those wetland plant are actually consumed ah the all the ah pollutants like some pollutants present in your ah wastewater majorly the nutrients through its root system and it will make it ah the moment it will come out of this this wetland ah it becomes completely pollutant free not completely I mean like some degree of ah removal is happening inside the inside this kind of wetland.

So, now, constructed wetland is what like it somehow it you reduce down the actual footprint of the wetland and you make it either vertical or horizontal ah compartments by which actually those water will either go up and down or you know directly straight or

upwards or downwards movement. So, through this different ah structures or the orientations we are treating the pollutant present in the wastewater and that after it will come out of this wetland it will be kind of pollutant free it will somehow reduce the efficient somehow reduce the actual ah amount of pollutant present in the inlet wastewater. So, it reduces suppose 70 percent 80 percent efficiency you can reach out of it. So, that is how it normally ah happens. So, in this ah wetland system also ah there are different concepts by which actually degradation mechanism is happening in people like there are researches where people have found out about the presence of sunlight is also very important here because it is not only the plant, but also the in presence of sunlight different aerobic microorganisms which can also has the capacity to reduce the to degrade those ah PPCBs are also ah come into the picture and they are actually helping the degradation or the biodegradation of this ah in emerging contaminants from the inlet wastewater.

So, this is just some example of ah different ah technologies. I will be discussing with you in details about this technologies in the very ah I mean like I think the seventh or eighth module of ah the lecture series where the tertiary treatment units will be discussed. I want you to be focusing on this technologies because it is very important for you to understand this basics before going into the further mathematical interpretations and all. So, ah how this technologies work that is our major concern and that is our major goal to understand. So, in conclusion in this ah lecture series we discussed about the emerging contaminants which can pose a environmental risk due to the persistent toxicity in the water bodies.

It is essential to employ advanced wastewater treatment technologies as I was discussing for the last 2 slides for effective removal of this ah contaminant to make the water suitable for use and prevent the accumulation of harmful compound and to prevent it to be ah entering to our food chain ok very good. So, sewage treatment plants ah like you know majorly they incorporate the tertiary treatment units which are able to remove this emerging contaminants as I was discussing and this tertiary treatment units are also ah designing ah with the concept of this irradiation either solar radiations or in the base of UV radiations I mean like if you doing it ah artificially you can go ahead with the ozone treatment you can go ahead with the photovoltaist and we can go ahead with the different other mechanisms are there bio electrochemical systems ah like ah we will discuss about it in the during the discussion on the tertiary treatment units and all ok. Our main goal is to guarantee the safety of the treated sewage for discharge into the water bodies surface water bodies or if I are using it for onsite reuse. So, we have to make sure that the wastewater treatment plant whatever will be designing it completely eradicate the presence of in emerging contaminants or the this whatever if it is like a PPCB's pharmaceutical or a personal care product or whatever if it is a persistent or any other ah

mobile chemicals and all ok. So, I hope you understand the concept ah of emerging contaminants and we will be discussing in details I would really request you to go through this references and if it is possible you personally you search for it and try to know more in details what is this emerging contaminants and what is the severity of this emerging contaminants in the scenario in the actual scenario.

So, I hope you get to know about this emerging contaminants and the microplastics PPCB's and the PCM's and all IPM's and all. So, ah we will continue with this discussion ah in the introductory session ah of lecture 4 ah till then. Thank you so much.