Water Supply & Sanitary Engineering (DI05006021)

Unit 11: Recycling of wastewater and Solid Waste
Lecture 43: Introduction to Wastewater Recycling and Reuse

GTU Diploma Engineering

Agenda

- Need for Wastewater Recycling
- Terminology: Reclaimed vs. Recycled Water
- Treatment Levels for Reuse
- Agricultural and Landscape Irrigation
- Industrial Water Reuse
- Urban Non-Potable and Potable Reuse
- Challenges in Wastewater Recycling

The Need for Wastewater Recycling

- Rapid urbanization and population growth place immense stress on finite freshwater resources.
- Climate change leads to unpredictable precipitation patterns and prolonged droughts.
- Discharging untreated or partially treated wastewater degrades receiving water bodies (eutrophication).
- Recycling wastewater provides a drought-resistant, reliable alternative water supply.

Terminology: Reclaimed, Recycled, and Reused Water

- Reclaimed Water: Wastewater that has been treated to meet specific water quality criteria with the intent of being used for beneficial purposes.
- Recycled Water: Often used synonymously with reclaimed water, though sometimes refers specifically to internal reuse within an industry.
- Direct Reuse: The use of reclaimed water that has been transported from a wastewater treatment plant to a reuse site without passing through a natural body of water.
- Indirect Reuse: Discharging reclaimed water into a natural water body (river, lake, aquifer) before abstracting it for use.

Treatment Levels Required for Reuse

- Primary Treatment: Usually insufficient for reuse due to high pathogen and suspended solids content.
- Secondary Treatment: Suitable for restricted agricultural irrigation (non-food crops) and some industrial cooling.
- Tertiary/Advanced Treatment: Involves filtration (sand, membrane) and high-level disinfection (UV, Chlorine, Ozone).
- Required for unrestricted agricultural irrigation, urban landscaping, and dual-pipe systems.

Agricultural and Landscape Irrigation

- Agriculture is the largest consumer of freshwater globally.
- Using reclaimed water for irrigation frees up high-quality potable water for domestic use.
- Nutrient Recovery: Treated wastewater often retains nitrogen and phosphorus, reducing the need for synthetic chemical fertilizers.
- Strict monitoring of heavy metals and pathogens (e.g., E. coli, Helminth eggs) is essential to protect soil and public health.

Industrial Water Reuse

- Industries utilize large volumes of water for cooling, washing, and processing.
- Cooling Towers: The most common industrial application for reclaimed water. Requires control of scaling (calcium, magnesium) and biological growth (biofouling).
- Boiler Feed Water: Requires highly treated water (often via Reverse Osmosis) to prevent scaling and corrosion at high temperatures.
- Zero Liquid Discharge (ZLD): Advanced industrial systems where 100% of wastewater is treated and reused internally, leaving only solid waste.

Urban Non-Potable Reuse

- Dual-Pipe Systems: Separate piping networks deliver potable water (clean, safe) and reclaimed water (purple pipes).
- Applications include toilet flushing, street washing, fire protection, and irrigating public parks and golf courses.
- Color Coding: Reclaimed water infrastructure is universally colored purple to prevent cross-connection with potable supplies.
- Requires stringent tertiary treatment to ensure public safety against accidental ingestion or aerosol inhalation.

Potable Reuse: Indirect vs. Direct

Concept 1	Concept 2

Indirect Potable Reuse (IPR): Highly treated wastewater is blended with natural water sources (groundwater aquifers or surface reservoirs) before being treated again at a drinking water plant.

Environmental buffer provides additional natural treatment and public psychological reassurance.

Direct Potable Reuse (DPR): Advanced treated wastewater is introduced directly into the potable water distribution system or immediately upstream of a water treatment plant.

Requires extreme multi-barrier treatment (Microfiltration + RO + Advanced Oxidation Process).

Groundwater Recharge

- A form of Indirect Potable Reuse.
- Methods: Surface spreading basins (percolation) or direct injection wells.
- Soil Aquifer Treatment (SAT): As water percolates through the soil, physical filtration, chemical adsorption, and biological degradation naturally purify it.
- Prevents saltwater intrusion in coastal aquifers and replenishes depleted groundwater tables.

Technological Barriers in Advanced Treatment

- Contaminants of Emerging Concern (CECs): Pharmaceuticals, personal care products, and endocrine-disrupting chemicals (EDCs) are not fully removed by secondary treatment.
- Membrane Bioreactors (MBR): Combine biological treatment with micro/ultrafiltration for superior effluent quality.
- Advanced Oxidation Processes (AOP): Use ozone (O3) and hydrogen peroxide (H2O2) with UV light to destroy complex organic micro-pollutants.
- Reverse Osmosis (RO): Essential for removing dissolved salts and micro-pollutants but generates a concentrated brine stream.

Challenges and Public Perception

- The 'Yuck Factor': Psychological resistance from the public regarding the consumption of 'toilet-to-tap' water.
- Economic Costs: Advanced treatment facilities (RO, AOP) and dual distribution networks are highly capital-intensive and consume significant energy.
- Regulatory Frameworks: Lack of uniform international or national guidelines specifically for various reuse categories.
- Brine Disposal: RO and membrane processes produce highly concentrated brine that must be safely disposed of without harming the environment.

Summary

- Wastewater recycling is essential for sustainable water resource management.
- Applications range from agricultural and industrial to urban non-potable and even potable reuse.
- The level of treatment must strictly align with the intended use to protect public health and the environment.
- Advanced technologies like MBR, RO, and AOP are critical for high-end reuse.
- Overcoming public perception and high economic costs are the primary challenges.