Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 07
Sanitation and Drainage Fundamentals
Lecture - 35
Sewage Systems Part III

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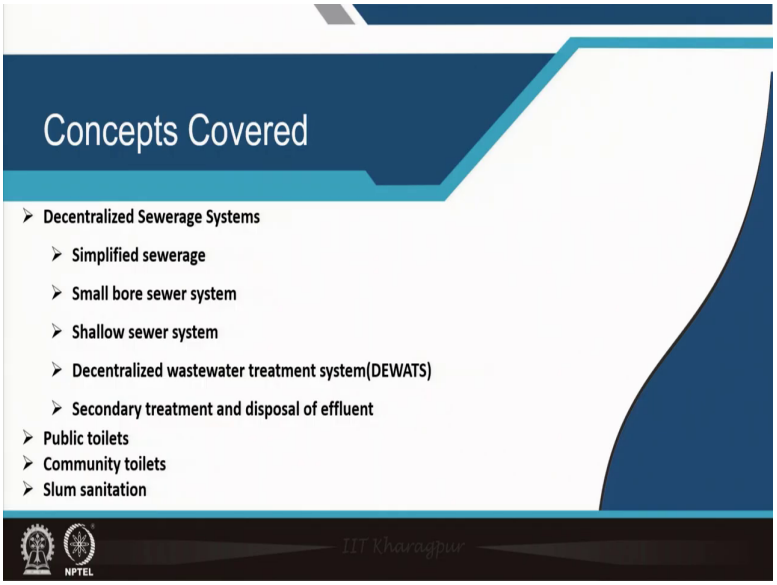

In lecture 35, the Sewage Systems Part III will be discussed. The different concepts that will be covered in this lecture are decentralized sewerage systems. This topic includes simplified sewerage, small bore sewer systems, shallow sewer systems, decentralized wastewater treatment system (DEWATS) and secondary treatment and disposal of effluent; and public toilets, community toilets and slum sanitation.

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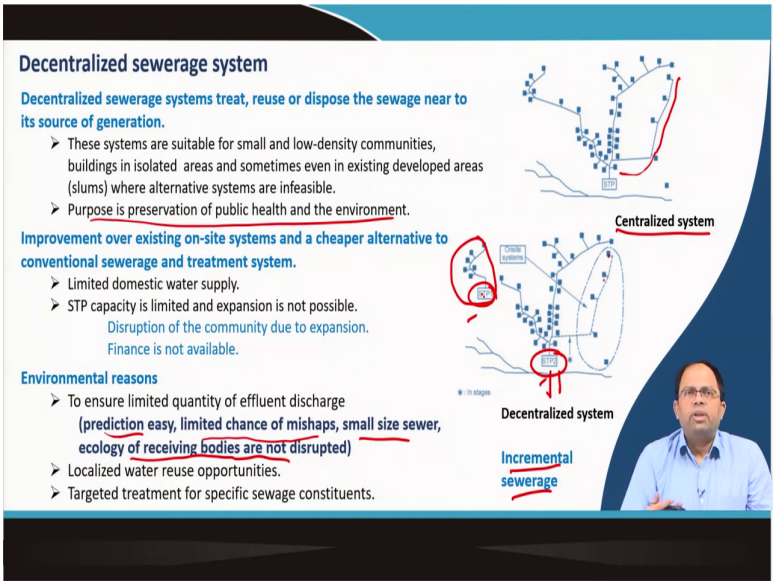

Decentralized sewerage systems

As depicted in this image, it is a centralized system which means that there is a STP and all the buildings are connected via sewer lines directly to this STP.

Regarding decentralized systems, we have a system where there is a sewer line which is connected with a local STP where it is getting treated. The STPs takes care of the existing network. The buildings are far apart and less dense and can actually have onsite systems for this particular area.

It is a mix of both onsite system a decentralized system as well as the standard conventional sewerage network system. It can be called as incremental sewage or sewerage as well. It can be built over time and different kind of systems can be added together and gradually build up this network for a particular area.

In decentralized system, we usually treat, reuse or dispose the sewage near to source of its generation ; that means, usually this treatment is done near to the source and disposal or reuse is also done near to the source as well.

This is the difference with the normal sewage treatment. In normal sewage treatment, the sewage is conveyed via sewer line to a faraway treatment plant. In decentralized system,

instead, the treatment is done locally. There are various benefits of this system. This is suitable for small and low-density communities, buildings in isolated areas and sometimes even in existing developed areas like slum where alternative systems are infeasible.

Sometimes if the area needs to be connected with the main line, the pipeline needs to be extended. Because of the invert levels, we have to provide slope to that pipeline and sometimes, it actually creates problems. A lifting station is needed for that sewage which will increase the cost. Sometimes to reduce the cost, it is better to construct a local treatment. In cases such as slums as there is no space, this kind of system can be adopted. Then, one of the primary purposes is preservation of primary health and environment.

Another main reason is the improvement over existing on-site systems and a cheaper alternative to conventional sewerage and treatment system. Thus, the benefits of a conventional sewerage and treatment system are obtained instead of the on-site system but at a relatively lower cost. This is also done when the domestic water supply is limited; that means, 130 LPCD water supply is not being provided or if STP capacity is limited and expansion is not possible. The STP may been built already and there is no further possibility to add extra sewage into this particular STP .

Additionally, there may be disruption in the community due to expansion and finance may not be available to do the construction. Thus, these are the reasons why communities go for this decentralized treatment systems.

Then, there could be environmental reasons as well to ensure limited quantity of effluent discharge so; that means, sewage is reused for some purpose which will reduce the total discharge from STP. Thus, if one wants to reduce the discharge of effluents, decentralized treatment can be adopted.

Prediction of the sewage generation is much easier, because we have to deal with few buildings. In addition, there is limited chances of mishaps. Also, the size of sewer lines would be less. Ecology of receiving bodies are also not disrupted due to the low quantity of sewage. Whereas, in case of final treatment if we put it in the river, the load may be too high for that river .

Then, localized water reuse opportunities and targeted treatment for specific sewage constituents is possible; that means, in particular area, we can have specific treatments specified for that area as well. These are the different reasons why we adopt decentralized sewerage systems.

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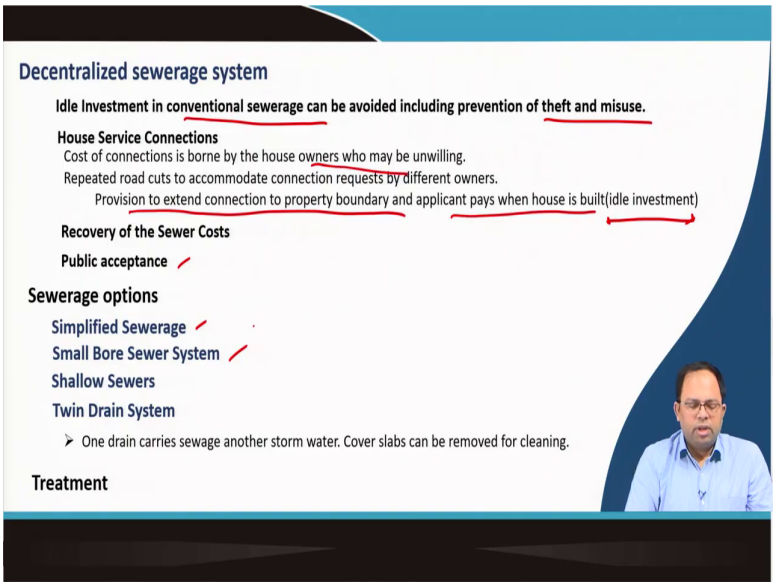

In addition to that in conventional sewerage systems, there is lot of idle investment; that means we have to construct lot of pipeline which would not be used and then, there could be theft and misuse of these.

Another issue is house service connection. Since, the cost has to be borne by house owners, they may be unwilling to connect their building with the sewerage network or some of them may construct their buildings much later than the installation of the sewerage network. So, there would be repeated cuts of the road to accommodate these connections by different owners.

There could be a provision to extend the connection from the sewerage line to the property boundary and applicant pays when the house is built. This could be possible, but this is idle investment by the municipality. The plot may never be developed or people may build a house much later. Recovery of sewer cost, and public acceptance are some of the issues which is the reason why we adopt decentralized systems. There are different kinds of

decentralized system such as simplified sewerage, small bore sewer system, shallow sewer system, twin drain system and then their treatment as well.

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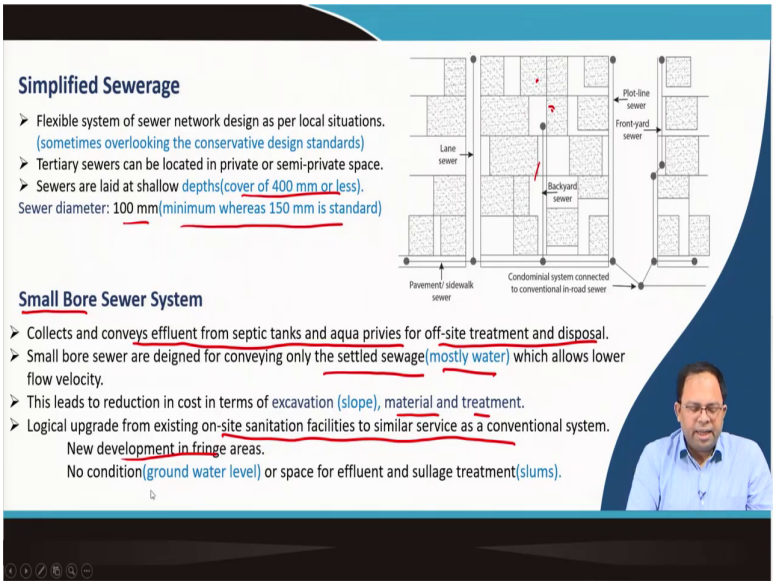

Simplified sewerage is a more flexible system, where we overlook some of the conservative design standards of sewerage networks. It is a flexible system of sewer network design as per the local situation and tertiary sewers can be located in private or semiprivate space. Sewer is designed so that we can serve the back yard of the building plots.

It is an unconventional way of laying sewer lines, but this is an efficient way because we are able to serve most of the plots from their back of course. So, this is more like an informal way of laying the sewer pipeline. Sewers are laid at shallow depths with cover of 400 millimeter or less and minimum diameter is 100 millimeter with standard diameter being 150 mm.

Thus, instead of designing various formal networks, informal network can be designed at lower depths for the final branch lines or connection lines to the individual houses. This could be done in an informal manner to accommodate all the different plots which would otherwise may not have been served. This is a good approach in slum areas.

Small Bore Sewer System

In small bore sewer system, smaller diameter pipelines are laid. In this case, the sewer system is designed primarily to collect the effluent from septic tanks and aqua privies for off-site treatment and disposal. For instance the toilets in slums do not have space for dispersion trenches, thus, the effluent needs to be disposed far away. In this case, the small bore sewer system can be designed.

These are designed for conveying only the settled sewage, mostly water, because settled sewage in a septic tank or aqua privy allows lower flow velocity and carries only water. Thus, we can have more flat slopes and lower flow velocities in the pipelines. This leads to reduction in cost in terms of excavation.

The pipeline material and treatment methods are also relatively cheaper in this case, because only the effluent part is dealt with. This is a logical upgrade from the existing on-site system facilities to similar services as a conventional system, because there is a septic tank and we are also able to get rid of the effluent using a sewer system.

This could be adopted for new development in fringe areas. This could also be applied in areas where groundwater level is high or there is no space for effluent and sullage statement. Particularly for slums, this kind of method is very useful.

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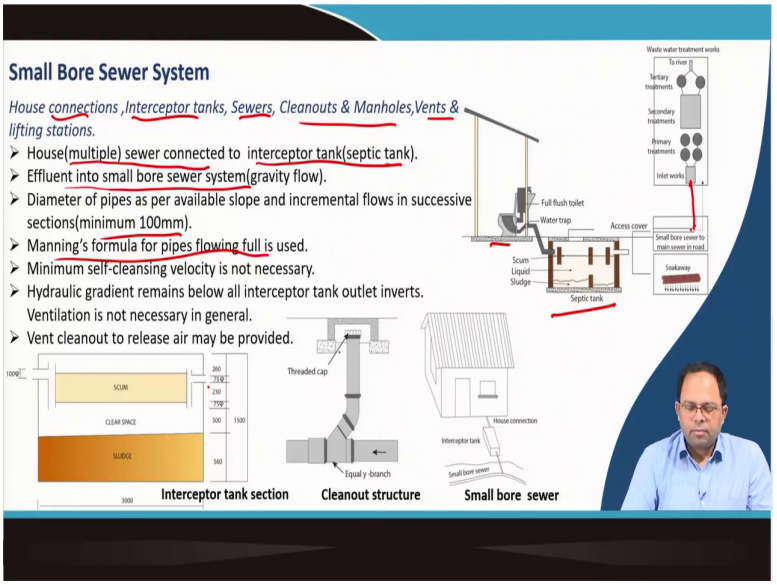

The design of small bore sewer system is as follows. A toilet with septic tank is connected with small bore pipeline instead of soak way or a dispersion trench. The small bore pipeline is connected to the main sewer line or it can be taken to an independent treatment unit as well. Treatment unit can be far away from this community or it could be a common treatment plant for a community or it could be connected to the conventional sewerage system. Thus, in many cases, slums are connected to the standard sewerage system.

In small bore sewer system, there are other components such as the house connection part, interceptor tank, sewers and clean outs.

If there is a sewer pipeline, there has to be certain clean outs or manholes, through which one can access the pipeline to clean for blockages. Lifting stations are designed if the pipeline is too long.

Multiple houses in dense areas could be connected to one septic tank or a interceptor tank. Then, effluent goes into the small bore system and follows gravity flow. Diameter of the pipelines and available slopes are less and minimum diameter is 100 mm.

Manning's formula can be used for pipe flowing full for estimating pipe diameters. Minimum self-cleaning velocity is not necessary in this case, because only the liquid is dealt with and hydraulic gradient remains below all interceptor tank outlet inverts.

Ventilation is not necessary, but vents can be added to release air. Clean outs can be added to clean the structure in case of blockages and release of gases.

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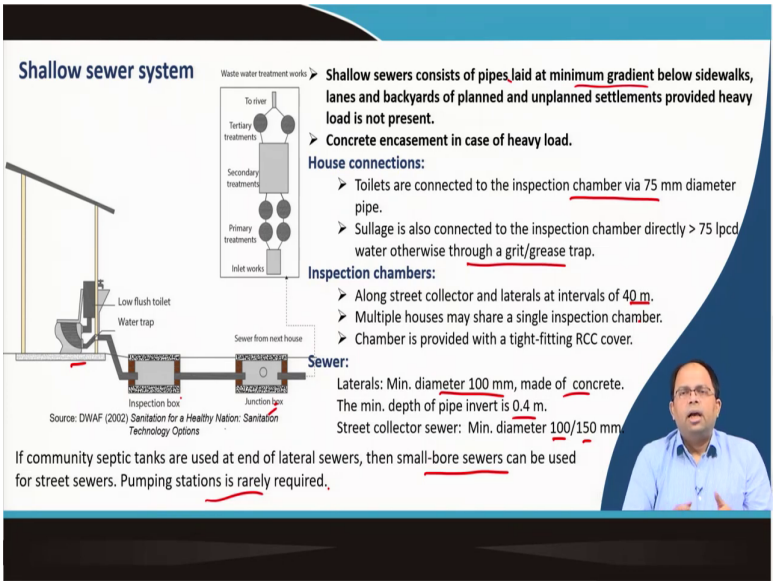

Shallow sewer system

Shallow sewer system is almost same as the small-bore system, but the only difference is that there is no need to have a septic tank. Toilets can be directly connected with this particular sewer system. Thus, a shallow sewer system consists of pipes laid at a minimum gradient below sidewalks, lanes and backyards of planned and unplanned settlements, provided heavy load is not present and concrete encasement in case of heavy load.

In this system, inspection chambers are designed which is connected to the toilet via 75 mm diameter pipe. Sullage is also connected to the inspection chamber directly if the water demand is greater than 75 lpcd water or through a grit and grease trap.

These inspections chambers are placed along the way and along the street collectors and laterals at intervals of every 40 meters, there could be inspection boxes like junction box. Multiple houses may share a single inspection chamber where multiple lines can get connected. The inspection chamber is provided with tight fitting RCC cover. It is an informal system as compared to a conventional sewerage network.

The minimum diameter of sewers is around 100 mm. These are made of concrete the minimum depth of the pipe invert is 0.4 meter and for the street collectors, it could be around 100 to 150 millimeter. There could be community septic tanks at the end of lateral sewers and then small-bore sewers can be designed for street sewers and pumping station is rarely required.

In the small-bore sewers, the septic tank can be near the house and then the effluent can be conveyed to existing sewerage network or can be taken for further treatment.

In shallow sewer system, septic tank is not designed inside the community; instead septic tank can be designed outside the community where the entire sewage is brought through small diameter pipelines at shallow levels below the foot paths. Inspection boxes or junction boxes can be designed for further connections through which the sewage is transported to a septic tank where it gets treated. Thus, wherever there is a space to design the septic tank, it can be designed and then the effluent can be treated or can get connected with the conventional sewage system.

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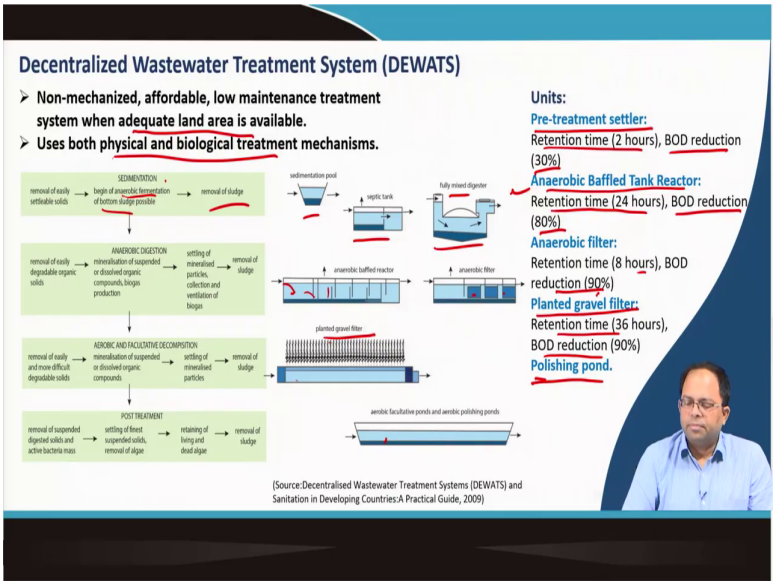

Decentralized Wastewater Treatment System (DEWATS)

Decentralized Wastewater Treatment System or DEWATS is particularly a non-mechanized system and it is affordable as well as low maintenance treatment system in case where

adequate land area is available. This means that the main challenge is availability of land area. Thus, it is possible in areas like semi urban areas and areas which are not dense. Both physical as well as biological treatments are employed. Let us look at the various treatments that are being employed. One is free treatment settler which means the sewage is allowed to settle for retention time of around 2 hours and this leads to BOD reduction of around 30 percent when some amount of sedimentation happens. Next is an anaerobic baffle tank reactor in which the retention time is around 24 hours and BOD reduction is around 80 percent. Then, aerobic reactor is where media is present and the sewage gets mixed with the media and gets acted upon by the bacteria in this particular media and gets digested.

Then there is anaerobic filter where retention time is around 8 hours and BOD reduction is 90 percent. In planted gravel filter, the retention time is around 36 hours and BOD reduction is around 90 percent.

In polishing pond, the final treatment is given to the effluent or the liquid waste so that it becomes relatively pure. That is why it is called as a polishing pond.

As see in the image, there is a sedimentation pool where sedimentation happens. It can also happen in septic tank/biogas plant/mixed digester to actually allow sedimentation but the sludge has to be removed as in the next stage, anaerobic digestion takes place in the anaerobic baffled filter. It is a settling tank where the water goes down, then gradually there could be an up-flow filter without media or with media.

Gradually, effluent can be treated from this particular septic tank. Aerobic and facultative decomposition happens in a planted gravel filter where plants are involved. Some amount of aerobic decomposition takes place in addition to the anaerobic processes. Finally for post treatment, there is an aerobic facultative pond and aerobic polishing pond through which removal of suspended digested solid and active bacterial mass happens and finally, the entire sludge comes to the bottom and clean water is obtained.

Thus, this is the basic DEWAT system which is a mix of different kind of systems such as physical and biological. These different systems when put in sequence it is a decentralized wastewater treatment system.

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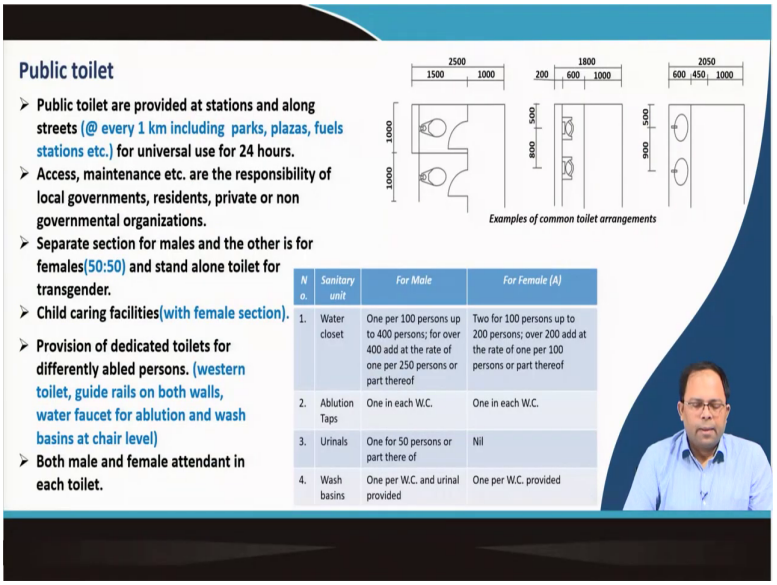

Public toilet

The public toilets and the community toilets are also called as on-site treatment process because in urban areas we need to provide public toilets at certain intervals and also people travelling or living along the streets can use these facilities .

Community toilets can be planned in slum areas where there is no space for setting up septic tanks or even individual toilets. Public toilets can be also provided in case of fair grounds or in parks.

These are the systems which are part of the entire sanitation system, but we cannot say that it is part of decentralized or centralized system, but these concepts also need to be understood.

Public toilet should be provided in urban areas places like stations or along streets at every 1 kilometer including parks, plazas, fuel stations etc. and should be for universal access for 24 hours.

The maintenance of these toilets or access to these toilets is the responsibility of local government, residents, private or non-government organizations. Sometimes, the governments construct these kinds of toilet, sometimes the community organizations or the local residents and sometimes NGO's or private organizations take up this task.

In these toilets, there is separate section for males and females and stand-alone toilets for transgender are also provided. Also, toilets for differently abled persons are provided along with child caring facilities in the female section.

Provision of dedicated toilets for differently abled persons should be planned with western toilet, guide rails on both walls, water faucet for ablution and wash basin at chair level. Both male and female attendant should be present in each toilet and there has to be a monetary charge for the use of these facilities for maintenance of these particular toilets.

Figure shows some basic designs of common toilet arrangements. The design standards include number of water closets for male and female, for example, one per 100 persons (up to 400 persons) and then at the rate of one per 250 persons or part thereof. Similarly for female, two closets can be designed for 100 persons. Thus, how many water closets are required depends on the number of people who will use these toilets.

In public facilities, we have to make those estimates and based on that, we have to provide the number of water closets or number of ablution taps; i.e., 1 in each WC's. For urinals, one for 50 persons or part thereof should be provided. Similarly, for washbasins, the numbers are to be provided as shown in the Table.

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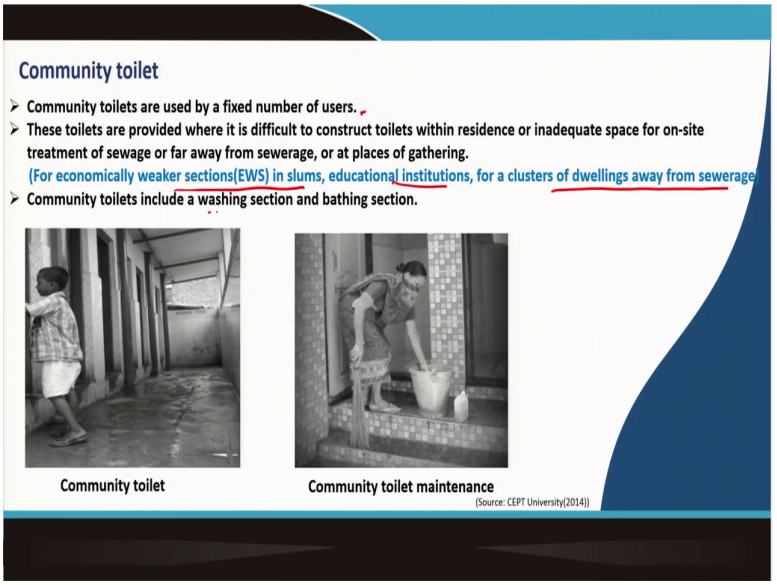

Community toilet

Unlike public toilets, these are used by fixed number of users. These are designed for a particular community or a group of people within that community or multiple community toilets can be constructed for a particular community.

These are used by fixed number of users. Based on this, the number of WC's required, number of taps and urinals required and the bathing area requirement is designed. These toilets are provided where it is difficult to construct toilets within residence or inadequate space for on-site treatment of sewage or far away from sewerage or at places of gatherings. These can also be designed for economically weaker section in slums, educational institutions or cluster of dwellings away from sewerage networks. These have a washing section and a bathing section.

The images of community toilets shows that these needs to be cleaned by staff members or people need to be engaged for cleaning these kinds of toilets. It must be ensured that these are regularly cleaned.

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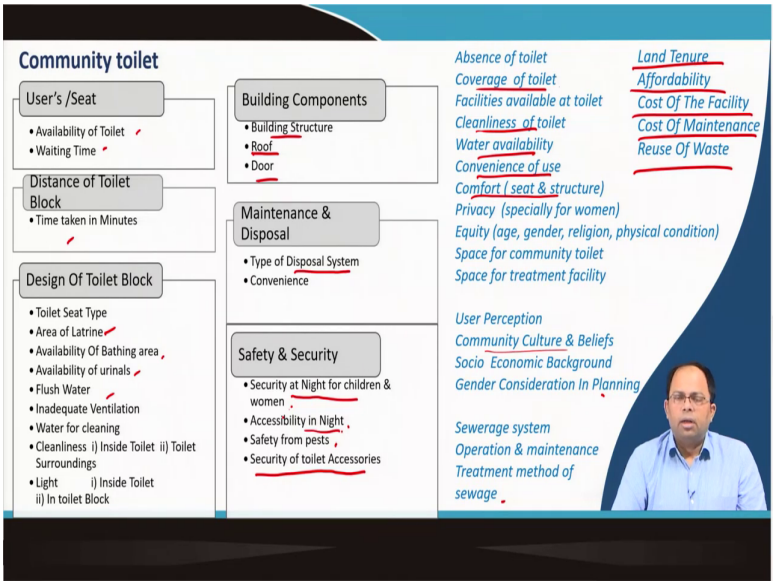

When we design community toilets, we should be considering several parameters, because it is a toilet which is designed for the community. So, we have to take the preferences of the community and the preferences are in regards to various aspects.

For example, we need to ensure the security at night for children and women which is the primary concern. There has to be adequate lights as well. Accessibility in night is also an important consideration if it is in an area where there are improper roads or it is a rural area. Thus, safe accessibility and safety from pest is important Security of toilet accessories is also important; that means, things should not get stolen. Then, maintenance and disposal is also important. The, roof, door and the building structure design is also important. The design of the toilet block includes the toilet seat type, area of latrine, availability of bathing area, availability of urinals, flushing system etc.

Then, time taken to reach the facility, or distance is also considered. Then how many toilets are available or how many seats are available per number of user; that means the number of people served by a WC. Other parameters include operation and maintenance, treatment method of sewage, user perception, community culture and beliefs of that community, socioeconomic background, gender consideration, privacy of women, comfort, convenience of use water availability, cleanliness, and coverage of toilet.

In addition, we also look into the land tenure, affordability of that particular community, cost of the facility, cost of maintenance, and reuse of waste(if possible)

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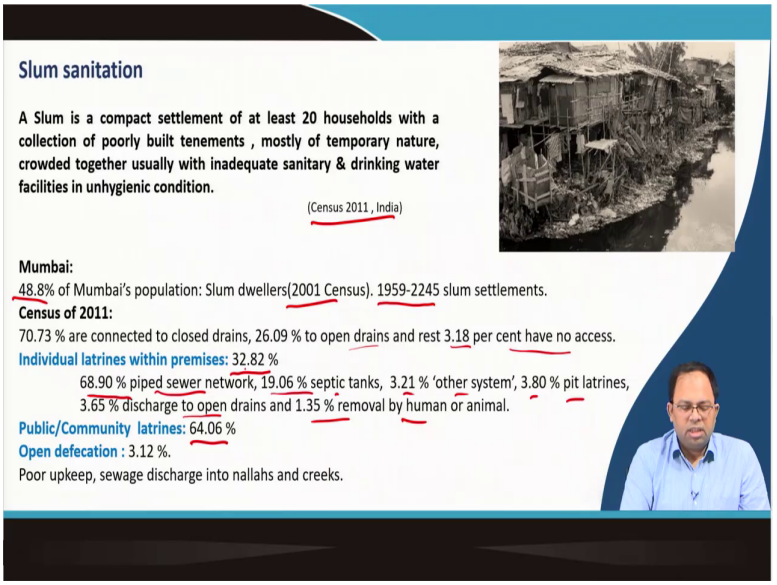

Slum sanitation

Slum sanitation is a big challenge in the Indian context.

It is evident from the given image that slums are usually developed around water bodies because the primary need for sanitation actually drives people to construct slums near water bodies so that the waste could be easily disposed of.

As is evident from the image that a slum is a compact settlement of at least 20 households with a collection of poorly built tenements, mostly of temporary nature, crowded together usually with inadequate sanitary and drinking water facilities in unhygienic condition (according to the definition of Census of India).

In Mumbai as per 2001 Census, around 49 percent of Mumbai's population is slum dwellers and there are around 2000 slum settlements in Mumbai. In 2011 Census, it was found that 70.73 percent are the slums are connected to closed drains, 26 percent to open drains and rest 3.1 percent do not have access to even drains.

The individual latrine within premises are present in only around 32.82 percent of buildings, 68.9 percent is connected to pipe sewer network, 19.6 percent to septic tanks, 3.2 percent to other systems and 3.8 percent is pit latrines and 3.65 percent discharge to open drains and in 1.3 percent, the waste/excreta is removed manually by human or animals which is a conservancy system.

The rest 64 percent of the population who does not have individual toilets uses public or community toilets. 3.12 percent population was found to defecate in the open. This results in the sewage discharge into nallahs and creeks.

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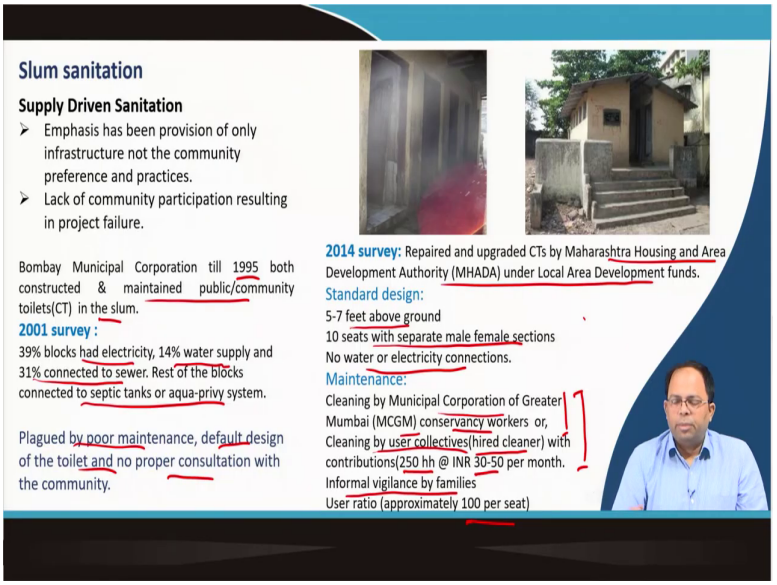

Community toilets are a part of slum and in most cases, the government constructs community toilets. These are designed or provided based on two approaches; supply side driven sanitation and demand side driven sanitation. In supply side driven sanitation, the emphasis is on provision of the infrastructure and the community preferences practices beliefs are not too much taken into consideration.

There is a standard design that government adopts for construction of community toilets. Also there is not much of community participation and in most cases this results in failures.

Bombay municipal cooperation till 1995 constructed and maintained public community toilets in slums. In 2001 survey, it was observed that 39 percent blocks had electricity, 14

percent water supply, 31 percent connected to sewers and the rest of the blocks are connected to septic tanks or aqua privy systems. These systems are plagued by poor maintenance. For the design of community toilets, the preferences/consensus of community was not taken into consideration in the decision-making process. This led to design of poorly-designed and unmaintained structures.

In 2014 survey; however, it was found that many of these toilets were repaired and upgraded by the Maharashtra Housing and Area Development Authority under Local Area Development Funds. It was found that the standard design is around 5 to 7 feet above ground and 10 seats with separate male female sections, but there are no water or electricity connection. The maintenance is done by Municipal Cooperation of Greater Mumbai conservancy workers or it was done by user collectives or hired cleaner with contributions from the community like 250 houses contributing 30 or 50 rupees per month. Informal vigilance is done by the families and the user ratio was found to be around 100 users per seat.

Even though it is modified or upgraded, there are problems such as high user ratio. The efficiency of cleaning or maintenance is not good where it is maintained by conservancy workers.

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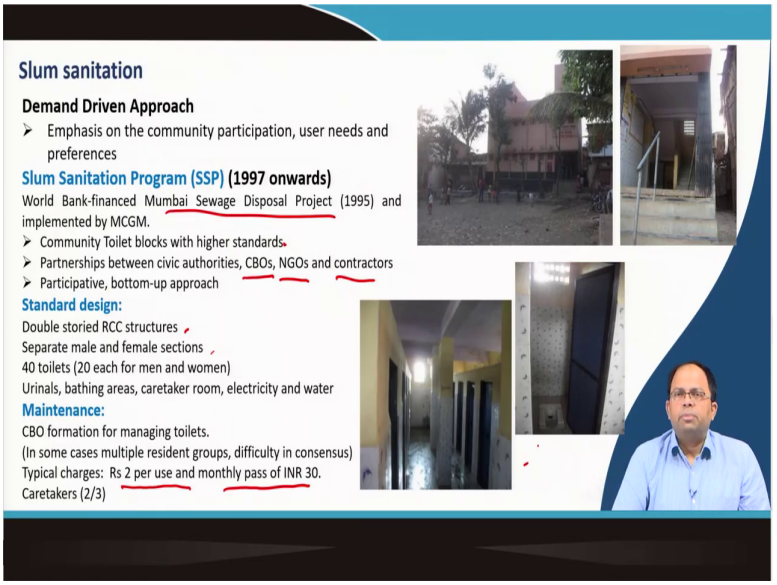

In demand driven approach, emphasis is on community participation, user needs, and preferences which means that the opinion of community has been taken into consideration.

The slum sanitation program started from 1997 onwards which is financed by the World Bank and the Mumbai Sewage Disposal Project. This is an example of demand driven approach. Community toilet were designed with higher standards and there was a partnership between the community-based organizations, non-governmental organizations, and the contractors resulting in a participative bottom-up approach.

As evident from the image of the community toilets, the two storied structures were also constructed. So, standard design is double storied RCC structures, with separate male female sections, and 40 toilets; instead of 10 toilets earlier. 20 toilets each for men and women were provided. In addition, urinals, bathing areas, caretaker rooms, and electricity and water connections were present. Maintenance was via community-based organizations and in some cases, multiple resident groups which is the only problem. Whenever there are different resident groups, there may be some disagreements. Overall, there are no issues and typical charges are rupees 2 per use and monthly pass of rupees 30 and there are usually two to three caretakers per toilet.

The condition of these toilets are better than the ones designed by supply driven approach.

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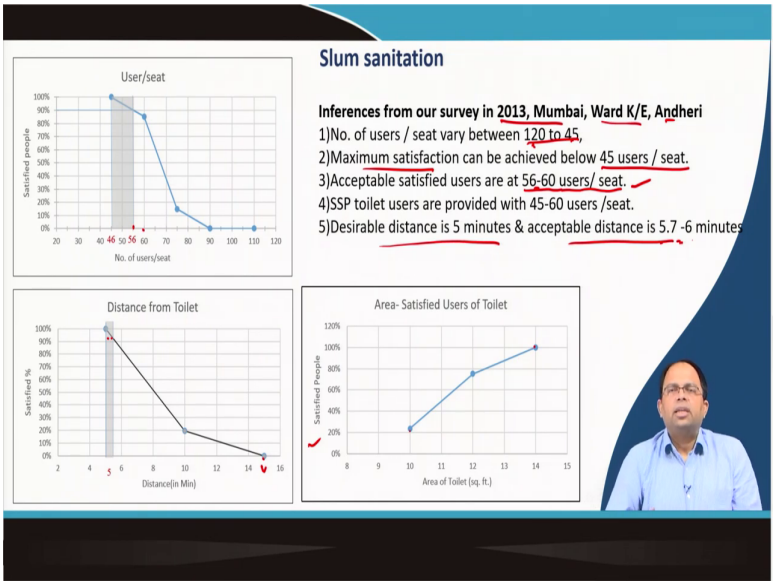

Based on a research conducted in our laboratory in 2013 in Mumbai Ward K/E, Andheri regarding what people want, it was found that the existing uses per seat vary from 120 to 45. But when people were asked about at what levels they were comfortable based on the use time, it was found that this could be achieved around 45 users per seat. The acceptable level is around 60 users per seat.

The desirable distance is 5 minutes; that means, people do not want to walk more than 5 minutes and acceptable distance is 5.7 to 6 minutes which is roughly similar. Based on this, we can design the coverage of the toilets and multiple community toilets can be designed within the one slum.

The number of WC's, urinals or the seats inside toilets could be decided based on these standards, where we can see that with 50 to 60 users per seat, people were more or less happy.

The chart shows that, the satisfaction level at 90 users per seat is almost 0. It gradually improves and 85 percent people are satisfied at the level of around 60 persons per seat and then, at around 45 to 60, most of the people are satisfied.

The existing range of distance starts from 15 minutes to 10 minutes. People are satisfied when the distance is around 5 to 6 minutes. Regarding the area inside toilets, the satisfaction level is around 20 percent for 10 square feet and when it is around 13 to 14 square feet, people are more or less happy.

These kinds of studies need to be conducted to get user opinion on what kind of toilets or community toilets should be provided. These should be provided under ODF and Swachh Bharat Mission. If these standards are made, automatically people would be satisfied using these toilets.

That is how we can actually incorporate the communities' feedback or decisions on what kind of services should be provided.

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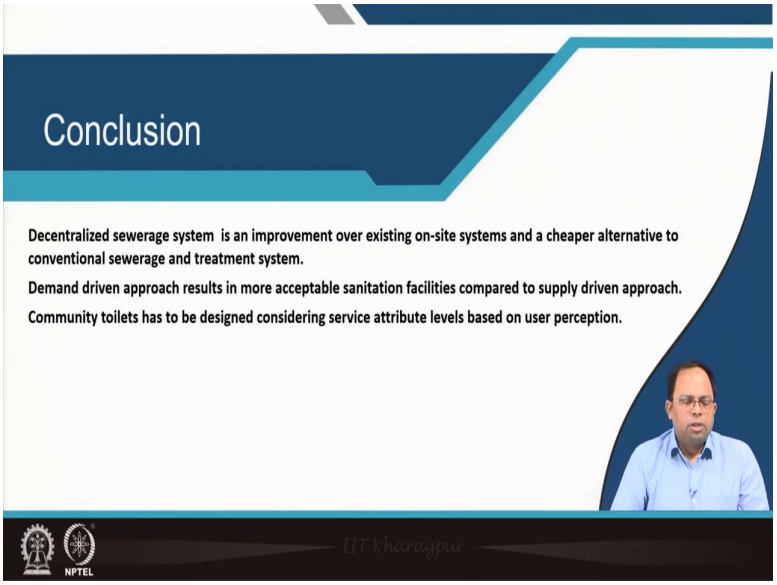

Conclusion

To conclude, decentralized sewerage system is an improvement over existing on-site systems and a cheaper alternative to conventional sewerage and treatment systems. Demand driven approach results in more acceptable sanitation facilities as compared to supply driven approach.

Community toilets has to be designed considering service attribute levels based on user perception

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References

These are the references you can consider.