Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 11
Sewage treatment
Lecture - 52
Natural Methods of Sewage Treatment

In lecture 52, Natural Methods of Sewage Treatment will be covered.

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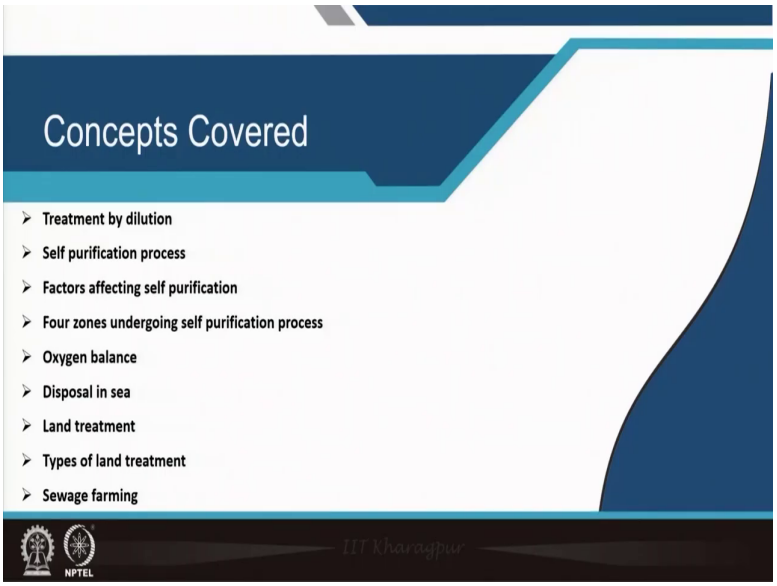

The different concepts to be covered includes

- Treatment by dilution,
- Self purification process,
- Factors affecting self purification process,
- Four zones undergoing self purification process
- Oxygen balance,
- Disposal in sea
- Types of land treatment
- Sewage farming.

Treatment by dilution

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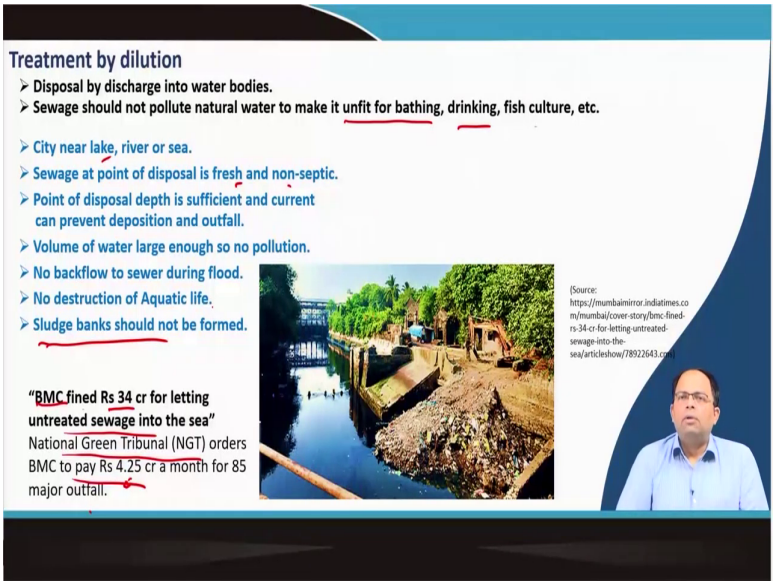

Natural treatment refers to the treatment of sewage with the action of microorganisms present in water or land naturally. For example, the disposed sewage in a waterbody gets decomposed eventually due to the action of microorganisms, water currents, due to sedimentation etc. The water quality is degraded upto a distance from the point of disposal as it gets naturally diluted and thus treated. It is important to consider the amount of sewage that can get naturally treated in a water body. Otherwise, the natural water may turn unfit for bathing, drinking, fish culture etc.

- The sewage from the city gets disposed of in lake, river or a sea.
- Sewage should be fresh and non-septic at the point of disposal. So, the travel time between the origin and the disposal point should have to be less.
- Point of disposal depth should be sufficient so that current can prevent deposition and outfall to avoid the formation of sludge banks.
- The volume of water should be adequate so that there is no pollution.
- The level of the outfall should be high so that there is no backflow to the sewer during the flood.
- No destruction of aquatic life

In India, untreated sewage is disposed into the water bodies. The National Green Tribunal acts on such issues. Most of the urban local bodies are mandated to treat sewage.

The bottom right image given in the above figure shows the case where untreated sewage is disposed (Mumbai). BMC was fined rupees 34 crores for letting untreated sewage into the sea. National Green Tribunal has ordered BMC to pay 4.25 crore per month for 85 major outfalls in Mumbai. This money can be utilized for setting up a sewage treatment plant.

Self-Purification process:

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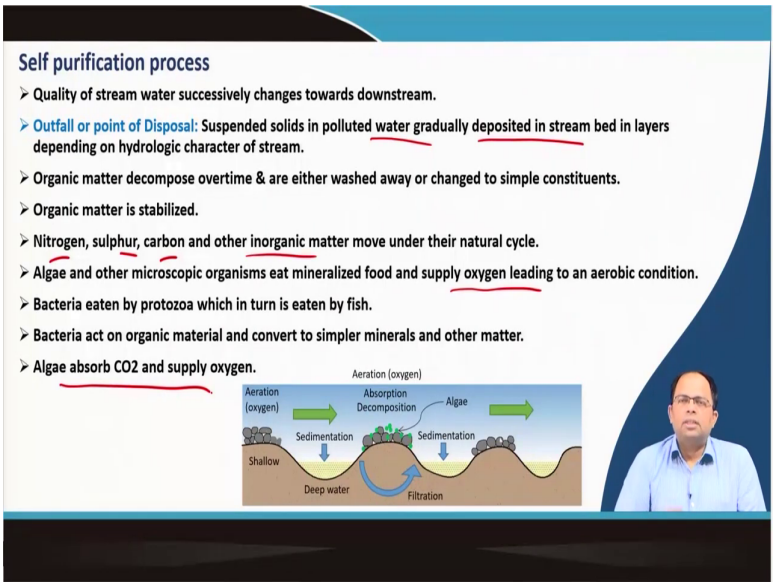

Quality of stream water successively changes towards downstream

- If sewage is disposed of at a location in a waterbody, the quality of water gets improved with distance downstream and becomes usable.

Outfall or point of Disposal: Suspended solids in polluted water gradually gets deposited in the stream bed in layers depending on the hydrologic character of the stream such as water currents.

- Very high current causes sewage to be carried farther; if the current is moderate, then the sewage is uniformly spread over a certain distance (which is preferred)

Organic matter decomposes over time & are either washed away or changed to simple constituents; Organic matter is stabilized.

- And organic matters decompose to simple constituents causing the reduction of BOD as the organic matter gets consumed by the microorganisms.

Nitrogen, sulphur, carbon and other inorganic matter move under their natural cycle (such as the action of light, etc).

Algae and other microscopic organisms eat mineralized food and supply oxygen leading to anaerobic condition which leads to anaerobic conditions.

Bacteria are eaten by protozoa which in turn is eaten by fish.

Bacteria act on organic material and convert it to simpler minerals and other matter.

Algae absorb CO2 and supply oxygen.

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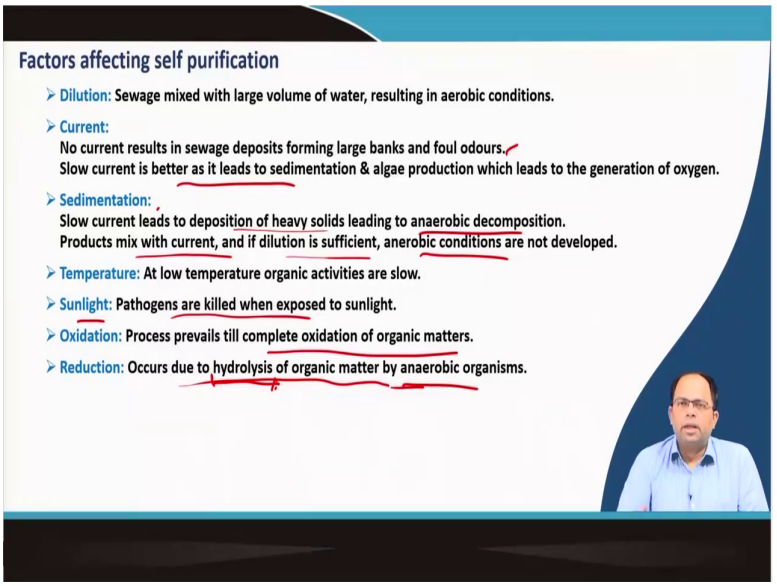

Factors affecting self-purification

Dilution - Sewage when mixed with a large volume of water results in aerobic conditions.

Current – Absence of current results in the formation of sludge banks and bad odour (Due to anaerobic conditions and the formation of hydrogen sulphide gas). Slow current is better as it leads to sedimentation and algae production which leads to the generation of oxygen and thus the aerobic decomposition process.

Sedimentation – Slow current leads to deposition of heavy solids leading to anaerobic decomposition. Products mix with current and if dilution is sufficient, anaerobic conditions are not developed.

Temperature - At low temperatures, organic activities are slow. The Indian condition (high temperature; sunlight exposure kills pathogens) promotes decomposition

Oxidation – Process prevails till total oxidation of the organic matter happens (oxygen from the atmosphere gets used)

Reduction - Occurs due to hydrolysis (oxygen is acquired from the organic matter itself) of organic matter by anaerobic organisms.

Four zones undergoing self-purification process

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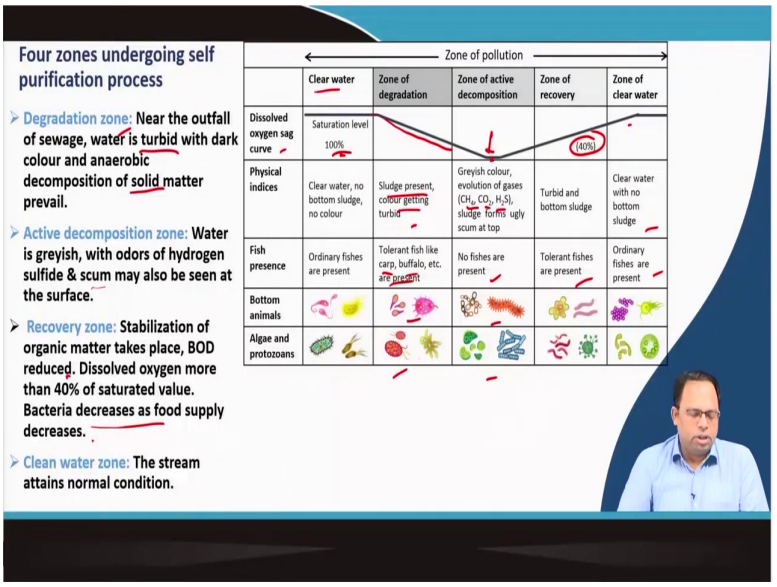

The entire area from the point of sewage deposition up to the location where water attains its pure state can be divided into four zones as listed in the table.

It can be noted that in the *Clearwater zone*, the saturated oxygen level is 100%. Bottom sludge is absent and hence, the water is clear and doesn't have any colour. At the *zone of degradation*, the oxygen level starts reducing and continues to reduce further at the *zone of active decomposition* where the oxygen level reaches its least value. Following this, the oxygen level starts to increase to reach 40 percent at the *zone of recovery* and the *clear zon*e is achieved again.

Degradation zone: near the outfall of sewage; water is turbid with dark colour and anaerobic decomposition of solid matters prevails. Some amount of sludge deposition prevails. Tolerant fish species such as carp, etc. animals and certain kinds of algae and protozoan are present.

Active decomposition zone: Water is greyish with smells of hydrogen sulfide; scum may be observed on the surface. This is the area where the most decomposition takes place. DO level reaches the lowest level. This leads to the creation of gases from anaerobic processes such as CH_4 gas, CO_2 gas, H_2S gas. Both aerobic and anaerobic processes occur. No fishes are present. Bottom animals, algae and protozoans are present.

Zone of recovery: Stabilization of organic matter takes place as it gets consumed by microbes causing the reduction in the BOD value. Dissolved oxygen becomes more than 40 percent of saturated value. Bacteria decreases as the food supply decrease. Only tolerant fishes live in this area.

Clearwater zone: The stream attends to the normal condition. There is no sludge at the bottom. Ordinary fishes, bottom animals, algae and protozoans exist.

Oxygen Balance

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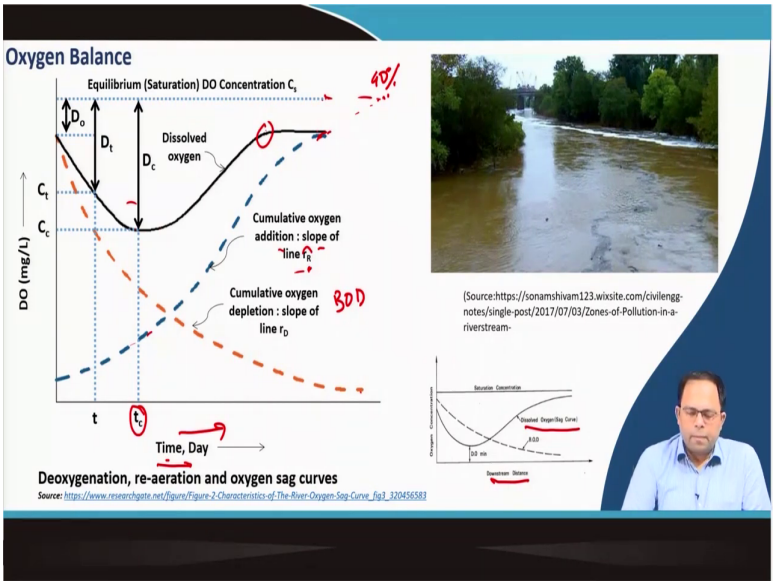

To understand the oxygen balance, Time with which water travels a particular distance (or the downstream distance) and the DO level is plotted. In the graph, the blue line indicates the normal oxygen addition rate (cumulative oxygen addition) and the slope of the line are given as r_R (indicates the rate at which oxygen gets added). The orange line represents the depletion of oxygen due to consumption of oxygen by bacteria (or the cumulative oxygen reduction). At one point, dissolved oxygen value reaches the least value at Dc followed by a gradual increase of oxygen to the normal value. This curve is called the sag curve. Cumulative oxygen depletion represents the BOD curve. After a point, the BOD stabilizes and then there is no further reduction. The normal condition is when the DO concentration reaches the Cs level which is 40%.

Disposal in sea

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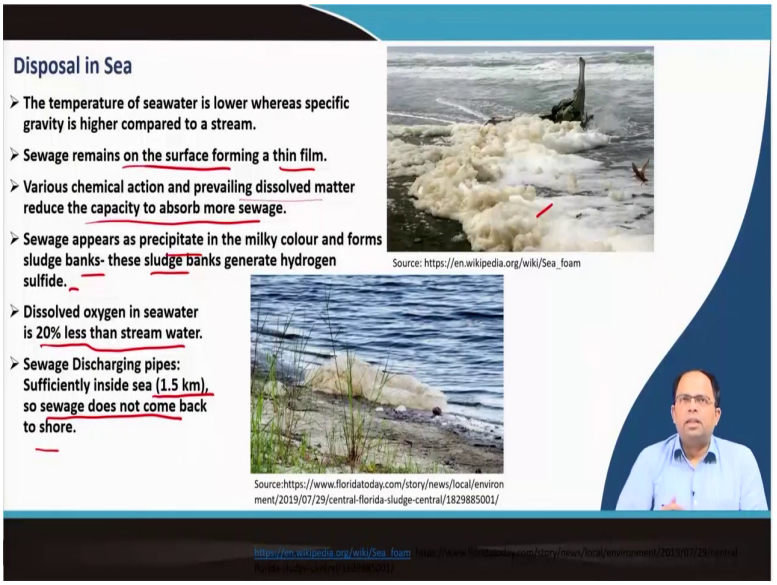

For urban areas with shoreline, waste is disposed of at the sea.

The temperature of seawater is lower and the specific gravity is higher compared to streams. High specific gravity is because of the presence of salt and other minerals and chemical action due to which sewage mostly remains on the surface forming a thin film. The prevailing dissolved matter reduces the capacity to absorb more sewage. Hence, sewage appears as a precipitate of milky colour and forms sludge banks. This generate hydrogen sulfide and scums; white froth is formed; the precipitate also gets back to the shore itself by the waves. Dissolved oxygen in seawater is 20 percent less than the stream water resulting in a higher time for decomposition. Hence, there is a need to dispose sewage far from the shore; this is achieved using sufficiently long sewage discharge pipes which disposes of the sewage such that it does not come back to shore.

Land Treatment

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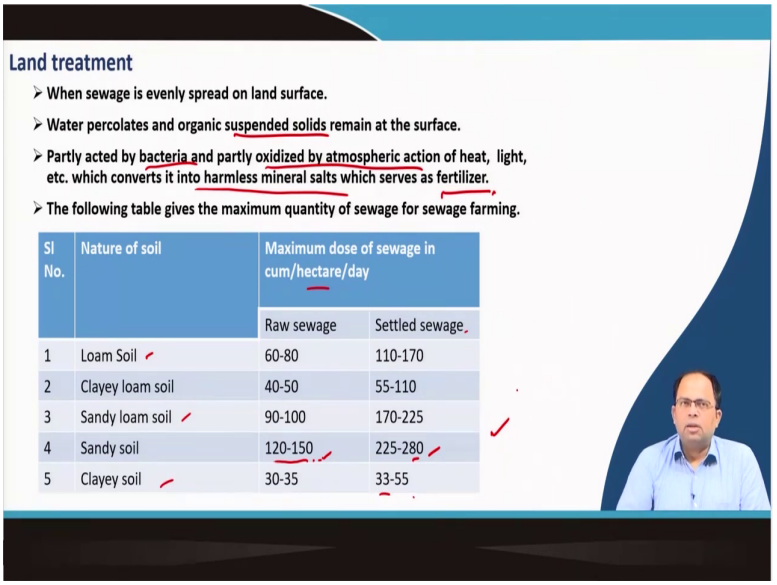

Land treatment is another natural method of treating sewage; the sewage is spread over a large area of land. The solid matter present in the sewage gets trapped in the pores of the soil and the water percolates down. The organic solids remaining on the surface is acted upon by bacteria present on the soil surface and gets partly oxidized by the atmospheric action of heat, light, oxygen etc. and thus gets converted into harmless mineral salts. The table given in the above figure shows the maximum dose of raw and settled sewage specific to the nature of the soil. Settled sewage is the resulting sewage from stabilization ponds or sedimentation tanks and has a lesser amount of solid matter; this reduces the chances of the soil pores getting clogged. The soil type with more pores such as the sandy soil can treat more amount of sewage. So, depending on the type of soil or the nature of the soil the rate of application of sewage has to be adjusted.

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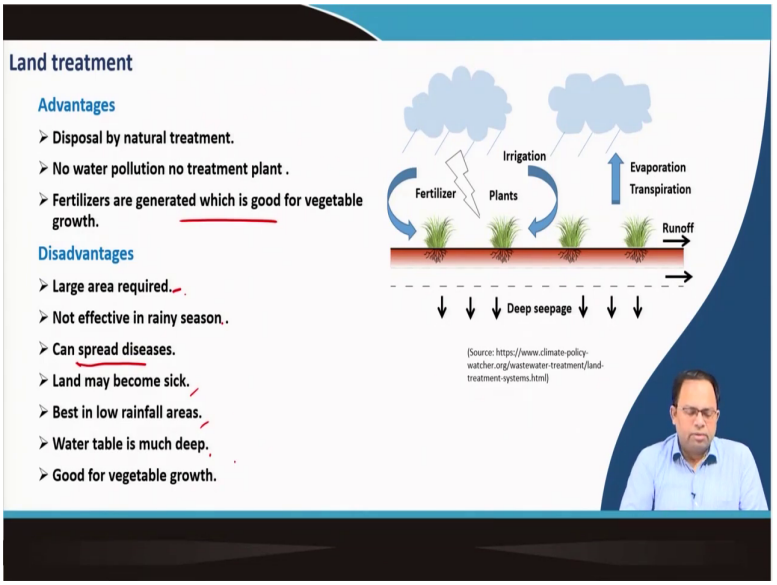

Advantages

- Disposal by natural treatment.
- No water pollution no treatment plant.
- Fertilizers are generated which is good for vegetable growth.

Disadvantages

- Large area required.
- Not effective in the rainy season.
- Can spread diseases (runoff spreads the sewage across a large area)
- Land may become sick (as the pores get clogged; anaerobic conditions prevail)
- Best in low rainfall areas.
- The water table is much deep.
- Good for vegetable growth.

Types of land treatment

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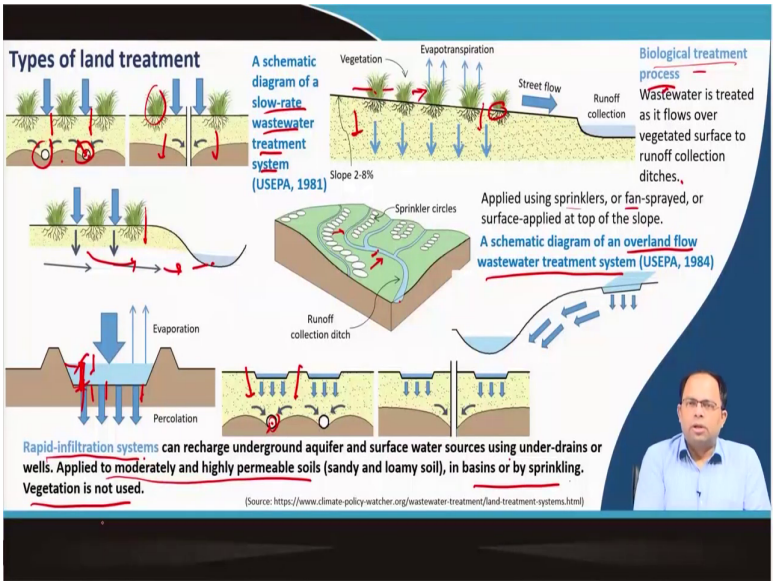

Slow rate wastewater treatment system – This involves the simple application of sewage on the surface and under drainage is installed in some cases or natural downward movement is relied upon which results in filtration leaving the water relatively pure as it reaches and mixes with the ground water table. Under drainage system (pipelines with pores disposing water at the outfall point) collects the excess water left when an impervious surface is reached.

Biological treatment process - where waste water gets treated as it flows over the vegetated surface to run off collection ditches. Some amount of sewage water gets filtered down; sewage is acted upon by vegetation and some amount gets absorbed due to evapotranspiration. Sewage gets trapped within the pores and turns into fertilizer and enriches the soil promoting plant growth.

Overland flow wastewater treatment system - Sewage is spread on the land surface using sprinklers or fans (at a higher level) and ditches collect the sewage (at the lower level); this increases the surface area over which sewage is spread. The ditches carry the sewage to the disposal point. This process is known as an overland flow wastewater treatment system. Here,

some amount of sewage gets percolated down, some solid particles get trapped with the soil pores as discussed earlier allowing for natural treatment.

Rapid filtration systems – A detention basin or retention basin or area is made and the sewage head (as marked in the figure) exerts pressure resulting in the faster percolation of the sewage downwards. This is done in multiple ways such as with and without (allowing aquifer recharge) under drainage.

Sewage Farming

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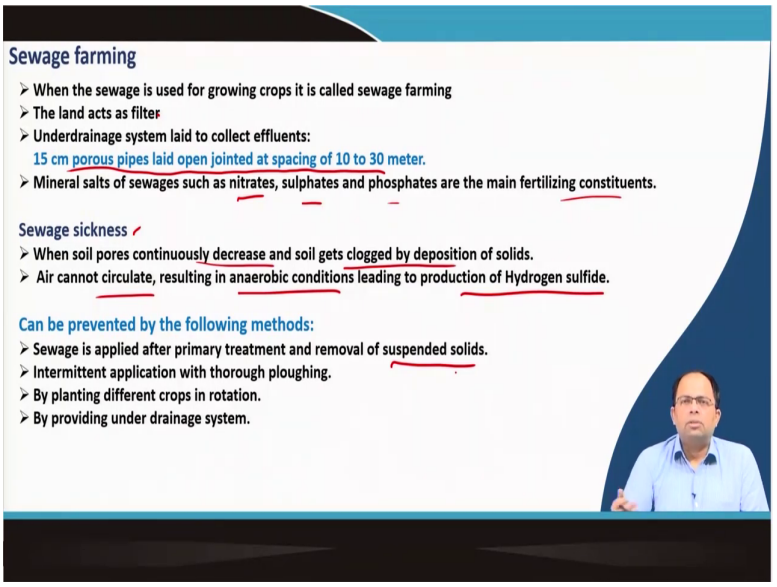

Sewage has the potential to become fertilizer for growing crops. Land act as a filter. The under drainage system is laid to collect the effluents (15 centimeter porous pipes are laid open jointed at a spacing of 10 to 30 meters) which conveys the percolated water to the disposal point. Mineral salts of sewage such as nitrates, sulphates, phosphates are the main fertilizing constituents that can help in the growth of vegetables or other crops.

Sewage sickness - Large sewage application leads to the clogging of pores and the reduction of soil pores resulting in anaerobic conditions, production of hydrogen sulfide etc. This can be addressed by introducing an appropriate amount of sewage or by introducing sewage after primary treatment, intermittent application, thorough ploughing to shuffle the soil layers,

planting different crops in rotation, or by providing under drainage system for the water to pass out.

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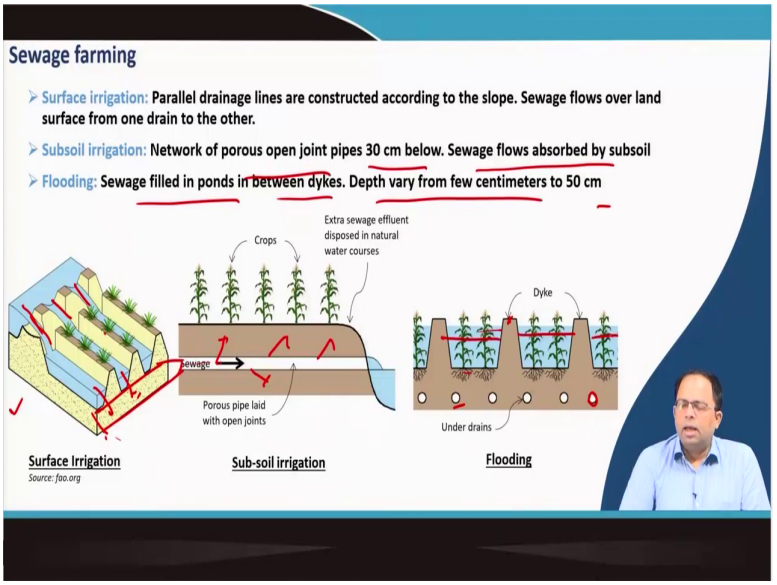

Different techniques of sewage farming

Surface irrigation - Parallel drainage lines are constructed according to the slope and sewage flows over the land surface from one drain to another. (refer to figure). Movement from one drain to another happens and the entire area is flooded.

Subsoil irrigation - Sewage is introduced through pipelines to the subsoil. Network of porous open pipes is given 30 cm below. Sewage flows are absorbed by the subsoil and this provides the fertilizer and water for particular plants to grow.

Flooding – Dykes and furrows are made and plants are grown in between the dykes where sewage is stagnated; depth of the furrow varies from a few centimetres to 50 centimetres depending on the soil type an on if under drainage system is provided or not.

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Ridge and furrow – This is similar to the previous one but the plants are grown on top of the dyke. Land ploughed deep into 30 centimeter levelled into plots and subplots. Plots enclosed by dykes form ridges and furrows in a subplot.

Spray irrigation - where sewage is filled into tanks where the solids settle and are sprayed over land. The sewage after primary treatment is sprayed.

Lagooning - where the sludge is allowed to go into a watertight pond where it is detained for a certain amount of time allowing the sludge to get stabilized. Dried sewage and stabilized sewage can be used as fertilisers.

Conclusion

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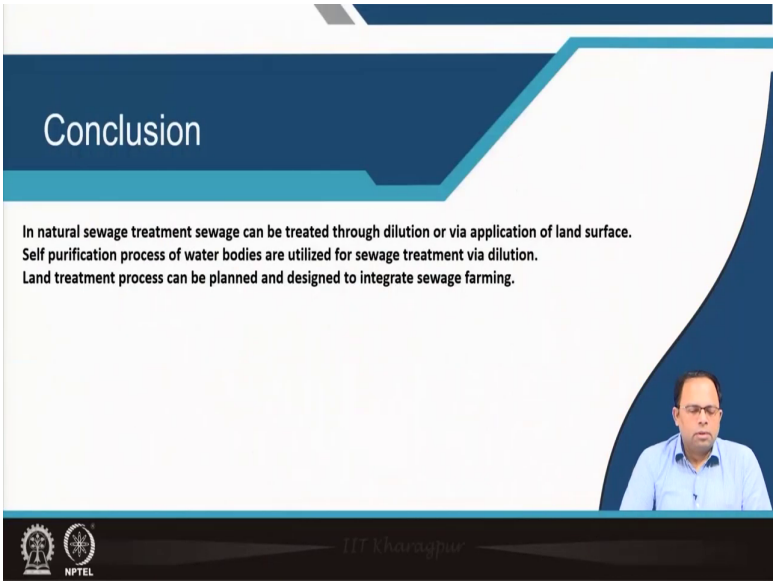

In natural sewage treatments, sewage can be treated through dilution or via the application on the land surfaces. The self-purification process of water bodies is utilized for sewage treatment via dilution. Land treatment process can be planned and designed to integrate sewage farming.

References

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