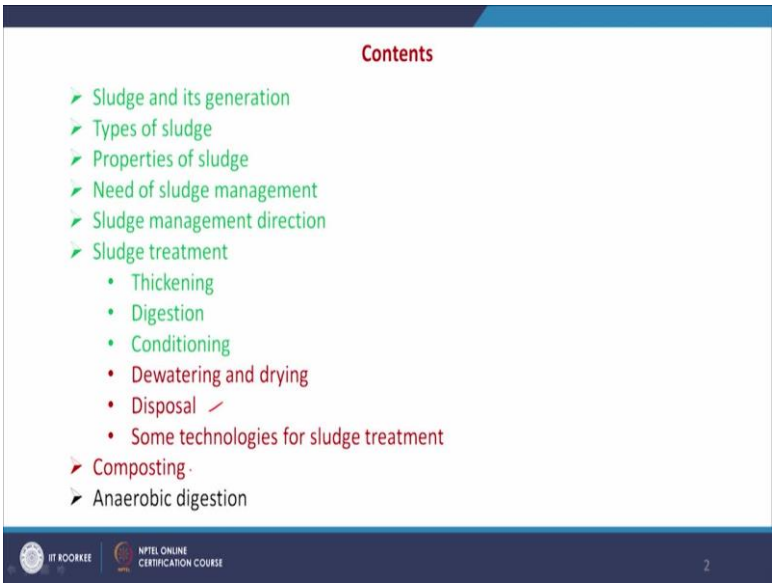
Basic Environmental Engineering and Pollution Abatement
Professor Prasenjit Mondal
Department of Chemical Engineering
Indian Institute of Technology, Roorkee
Lecture 42
Sludge Management - 2

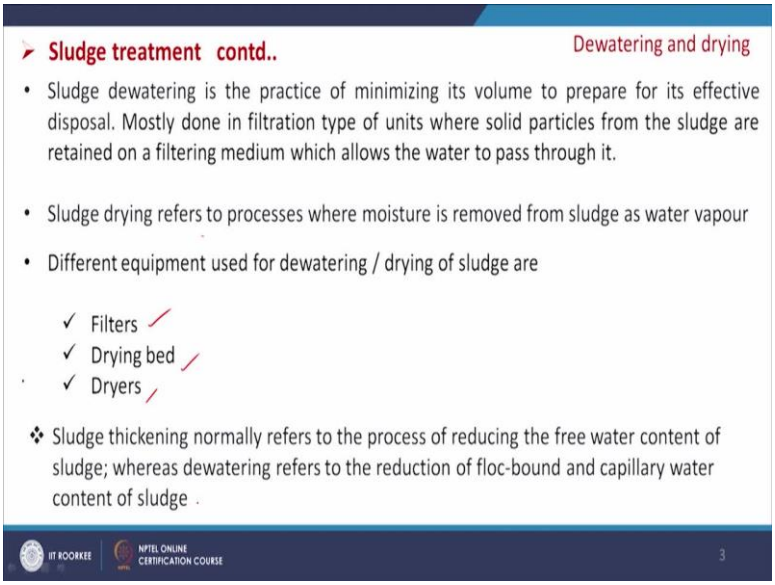
Hello everyone, now we will discuss on the topic sludge management part 2.

(Refer Slide Time: 0:39)



In this class we will discuss on dewatering and drying, disposal and some techniques for sludge treatment, which are the part of sludge treatment and then we will also discuss on the composting.

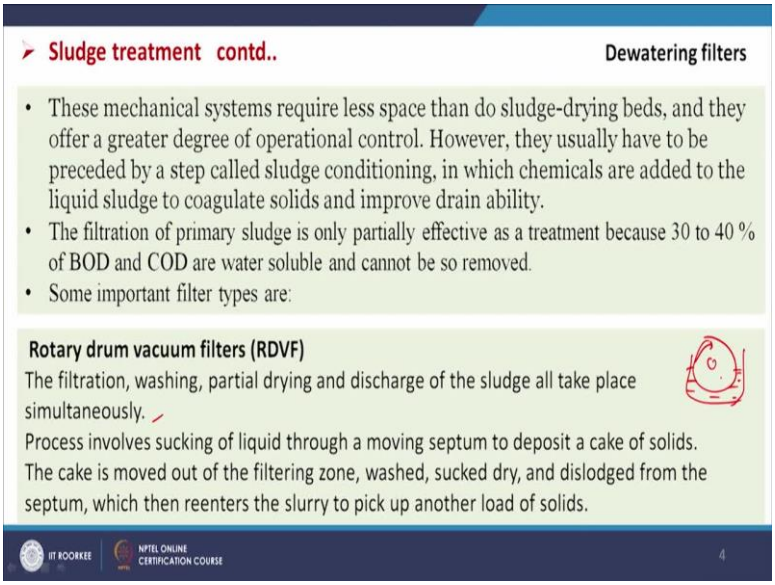
(Refer Slide Time: 0:54)



So already we have discussed that the sludge treatment includes its thickening, and concentration, digestion, conditioning and then dewatering. So this dewatering basically the removal of water present in the sludge and this removal may be possible by filtration or by application of heat. So the sludge dewatering is the practice of minimizing its volume to prepare for its effective disposal mostly done in filtration type of units where solid particles from the sludge are retained on a filtering media which allows the water to pass through it. And sludge drying refers to processes where moisture is removed from sludge as water vapor. So here applying heat maybe sunlight or the application of heat.

And then different equipment used for dewatering or drying of sludge are filters and then drying bed and dryers. One similar term we have seen in our previous classes that thickening, so thickening also deals with the removal of moisture content of it, but this sludge thickening normally refers to the process of reducing of pre water content of sludge, whereas dewatering refers to the reduction of floc-bound and capillary water content of sludge. So this is the basic difference between the thickening and dewatering process.

(Refer Slide Time: 02:34)

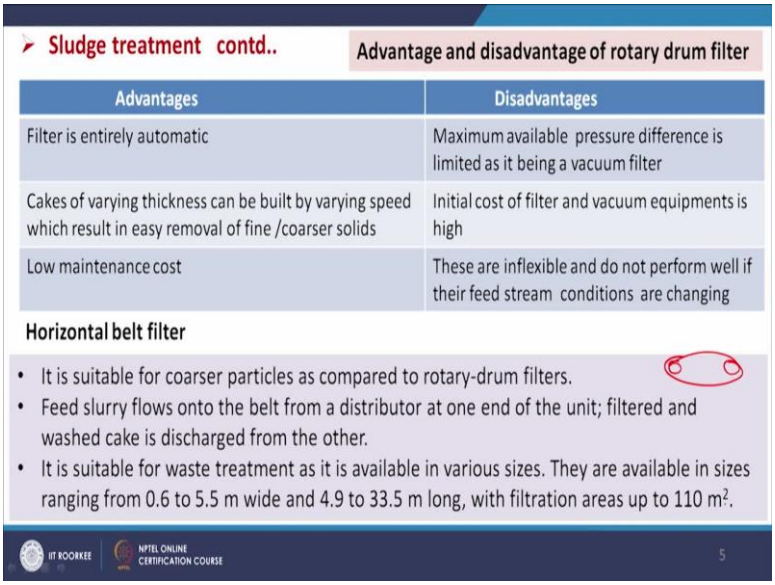


Now, we will see different types of filters used for dewatering purpose. So these are mechanical systems which require less space than do sludge drying beds and they offer a greater degree of operational control. However, they are usually have to be preceded by a step called sludge conditioning, in which chemicals are added to the liquid sludge to coagulate solids and improve durability. And the filtration of primary sludge is only partially effective as a treatment because 30 to 40 % of BOD and COD are water soluble and cannot be removed.

Some important filter types are rotary vacuum filters, plate and film filters, and then we will see centrifuge and bed filter etc. So rotary drum vacuum filters, so this is a continuous filtration unit. Where, filtration, washing, partial drying and discharge of the sludge all take place simultaneously. Already we have discussed in our previous classes. In this case, the process involves sucking of liquid through a moving septum to deposit a cake of solid.

The cake each moved out of the filtering zone washed, sucked, dry and dislodged from the septum, which then reenters the slurry to pick up another load of solids. So this type of we have discussed in our class. So this will be rotating and it will half filled with the waters and then there will be some vacuum, so the liquids will go and solids will be detained here, so that will be.

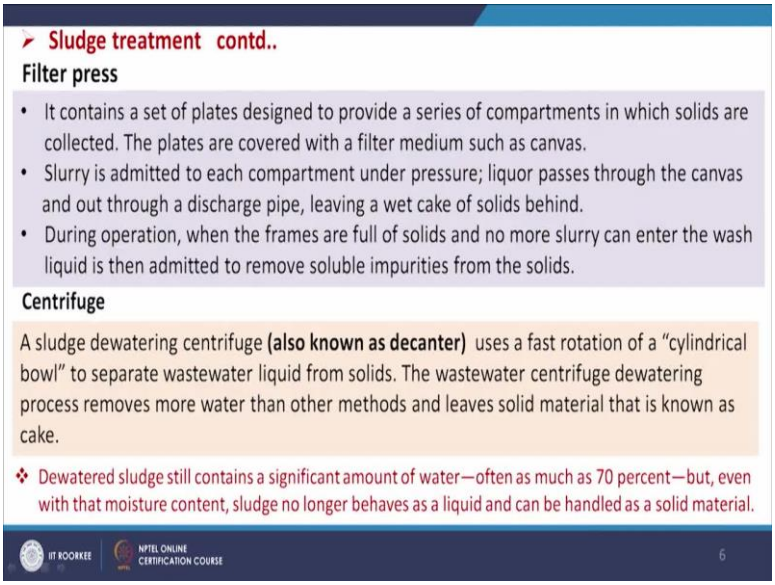
(Refer Slide Time: 04:29)



And the advantage and disadvantage of this rotary drum filter. So this filter is essentially automatic and cakes or varying thickness can be built by varying speed, which result in easy removal of fine and coarse solids, so both fine and core solids can be removed and then low maintenance cost. But disadvantages are maximum available pressure differences limited as it being a vacuum filter. Initial cost of filter in vacuum equipment is high, these are inflexible and do not perform well if their feed stream conditions are changing.

Then horizontal belt filter it is suitable for coarser particle as compared to rotary drum filters. And feed slurry flows onto the build from a distributor at one end of the unit filtered and washed cake is discharged from the other end. So just like this a it will be like this and then from this it is entering it that is collected. So it is suitable for waste treatment as it is available in various sizes. They are available in sizes ranging from 0.6 to 5.5 m wide and 4.9 to 33.5 m long, with filtration areas up to 110 m^2, there are some typical values.

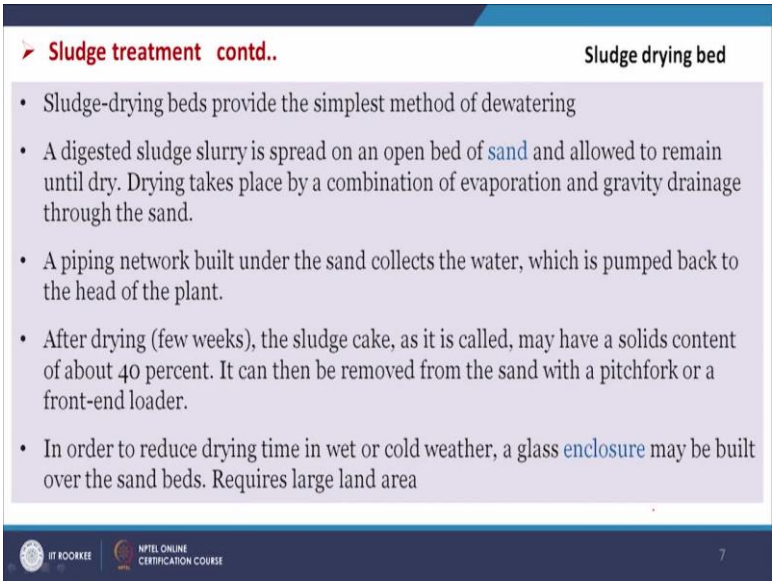
(Refer Slide Time: 05:52)



Filter press, it contains a set of plates designed to provide a series of compartments in the solids are collected, the plates are covered with a filter medium such as Canvas, and slurry is admitted to each compartment under pressure, liquor passes through the canvas and out through a discharge pipe leaving a wet cake up solids behind. During operation when the frames are full of solids and no more slurry can enter the worst liquid is then admitted to remove soluble impurities from the solids, so this is a batch type of operation we can say.

And centrifuge, a sludge dewatering centrifuge is also called as decanters, uses a fast rotation of a cylindrical wall to separate wastewater liquid from solid, the wastewater centrifuge dewatering process removes more water than other methods and leaves the solid material that is known as cake. And dewatered sludge still contains a significant amount of water often as much as 70 %, but even with that moisture content sludge no longer behaves as a liquid and can be handled as a solid material.

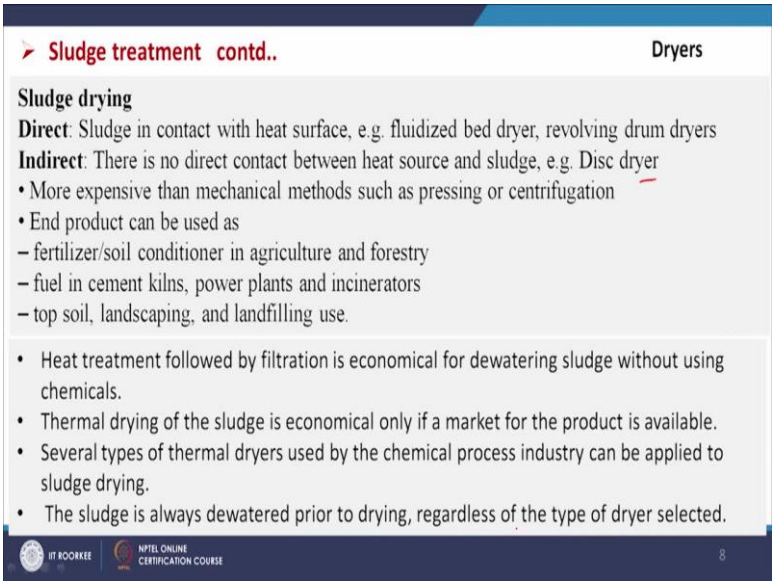
(Refer Slide Time: 07:12)



Then we will see sludge drying bed. So sludge drying beds provide the simplest method of dewatering, simply we can use sunlight for the drying of bed for the evaporation of the water. A digested sludge slurry is sprayed on an open bed of sand and allowed to remain until dry. The drying takes place by a combination of evaporation and gravity drainage through the sand. So we are giving sand bed means water will be drained through the sand as well as it will be vaporized. So then, the drained water that a piping network built under the sand collects the water which is pumped back to the head of the plant, so some part water is recycled back.

And after drying the sludge cake as it is called may have a solids content of about 40 %, so few weeks drying in necessary and it can then be removed from the sand with a pitchfork or a front end loader. In order to reduce drying time in wet or cold weather a glass enclosure may be built over the sand beds, it requires large land area, so that is the main drawback of this process.

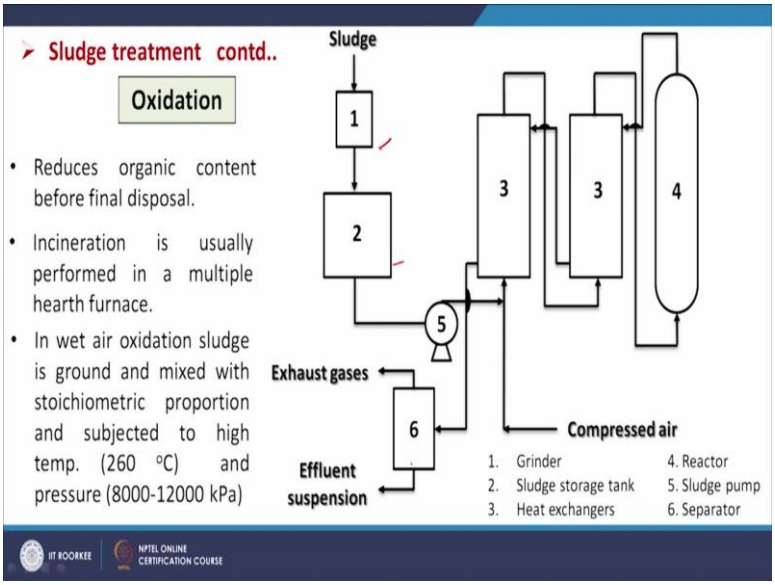
(Refer Slide Time: 08:29)



And dryers this dryers method you know we apply heat, it may be direct contact with the heat or indirect heating. So sludge is in contact with heat surface that is direct heating that is fluidized with dryer and revolving drum dryers. And indirect there is no direct contact between heat source and sludge that is disc dryer, but these processes are very costly process and not suitable for normal application until the sludge after drying becomes very costly and very useful, in that case only it can be used.

And end products can be used as fertilizer, soil conditioner in agriculture and forestry. Fuel in cement kilns, power plants and incinerators, top soil, landscaping and landfill use. Heat treatment followed by filtration is economical for dewatering sludge without using chemicals. So if we use heat treatment, initially followed by dewatering then this process may be economical. So thermal drying of the sludge is economical only if a market for the product is available. Several types of thermal dryers used by the chemical process industry can be applied to slash drying. The sludge is always dewatered prior to drying, regardless of the type of dryer selected.

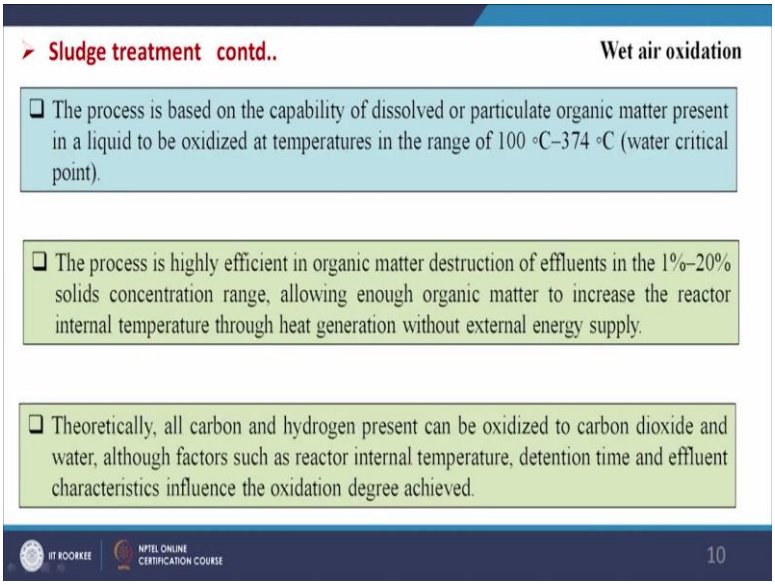
(Refer Slide Time: 09:52)



Now we will discuss on the oxidation. So there are 2 types of methods through which oxidation can take place that is wet air oxidation and incineration. Incineration basically dried material is combusted and in case of wet air some moisture content is necessary. So in wet air oxidation sludge is ground and mixed with stoichiometric proportion and subjected to high temperature that 260 ^{o}C and pressure. So here we see one that is equal to grinder, then sludge is coming after grinding, it is going to storage tank then it is being pumped to this 2 chambers that is heat exchangers and from the heat exchanger is coming to the fore that is reactor.

So from this reactor we are providing either compressed air or oxygen. So here this will be in chamber 3 that will be heat exchanger in presence of air and in 4 the high temperature will be there and pressure will be the show more oxidation of the organic compound will take place and after that it will be again pass through these 3 that means, this hot stream coming out from the 4 will be used to increase the temperature of the inlet stream in chamber 3 and then from this it is coming and after separation it just gases we are getting an effluent suspension we are getting. So now, the organic content present in this that is reduced here. So that is the mechanism of the wet air oxidation.

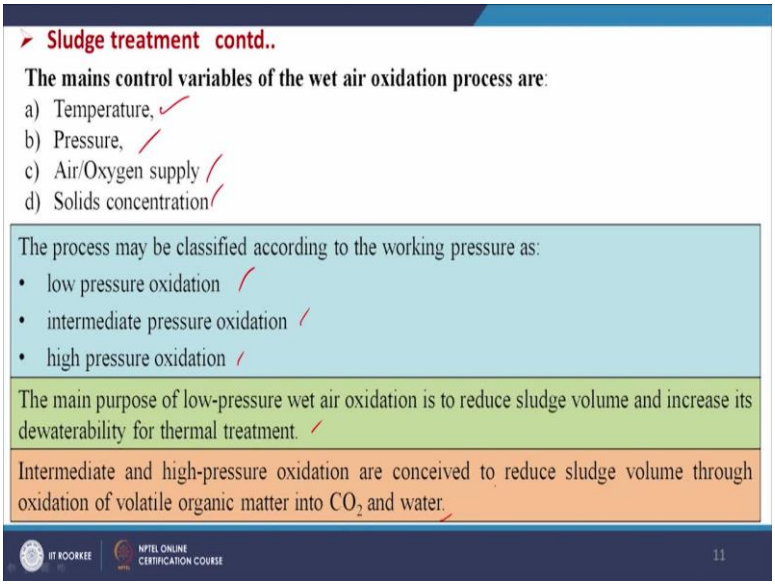
(Refer Slide Time: 11:33)



And this wet air oxidation the process is based on the capacity of the dissolved or particulate organic matter present in a liquid to oxidized that temperature in the range of 100 to 374 ^{o}C. The process is highly efficient inorganic matter destructions of effluence in a 1 to 20 % solids concentration range, allowing enough organic matter to increase the reactor internal temperature through heat generation without external energy supply.

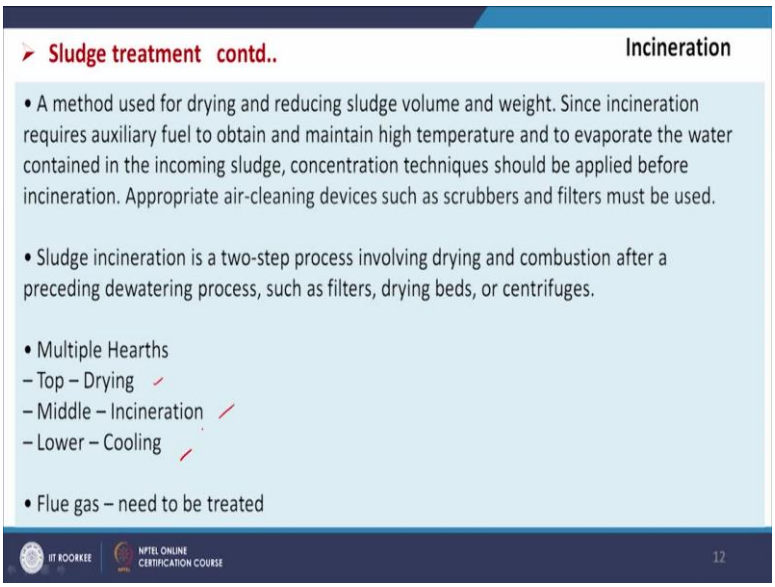
That means that oxidation processes a combustion process and exothermic process so heat is released so high solid content is available that means additional heating to maintain the temperature may not be needed. And thermally all carbon and hydrogen present can be oxidized to carbon dioxide and water. Although factors such as reactor internal temperature, detention time and effluent characteristics influence the oxidation degree achieved in this process.

(Refer Slide Time: 12:28)



There are many factors which influence the performance of wet air oxidation, like say temperature, the pressure, air or oxygen supply, and solids concentration. And the process may be classified according to working pressure as, low pressure oxidation, intermediate pressure and high pressure oxidation. The main purpose of low pressure wet air oxidation is to reduce sludge volume and increase its dewaterability for thermal treatment. And the intermediate and high pressure oxidation are conceived to reduce sludge volume through oxidation of volatile organic matter into CO_2 and water.

(Refer Slide Time: 13:07)

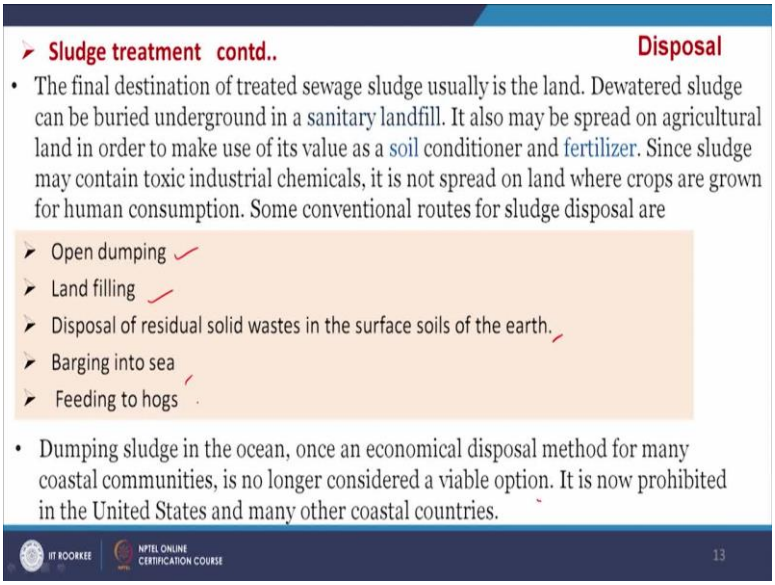


Next, another method is incineration. That I told you this is a combustion, the sludge is dried and solid content is increased then it is combusted by the application of heat. So a method

used for drying and reducing sludge volume and weight since incineration requires auxiliary fuel to obtain and maintain the high temperature and to evaporate the water contained in the incoming sludge concentration techniques should be applied before incineration. And in this case, since the auxiliary fuel we are using so the air pollution possibilities will be there.

So appropriate air cleaning devices such as scrubbers and filters must be used. And sludge Incineration is a 2 step process involving drying in combustion after a preceding dewatering process such as filters, drying beds or centrifuges. And in this process, we can use the incinerator maybe of multiple hearths at top drying, then middle incineration, and lower in the cooling. The flue gas that need to be treated, the auxiliary fuel is used so flue gas is generated that need to be treated, so this is the incineration. And we will be having detailed discussion on incineration in solid waste management and the same methods is applicable for the incineration of the sludge also.

(Refer Slide Time: 14:29)

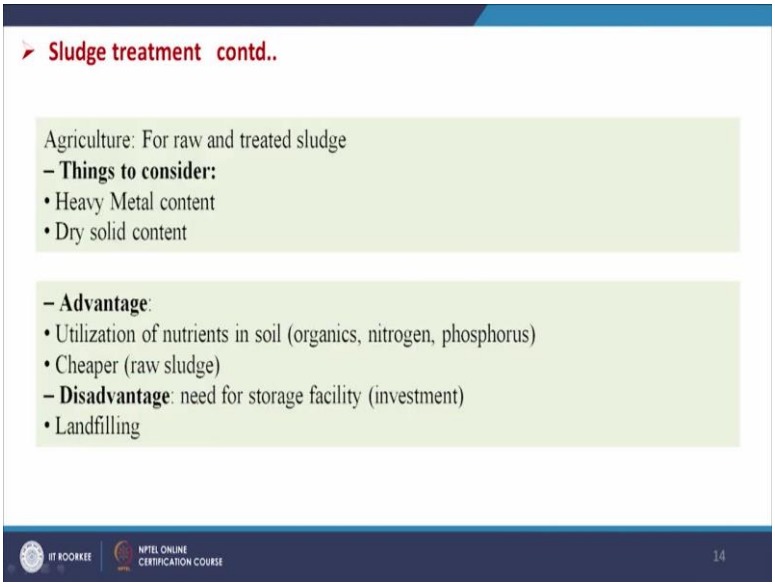


Now we are coming to disposal part, so disposal the final destination of treated sludge usually is the land. So dewatered sludge can be buried underground in a sanitary landfill, it also may be spread on agricultural land in order to make use of its value as a soil condition and fertilizer. Since sludge may contain toxic industrial chemicals, it is not sprayed on land where crops are grown for human consumption.

Some conventional routes for sludge disposal are, so open dumping, landfilling, disposal of residual solid waste in surface soils of the earth, and barging into sea. And this dumping sludge in the ocean, this once an economical disposal method for many coastal communities

is no longer considered a viable option. It is now prohibited in the US and many other coastal countries. Feeding to hogs is also one options that is not that important.

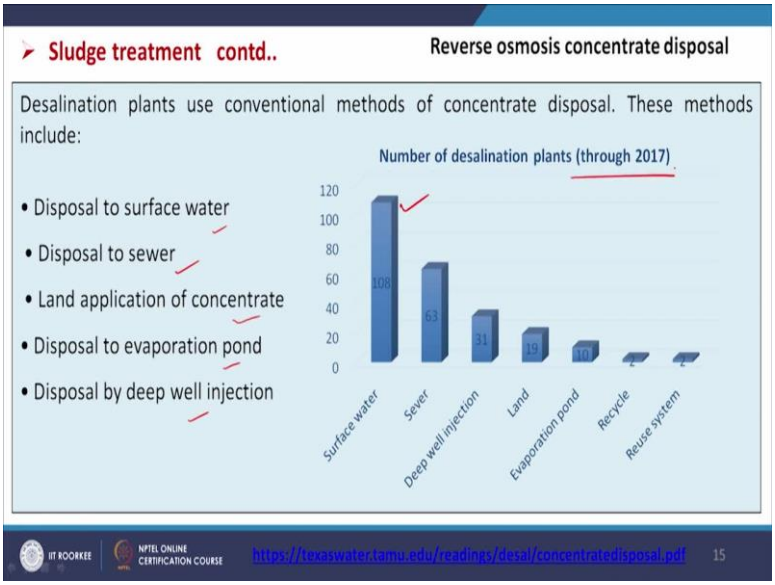
(Refer Slide Time: 15:43)



And then, so if the dried sludge is having some nutrient value and very less toxicity, since that can be used for agriculture purpose. And when we are considering for the use of sludge in agriculture purpose, we must consider the heavy metal content present in it and dry solid content present in it and what are the nutrients present in it. And the advantage we can get through this process because that utilisation of nutrients in soil, organic, nitrogen, phosphorus, and then cheaper source for nutrients.

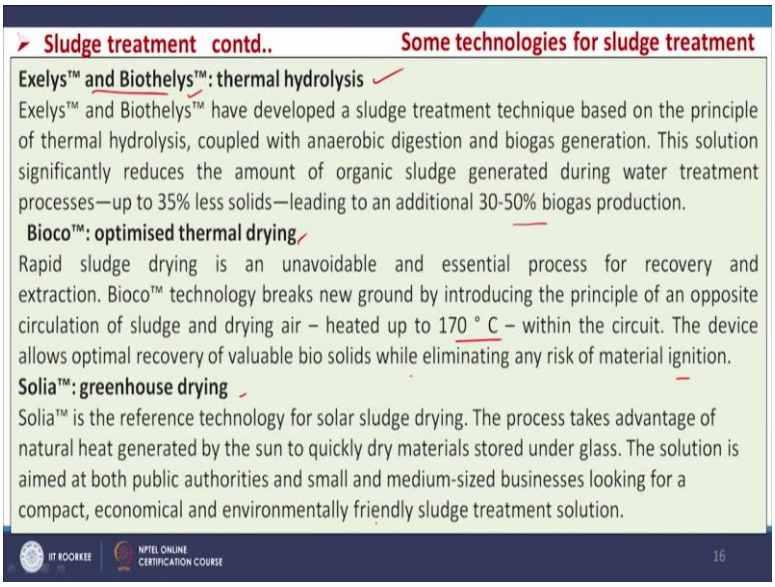
If particularly we use the raw sludge, then the sludge treatment cost is also not involved. But it had some disadvantage, there is need for storage facility that requires investment and land filling. So gradually if we use these for a longer period, so accumulation of sludge that will increase the lassie volume and landfilling will take place the height or the land will increase.

(Refer Slide Time: 17:12)



Now we will see that reverse osmosis concentrate disposal. So this disposal is related with the disposal of the solids generated through that tertiary method. So this desalination plants use conventional methods of concentrate disposal, these methods include disposal to surface water, disposal to sewer, land application of concentrate disposal to evaporation pond, and disposal by deep well injection. So these are the different methods which have been followed or used for the disposal of the tertiary treatment methods that is reverse osmosis concentrate and you see the maximum use of the surface water disposal. And these data are given as per this report in 2017.

(Refer Slide Time: 17:54)

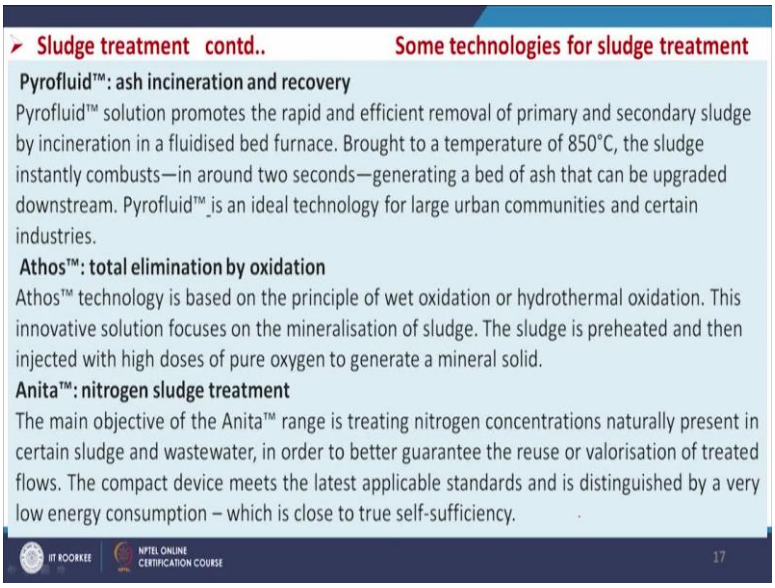


Now, we will see some technologies for sludge treatment. So we have made different methods and techniques which can be implemented for the management of sludge. Now, we will see some patented technology, which have been developed on the basis of different techniques for the real field application like say, Exelys^{TM} and Biothelys^{TM}, so this method is basically called thermal hydrolysis, we have made discussion on thermal hydrolysis, so this is another this technology.

Exelys ^{Tm} and Biothelys ^{TM} they have developed a sludge treatment technique based on the principle of thermal hydrolysis coupled with anaerobic digestion and biogas generation. This solution significantly reduces the amount of organic sludge generated during water treatment process up to 35 % less solids leading to an additional 30 to 50 % biogas production. So that already have discussed that in that case, biogas production increases.

And Bioco ^{TM} process that is optimized thermal drying. So in this case counter current use of dryer and the sludge has been used, and it is heated up to 170 ^{o}C within the circuit, the device allows optimal recovery of valuable biosolids while eliminating any risk of material ignition. Then Solia ^{TM} that is greenhouse drying. In this method, the solar sludge drying has been implemented, the process takes advantages of natural heat generated by the sun to quickly dry material stored under glass. The solution is aimed at both public authorities and small and medium sized business looking for a compact, economical and environmentally friendly sludge treatment solution.

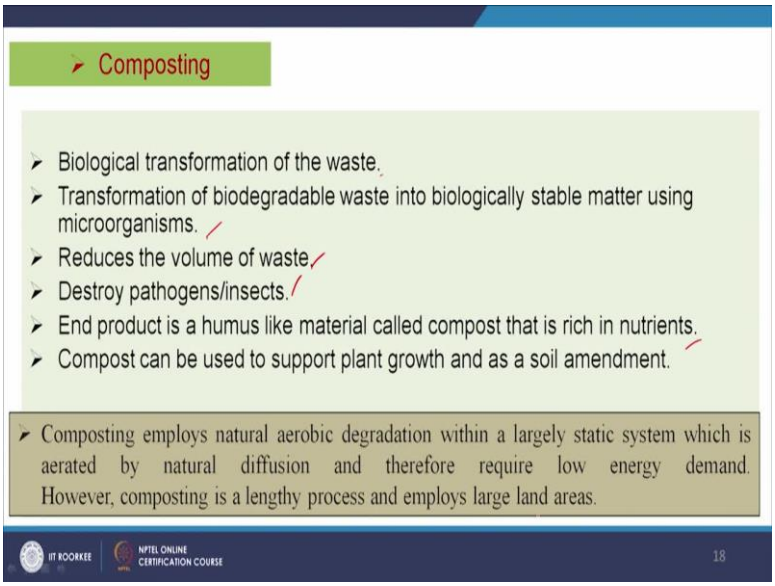
(Refer Slide Time: 19:50)



And Pyrofluid ™ that is based on ash incineration and recovery in focus, and this method promotes the rapide an efficient removal of primary and secondary sludge by incineration in a fluidized bed furnace, brought to a temperature of 850 ºC. The sludge instantly combust in around 2 seconds generating a bed of ash that can be upgraded downstream. And pyrofluid™ is an ideal technology for large urban communities and certain industries.

And Athos™ total elimination by oxidation. So this technology is based on the principle of wet oxidation or hydrothermal oxidation. This innovative solution focuses on the mineralization of sludge, the sludge is created and then injected with high doses of pure oxygen to generate a mineral solid. And Anita™, this is nitrogen sludge treatment. Basically, the main objective of the Anita™ range is treating nitrogen concentrations, naturally presenting certain sludge and wastewater in order to better granted or reuse or valorization of treated flows. The competitive device meets the latest applicable standards and is distinguished by a very low energy consumption, which is close to true self-sufficiency.

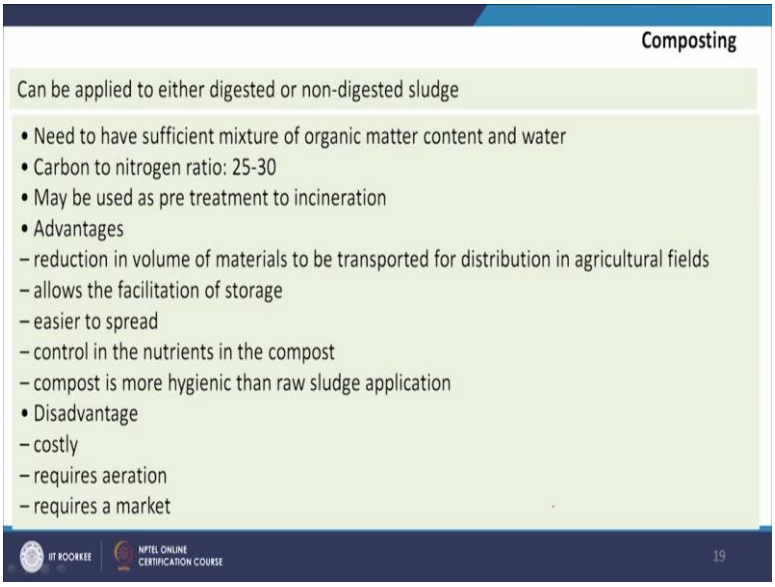
(Refer Slide Time: 21:13)



Now, we will discuss on composting. So this is also one important way of sludge management, so this is applicable for the management of sludge as well as the solid waste. So in this case what happens the organic compounds are converted into manure. So it is a biological transformation of the waste. The transformation of biodegradable waste into biologically stable matter using microorganisms, it reduces the volume of waste, it destroys pathogens and insects. In end product is a humus like material called compost that is rich in nutrients and compost can be used to support plant growth and as a soil amendment. And composting employs natural aerobic degradation with a largely static system, which is

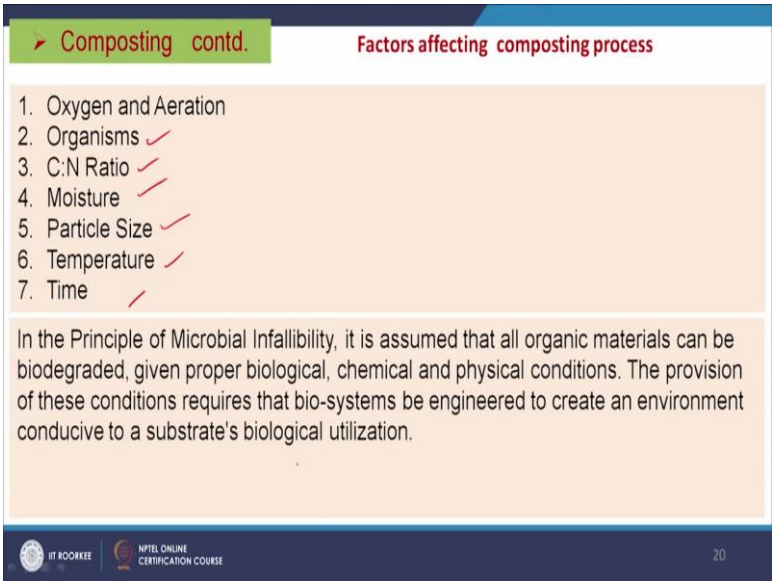
aerated by natural diffusion and therefore require low energy demand. But it is a lengthy process and implies large land areas.

(Refer Slide Time: 22:17)



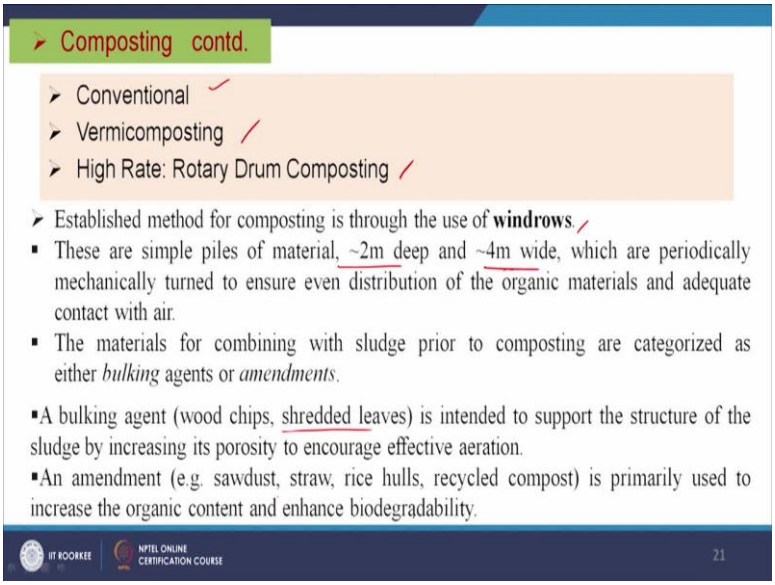
This can be applicable to either digested or non-digested sludge as I told you, it may be digested sludge may be non-digested sludge or it may be some other organic compounds within it. So need to have sufficient mixture of organic matter, content, and water, carbon to nitrogen ratio that is 25 to 30, and may be used as pretreatment to incineration. And it has some advantages that is reduction in volume of materials to be transported for distributions in agricultural fields allows the facilitation of storage and easier to spread controlling the nutrients in the compost. Compost is more hygienic than raw sludge application. But it has some disadvantages like it is costly, requires aeration and requires market.

(Refer Slide Time: 23:12)



We will see different factors which influence the performance of the composting process. Like say the oxygen and aeration, what type of organisms we are using that will also influence the performance. Carbon and nitrogen ratio that is 20 to 30 %. And moisture is also an important fact for the biological growth and then the particle size also important because aeration here diffusional be influenced by this. Temperature is necessary for the microbial growth time is also required for the conditions of the organic compound. And in a principle of microbial infallibility, it is assumed that all organic materials can be biodegraded, given proper biological, chemical and physical conditions. The provisions of these conditions requires that bio systems be engineered to create an environment conducive to a substrate biological utilisation.

(Refer Slide Time: 24:10)



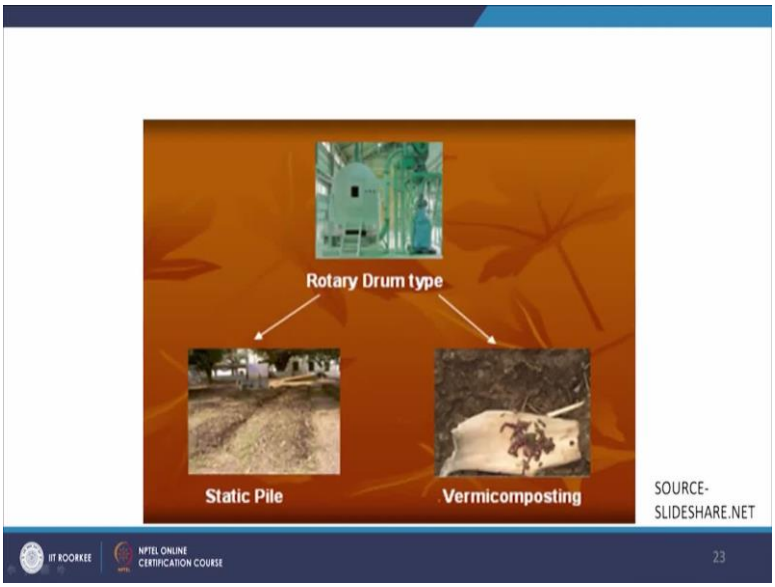
Now, if we see there are different types of composting methods, let us say conventional, vermicomposting and high rate or rotary drum composting. So this conventional composting basically this is an established method for composting through the use of windrows. These are simple piles of material, 2 m deep and 4 m wide, which are periodically mechanically turned to ensure even distributions of the organic materials and adequate contact with air.

The materials for combining with sludge prior to composting are categorised as either bulking agent or amendments. So as I told you that sludge can be mixed with some other organic compounds for effective composting and these compounds are called bulking agents or amendments. A bulking agents like say woodchips shredded leaves is intended to support the structure of the sludge by increasing its porosity to encourage effective aeration and an amendment that is sawdust, straw, rice hulls, recycled compost is primarily used to increase the organic content and enhance biodegradability.

(Refer Slide Time: 25:30)

Now these slides shows us some vermicomposting photographs, so these are different types of worms are used in this case of composting.

(Refer Slide Time: 25:41)



Now, this slide shows us static pile, then rotary drum and vermicomposting, so 3 major type of composting which are used for the production of compost from the solid waste as well as the sludge. So Rotary drum type having more rate and the conditions are more effectively controlled. So these are the different methods which are used for the composting purpose. So up to this in this class, thank you very much for your patience.