Course Name: Industrial Wastewater Treatment

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Week – 12

Lecture 57: Mine Wastewater including Acid Mine Drainage and Industrial Complexing for Zero Pollution Attainment

Welcome you all. Today I am going to deliver lecture 2 of module 12, which is on the Mine Wastewater including acid mine drainage and industrial complexing for zero pollution attainment.

So if we recall in the previous lectures, we have seen like how mine water is generated, what are the variation in the characteristics of the mine water. There are two streams alkaline streams and then acidic mine water. So, both these streams are generated. So, under this lectures we will be covering mostly the treatment technologies which are used.

So, we will start with an overview of various treatment technologies which are available for the treatment of mine water especially alkaline and acidic mine water both and then we will be starting with detailed elaboration on the methods of treatment of alkaline mine water. So that is along with the treatment system and then we will be also looking on the low-cost treatment system which is used for alkaline mine water and then finally we will be looking about the methods of treatment of acid mine drainage. So, for acid mine drainage there are various methods like active methods, passive methods and then in-situ treatment. So, all three treatments techniques we will be going in detail in the forthcoming slides.

So let us start with the various treatment technologies which are available for the treatment of mine wastewater. So, here if we see these are the treatment methods and these are the examples and here their application in the mine water treatment. So out of the various treatment technologies this neutralization is one of the most important techniques that is mostly used for acid mine drainage. So, this acid mine drainage contains lot of acidity the pH level varies from 2 to 5, so this can be neutralized. So, neutralization is the first step in mine water treatment especially when acid mine drainage treatment is concerned. So, this is done by lime or limestone addition, so this lime is basically it's a lot of alkalinities into the water which neutralize the acidity present into the acid mine drainage. And then we talk about the passive treatment system which are basically the natural wetland system which are used mostly for removal of metals precipitation of metals from the acid mine drainage. So, we will be also looking about the various passive treatment techniques which are used so for that mostly this wetland systems are there. So, wetland system further if we go in detail there are aerobic wetland system and then there are anaerobic wetland system so both of these aerobic and anaerobic wetland system we will be going in the coming slides. And then there are lot of metal contents present into the mine waste waters so this metal recovery. So, metal recovery process basically involves the sulfide

precipitation biological filters and fluidized bed reactors they are used in metal recovery process and after metal is recovered it is sent for sale. And there are also like other precipitation process, like hydroxide precipitation process which we also say that is HDS process and then other chemical treatment system, like coagulation, flocculation followed by sedimentation or clarification of the water that is being practiced for removal of heavy metals present into the acid mine drainage and after precipitation and recovery of metals that can be sent for sale. Then there is biological treatment system these type of treatment system they are mostly used like fixed film reactors attached growth system or suspended growth systems there are nowadays hybrid system which combines both suspended and attached growth systems. So, these reactors basically they are used for removal of organic metal like phenol, BOD, nitrogen which are present into the mine water. So, then there is another technique which are used like dewatering, so this dewatering is basically to remove out the sludge solids present into the mine water. So, this is done by designing number of clarifiers primary clarifiers, secondary clarifiers and then the floating impurities which are present into the mine water like oil and grease they are removed by dissolved air flotation techniques. So, this basically involves the volume reductions of the tailings and filtration and thickening that is another treatment technology which involves pressure filters and base thickness which basically thickens the biosolids and then these solids they are separated from the tailings. And then there are cyanide treatment some of the mine water that may contain a lot of cyanide. So, this alkaline chlorination technique as we have discussed in coke oven effluent, so this alkaline chlorination system oxidation of cyanide that is carried out and then H_2O_2 process are also there which oxidize the cyanide and convert into carbon dioxide and nitrogen. So, these are mostly used in gold mine effluent which are generated from the gold mines.

So these are the various treatment techniques which we can use depending upon the quality and the characteristic of the wastewater and as we have seen the characteristic of the mine water generated from individual mines that vary significantly because of variation in the geological formation existing over mine to mine and these geological formation basically they are responsible for variation in the characteristic of the wastewater. So, depending upon the type of the mine water which is generated from a particular coal field that has to be characterized and then accordingly the treatment technology we have to select for their removal.

Then let us talk about the alkaline mine water treatment technologies which are basically generated from the Gondwana type of coal field. So, in this type of coal field mostly this alkaline mine water is generated and which has mostly if we see the characteristic of alkaline water so it contains a lot of TDS, it contains hardness and also there are a lot of fine suspended inorganic and organic impurities may be present in the water so this alkaline water has to be treated using various treatment system so this basically shows the flow diagram of the mine water treatment system which are used in a particular coal mines. So, in this the mine water after generation is stored in the mine pit and from this mine pit there are the pumps which used to pump this water to the surface and in the surface, there are raw water sump, which basically is used to collect all the mine pit water. The storage of this mine water sump is decided based on the generation of the mine water and the entire mine water which is coming out from the mine pit that is equalized within this raw water sump and then after equalization the water first goes to the aeration system where this is aerated with the diffused aeration system, surface aeration system. So, there are

different types of aerators which are available, so in the aeration basins the entire water which is coming from the sump that has to be aerated so this aeration is carried out in fact to oxidize the iron and manganese present into the water normally these type of alkaline mine water that contains little quantity of iron and manganese which can be removed by aeration process so during this aeration this iron and manganese that gets oxidized and then this forms the precipitates and then after this goes for chemical treatment where coagulation and flocculation is carried out this alum and lime dosing is carried out depending upon the alkalinity present into the wastewater, so this alum and lime when it is added they forms the aluminum hydroxide precipitates and this lime basically aids the alkalinity in the water which is reacted with the alum and forms its precipitates these precipitates arrest all the fine particulate matter and the precipitates of iron and manganese along with this goes to the mixing chamber, this mixing chamber acts as a flocculation tank where the entire coagulant mixed water comes here and then it is flocculated in this chamber during this the entire water that has to be rotated within the chamber at a very slow speed of 1 to 2 rpm. So, during this floc formation takes place bigger size of flocs are formed and these flocs then they are precipitated here in the clarifier and separated from the rest of the water. So, this clarifier basically works on the principle of sedimentation, so all those particles and flocs which are of bigger size having higher specific gravity they used to settle at the bottom and from the bottom they are removed as a sludge and then the clarified water that comes out from this is collected again in the sump which is called as the filter water sump and the precipitates and the sludge which are formed here they are separated in the at the bottom of the clarifier and then further disposed after the sludge treatment and whatever the clarified water that is generated after this sedimentation tank that is collected into the filter water sump and from here there are the two pumps of 10 HP capacity they are installed here so they will pump out this water clarified water to the filter so next operation is the pressure filter is used having the capacity of say 5000 gallon per minute. So, these pressure filters they are put into the parallel so entire water that has to be distributed into these two pressure filters and this pressure filter basically acts as a filter media for separating the very fine particulate matter presented to the mine water after the chemical coagulation and flocculation process and then the water treated after the pressure filters they are directly either be taken for the rest of the treatment which is basically the chlorination process where chlorine is added into the finally treated water and to disinfect the water and after this disinfection of the water that water is stored into the reservoir but this treatment system works when there is not very high hardness if the mine water contains lot of hardness then the water after this pressure filtration that has to be brought to the softeners though so here there are two softeners which receives the filtered water from the pressure filters and these softeners here we ate lime and soda or maybe we can have ion exchange process we can have other softening process that can be used for removal of hardness present into the mine water and after this hardness is removed after the entire treatment the water is taken to the chlorination process where this chlorine is added for disinfection of water so this this will disinfect all the microbial and pathogens present into the mine water and after this treatment entire water that is stored in the reservoir that will be supplied to the distribution network so these are the nearby distribution supply system where using these two pumps the entire mine water that will be supplied for drinking purpose. So these are the treatment technologies that have been proposed and working in most of the mines and they are converting this alkaline mine water for its safe utilization as a drinking water and many other activities.

Then this is proposed low-cost techniques which are used in the small-scale mines who cannot afford a lot of funds for the treatment of mine water so here what happens in this mine water whatever is comes out from the mine pit that has to be pumped into this reservoir from this reservoir the water is pumped into first that is the lime soda process so this tank basically a tank is constructed and a divider wall is made in between and from this divider wall there is an inlet provided so that the water after the first treatment can go into the second chamber for its clarification where which is which acts as a sedimentation tank. So, here mostly we do this chemical treatment system where we aid lime soda or alum depending upon the hardness and alkalinity present into the water and then the reaction of lime and soda or alum that will form the precipitates flocs and these flocs along with the water will be taken to the sedimentation tank here and in the sedimentation tank by way of gravity separation techniques whatever the precipitates they will be collected at the bottom here and then the clarified water here that will be taken up by siphonic action which is connected to the next chamber which acts as a rapid sand filter so this consists of the filter media made of sand and gravel. So, this acts as a rapid gravity sand filters where the clarified water from the sedimentation tank is taken and in the filtration when the water moves through the filter through the different process that the very fine particulate matter which could not be clarified which could not be removed in the sedimentation tank that that will be attached with the filter media and a very fine quality of water three of these fine particulate matter colloidal impurities that will come out from this tank, from this outlet and after this we can see this is the chamber which contains chlorine so this acts as a chlorine dozer and here from we inject the liquid chlorine or we can add the bleaching powder for disinfection of water and after this entire treated water that is stored in a next tank which acts as a reservoir for the treated water and from here this is pumped out to the service reservoir for distribution of drinking water supply. So, this kind of system basically that is the low-cost treatment system which are mostly adopted in the mines.

Then let us talk about the acid mine drainage which is exactly very concentrated streams which are generated mostly from the tertiary coal field which is available in the eastern part of our country so that tertiary coal fields mostly generates the acidic runoff which has a pH varying from 2 to 5 so it contains a lot of acidity and lot of metal concentration, so these metals they are very rich in acid mine drainage and the concentration of metal and the type of metal present in the acid mine drainage that also affects the treatment process and their concentration in the acid mine drainage that will also entirely depend upon the type of geological formations where from this acid mine drainage comes out. So, for this there are different treatment techniques we can adopt for the management of this acid mine drainage. So, here we can see there are passive methods there are active methods and then there are in situ techniques so there are different types of treatment techniques available so one by one we will be looking about all these treatment system which can be used for the treatment of acid mine drainage. So, in the passive methods if we talk about so these are like the natural treatment systems like wetland system where we don't have much control on the process parameters and the efficiency of the treatment system, so this type of treatment system they are mostly occurs naturally and they are mostly cost effective system where there is a very low energy input and the process does not require much of coagulant and chemicals, so it is low cost treatment system mostly adopted in the coal mine industry for the management of their acid mine drainage. So, under this there are the wetland system that is

aerobic wetland system and then there are anoxic limestone drains and there are also an aerobic wetland system. So, one by one we will be discussing about this aerobic wetland system, anaerobic wetland system and then anoxic limestone drains which are used as a passive methods for the treatment of acid mine drainage. And then if we talk about the active methods so active methods are those methods which we engineered and we have full control on its process parameters and because of this the efficiency is very high using this treatment system so treatment efficiency is good and but this system because requires energy input, requires a lot of chemicals, requires a lot of process control so it is relatively costlier than this passive methods but in terms of efficiency this treatment system is much-much better than the passive treatment system so this is basically we can say these are like controlled limestone neutralization and precipitation techniques that is conventional technique used in the treatment of acid mine drainage in most of the coal mines in India. So, these are the majority of the mines they are using this limestone precipitation techniques for precipitation and removal of the metal contains neutralization of acid tea present in the acid mine drainage and then there are ion exchange methods also which are used for removal of selective metal ion concentration from the acid mine drainage then we have membrane extraction technique reverse osmosis technique solvent extraction methods and then biological treatment systems are also available. So, these are the various treatment systems which are classified under active methods for the treatment of acid mine drainage. And then we have in situ treatment system in situ treatment system they are the mine water where from it is generated and this is mostly used for remediation of the affected land from the mine water like alkaline injection technique if any particular land where this acid mine drainage has degraded the soil quality and made the land barren. So, this alkaline injection technology is used for the neutralization of acid tea present into the soil and making the land fertile. So, one by one we will be discussing about all these treatment systems which are used in the treatment of acid mine drainage.

So these are the passive methods for the treatment of acid mine drainage. So, if we see the first one that is aerobic wetland system so in aerobic wetland system if we see it contains a layer of 1-3 inch of water at the top and then the water layer that is overlying over the organic matter layer of 1-3 feet. So, these are basically the organic matter filled into wetland and then this is the acid mine drainage that is to be applied on the surface of this organic matter and these are basically the specific type of plants which are used for adsorption of heavy metals present into the acid mine drainage. So, like there are different species like typhus. So, these typhus species they are used for removal of heavy metals from the water under aerobic conditions so here this oxidation occurs naturally because this surface is open to the atmosphere. So, and there are natural oxidation of metals takes place and then these metals after oxidation they get precipitated and finally, they are absorbed by these aquatic plants the species which are grown over the surface of this aerobic wetland system. So, similarly there are anaerobic wetland system comparatively deeper wetland system so here again there is a layer of this organic matter then there is a limestone filled at the bottom so as to create the neuro obesity and neutralization into the bed and then over this the water layer is there and then there are the plants are the species which are planted over the surface to remove out these heavy metals so this basically the organic matter and the limestone basically helps in removing the acidity and this organic matter provides the substrate for the plants to grow over this and these heavy metals present into the mine water that is absorbed with the plants and

retained in the wetland for a period of 10 days 15 days and finally the clarified effluent free from this heavy metal is taken out from this wetland system. So, these are essentially like horizontal flow systems which are adopted in this wetland. So similarly there are alkalinity producing systems so alkalinity producing system at the bottom you can see these are the limestone beds which are overlying with the organic matter to provide the substrate and then this water is there so at the top this acidic water is applied so this acidic water uses the alkalinity present at the bottom and gets neutralized so this is a kind of system for neutralization of acid mine drainage. Similarly, there are anoxic limestone drains which are provided. So, here in anoxic conditions the precipitation of metals takes place, so this is mostly consist of a liner all over this drain that is provided by 20 to 40 millimeter plastic liner and there is a top layer made of this 2-4 feet of soil and then this is surrounded by limestones so this trench is filled with the limestone and water is allowed to flow through this drain where this water gets neutralized and under the anoxic conditions metals they are precipitated and finally they are removed from the water. So, similarly there are limestone ponds then open limestone channels where they are mostly used as a neutralizing system for acid mine drainage.

So, let us talk about this wetland system little more details about the aerobic wetland system so this aerobic wetland system, basically they are typically designed to precipitate out the metals present into the acid mine drainage under aerobic conditions which is usually done in a horizontal flow system so this is the water layer basically that is provided and its thickness that is hardly 2.5 to 7.5 centimeter thick water layer is passed over the layer of this 30 to 90 centimeter organic matter so this is relatively shallow type of wetland system where the total depth does not exceed more than one meter and at the top here the species like Typha and Sphagnum. They are basically used for adsorption of the heavy metals presented to the mine water after the precipitation these plants also prevent channeling and filter and stabilize the accumulating ferric precipitates from after neutralization of wastewater, so they are basically works on the natural oxidation and precipitation process where iron and manganese gets oxidized and gets precipitated in the form of their hydroxide. So, these aerobic wetlands they are especially effective when the incoming water that is mostly alkaline and then the efficiency of this treatment system that mostly depends upon the concentration of dissolved metals, dissolved oxygen, air, pH and the alkalinity of the acid mine drainage, active microbial biomass and the retention time. So, there are many factors which affects the efficiency of the aerobic wetland system for treatment of acid mine drainage and also for alkaline mine water.

So this is anaerobic treatment system, so this is anaerobic wetland methods in anaerobic wetland methods they are basically the modification of the natural wetland system so these are relatively deeper wetland system and consist of a layer of an organic substrate which is provided here is provided here and mine water passes urgently through a layer of thick oxygen free layer which is made of spent mushroom. So, this is basically the spent mushroom through which the water is allowed to pass through and this basically contains 10 % of calcium carbonate which breaks down the sulfate and removes the oxygen and creates the anaerobic conditions into the wetlands and this material can also be like other compost materials such as sawdust, peat moss and the wood chips or Hay, they can also be used as a compost material at the bottom instead of the spent mushroom and these bed plants are used to treat the acidic discharge at application rate of 3.5 gram of acidity per meter square per day.

So this is basically the surface application rate or the loading rate of the acidity into the wetland that has to be provided. And in anaerobic conditions because the acid mine drainage that also contains lot of sulfur so this sulfur basically anaerobically in presence of the substrate which is basically here the organic matter which acts as a carbon source so this sulfate gets anaerobically decomposed into H_2S and this bicarbonate alkalinity is also produced. So, this is like the system which are used for removal of heavy metals and degradation of sulfate so here whatever this sulfate that will get converted into H_2S that will be removed from the water ($2H_2O + SO_4^{2-} + C\ (organic\ matter) \rightarrow\ H_2S + 2HCO_3$).

So, these are the advantages and disadvantages of passive methods and active methods. So, if we talk about the advantages of passive methods so these are basically naturally occurring process occurs through the biological and geochemical process, so they require basically low energy input and limited edition of the reagent or chemicals low operation and maintenance cost. So, they are basically cheaper and low-cost treatment systems but if we talk about the efficiency of the system. So, these systems basically they are very slow and cannot be controlled effectively, so because of this the treatment efficiency of passive treatment system they are relatively lower than the active treatment systems and moreover it requires a lot of land for its construction and design and in this system also if we see there is a built up of heavy metal takes place in the wetland and in the plants that all the heavy metal get collected and stored into the plants so built up of the heavy metal takes place rather than its removal and treatment. And then generation of the hazardous sludge and the gases like H_2S a very corrosive gases that are generated through this passive method, so lot of sludge that will be also generated after the treatment process is completed. So, this further require its disposal and then the production of clean water and possibility of recovery of various metal contains there are precious metals which are present into the acid mine drainage, so that option cannot be exercised into these passive methods.

So, these are the references you can use for your study.

And then thank you.