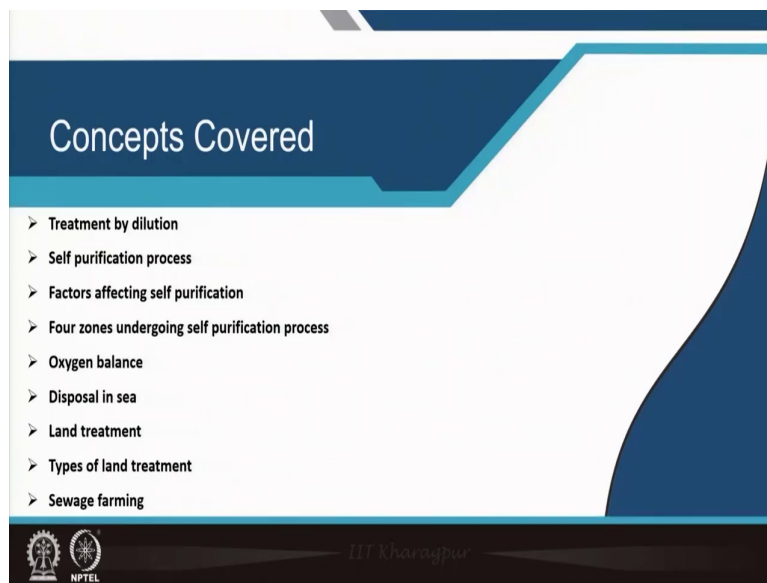


Urban Utilities Planning: Water Supply, Sanitation and Drainage
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Module - 11
Sewage treatment
Lecture - 52
Natural Methods of Sewage Treatment

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

(Refer Slide Time: 00:34)



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

(Refer Slide Time: 01:01)

Treatment by dilution

- Disposal by discharge into water bodies.
- Sewage should not pollute natural water to make it unfit for bathing, drinking, fish culture, etc.
- City near lake, river or sea.
- Sewage at point of disposal is fresh and non-septic.
- Point of disposal depth is sufficient and current can prevent deposition and outfall.
- Volume of water large enough so no pollution.
- No backflow to sewer during flood.
- No destruction of Aquatic life.
- Sludge banks should not be formed.

"BMC fined Rs 34 cr for letting untreated sewage into the sea"
National Green Tribunal (NGT) orders BMC to pay Rs 4.25 cr a month for 85 major outfall.

(Source: <https://mumbai.mirror.indiatimes.com/mumbai/cover-story/bmc-fined-rs-34-cr-for-letting-untreated-sewage-into-the-sea/articleshow/78922643.com>)

The slide features a video inset showing a polluted waterway with a large pile of sludge and debris on the bank. A man in a light blue shirt is visible in the bottom right corner of the slide, likely the presenter.

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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Self purification process

- Quality of stream water successively changes towards downstream.
- **Outfall or point of Disposal:** Suspended solids in polluted water gradually deposited in stream bed in layers depending on hydrologic character of stream.
- Organic matter decompose overtime & are either washed away or changed to simple constituents.
- Organic matter is stabilized.
- Nitrogen, sulphur, carbon and other inorganic matter move under their natural cycle.
- Algae and other microscopic organisms eat mineralized food and supply oxygen leading to an aerobic condition.
- Bacteria eaten by protozoa which in turn is eaten by fish.
- Bacteria act on organic material and convert to simpler minerals and other matter.
- Algae absorb CO₂ and supply oxygen.

The diagram illustrates the self-purification process in a stream. It shows a cross-section of the stream bed with layers of sedimentation. Key processes labeled include Aeration (oxygen), Absorption, Decomposition, Algae, Sedimentation, and Filtration. The water is shown moving from shallow to deep water. A person is visible in the bottom right corner of the slide.

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).

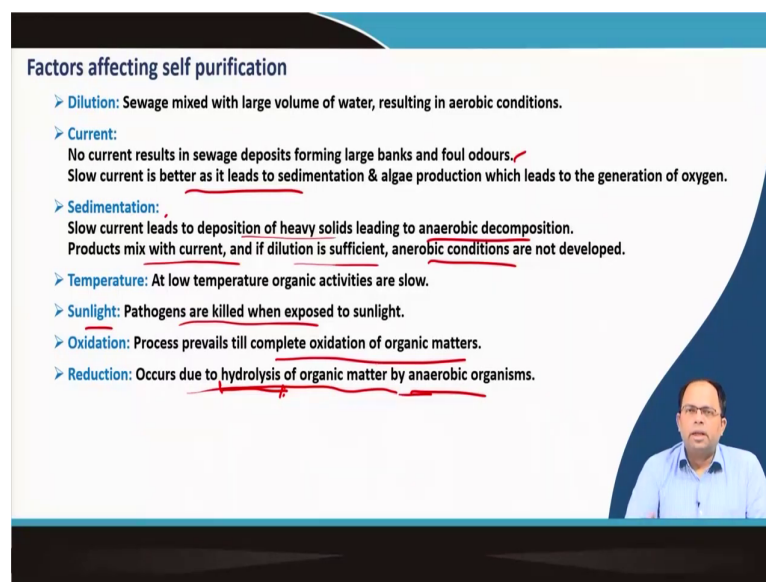
Algae and other microscopic organisms eat mineralized food and supply oxygen leading to anaerobic condition which leads to anaerobic conditions.

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 mixed with large volume of water, resulting in aerobic conditions.
- **Current:**
No current results in sewage deposits forming large banks and foul odours.
Slow current is better as it leads to sedimentation & algae production which leads to the generation of oxygen.
- **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 temperature organic activities are slow.
- **Sunlight:** Pathogens are killed when exposed to sunlight.
- **Oxidation:** Process prevails till complete oxidation of organic matters.
- **Reduction:** Occurs due to hydrolysis of organic matter by anaerobic organisms.

(Note: The original image contains red underlines and checkmarks under several points.)

(A video inset in the bottom right corner shows a man in a light blue shirt speaking.)

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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Four zones undergoing self purification process

- **Degradation zone:** Near the outfall of sewage, water is turbid with dark colour and anaerobic decomposition of solid matter prevail.
- **Active decomposition zone:** Water is greyish, with odors of hydrogen sulfide & scum may also be seen at the surface.
- **Recovery zone:** Stabilization of organic matter takes place, BOD reduced. Dissolved oxygen more than 40% of saturated value. Bacteria decreases as food supply decreases.
- **Clean water zone:** The stream attains normal condition.

	Zone of pollution				
	Clear water	Zone of degradation	Zone of active decomposition	Zone of recovery	Zone of clear water
Dissolved oxygen sag curve	Saturation level 100%				100%
Physical indices	Clear water, no bottom sludge, no colour	Sludge present, colour getting turbid	Greyish colour, evolution of gases (CH ₄ , CO ₂ , H ₂ S), sludge forms ugly scum at top	Turbid and bottom sludge	Clear water with no bottom sludge
Fish presence	Ordinary fishes are present	Tolerant fish like carp, buffalo, etc. are present	No fishes are present	Tolerant fishes are present	Ordinary fishes are present
Bottom animals					
Algae and protozoans					

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 zone* 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.

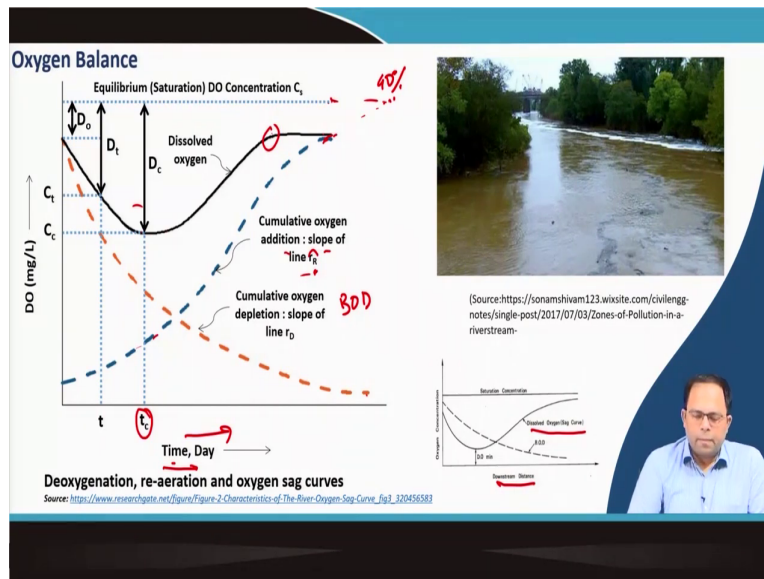
Active decomposition zone: Water is greyish with smells of hydrogen sulfide; scum may be observed on the surface. This is the area where the most decomposition takes place. DO level reaches the lowest level. This leads to the creation of gases from anaerobic processes such as CH₄ gas, CO₂ gas, H₂S gas. 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 D_c 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 C_s level which is 40%.

Disposal in sea


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Disposal in Sea


- The temperature of seawater is lower whereas specific gravity is higher compared to a stream.
- Sewage remains on the surface forming a thin film.
- Various chemical action and prevailing dissolved matter reduce the capacity to absorb more sewage.
- Sewage appears as precipitate in the milky colour and forms sludge banks- these sludge banks generate hydrogen sulfide.
- Dissolved oxygen in seawater is 20% less than stream water.
- Sewage Discharging pipes: Sufficiently inside sea (1.5 km), so sewage does not come back to shore.



Source: https://en.wikipedia.org/wiki/Sea_foam



Source: <https://www.floridatoday.com/story/news/local/environment/2019/07/29/central-florida-sludge-central/1829885001/>

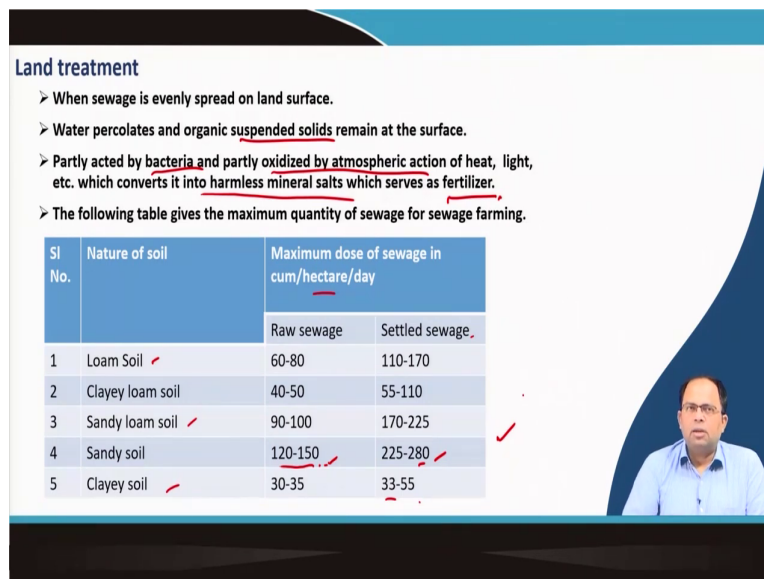


For urban areas with shoreline, waste is disposed of at the sea.

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

- When sewage is evenly spread on land surface.
- Water percolates and organic suspended solids remain at the surface.
- Partly acted by bacteria and partly oxidized by atmospheric action of heat, light, etc. which converts it into harmless mineral salts which serves as fertilizer.
- The following table gives the maximum quantity of sewage for sewage farming.

Sl No.	Nature of soil	Maximum dose of sewage in cum/hectare/day	
		Raw sewage	Settled sewage
1	Loam Soil ✓	60-80	110-170
2	Clayey loam soil	40-50	55-110
3	Sandy loam soil ✓	90-100	170-225
4	Sandy soil	120-150 ✓	225-280 ✓
5	Clayey soil ✓	30-35	33-55

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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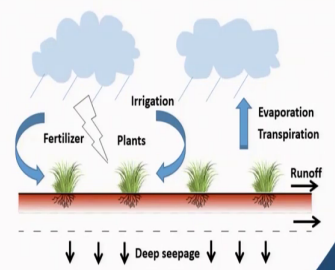
Land treatment

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 rainy season .
- Can spread diseases.
- Land may become sick.
- Best in low rainfall areas.
- Water table is much deep.
- Good for vegetable growth.



The diagram illustrates the land treatment process. It shows a cross-section of the ground with plants growing on it. Above the ground, there are clouds representing rain. A lightning bolt labeled 'Fertilizer' strikes the ground. A blue arrow labeled 'Irrigation' points to the plants. From the plants, blue arrows labeled 'Evaporation' and 'Transpiration' point upwards. A red arrow labeled 'Runoff' points to the right. Below the ground, several downward arrows are labeled 'Deep seepage'. A small text box at the bottom of the diagram reads: [Source: <https://www.climate-policy-watcher.org/wastewater-treatment/land-treatment-systems.html>]

[Source: <https://www.climate-policy-watcher.org/wastewater-treatment/land-treatment-systems.html>]

Advantages

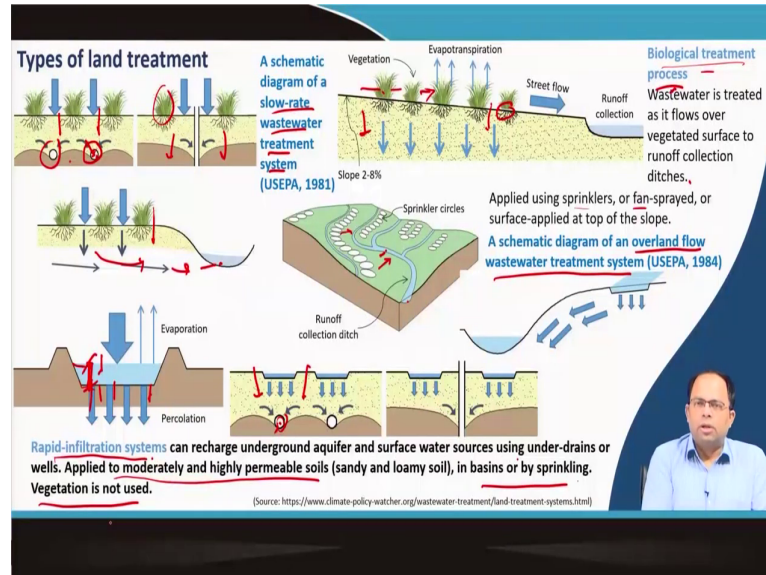
- Disposal by natural treatment.
- No water pollution no treatment plant.
- Fertilizers are generated which is good for vegetable growth.

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.

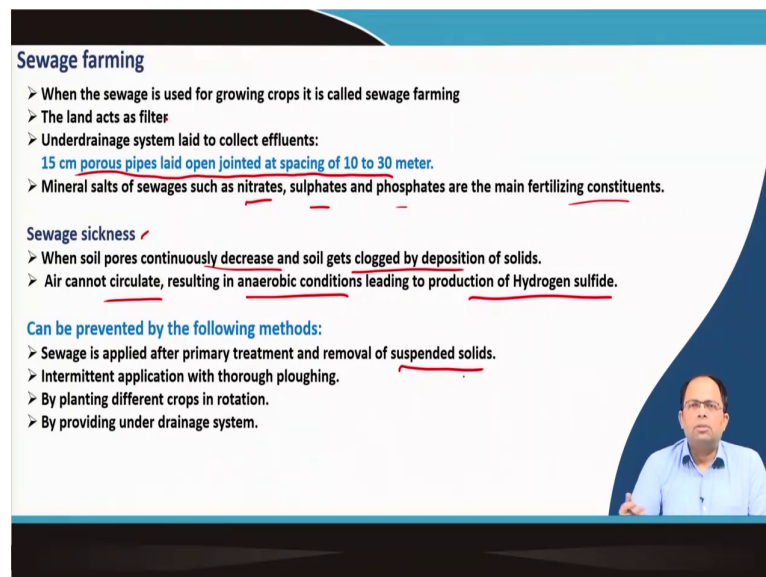
Overland flow wastewater treatment system - Sewage is spread on the land surface using sprinklers or fans (at a higher level) and ditches collect the sewage (at the lower level); this increases the surface area over which sewage is spread. The ditches carry the sewage to the disposal point. This process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

(Refer Slide Time: 28:38)



Sewage farming

- When the sewage is used for growing crops it is called sewage farming
- The land acts as filter
- Underdrainage system laid to collect effluents:
15 cm porous pipes laid open jointed at spacing of 10 to 30 meter.
- Mineral salts of sewage such as nitrates, sulphates and phosphates are the main fertilizing constituents.

Sewage sickness ✓

- When soil pores continuously decrease and soil gets clogged by deposition of solids.
- Air cannot circulate, resulting in anaerobic conditions leading to production of Hydrogen sulfide.

Can be prevented by the following methods:

- Sewage is applied after primary treatment and removal of suspended solids.
- Intermittent application with thorough ploughing.
- By planting different crops in rotation.
- By providing under drainage system.

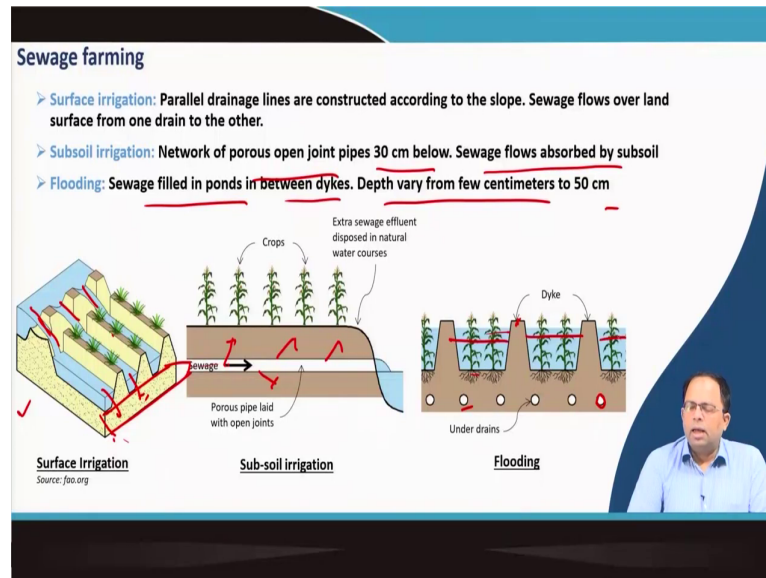
The slide includes a small video inset of a man in a light blue shirt speaking in the bottom right corner.

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.



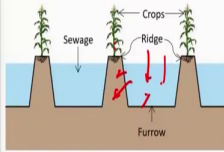
Subsoil irrigation - Sewage is introduced through pipelines to the subsoil. Network of porous open pipes is given 30 cm below. Sewage flows are absorbed by the subsoil and this provides the fertilizer and water for particular plants to grow.

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 and on if under drainage system is provided or not.

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Sewage farming

- **Ridge & Furrow:** Land ploughed deep into 30 CM, levelled into plots and sub-subplots. Plots enclosed by dykes forming ridges and furrows in subplot.
- **Spray irrigation:** Sewage is filled into tanks where the solids settle and is sprayed over lands.
- **Lagooning:** The sludge is allowed to go in a water tight pond where it is detained for a period. Within this period the sewage sludge is stabilized and dried.



Ridge and furrows

Effluent spraying, Waikato Regional Council, NZ

Sludge build-up in lagoons

[Source: <https://www.stuff.co.nz/business/farming/98473137/sensible-effluent-spreading-ensures-farms-benefit>]

[Source: <https://lagoons.com/blog/sludge/wastewater-lagoon-sludge-buildup/>]

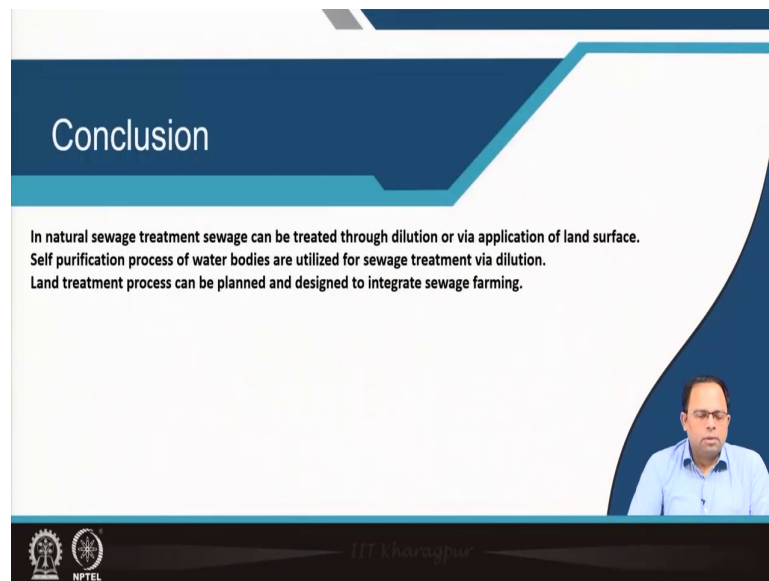
Ridge and furrow – This is similar to the previous one but the plants are grown on top of the dyke. Land ploughed deep into 30 centimeter levelled into plots and subplots. Plots enclosed by dykes form ridges and furrows in a subplot.

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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Conclusion

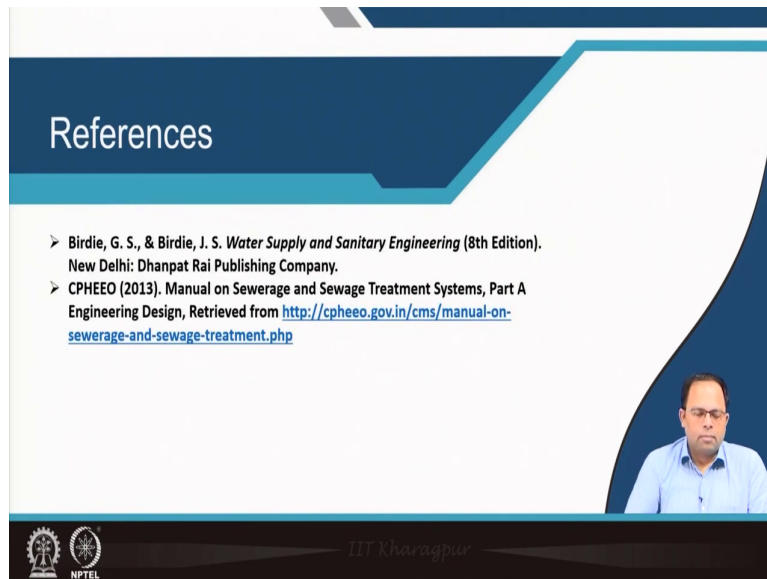
In natural sewage treatment sewage can be treated through dilution or via application of land surface.
Self purification process of water bodies are utilized for sewage treatment via dilution.
Land treatment process can be planned and designed to integrate sewage farming.

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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

(Refer Slide Time: 34:36)



References

- Birdie, G. S., & Birdie, J. S. *Water Supply and Sanitary Engineering* (8th Edition). New Delhi: Dhanpat Rai Publishing Company.
- CPHEEO (2013). Manual on Sewerage and Sewage Treatment Systems, Part A Engineering Design, Retrieved from <http://cpheeo.gov.in/cms/manual-on-sewerage-and-sewage-treatment.php>

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