Course Name: Industrial Wastewater Treatment

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Week – 11

Lecture 1: Treatment of wastewater produced from pharmaceutical industry

So, welcome back. We are in module 11 and lecture 1. So, here we will be talking about the treatment of the wastewater which is generated from the pharmaceutical industries. So, the topics covered in this lecture are on the introduction to the pharmaceutical industries and then we will talk about the type of the pharmaceuticals that are present in the today's world. We will also talk about a very important term which may be generated because of the abuse of the pharmaceuticals that we use as the antibiotic resistance genes. So, they are also known as ARGs and then we will talk about what are the roots of this ARGs into the environment.

We will also talk about the roots of the pharmaceutical contaminants that is species in the environment and later we will talk about what are the environmental impacts of the pharmaceuticals if they go into the various components of the environment. We will also talk about the groundwater concentrations of the various PPCPs. Here PPCPs means pharmaceutical and personal care products which are reported globally. Similarly, the target PPCPs in the wastewater treatment plants in different countries.

So, the Indian pharmaceutical industry is the third largest industry in the world by volume and it is also the 14th largest industry in terms of its value. So, the major segments of the pharmaceutical industries in India, so they manufacture a generic drug. So, these generic drugs are the drugs which are cheap in nature, and they contain the basic salts as the salts which are there in the brandy drugs. So, they are quite economical in nature. So, that's why these drugs are produced for the people who cannot afford the costly drugs and similarly there can be lot of manufacture of the OTC medicines that is the medicines that we can buy without any prescriptions.

Similarly, we are having the active pharmaceutical ingredients or the bulk drugs produced, the vaccines are produced, then we have the contact research and manufacturing. Similarly, we have biosimilars and biologics. So, these are the major segments of the pharmaceutical industries and India has the second highest number of the US Food and Drug Administration approved plant which is outside the US and India accounts for nearly 60 percent of the global vaccine production and it contributes to nearly 40 to 70 percent of the WHO demand for diphtheria, tetanus and DPT and BCG vaccines and similarly it also meets 90 percent of the WHO demand for the measles vaccines. So, India is one of the

largest providers of the generic drugs globally. So, that's why a lot of countries they depend on India for the manufacture of the generic drugs.

Similarly, India also produces a very economical pharmaceuticals for the treatment of HIV AIDS and that's why it is one of the greatest success stories in medicine for India and similarly India is also one of the biggest suppliers of low-cost vaccines in the world and because of the low price and high quality, so Indian medicines are preferred worldwide that's why it's right to say that India is the pharmacy of the world. So, then we can have different type of pharmaceuticals which are produced from the pharmaceutical manufacturing units. For example, we can have analgesics. So, these analgesic drugs are simply known as analgesic or, so they are the pain reliever, or they are also the pain killer and these drugs basically they are used for the pain management. So, these analgesics they are used as for the pain management without addressing the underlying cause.

So, if the cause is also not known, so in that case also these analgesics may be taken and they do not address the cause of the pain, but they can basically provide the relief from the pain. Similarly, they can also reduce the inflammation at the site of the pain wherever the pain is occurring, or they can also change the perception of the brain for the feeling of the pain. So, that's why they can reduce the pain in the body. They can be used for a number of applications. For example, it can be used for post-surgical pain.

It can also be used for acute pains like for example, headaches or toothaches or broken bones. It can also provide relief from the chronic pains that is the pains which are happening from the long-term diseases like arthritis, from neuropathy as well as from the cancer. So, there can be number of drugs which are available in form of the analgesics. For example, we can have non opioid drugs which does not contain any opium or narcotics. So, these are ibuprofen, we can have aspirin, naproxen etc.

Similarly, the drugs which contains opium, or they are narcotic drugs. So, these are basically called the opioid drugs, and these opioid drugs may include morphine, codeine etc. And then we can have the drugs which are the combination of the non opioid as well as the opioid drugs. For example, we can have co-codamol. So, the antibiotics are the next form of the drugs that are commonly used.

For example, these drugs are mainly used for fighting against the bacterial infections. So, these drugs may be made from the naturally occurring substances as well as they can be made from the synthetic substances. So, these antibiotics they provide the resistance against the bacterial infections. So, these antibiotics they can provide relief against the bacterial infection and these antibiotics may be effective against specific type of bacteria. So, they are used for the limited type of bacterial infections. Whereas there can be other antibiotics which can have a large spectrum antibiotic which can be used for a wide range of the bacteria, and they can basically provide relief against a number of the bacterial

infections in the body. There can be different type of antibiotics. For example, we can put it into 6 different groups which includes penicillin, it includes cephalosporins, it includes amino glycosides, tetracyclines, macrolides and fluoroquinolols. Then another category of the drugs is the antidepressants and these antidepressants as the name suggests. So, it is used for providing the treatment for the depressed patient or basically provide the medicines for the mood lifting or they basically act against the depression causing agents.

So, this basically may be grouped into 3 main groups. So, we can have tricyclics, we can have monoamine oxidase inhibitors, or we can also have selective serotonin uptake inhibitors where the serotonin is basically known as the mood lifting agent. So, then we can have antivirals. These antirirals drugs are basically used from the relief from the diarrhea and basically these drugs they act on the body in a very simple way that is they slow down the contractions of the bowel muscles. So, that is why the contents, so they are propelled very slowly and that is we are basically they provide the relief against the diarrhea.

Similarly, we can have antimetics which are known for the treating nausea as well as the vomiting. And antifungals they can be used against the fungal infections and these fungal infections may affect our hairs or skins, nails or the mucous membranes. So, they can provide the treatment against the fungus that is growing in these parts. So, then we can have another group of the pharmaceutical which is known as the antihistamines. They counteract the effect of the histamine, and this histamine is responsible for the allergic reactions in the body.

So, these drugs are used in case of the allergic reactions. Then we can have anti hypersensitive, so which are used for lowering down the blood pressure. So, these type of anti hypersensitives so they include the diuretics, they can include the beta blockers, they can include the calcium channel blockers, they can include angiotonin converting enzyme that is ACE inhibitors, and they include centrally acting hypersensitive or sympatholytics. Then we can have the anti-inflammatories. So, these drugs they reduce the inflammation.

So, they reduce the swelling basically, they reduce the redness that is caused because of the inflammation, they reduce the heat that is produced from the inflammation, and they increase the blood flow towards the infected part and then basically it can also be used in a number of long term non-infective diseases such as rheumatoid arthritis or in the treatment of the gout. Then there can be drugs known as anti-neoplastics which are known for the fighting cancer. So, they are used for the treatment of the cancer. So, these are called anti-neoplastic drugs. Similarly, we can have anti-psychotic drugs which are used for the treatment of the severe psychiatric disorders and these drugs are also known as the major tranquilizers.

And then we can have antipyretics which are used for reducing the fevers, we can have antivirals which are used for treating the viral infection inside the body and they can provide the protection against the infection such as influenza and then there can be the drugs which are called beta blockers. So, these beta blockers are basically the drugs which can reduce the oxygen need of the heart so that the heartbeat rate can be reduced. So, it provides the less basically load on the heart. So, in case of the patient which are suffering from the cardiac diseases, so they are mostly given beta blockers so that the load on the heart can be reduced. Then we can have vitamins.

So, vitamins are required for our body in very small quantities. These vitamins we can get from our food also that is whatever the normal diet we take. So, in that the vitamins may be present, but people who take inadequate diets or basically who are having the problem of the digestive tract or basically they are having the liver disorders, and they may need to take these vitamins as a supplementary vitamin. So, there that vitamins basically may be given in form of either liquid or in form of the tablets or basically capsules. Similarly, we can have antacids and these antacids they provide relief against the indigestion and the heartburn which basically may occur because of the stomach acid.

So, the acid reflex that is caused because of the acid in the stomach which is produced during the digestion process, so that may lead to the indigestion and the heartburn. So, we provide antacids so that this acid which is there which can be utilized by antacids. Similarly, we can have anti-anxiety drugs which suppresses the anxiety, and they relax the muscles also. So, they are sometimes called anxiolytics, or they are called sedatives, or they are also known as the minor tranquilizers. For example, we have talked about the anti-depressants, so they are called the major tranquilizers.

So, these anti-anxiety drugs basically are the minor tranquilizers. Similarly, we have drugs called anti-arrhythmics. So, these drugs are used for controlling the irregularities of the heartbeat. So, the patients which are suffering from different cases of the irregular heartbeats, so their heartbeat basically is not normal. So, in that case this anti-arrhythmic may be given to the patient for making the heartbeat regular.

So, then we can have the anticoagulants or thrombolytics. For example, the anticoagulants are given to the patients who are suffering from the blood clotting. So, these drugs are the thrombolytics, so they can help dissolving and dispersing the blood clots which has formed inside the body. So, it is prescribed for the patient which are having the arterial or venous thrombosis. So, in that case whatever the blood clots have been formed, so they can basically be used for dissolving those.

And anticoagulants basically are needed, so that they can prevent the blood from clotting. Whereas anticonvulsants are also used for the treatment of the epileptic seizures, so they can be treated by using anticonvulsant drugs. Similarly, we can have the drugs for

antibacterials which treats infections due to bacteria. So, these are some of the drugs that are generally used for the treatment of the living organisms. We can see here that there is different market for these types of drugs.

For example, nearly 60 percent of the market basically is occupied by anti-infective drugs. Similarly, 11 percent of the market is captured by gastrointestinal drugs. Similarly, 10 percent of the market basically goes to the cardiac drugs. 10 percent for the respiratory drugs. Then basically 10 percent for the vitamins, minerals and the nutrients. Then 11 percent goes to the painkillers or the analgesics. Similarly, 5 percent of the drugs basically contributed by the skin diseases. And similarly, next 5 percent may be contributed by the gynecological problems. Similarly, next 5 percent may be contributed by the neuropsychiatry. And the 5 percent again may be imparted to the anti-diabetic drugs. And similarly, 2 percent goes to pathological, and 11 percent basically contributes to the other type of drugs that are used in the Indian markets. So, we can see here that there can be a number of ways by these drugs can be given or these drugs can be monitored. So, they can be basically given by the oral route. For example, we can have number of tablets, capsules or the basically we can say the thin films, the medicated gums, granules and then solutions or suspensions, the emulsions or braids. So, they all basically contribute towards the oral route of the drug administration.

So, here we can also take the drugs by the route of the inhalation. So, we can have dry powders and the liquid sprays which may contribute towards the inhalation of these drugs. For the nasal area, we can have drops as well as the sprays by which the drugs can be administered. Similarly, for the ear also we can have different routes for example topical or intra tympanic or intra cochlear. Similarly, for the ocular that is we can have different type of solutions, emulsions, suspensions for the eyes, we can have ointments, we can have contact lenses, several implants we can use for improving the eyesight inserts or intra vitreous.

Similarly, the topical or the transdermal route may be there for example, when we are taking care of the skin or when we are fighting the skin diseases in that case ointments, skins, lotion, gel sprays or patches basically can also be used. Similarly, we can have the application through the rectal or vaginal route also and then we can have the number of injections that can be used for the intramuscular applications, we can have the injections for the subcutaneous applications, we can have the intravenous applications, we can have the intra dermal applications depending upon where we are providing the injection in which area. So, as these drugs they are being produced in large quantity and they are also being used in large quantities by the population. So, these drugs may find their way in different components of the environment. So, this may lead to the development of the antibiotic resistance genes.

Now, these antibiotic resistance genes are caused due to the changes or mutations in the DNA of the bacteria and these changes or mutations in the DNA may happen because they are exposed to these types of drugs. So, with time basically they can mutate or their DNA may change and they can adapt those drugs and slowly and slowly they become resistant to those drugs and these antibiotic resistance genes can then be transferred either horizontally or vertically to the So, this means that once these antibiotic resistance genes is developed in one of the bacteria so then they can be transferred to the other bacteria also either by the vertical route or through the horizontal routes. So, that is why it is a very very important concern that if these bacteria are developed which gets acclimatized or which gets resistant to the different type of antibiotics that we are producing then these antibiotics will become useless, and they cannot be used further for getting relief from such bacterias. So, that is why these antibiotic resistance genes are also known as the emerging environmental contaminants.

So, these ARGs they can be transferred and transformed in various environmental components for example, in groundwater, in the surface water or in the soil. So, they can be transferred from one bacterium to another bacteria or they can be transformed in the same bacteria and then basically these ARGs can develop, and they can spread a lot this is causing a lot of concern today and this happens because of the abuse of the drugs that we are using. So, they are going into the environment indiscriminately and that is why it is leading to the growth of these ARGs. So, these ARGs basically can move horizontally through a number of mobile genetic elements for example, they are called integrons or they are called transposons or the plasmids. So, they are transferred from one bacterium to another bacteria through the horizontal gene transfer whereas, they can be transferred vertically also when the bacteria go for the production.

So, in that case they may be transferred to the next generations. So, these antibiotic-resistant genes may be spreading into the environment because of number of factors for example, we can have the heavy metals being exposed to these bacteria and because of which they become resistant to those metals also and similarly we use a number of disinfectants and slowly and slowly these bacteria may mutate, and they can also become resistant to these disinfectants. Similarly, we use a number of antimicrobials for example, we use it in intensive agriculture as well as in the livestock farming. So, we are using these antimicrobials. So, they basically are exposed to those bacteria which basically develop the resistance during the exposure and during the process of getting to adapt to these toxic elements.

Similarly, the wastewater treatment plant disposal may also pose a problem, they may also lead to the generation of the antibiotic-resistant genes because these wastewater treatment plants. So, they are using conventional treatment processes, and these conventional processes may not basically treat the pharmaceuticals which are going into the wastewater completely and that is why this basically may lead to the exposure of these pharmaceuticals

to the bacteria. Similarly, we use a number of antimicrobials in case of aquaculture also. So, from this aquaculture also we can get the generation of these ARGs. And we are also using antibiotics as a growth promoters or as a disease prevention in case of the animals.

So, from there also the antibiotics may go into the environment for example, these basically the excretion of these animals basically may lead to the contamination of the soil and from there it may basically be transferred to the other components of the environment. So, we can see here that when we use extensively the antibiotics, so it can result in the formation of the drug resistant or the antimicrobial resistant bacterias and these bacteria basically may lead to the spreading of these ARGs in form of mobile genetic elements such as integrons. So, they play a major role in the spreading of these ARGs. So, they spread in various components of the environment through this horizontal and the vertical transport. Similarly, from here the drug-resistant bacteria or the ARGs, so they may be spread into the different components of the environment and this basically may lead to the environmental contamination.

Similarly, these ARGs may also be produced from the wastewater treatment plants or from the agricultural fields from the humans and the animal wastes. So, they also basically lead to the commission of the ARGs into the environmental components and then these ARGs basically they can come into the water or the wastewater that we are having. So, these ARGs may be transferred into the water that we are drinking because ultimately the wastewater if it is not able to feed it, so they may ultimately go into the environment and then basically it may come back to the humans as well as to the animals and plants also. So, they pose a risk to the public health. So, that is why we can see that it is basically a cyclic process.

So, we are using these antibiotics for the treatment of the body and ultimately these antibiotics basically are becoming useless in the sense because the ARGs are being developed and these ARGs are very very resistant to these antibiotics. So, we can see here that the pharmaceuticals basically they can find their way from the hospitals and the domestic use. So, where a lot of pharmaceuticals are used. So, it is used in the hospitals also, it is basically used in the houses also. So, from there if we are going for the indiscriminate disposal of these drugs for example, the drugs may basically become expire and their improper disposal may find its way into the landfill sites and these landfill sites if they are non-engineered site.

So, they do not have any liners provided. So, the leachate that is generated from these types of landfills. So, this may result in the leakage and this landfill leachate basically may leach into the groundwater and this may contaminate the groundwater. Similarly, we can also find these pharmaceuticals from the hospitals and the domestic use. So, they may go into the sewer lines also and from the sewer lines it ultimately goes into the wastewater

treatment plants. So, in the wastewater treatment plants as we are using the conventional processes.

So, it is possible that they may not be able to treat these pharmaceuticals completely and they find their way into the surface water. Similarly, the sewer may also be leaking. So, these leaking sewers may again lead to the contamination of the surface water and similarly we a number of drugs which are used for the animals. So, they may find their way into the soil due to the excretion or the dead animals that basically go into the soil.

So, ultimately when the soil is contaminated. So, from the contaminated soil the leaching may happen and because of the leaching these pharmaceuticals may find their way into the groundwater and the groundwater is again connected to the surface water. So, it may also lead to the contamination of the surface water and once the surface water is contaminated and we are using the surface water for as a source for our drinking purposes. So, this basically will ultimately go into the water distribution and this basically ultimately come back to the humans. In basically the way that the water distribution, the water treatment plants also are not able to address these contaminants, and they are present in very small quantities also. So, they find their way, they basically escape from the treatment process, and they may find their way and ultimately it will come back to us in form of the drinking water.

So, there can be number of environmental impacts of the pharmaceuticals. For example, we know that the pharmaceutical compounds, so they are very beneficial to the modern society because we are fighting with the number of diseases that has been caused by a number of our unhealthy practices. So, these pharmaceuticals they provide us relief against a number of these diseases, but it is also evident that the pharmaceutical industries, so they release very toxic contaminants in the environment. So, either it can be directly released or basically it can be released after certain chemical modifications which happens during the manufacture of these pharmaceuticals. So, the pharmaceutical industries, so they can generate a huge quantity of wastes during the manufacturing process as well as the maintenance operations.

And the pharmaceuticals have also been detected in the wastewater treatment plants, effluents as well as in the drinking water sources as we were just now talking that these basically the wastewater treatment plant or the drinking water sources, so they have not been designed for the treatment of such type of pharmaceuticals which are present in the water or the wastewater. So, that is why it is possible that these plants may not treat these drugs efficiently and they find their way into the water. Similarly, there can be different routes which includes the treated wastewater going into the water bodies. Basically, the seepage from the landfill sites, the sewer lines as well as the runoff from the agricultural and animal waste, so they also basically can lead to the induction of the pharmaceuticals into the environment. So, basically when we are talking about the runoff from the animal

waste or we are talking about the sewer lines, so there we find that since we are consuming a lot of medicines also even though if we are not disposing it off directly into the environment, but our waste basically may contain lot of these pharmaceuticals which are unutilized in our body.

So, they basically find their way and they go out in the excretion, and this may lead to the contamination of the environmental components. So, then we can have the wastewater which is coming out from the pharmaceuticals as well as the personal care products, so it is called PPCPs. So, it is discharged into the water bodies or if it is discharged into the environment, so it can lead to a number of adverse effects on the humans as well as the animals and plants. So, it can be genotoxic, it can be mutagenic, it can have ecotoxicological effects. So, things happens when the pharmaceuticals and the personal care products they find their way into the environment.

And similarly, if we are constantly releasing these pharmaceutical contaminants to the water bodies, so the long-term exposure basically may result in the chronic effects in the aquatic plants as well as in the animals. And similarly, the long-term exposure to the pharmaceutical contaminants, so it may also lead to the change in the inherited trait because it basically is genotoxic as well as mutagenic. So, it basically will change the inheritance, it will change the DNA of the people who are taking it and similarly, it will also basically change the behavior of the living beings. Similarly, the PCs, they are present in the drinking water, so they can basically produce a lot of harmful effects on the newborn babies, it can also affect the elderly peoples, it can also affect the people who are suffering from the diseases like kidney disease or the liver failure because these peoples, so they are having very very low immunities. In this way, these PCs if they are present in the water even if they are present in very small amounts also, then also it can cause lot of problem to the people who are taking it.

Similarly, when we talk of the anti-cancer drugs, so if they are present in the water, so they can penetrate the blood placenta barrier and they can cause teratogenic and embryotoxic effects. So, that is why it is highly dangerous to the pregnant women because of their cytotoxic activities. So, they can basically cause damage to the cells, and it is also seen that around 95 percent of the antibiotic compounds, so they can be released unaltered into the sewage system. So, they are basically not modified, they are not altered at all, and they find their way directly into the sewage system and they are not basically decomposed or degraded or altered when they go into the sewage system. And higher concentrations of antibiotics which basically is there, it can lead to the change in the microbial community also structure because when we are having high concentration of antibiotics, so it may kill certain type of bacteria and the microbial community basically may be harmed because of it and ultimately it will also affect the food chain in the ecosystem.

So, we can find that Ibuprofen, Ketoprofen, Naproxen, Indomethacin, Diclofenac, Acetyl Salicylic acid and Phenazone, so they have been found in the surface water systems. So, Ticlofenac, Iuprofen and Propi-Phenazone, so they are the most commonly found drugs in the water bodies and after the clofibric acid. So, we see that a number of drugs basically they are found in the water and these Diclofenac, so they have proved to be highly toxic to the vultures and to the cattles. So, it has been proved already that the Ticlofenac which is present in the caracas of the dead bodies of the cattles, so they may contain high amount of Ticlofenac. So, these Diclofenac are basically taken by the vultures, and these vultures basically can take this the flesh that contains high amount of diclofenac, and it may lead to their kidney failures, and this may lead to the extinction of these vultures in India.

So, sewage treatment plants, so they are not always successful in removing the active chemicals or we can say the pharmaceutical compounds from the wastewater and that is why they may find their way in the aquatic environment, and they can directly affect the aquatic organism, and they can also basically come into the food chain. So, in a recent study it has been found that very high levels of the several drugs were found in the affluence which are coming out from the wastewater treatment plants in Vishakhapatnam in India. So, this has been reported by Patneedi et al. in 2015 and this shows that the wastewater treatment plants, so they are not able to treat the pharmaceuticals which are present in the sewage.

That is why it is very essential that we create the effective and efficient treatment methods for the removal of the pharmaceutical contaminants from the wastewater. So, there can be a number of mechanism and techniques which are being studied nowadays. For example, we can have advanced oxidation process, we can have the use of the membrane processes etc. So, but it is found that the adopted methods are mainly the biological approaches we are using which we find that they are not as efficient as the other processes which we use, so that we can treat these drugs to the desired level. So, these pharmaceutical contaminants like antibiotics, analgesics and anti-inflammatory or anti-depressants, so these basically may find their way into the wastewater and they can find their way from the human waste or from the animal by-product or the pharmaceuticals affluence or from the hospital waste, so they may come into the environment.

And they can basically cause lot of risk to the aquatic life, they can cause endocrine disruptions to the people who are taking it, similarly they can also basically lead to the antibiotic resistance. So, number of technologies are being used, for example, membrane technologies, advanced oxidation process and we are also using activated stress process, so we can have a combination of these technologies along with the biological process also. Similarly, people have also tried micro algae treatment, electrochemical treatment is also being used nowadays for the treatment of certain type of drugs which are highly reconsidering in nature, and they are basically not treated through the conventional processes. Similarly, people are also trying the constructed wetlands for the removal of

these pharmaceutical contaminants. So, now we can see here that a lot of countries have reported that the groundwater they contain a wide spectrum of the pharmaceutical and personal care products.

So, these are found in the groundwater, for example, doxycycline is found nearly in a concentration of 2000 nanograms per liter, and this is by having the source from natural springs, this has been reported from Spain. Similarly, trypofloxacin has been reported to be nearly 14000 nanograms per liter and this has been found in the wells of India. Amoxicillin has been found in 6490 nanograms per liter and this has been reported in the wells and the boreholes in Nigeria. Similarly, ampicillin has been reported to be nearly 3690 nanograms per liter in the wells from the US. Similarly, olfloxacin has also been reported as high as 14940 nanograms per liter from the wells of US and similarly, India has also reported nearly 480 nanograms per liter in the wells.

Azithromycin has been found nearly 1620 nanograms per liter in the pumping wells and in the piezometers in Spain. Similarly, diclofenac has been reported to be very high, for example, we can have nearly 1300090000 nanograms per liter has been reported in the bore wells in India. Similarly, ibuprofen has also been reported to be nearly 3110 nanograms per liter in the well's springs and some of US. The acetaminophen has been reported to be nearly 15580 nanograms per liter in the wells in the US and similarly, naproxen has been reported to be 98390 nanograms per liter in the wells from the US.

The ketprophane has been reported to be 23.4 nanograms per liter in the hand pumps along the Ganga River basin in India and codeine has been found to be nearly 2440 nanograms per liter in the wells and bore wells of Nigeria and salicylic acid has been reported to be nearly 2015 nanograms per liter in the wells from China. Similarly, we can see here that the beta blockers like metoprololol is found nearly 19 nanograms per liter in the wells in India and similarly, nearly 355 nanograms per liter has been observed in the pumping wells as well as the piezometers in Spain. Atenolol that has been found to be nearly 106 nanograms per liter in the monitoring wells of the Spain and propionolol has been found to be nearly 9.38 nanograms per liter in Spain piezometers.

Similarly, we can find these drugs in a number of wastewater treatment plants also. So, it has been reported that the wastewater treatment plant may contain the drugs in the influent as well as the effluent concentration basically is also showing that it is not effective in treating these drugs. For example, we can see that in from the China when we are treating the wastewater by using active resistance process along with the ultrafiltration and ozonation plant. So, they it we find that nearly 0.35 microgram per liter declofenac was there in the influent.

So, it was able to remove only 0.15 microgram per liter of the diclofenac. Similarly, we can see that trimethoprim. So, nearly 0.3 was there in the influent and 0.1 basically is there

in the effluent metoprolol. So, it is 0.1 in the influent and nearly 0.09 in the effluent. The gemfibril. So, it is 0.04 in the influent and 0.03 in the effluent. Similarly, bezafibrate. So, it is basically 0.04 in the influent and 0.01 in the effluent. Carbamazepine. So, it is 0.15 in the influent and 0.12 in the effluent and similarly we see that caffeine is nearly 6 microgram per liter in the influent and 0.01 microgram per liter in the effluent. So, we can see here that the concentration of these drugs is still found in the water even after treatment and they have used the treatment like under filtration and the ozonation plant also along with the ASP. And here we can find that the constructed wetland in US. So, they have reported that the concentrations of these drugs. So, they can be removed to a greater extent, but some of the drugs for example, acetaminophen has been removed to nearly 0.02 microgram per liter. Similarly, ibuprofen is quite effectively removed. Similarly, sulfamethoxazole. So, it has been also quite effectively removed, but we find that the metoprolol is also we effectively removed and gemfibril is not removed, but it is increased. Similarly, carbamazepine is basically enhanced whereas the caffeine is effectively removed in the constructed wetland. So, we can see here that the drugs from the treatment by activity stretch process or the conventional activity stretch plants. So, they basically are not able to remove these drugs very effectively.

Similarly, in US also they have reported by using the activity stretch process. So, sulfamethoxazole 1.1 microgram per liter in the effluent and nearly 0.1 microgram per liter is reported in the effluent whereas the carbamazepine is basically increased in the effluent whereas the caffeine is effectively removed by the activity stretch process. So, we can find in the Canada where they were using the legumes treatment, or they are using the activity stretch process plants along with the media filtration. So, the diclofenac has not been removed easily whereas the ibuprofen has been removed effectively whereas gemfibrozil basically is it is basically nearly 50 percent is removed, estrone basically is also it is not effectively removed and triclosan.

So, it is basically effectively removed from this process. So, similarly we find that in UK the diclofenac has been effectively removed by using activity stretch process and the sand filters and we find that the sulfamethoxazole has been also removed whereas the carbamazepine basically it has not been removed effectively. And in the Sweden also the similar reports have been received for example diclofenac has been reported to be increased in the effluent whereas the ibuprofen is effectively removed and estrone basically is also increased in the effluents whereas the estradiol is also not effectively removed. And we see that the in Italy the estrone basically is also not removed by the activity stretch process estradiol basically is removed effectively in the activity stress. So, these are the different reports where we see that it is possible that even after the treatment by using different conventional techniques the drugs basically may come into the effluent and these drugs, they find their way into the water bodies and they may contaminate the aquatic environment. So, we stop here today we will be talking about the manufacturing of these

pharmaceuticals in our coming lectures, and we will also talk about that what are the wastewater characteristics that will be generated by different type of manufacture of these pharmaceuticals. So, these are the references that we have used for the preparation of this lecture.

Thank you.