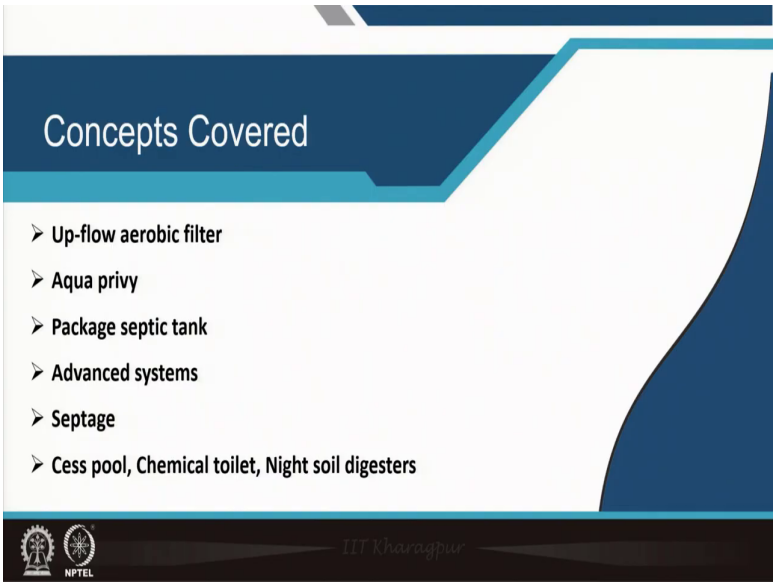
Urban Utilities Planning: Water Supply, Sanitation and Drainage
Prof. Debapratim Pandit
Department of Architecture and Regional Planning
Indian Institute of Technology, Kharagpur

Module - 07
Sanitation and Drainage Fundamentals
Lecture - 34
Sewage Systems Part II

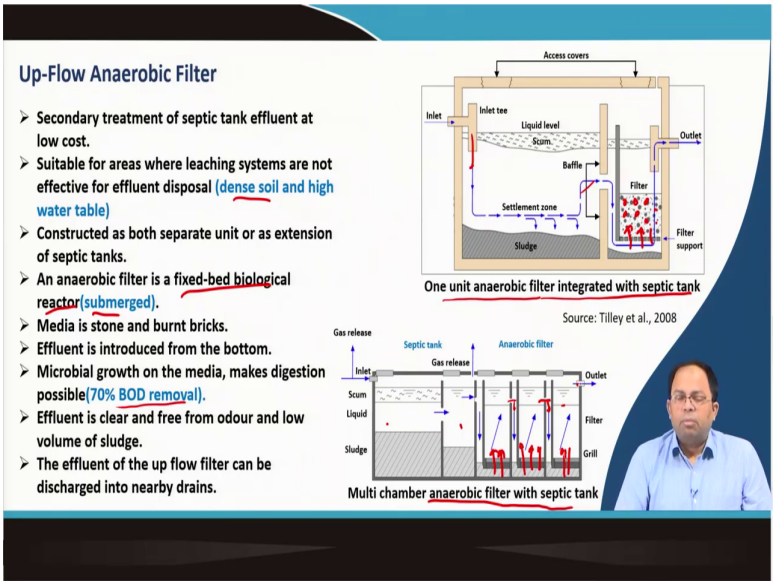
Welcome back. In lecture 34, Sewage Systems Part II will be covered.

(Refer Slide Time: 00:34)



The different concepts that will be covered in this lecture are up-flow aerobic filters, aqua privy, package septic tanks, advanced systems, on-site systems, septage, cesspool, chemical toilets and night soil digesters.

(Refer Slide Time: 00:55)



Up-flow anaerobic filter

Instead of disposing of the effluent that comes out of septic tanks using dispersion trenches and soakage pits, this alternative system treats the effluent further. It involves secondary treatment of septic tank effluent. This is possible at low cost. It is suitable for areas where leaching systems are not effective for effluent disposal such as having a very dense soil with a high water table etc. and dispersion trenches or soak pit is not recommended. So there is a requirement to treat the effluent before releasing it into the open drains or land disposal. It can be constructed as an individual unit or as an extension of the septic tank. Anaerobic filter is a fixed-bed biological reactor that involves the breaking down of impurities in the effluent to simpler components with the action of bacteria and also known as secondary treatment.

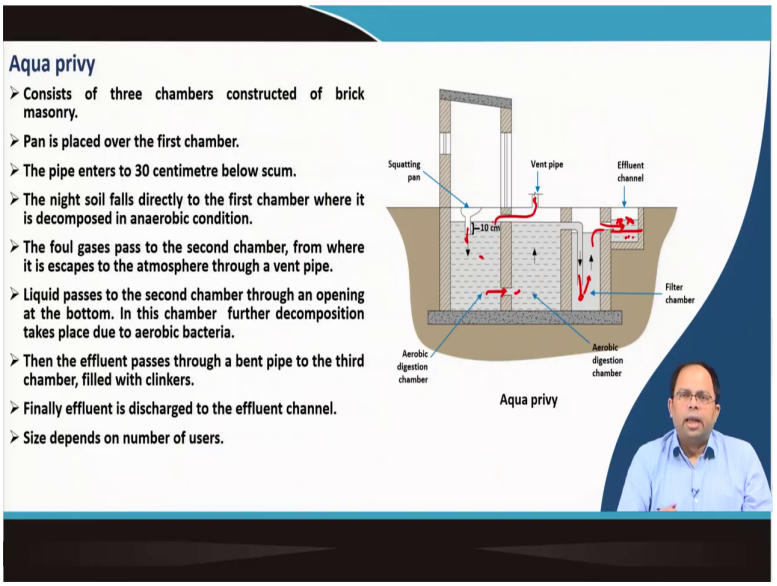
The image shows a single unit anaerobic filter integrated with the septic tank. The first chamber consists of the water inlet which allows the sewage inside and a settlement zone, where the settlement of the sludge occurs. The water is then conveyed across the baffle as shown in the image to the adjacent chamber where the effluent flows upward from the bottom to pass through the filter media which consists of components such as brickbats. Bacterial action also occurs in this chamber. This process leaves the effluent treated. The treated water is conveyed out of the chamber through the outlet. The filter media is generally stone and burnt bricks. Microbial growth in the media makes digestion possible and leads to around 70

percent of the BOD. So, effluent is made clear and free from odour and a low volume of sludge is produced. Thus, discharging the effluent from the up-flow filter into nearby drains is possible.

Multi-chamber anaerobic filters are also designed. Two chambers constitute the septic tank and the adjacent 3 chambers consist of the filter media where the biological action takes place as shown in the bottom image in the above figure. The effluent from the septic tank is conveyed down and is allowed to move up from the bottom through the up-flow filters of the first chamber. Similarly, it is conveyed down again to the bottom of the third chamber to convey it upward through the upflow anaerobic filter and so on. As three chambers are involved to allow subsequent treatment, almost the entire BOD can be removed. The water after this treatment is thus safe to be discharged eliminating the contamination of soil or can be used for farming or gardening purposes.

Aqua privy

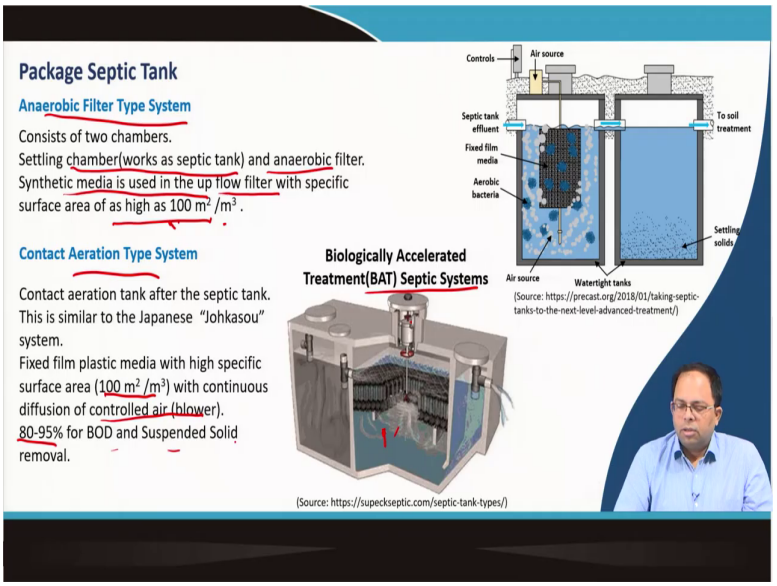
(Refer Slide Time: 05:26)



Aqua privy is a toilet that is often used in the slums. This system consists of a toilet, septic tank and an up-flow anaerobic filter system. It consists of three chambers constructed of brick masonry. Pan is placed over the first chamber and the pipe enters to 30 centimetres below the scum as shown in the above figure to ensure the water seal. The night soil falls directly to the

first chamber where it is decomposed in anaerobic conditions. The foul gases pass to the second chamber (anaerobic digestion), from where it escapes into the atmosphere through the vent pipe. The liquid then passes to the second chamber through an opening as marked in the figure. Further decomposition takes place in the second chamber and involves the action of aerobic bacteria following which the effluent passes through a bent pipe to the third chamber filled with clinkers or brickbats which acts as an up-flow anaerobic filter and finally, the effluent gets discharged through the effluent channel as marked in the above figure. This may be conveyed further to a nearby drain. The size of the system depends on the number of users. This integrated system can be used in areas with space constraints.

(Refer Slide Time: 07:18)



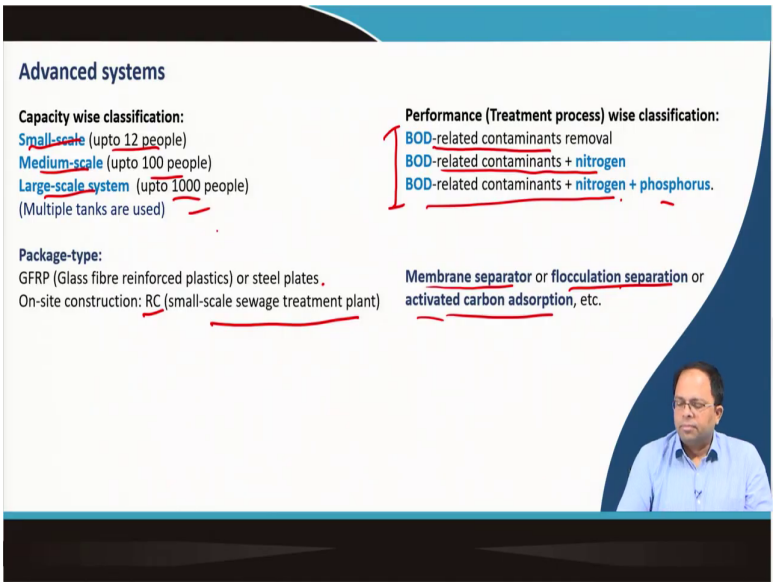
Package septic tanks

These systems can employ both aerobic filtration as well as anaerobic filtration.

Anaerobic filter type system – It consists of two chambers of which one is a settling chamber and works like a septic tank and the other one consists of a synthetic media used as an up-flow anaerobic filter with a specific surface area as high as 100 meters square per meter cubes. Efficient treatment happens because of such a large surface area. This can be made as a package system.

Contact aeration type system – Unlike the previous system, provision for exposure to air can be provided as in case of the biologically accelerated treatment septic systems which has access to an air source on the top, a compression pump and the media as shown in the bottom image of the above figure. The first part is the settling tank and from where the effluent is conveyed across the media along with aeration and thus achieving efficient digestion. Contact aeration tank, after the septic tank. It is similar to the Japanese Johkasou system. Fixed film plastic media with high specific surface area (100 m^2 /m^3) with continuous diffusion of controlled air via blower is employed. 80 to 90 percent of BOD and suspended solids are removed. As aeration is also involved along with the action of the filter media, the mixing becomes much more efficient helping in the digestion process.

(Refer Slide Time: 09:55)



Advanced systems

Performance (treatment process) wise classification – Systems can be designed with a target to achieve particular processes such as BOD removal, Nitrogen removal etc such as:

- BOD-related contaminants removal
- BOD-related contaminants + nitrogen
- BOD-related contaminants + nitrogen + phosphorus.

Package type

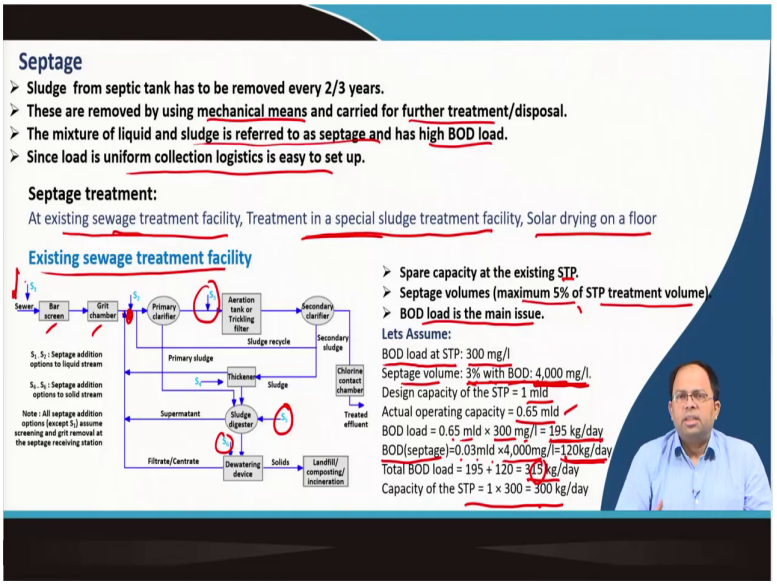
- GFRP (Glass fibre reinforced plastics) or steel plates
- On-site construction: RC (small-scale sewage treatment plant

Based on the treatment processes – Different systems such as membrane separators or flocculation separation or activated carbon adsorption etc. can be employed. In a Membrane separator, a membrane separates the solid particles as it cannot pass through the membrane and results in clearer water passing through it. In a flocculation-based separation system, coagulants are used to achieve flocculation followed by sedimentation for treatment.

Capacity wise calculation

- Small-scale (upto 12 people)
- Medium-scale (upto 100 people)
- Large-scale system (upto 1000 people) - Multiple tanks are used. It is similar to a decentralized system.

(Refer Slide Time: 11:43)



Septage

Septic tanks are mostly used in the Indian urban areas. Usually, the septic tank content is pumped to the municipality vehicle followed by the further treatment of the waste. Sludge from the septic tank has to be removed every 2 or 3 years by mechanical means and then carried for further treatment or disposal. The mixture of liquid and sludge is referred to as septage and has a very high BOD load. As the load is uniform, collection logistics is easy to set up. The septage treatment can be done in different ways. It can be treated in the existing sewage treatment facility or in a special sludge treatment facility only dedicated for septage treatment or based on solar drying on the floor. The sewage treatment plant consists of *bar screen, grit chamber, primary clarifier, aeration tank* or *trickling filter* which allows mixing of sewage with the air resulting in the generation of scum which has a lot of bacteria which helps to further improve the digestion of waste, *secondary clarifier* which results in scum formation and further sedimentation, digestion and reduces the amount of sludge, *thickener* to remove the water from the sludge and thicken it, *a dewatering device* which separates the sludge from the water mechanically by pressing the sludge and the solid part can be conveyed to the landfill or incinerated and the water can be sent back to the same system, and a *Chlorine contact chamber* which disinfects the water coming after the secondary clarification.

If it is treated in an existing sewage treatment facility, then there are multiple options to introduce the septage as represented in the above figure as S1, S2, S3, S4, S5 and S6. S1 and S2 represent the septage addition to the liquid stream along with the sewage coming to the plant. It can be added just before aeration as there is no need or remove course material or grit etc. It can be directly added to the sludge digester or the dewatering device. Based on the treatment which has to be achieved, septate can be added appropriately at a specific stage.

<u>Problem:</u>

Assume that in an existing STP in a particular urban area, there is spare capacity. Septage volume (maximum around 5 percent of the STP treatment volume) means, the total amount of sludge that is generated out of this treatment is upto a maximum of 5 percent. BOD load is the main issue.

BOD load at STP: 300 mg/l

Septage volume: 3% with BOD: 4,000 mg/l.

Design capacity of the STP = 1 mld (assumption)

This indicates that the entire capacity is not utilized.

Actual operating capacity = 0.65 mld (as there are multiple sedimentation chambers and all of it may not be operated at once.)

BOD load = 0.65 mld × 300 mg/l = 195 kg/day

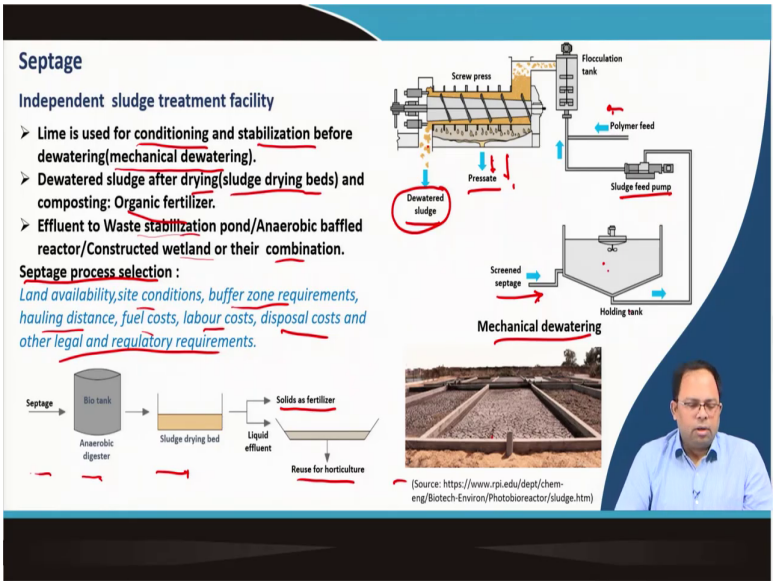
BOD (septage)=0.03mld ×4,000mg/l=120kg/day (is the extra load because of the addition of the septage for the STP which is designed for the conventional sewerage network)

Total BOD load = 195 + 120 = 315 kg/day

Capacity of the STP = 1 × 300 = 300 kg/day

The addition of septage results in a load of 315 kg/day and exceeds the actual capacity of the plant by 15 kg. This indicates that a lesser amount of septage can only be added. Otherwise, a separate facility has to be constructed. This explains the method to determine the feasibility of using an existing facility.

(Refer Slide Time: 19:29)



Independent sludge treatment facility

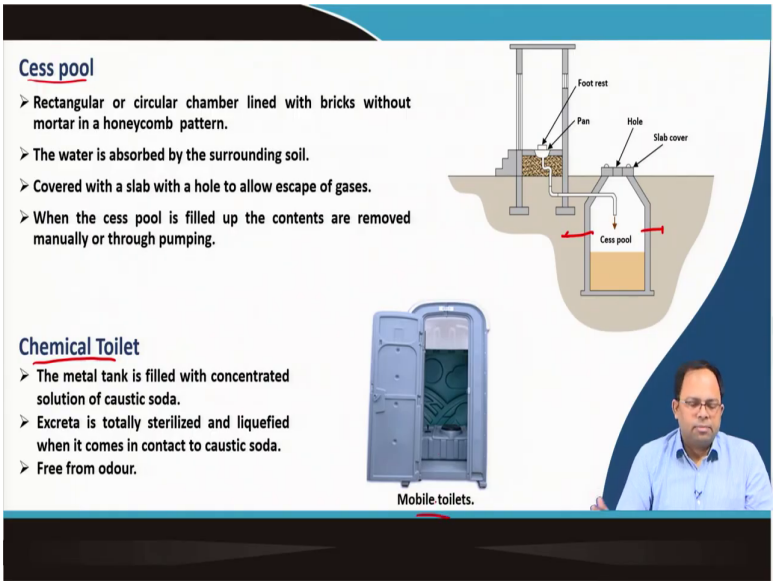
Lime is used for conditioning and stabilization before dewatering (mechanical dewatering). As shown in the above figure, Screened septage is allowed to enter the holding tank; the

sludge feed pump the sludge volume to the flocculation tank where it is mixed with polymers from where it is then conveyed to the mechanical device for dewatering. The screw press rotates to press the septage and removes the pressate (liquid part) and the dewatered sludge is sent out which gets reduced in volume.

Dewatered sludge after drying (sludge drying beds) could be used for composting and used as organic fertilizer. Effluent can be transported to waste stabilization pond / Anaerobic baffled reactor / Constructed wetland or their combination. The selection depends on land availability, site conditions, buffer zone requirements, hauling distance, fuel costs, labour costs, disposal costs and other legal and regulatory requirements (need for maintaining a specified buffer distance from certain areas / landuses.

Septage goes into an aerobic digester after which it is put on the sludge drying bed; the solids can be used as fertilizer and the liquid part goes as effluent which can be again used in horticulture.

(Refer Slide Time: 23:45)



Cess pool

Cesspool is a rectangular or circular chamber lined with bricks without mortar in a honeycomb pattern. It can be considered as a community facility to which multiple toilets are connected and the water is absorbed into the surrounding soil (infiltration when it gets filled).

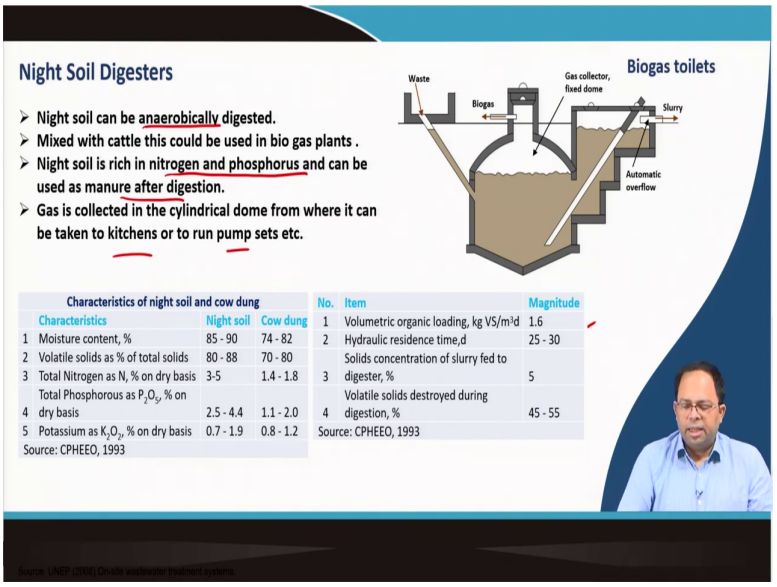
The chamber is covered with a slab with a hole to allow the escape of gases and when the cesspool is filled up, the contents are removed manually or through pumping.

Chemical toilet

These are primarily used as temporary structures and can be used during events etc. It consists of a metal tank that is filled with a concentrated solution of caustic soda. The excreta gets sterilized and liquified when it comes in contact with caustic soda and becomes free from odour.

Night digester

(Refer Slide Time: 25:15)

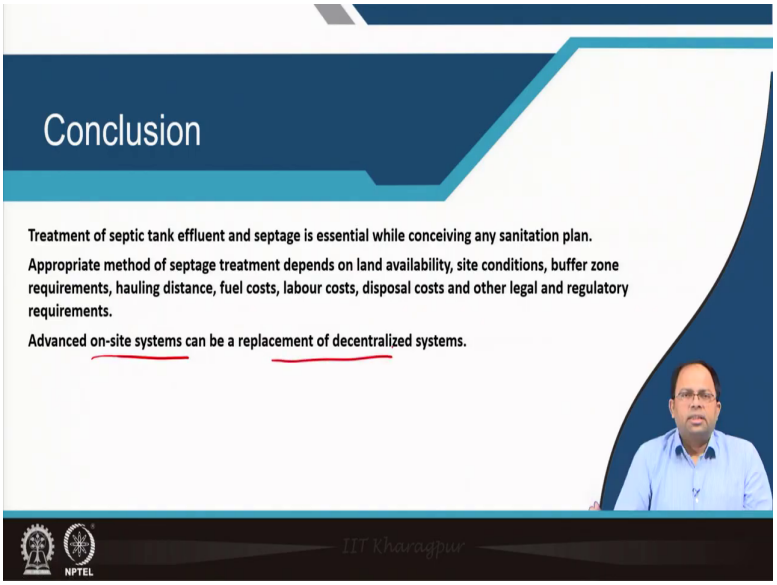


Night soil or human excreta is digested anaerobically and is mixed with cattle excreta for use in a biogas plant. Night soil is rich in nitrogen and phosphorus and can be used as manure after digestion. Gas is collected in the cylindrical dome from where it can be taken to kitchens or to run pump sets and so on. Thus the gas produced during the process and the sludge after treatment can be used.

Characteristics of the night soil and the cow dung is listed in the table (refer to previous figure)

Conclusion

(Refer Slide Time: 26:55)



- The treatment of septic tank effluent and septage is essential while conceiving any sanitation plan.
- Appropriate method of septage treatment depends on land availability, site condition, buffer zone requirement, hauling distance, fuel cost, labour cost, disposal cost and other legal and regulatory requirements
- Advanced onsite systems can be a replacement of decentralized systems.

References

(Refer Slide Time: 27:33)