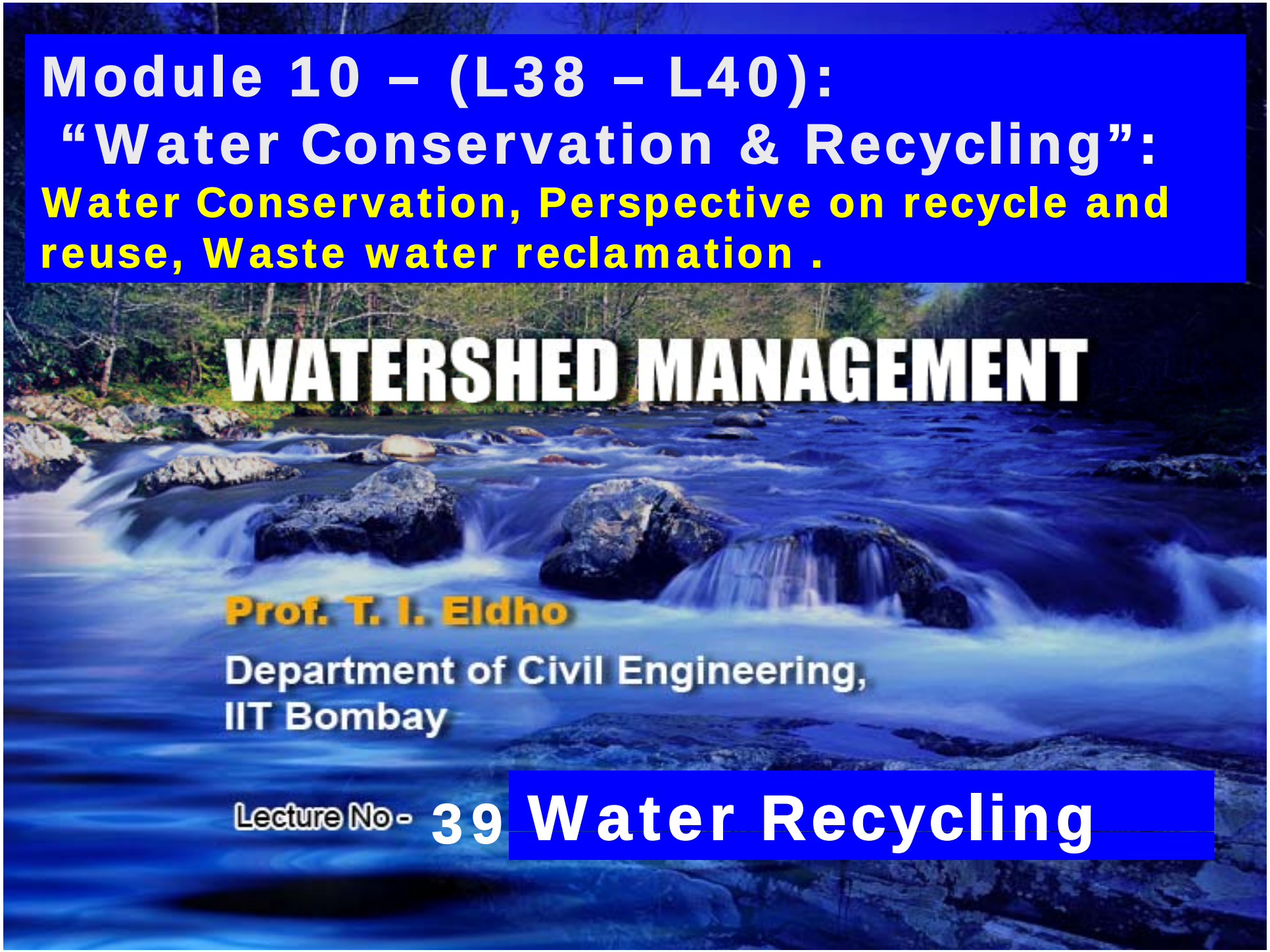
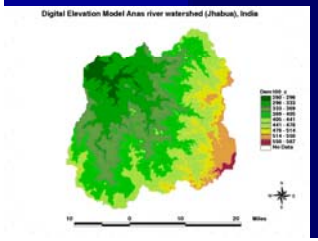
Module 10 – (L38 – L40):
"Water Conservation & Recycling":

Water Conservation, Perspective on recycle and reuse, Waste water reclamation .



L39– Water Recycling

- **Topics Covered**
- Water Recycling, Uses, Benefits, Water management solutions, water recycling treatments, Primary treatment, Secondary treatment, Tertiary treatment, Conventional & modern techniques
- Keywords: Water recycling, waste water treatments



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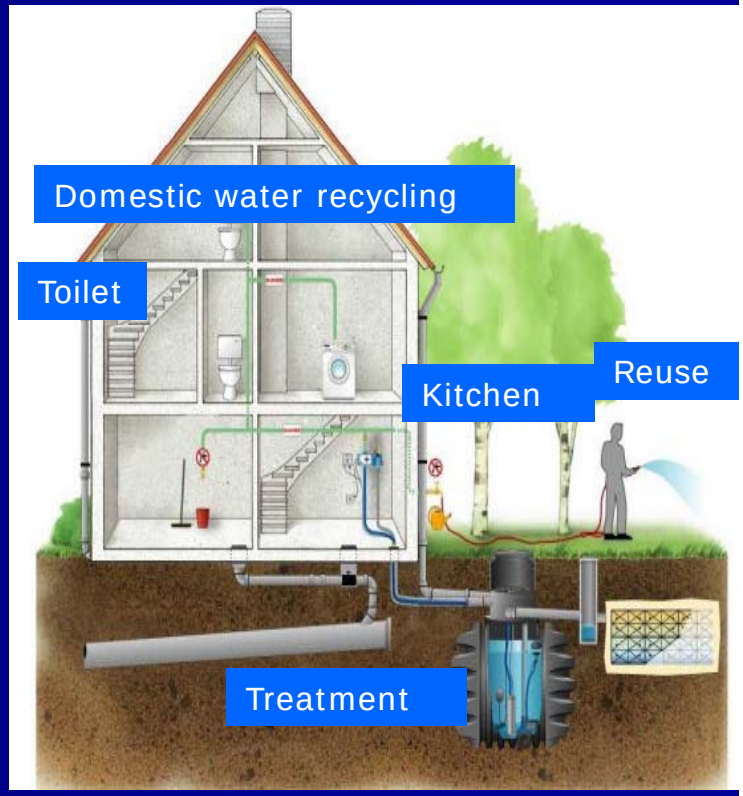
Introduction- Water Recycling

- Water recycling- reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing & groundwater recharge.
- A common type of recycled water is water that has been reclaimed from municipal wastewater or sewage.
- Through the natural water cycle, the earth has recycled & reused water for millions of years.



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Introduction – Water Recycling

- Water recycling offers resource and financial savings.
- Wastewater treatment can be tailored to meet the water quality requirements of a planned reuse.
- Recycled water for landscape irrigation requires less treatment than recycled water for drinking water.
- **Water is sometimes recycled and reused onsite.** Eg Industrial facility recycles water for cooling processes.
- Another common type of recycled water is water that has been reclaimed from municipal wastewater, or sewage.
- Gray water, or grey water, is reusable wastewater from residential, commercial & industrial bathroom sinks, bath tub shower drains, & clothes washing equipment drains.
- Gray water is reused onsite, for landscape irrigation.

Uses of Recycled Water

- Not used for potable, but used for non-potable purposes
- Agriculture
- Landscape
- Public parks
- Golf course irrigation
- Cooling water for power plants and oil refineries
- Processing water for mills, plants
- Toilet flushing
- Dust control, Construction activities, Concrete mixing
- Artificial lakes
- Recharging groundwater aquifers & augmenting surface water reservoirs

Benefits of Water Recycling

- Reduction of treated wastewater discharge to sensitive or impaired surface waters, reduction of imported water & avoided costs associated with importing water
- Environmental benefits -sustainable water resource.
- Recycled water can also be used to create or enhance wetlands and riparian habitats.
- Conservation of other resources besides water (e.g. Chromium removal from leather industry).
- Reuse at little extra cost
- Savings on water abstraction costs
- Reduced dependence on vagaries of river flows.
- Gaining tax advantages in arid & designated zones.
- Reduction in effluent discharge volume.

Water Management Solutions

- Water Stress Index: Annual renewable water resources per capita that are available to meet needs for domestic, industrial & agricultural use.
- Water Stress index is a common approach used to evaluate water availability
- 2/3 of world population will be under moderate high water stress – according to projections that predict in 2025
- 50% of the population will face constraints in water supply
- Water management solutions.
  - Surface water Management Solutions
  - Drainage and waste water management
  - Polluted water management
  - Water Recycling management

Surface water Management Solutions

Modular water storage units:

- Polystorm from Polypipe- lightweight cells- a high void ratio
- Applications: rainwater soakaways or stormwater attenuation

Permeable geotextiles

- conjunction with modular storage units- rainwater soakaway
- Tape & wrap package for self installation - for low risk areas

Silt traps

- To intercept silt & small objects from water drainage systems
- Situated upstream of the modular water storage units

Vortex flow controls: Used with stormwater attenuation system

- Ensure optimum designated water flow rates at discharge outlet by utilising an internal vortex-makes them more efficient

Drainage & Waste water management

Pumping stations (for small applications)

- Packaged tank & pump systems designed to lift small quantities of wastewater to reach existing drain or sewer

Pumping stations (for large applications)

- Packaged chamber & pump systems- to lift large quantities of wastewater to reach existing drain or sewer

Sewage treatment plants

- Designed for use where septic tank is either impractical & a connection to the main sewer is impossible.

Grease traps and separators

- Primarily used in catering & commercial premises
- To prevent vast amounts of grease, animal fats & oils from entering & solidifying in the drainage system

Polluted Water Management Solutions

Bypass separators

- Designed to intercept oil, petrol and silt from lightly contaminated surface water drainage systems

Full retention separators are designed

- To intercept oil, petrol & silt from heavily contaminated surface water drainage systems in high risk areas
- Treating the full flow that can be generated from the catchment area through the drainage system

Water Recycling Management Solutions

Greywater recovery systems (for domestic applications)

- Used in combination with rainwater harvesting
- Capture, treat & store lightly soiled water used within a dwelling
- Reused around the house for supplying water to flush toilets, wash clothes or water the garden.

Greywater recovery systems (for industrial and commercial applications)

- Used in combination with rainwater harvesting: capture, treat & store lightly soiled water used
- Reused for supplying water to flush toilets, wash clothes or water fields, sports grounds or gardens

Water Recycling Treatment & Uses

Water Collection **Primary Treatment:** Sedimentation	**Secondary Treatment:** Biological Oxidation, Disinfection	**Tertiary / Advanced Treatment:** Chemical Coagulation, Filtration, Disinfection	**Indirect potable reuse:**
No uses Recommend ed	Surface irrigation (Non-food crop) Restricted Landscape, Wetlands, wildlife habitat, stream Augmentation, Industrial cooling	Landscape & golf course irrigation Toilet flushing Vehicle washing Food crop irrigation Unrestricted Recreational impoundment	Groundwater recharge of potable aquifer and surface water reservoir augmentation

Stages of Wastewater Treatment

Depending on wastewater nature – treatment given before recycling

- **Preliminary treatment**:
  - removal of heavy solids like wood, rags and grit.
  - done by passing the inkling wastewater through a screen with bars 25-50 mm apart.
- **Primary treatment:**
  - slowing the wastewater down - settlement chambers or sedimentation tanks are used
  - In domestic situation, septic tank can be used as a settlement chamber, which may remove about 30-50 % of the BOD and suspended solids.

Stages of Wastewater Treatment

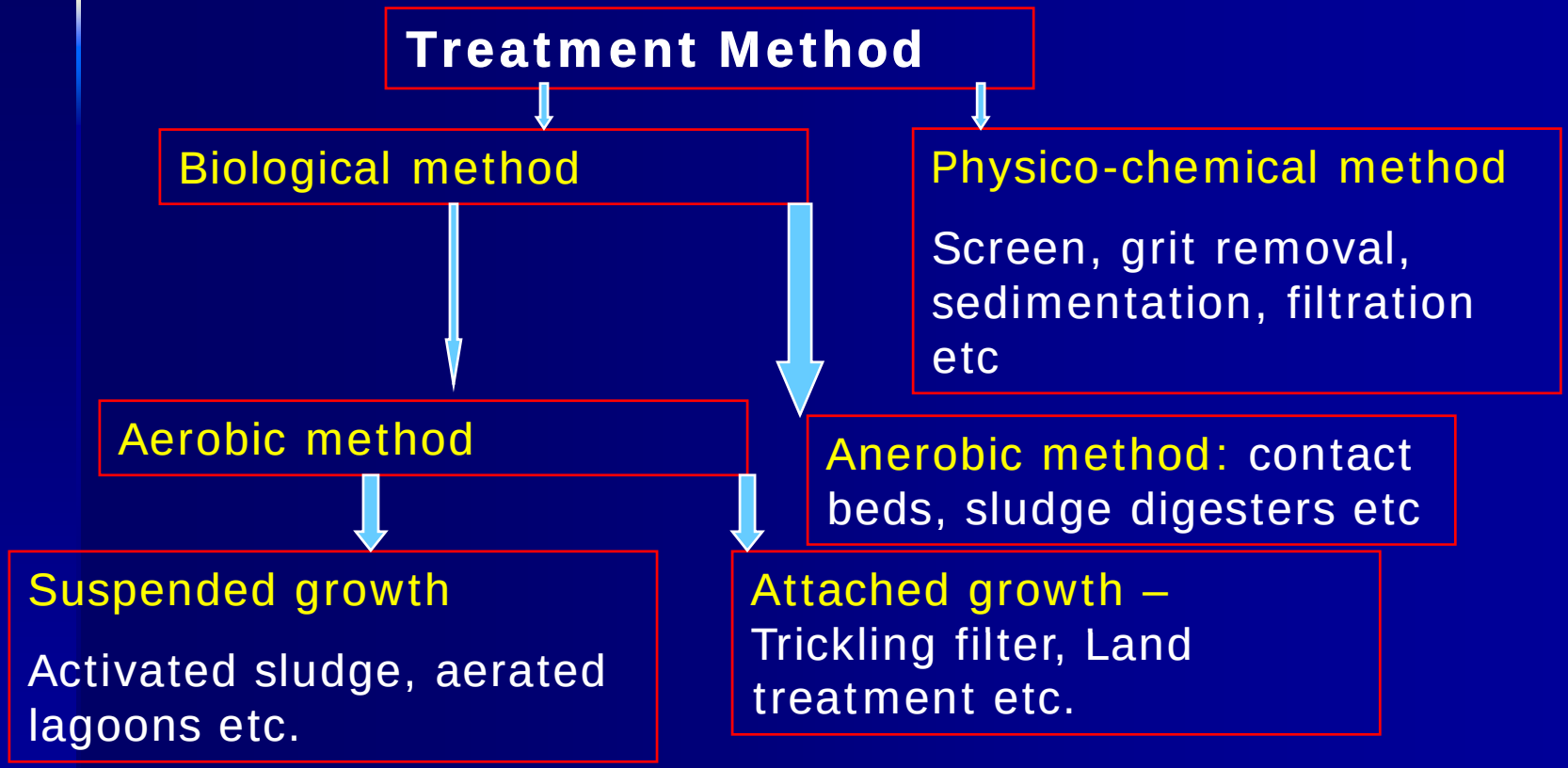
- **Secondary treatment:**
  - biological treatment (use of micro organisms) removes the remaining BOD and suspended solids.
  - During later stage of secondary treatment, the nitrification process begins. (when ammonia present in waste water is transformed into nitrate)
- ***Tertiary treatment:***
  - involves, taking the wastewater through a further biological, physical or chemical step.
  - further removal of BOD, suspended solids, nitrogen, phosphorous and pathogens.
  - can also be provided by using 'natural systems' of treatment such as ponds, lagoons, constructed wetlands, & methods where land is available.

Stages of Wastewater Treatment

Tertiary treatment for industrial reuse is usually done by using mechanized, physio-chemical processes:

- Activated carbon treatment (powdered or granular)
- Chemical oxidation & other advanced oxidation processes
- Multi-media filtration
- Softening (lime soda or zeolite)
- Demineralization (ion exchange)
- Disinfection (chlorine, hypochlorine, ozone, U-V)
- Membrane processes (microfiltration, ultrafiltration & reverse osmosis).

Tertiary treatment Method



Methods of Treating Wastewater

- **Conventional way of Treating Wastewater:**
  - ***Cesspools (Containment, decentralized):***
    - A cess pool is a big tank of at least 18 cubic metres; It has an inlet but no outlet; Do not treat wastewater, but store it until it is removed by a sludge tanker; Due to the environmental pollution especially to groundwater, not preferred in the urban environment.
  - ***Septic tanks (primary treatment, decentralized):***
    - Septic tanks have both an inlet & outlet- much smaller
    - Suitable for small scale waste water treatment & can be adopted for domestic/ hotels sewage treatment.
    - Provide primary treatment & should be followed by a soak pit or leach field.

Methods of Treating Wastewater

- ***Leach fields (Secondary, tertiary & dispersal– centralized/ decentralized):***
  - Last stage of a conventional treatment system.
  - Preceded by a septic tank & this combination is often referred to as a 'septic tank system'.
  - A leach field is a series of perforated pipes, surrounded by gravel, that run in underground trenches.
- ***Waste stabilization ponds (all stages possible, centralized/ decentralized):***
  - Solar ponds, settlement ponds, lagoons or sewage ponds -with a small anaerobic pond in the beginning, followed by larger aerobic ponds.
  - Placed in tandem with reed beds, making system more attractive - large surface area is required.

Methods of Treating Wastewater

- ***Constructed wetlands (centralized/ decentralized):***
  - Human made wetlands designed to closely imitate the treatment functions that occur in a natural wetland ecosystem - operate on ambient solar energy & require low external energy input.
- ***Duckweed pond (centralized/ decentralized):***
  - green coloured small plants which grows in sewage holding ponds - feed on the organic elements in the wastewater for growth - for the treatment of low-strength community wastewater- Duckweeds help in removing nutrients and heavy metals by absorbing nitrogen, phosphorous, sulphur and trace elements.

Methods of Treating Wastewater

- ***Trickling filters (secondary treatment, decentralized):***
  - Trickling filters are always preceded by a primary settlement stage, usually a septic tank, and followed by a humus tank.
  - They are also known as percolating filters, biological filters and filter beds.
  - A trickling filter is a container, usually filled with blast furnace clinker or stones, called as media.
  - Sewage is distributed over the surface of this media and drains freely to the base. The method is relatively robust, tolerant of peak loadings and does not require power, if a fall is available.

Treating Wastewater – Modern Techniques

***Upflow Anaerobic Sludge Blanket Reactor (UASBR)*:**

- Treatment plant - shop assembled - A sludge blanket cultured in the lower portion of the UASBR very effectively traps suspended & dissolved organic matter.
- Rotating Biodisc Contactor (RBC)- second unit in the series, takes the atmospheric oxygen.
- An attached growth anoxic reactor is built into the upper portion of the UASBR for conversion of nitrites & nitrates into nitrogen gas.
- Entire operation is simple & system once stabilized, can be left to itself without much human intervention.
- The treated water may be used for irrigation purpose, depending on the nature of the waste water.

Treating Wastewater – Modern Techniques

Cyclic activated sludge process (c-tech):

- Cyclic activated wastewater treatment process - carbon oxidation, nitrification, denitrification & bio-phosphorous removal are carried out simultaneously.
- Ensures that all the effluent processes like equalization, aeration, settling & decanting carried out in a single tank.
- Treats the effluent to a level specified by authorities for irrigation or discharge into open water sources like rivers.
- Treated effluent has the characteristics such as BOD< 30 mg/l, COD<150 mg/l & ammonia nitrate < 5mg/l etc.
- The technology is automatic and found to be economical.

Treating Wastewater – Modern Techniques

Membrane processes:

- Membranes- semi-permeable materials designed to separate particulate, colloidal & dissolved substances from liquid solutes.
- Allow substances smaller than the membrane pores to flow through, while holding back substances larger than the pores.
- Membranes - produced from a wide variety of materials such as cellulose acetate, polyamides, polysulfones, polypropylene, nylon, polyvinyl alcohol etc.
- The four most common configurations are: tubular, plate and frame, spiral wound and hollow fibre

Modern Techniques – Membrane Processes

- ***Micro-filtration (MF):***
  - MF membranes (pores > 50 nm (nano-metre)) are the least expensive membranes
  - Used in wastewater treatment for turbidity removal, solids separation after biological treatment, as in Membrane Bioreactors (MBRs), removal of helminth ova, other organisms etc.
- ***Ultrafiltration (UF)***:
  - UF membranes (pore sizes 2-50 nm) have been used in wastewater treatment for many of the same applications as MF membranes except that UF systems give a better separation of finer colloids, bacteria, viruses etc.

Modern Techniques – Membrane Processes

- **Nanofiltration (NF):**
  - In NF membranes, the pores should be less than 2 nm.
  - The pressures vary between 520-1400 kPa and flux rates vary from 200-800 L/ m^2/d.
  - Used in water purification for potable purpose
- **Reverse Osmosis (RO)**:
  - Membranes have pores < 2nm and have the lowest molecular weight cut-off; high operating pressures of > 1400 kPa &Flux rates vary from 300 – 500 L/ m2/d.
  - Used in desalination operations.
  - RO in further treating - pre-treated by MF & UF to produce waters of high quality for indirect reuse applications
  - ***Ultraviolet (UV) Disinfection*:**

Overview of Water Recycling Practices

- Water recycling is a growing practice in many regions of the world including USA, Europe, India, Australia, Israel etc.
  - About 13 million m^3/d is recycled & reused in USA - a small fraction of total volume of wastewater generated.
  - Out of 140 million m^3/d, only about 10% of wastewater is recycled, suggesting the potential of recycling
  - Recycled water use on a volume basis is growing at an estimated 15% per year in the US.
  - All evidences suggest that water recycling will play major role in the water management in the 21st century.
  - In US, at a compound annual growth rate of 15%, the volume of recycled water would amount to 45 million m^3/d by the year 2015.

Water Recycling Practices in India

- In India, presently water recycling is not so common.
- In India, some of the methodologies adopted include (Arcevala and Asolerkar, 2007):
  - Plain water conservation
  - Reuse without any treatment
  - Reuse after treatment using on-site toilet waters and some easily treated industrial wastewaters
  - Reuse after treatment using off-site sources of municipal wastewater
  - A study of the reuse of waste water in India shows that the reuse has achieved in affordable costs and some industries have in fact, saved money by reusing their wastewaters.

Water Recycling Practices in India

- In India, water recycling has first begun in Mumbai in 1964-65, by textile industry, - shown that nearly 15-20 % of water can be recycled without any pre-treatment.
- Cost of providing direct reuse was relatively small
- Cost/benefit ratios- high & cost recovery periods is low.
- The recycling was carried out in as many as 22 mills of Mumbai and later few more industries started recycling.
- A typical treatment scheme for toilet waters for reuse in cooling water make-up is as follows:

  Wastewater -> Screening -> Extended aeration -> Chemical dosing + Flocculation -> Sand filtration -> Zeolite softening + acid correction + occasional chlorine shock dose -> make-up water to cooling towers.

Sludge & other wastewaters- returned to sewer line.

Water Recycling in India - Examples

- ***Oswal Agro (Union Carbide Plant), Chembur, Mumbai:***
  - Tertiary treatment plant built in 1968-69 for sewage water reclamation with capacity of 5 -10 Mld - raw sewage was obtained from Municipal Corporation.
  - Dependable source of water.
  - The treated water used for cooling purpose - The treatment scheme include the following:

  Wastewater -> Screening -> Grit removal -> Extended aeration -> Chemical dosing + Flocculation -> Sand filtration -> Zeolite softening + acid correction + occasional chlorine shock dose -> make-up water to cooling towers.

Water Recycling in India - Examples

- ***Rashtriya Chemicals & Fertilizers (RCF), Chembur, Mumbai:***
  - Recycling plant of 23 Mld capacity built in 2000 with a plant cost of Rs. 40 crores.
  - Complicated treatment process including RO. In 2005, the operating cost was Rs. 39 per m3.
  - With success of recycling schemes -Municipality charge Rs. 6/- of m3 raw wastewater.
  - The plant in RCF has the following flow sheet
  - *Wastewater -> Screening -> Grit removal -> Activated Sludge System -> Clarifier -> Sand Filter -> Pressure Filter-> Cartridge Filters ->Reverse Osmosis -> Degasser to Remove CO2 -> Reuse in Industry.*

Future of Water Recycling

- Water recycling has proven to be effective and successful in creating a new and reliable water supply without compromising public health.
- Nonpotable reuse is a widely accepted practice that will continue to grow.
- Advances in wastewater treatment technology and health studies of indirect potable reuse may lead to indirect potable reuse.
- Recycling waste & gray water requires far less energy than treating salt water using a desalination system.
- Water recycling is a sustainable approach and can be cost-effective in the long term
- Public be informed & involved in the planning process.

References

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- P.H. McGauhey "Man Made Contamination Hazards", J. Groundwater, July 2006.
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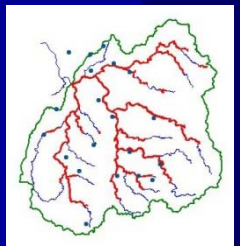
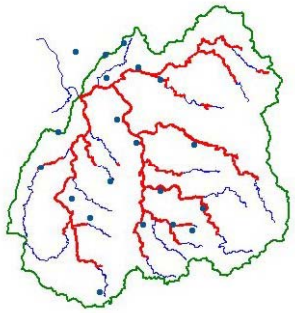
Tutorials - Question!.?.

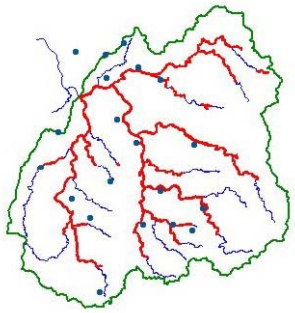
- Critically analyze and study the scope of water recycling in India.
- Whether water recycling & reuse a solution for water scarcity in India?.
- Study and compare various case studies available and evaluate the economics.
- (Ref: Arceivala, S.J., and Asolekar, S.R., (2007), “Wastewater Treatment for Pollution Control and Reuse”, Tata-McGraw-Hill, New Delhi.)





Self Evaluation - Questions!.

- Illustrate water recycling & its importance.
- What are the benefits of water recycling?.
- What are the different stages of wastewater treatment?.
- Illustrate various conventional ways of treating wastewater?.



Assignment- Questions?.

- Discuss various uses of recycled water.
- Describe various water management solutions
- Describe the various stages of tertiary treatment methods.
- Illustrate various modern ways of treating waste water.

THANK YOU

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