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WASTEWATER TREATMENT AND RECYCLING

Dr. MANOJ KUMAR TIWARI
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WASTEWATER TREATMENT AND RECYCLING
Course Introduction
Week 1- Lecture 1

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COURSE INTRODUCTION

What is Wastewater ?

o **Water that has been used in the home, in a business, or as part of an industrial process.** *(Oxford Dictionary)*

o **Water that has been used in washing, flushing, manufacturing etc.** *(http://www.dictionary.com)*

Image Source: http://www.downtoearth.org.in/news/-78-of-sewage-generated-in-india-remains-untreated--53444

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COURSE INTRODUCTION

Wastewater: A burden or A resource ?

Burden:
As it Contains pollution

Resource:
Generally, > 99% fraction is water

Image Source: https://agriorbit.com/using-wastewater-agricultural-resource/

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COURSE INTRODUCTION

What is Wastewater Treatment ?

Processing of wastewater for removal of contaminants

Image Source:
https://www.conserve-energy-future.com/process-of-wastewater-treatment.php

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COURSE INTRODUCTION

What is Wastewater Recycling ?

Reusing treated wastewater (reclaimed water) for beneficial purposes

Potable Water

Waste Water

Image Source:
https://sustainabilityworkshop.autodesk.com/buildings/wastewater-recycling

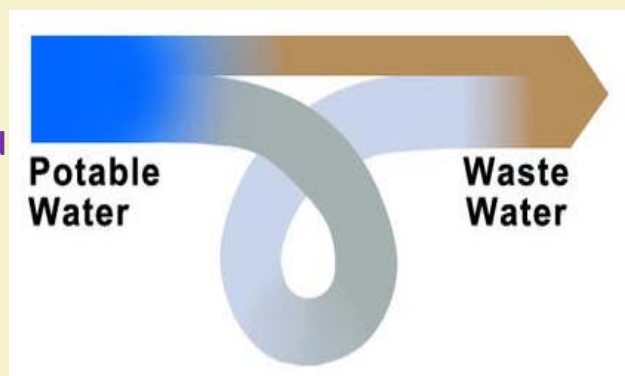| IIT KHARAGPUR	NPTEL ONLINE CERTIFICATION COURSES	MANOJ KUMAR TIWARI SCHOOL OF WATER RESOURCES IIT KHARAGPUR

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COURSE INTRODUCTION

Why learn wastewater management ?

To transform the "burden" into "resource"

This Requires:

Engineering/Technological approaches

Social acceptability

Financial / economic viability

Environmental sustainability

Image Source: http://www.indiawaterportal.org/events/wastewater-management-india-iqpc-23rd-26th-may-2011-new-delhi

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COURSE INTRODUCTION

Objectives of learning wastewater treatment and recycling:

o Understanding the value of wastewater as a recourse.

o Recognizing and the available technologies for wastewater treatment and grasping knowledge on major tools and approaches for wastewater treatment.

o Awareness on modern-age issues and challenges in wastewater treatment and recycling.

o Gaining knowledge on tools and techniques suitable for wastewater reclamation and recycling.

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COURSE INTRODUCTION

What to Study

- Wastewater Generation and Characteristics
- Natural Attenuation of Pollutants
- Treatment Philosophy
- Wastewater Treatment Units and Processes
- Issues and Challenges with Conventional Treatment
- Advanced Treatment Processes
- Concept of Wastewater Recycling
- Recycling Requirements
- Technology Selection and Decision Making

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WASTEWATER TREATMENT AND RECYCLING
Sources and Types of Wastewater
Week 1- Lecture 2

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Wastewater

Wastewater is liquid waste, often produced as the byproduct of many uses of water.

➢ Household uses
➢ Industrial uses
➢ Commercial uses
➢ Agricultural uses
➢ Livestock uses

Image Source:
http://techalive.mtu.edu/meec/module21/HouseholdTreatment-BrittaFilters.htm

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Wastewater Sources

Source of wastewater

1. Agricultural	2. Domestic	3. Industrial

1. Point source
- Poultry waste
- Piggery waste
- Silage liquor
- Dairy farming waste
- Slaughtering waste
- Vegetable waste
- Firewater

2. Non-point sources
- Sediment runoff
- Nutrient runoff (Commercial fertilizer)

Domestic
- Washing / laundry
- Shower
- Kitchen
- Toilet /
- Septic tank
- Schools
- Hospitals
- Hotels/ restaurants
- Office
- Small business activities

Industrial
- Canaries
- Milk dairies
- Sugar factories
- Breweries
- Beverages
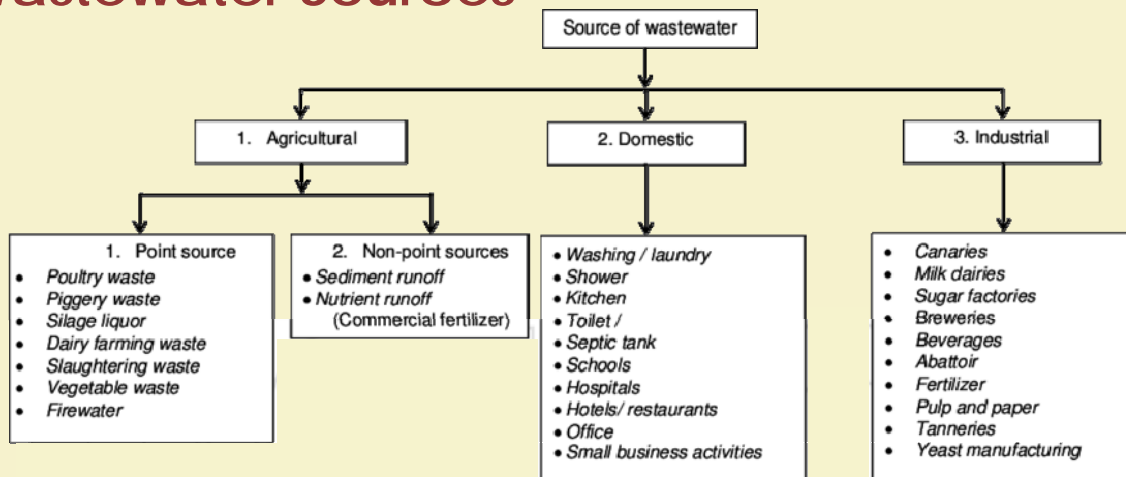- Abattoir
- Fertilizer
- Pulp and paper
- Tanneries
- Yeast manufacturing

Image Source: Irrigation and Drainage - Sustainable Strategies and Systems, Publisher: INTECH, Editors: M S Javaid, pp.55-75

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Wastewater Types

- Domestic Wastewater
  (Municipal wastewater or sewage)

- Industrial Wastewaters
  (Industrial effluents)

- Agricultural wastewater
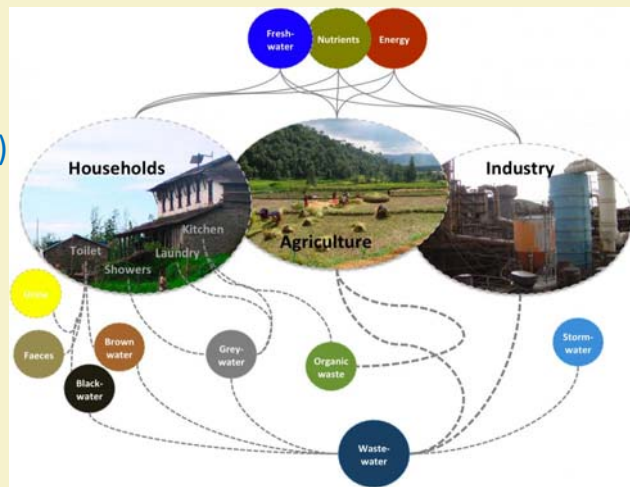 (Agricultural runoff)

- Stormwater Runoff

Image Source: https://www.sswm.info/sswm-university-course/module-6-disaster-situations-planning-and-preparedness/further-resources/sanitation-systems

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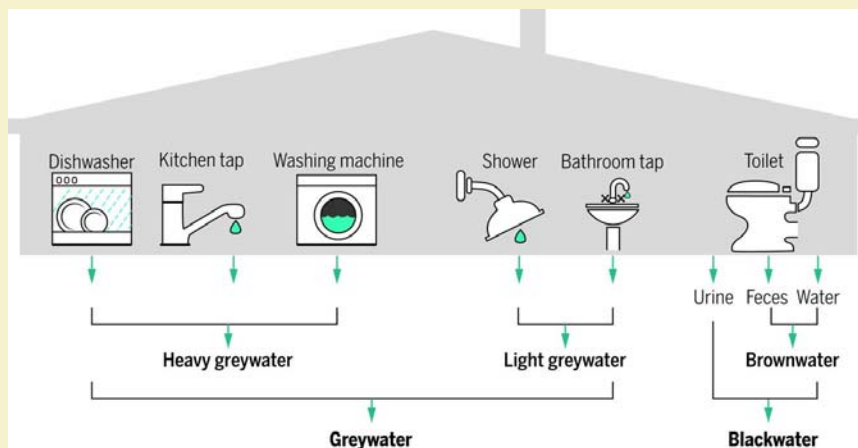
Wastewater Sources and Types: Domestic

Image Source: Larsen et al, (2016), Emerging solutions to the water challenges of an urbanizing world, Science , 352 (6288), pp. 928-933

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Wastewater Sources: Industrial

Image Source: https://www.iswa.uni-stuttgart.de/lsww/arbeitsbereich/iwt/index.en.html

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Wastewater Sources: Agricultural

Image Source:
http://www.deeproot.com/blog/blog-entries/whats-the-point-of-non-point

Image Source:
https://www.usda.gov/media/blog/2013/04/25/water-quality-index-agricultural-runoff-streamlined-and-accessible

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WASTEWATER TREATMENT AND RECYCLING
Pollutants in Wastewater: Point and Non-point Sources
Week 1- Lecture 3

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What is a pollutant ?

➢ Where it is present ?

➢ Quantitative aspects ?

➢ Natural or anthropogenic ?

➢ Adverse health effect or not ?

POLLUTANT VERSUS CONTAMINANT

| Pollutant is a harmful or poisonous substance that pollutes something. | Contaminant is a foreign substance or impurity that contaminates something. |

| Pollutants always create harmful effects. | Contaminants do not always create harmful effects. |

| Pollutants can be either foreign substances or a component of the original substance that has exceeded the harmless level. | Contaminants usually refer to foreign matter that are introduced from the outside. |

Image Source: http://pediaa.com/difference-between-pollutant-and-contaminant/

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Wastewater Sources: Point vs Non-Point

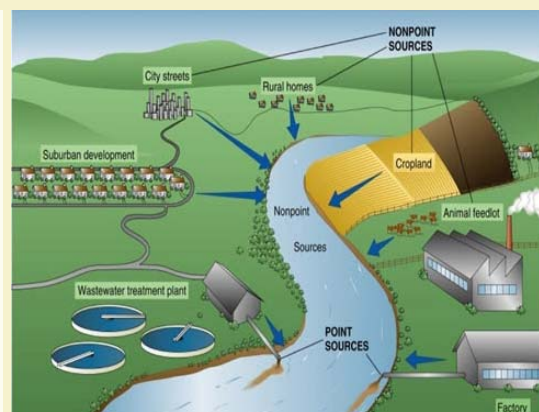|	Point Source Pollution	Nonpoint Source Pollution
What is it?	An identifiable source of pollution from which pollutants can be measured and discharged, such as pipes, ditches, smokestacks, and wells	An indeterminate source of pollution from which pollutants cannot be measured
Where does it come from?	Sewage treatment plants Oil refineries Manufacturers of chemicals, electronics, and automobiles Animal feeding operations Ships and other watercraft Septic tanks Landfills	Excess fertilizers and pesticides from agricultural lands and residential areas Paint, oil, grease, and toxic chemicals from urban runoff Sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks Salt from irrigation practices and acid drainage from abandoned mines Bacteria and nutrients from livestock, pet wastes, and faulty septic systems

Source: U.S. Environmental Protection Agency, www.epa.gov.

Source: http://www.ift.org/knowledge-center/read-ift-publications/science-reports/scientific-status-summaries/just-add-water.aspx

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Wastewater Sources: Point vs Non-Point

Differences between point and Non-point Sources of Pollution

Point Sources (PS)	Non-Point Sources (NPS)
Discharge usually controlled by permits	Many small difuse sources from many different locations
Relatively easy to control because we know the type of contaminants, and location of discharge	Individual contributions are small but cumulative effects can be significant
Easy to monitor above & below discharge, and dilution rates can be calculated	Difficult to monitor, requires many stations
Industry can be fined if they do not comply with permit regulations	Difficult to develop permit systems and difficult to enforce regulations
	Difficult to determine despersion rates

Source: http://ubclfs-wmc.landfood.ubc.ca/webapp/IWM/course/land-use-water-4/introduction-5/

Image Source: http://pest.ca.uky.edu/PSEP/6environment.html

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Wastewater Sources: Point Source Examples

Image Source: https://oceanservice.noaa.gov/education/kits/pollution/03pointsource.html

Image Source: http://www.indiacelebrating.com/environmental-issues/sources-and-causes-of-water-pollution/

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Wastewater Sources: Non-Point Source Examples

Image Source:
https://commons.wikimedia.org/wiki/File:Sediment_runoff_NRCS_2016a.jpg

Image Source:
http://www.hoffmanestates.org/government/finance/water-billing/stormwater-utility-program

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WASTEWATER TREATMENT AND RECYCLING
Wastewater Management: Concept of Treatment and Recycling
Week 1- Lecture 4

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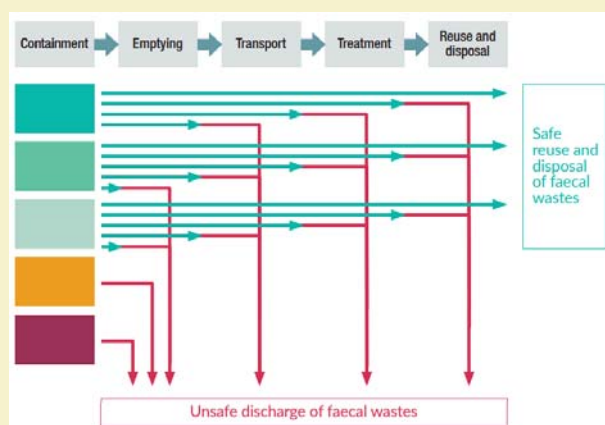SCHOOL OF WATER RESOURCES
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Need of Wastewater Management

➢ The discharge of untreated or partially treated wastewater results in environmental pollution and may have severe consequences that can be classified into three groups:

➢ **Adverse human health effects** associated with reduced water quality;

➢ **Negative environmental effects** due to the degradation of water bodies and ecosystems; and

➢ **Potential effects on economic activities**

Source: http://unesdoc.unesco.org/images/0024/002471/247153e.pdf

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Need of Wastewater Management

Human health effects

Sanitation associated risk of diarrhoeal disease

➤ Sanitation and wastewater-related diseases remain widespread in regions with poor wastewater management.

➤ In 2012, an estimated 8,42,000 deaths in middle- and low income countries were caused by contaminated drinking water, inadequate cleaning and sanitation services
(**Source:** apps.who.int/iris/ bitstream/10665/150112/1/9789241564823_eng.pdf).

➤ Improving sanitation and wastewater treatment is a key intervention strategy to control and eliminate many diseases, including cholera, dengue, diarrhoea, helminths etc.

Source: http://unesdoc.unesco.org/images/0024/002471/247153e.pdf

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Need of Wastewater Management

Environmental effects

➤ The discharge of untreated wastewater **pollutes the receiving water body** which in turn affects the amount of water resources available for direct use.

➤ Lately, water pollution has been increasing in most rivers in India as well as in several other countries from Africa, Asia and Latin America, mainly due to the release of sewage and industrial effluents with no (or inadequate) treatment.

➤ The environmental pollution due to inadequate wastewater management has also a direct impact on ecosystems and the services they provide. For e.g. eutrophication, driven by excess nitrogen and phosphorus, can lead to potentially toxic algal blooms and declines in biodiversity.

Source: http://unesdoc.unesco.org/images/0024/002471/247153e.pdf

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Need of Wastewater Management

Economic effects

➢ As the freshwater availability is critical for economic welfare and growth, poor water quality constitutes an additional obstacle to economic development.

➢ Poor water quality **can directly affect economic activities that use water**, such as agriculture, industrial production, fisheries, aquaculture, navigation and tourism.

➢ With improper management of wastewater, external costs (externalities) are generated and the potential benefits of using wastewater are lost.

➢ An economic argument for improved wastewater management can be made in order to minimize the negative impacts it can cause and to maximize the benefits it can generate.

Source: http://unesdoc.unesco.org/images/0024/002471/247153e.pdf

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Need of Wastewater Management

Negative Impacts of Poor Wastewater Management

Impacts on	Examples of impacts
Health	• Increased burden of disease due to reduced drinking water quality • Increased burden of disease due to reduced bathing water quality • Increased burden of disease due to unsafe food (contaminated fish, vegetables and other produce irrigated) • Increased risk of disease when working or playing in wastewater-irrigated area
Environment	• Decreased biodiversity • Degraded aquatic ecosystems (e.g. eutrophication and dead zones) • Foul odours • Diminished recreational opportunities • Increased greenhouse gas emissions • Increased water temperature • Bioaccumulation of toxins
Economy	• Reduced industrial productivity • Reduced agricultural productivity • Reduced market value of harvested crops, if unsafe wastewater is being used for irrigation • Reduced opportunities for water-based recreational activities (reduced number of tourists, or reduced willingness to pay for recreational services) • Reduced fish and shellfish catches, or reduced market value of fish and shellfish • Increased financial burden on healthcare • Increased barriers to international trade (exports) • Higher costs of water treatment (for human supply and other uses) • Reduced prices of properties near contaminated water bodies

Source: http://unesdoc.unesco.org/images/0024/002471/247153e.pdf

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Need of Wastewater Treatment

➢ Recycling wastewater is believe to be the most sustainable approach for wastewater management, however recycling needs quality of water to be fit for the designated uses.

➢ Therefore, the quality of wastewater needs to be improved through suitable treatment processes before it is recycled.

➢ Wastewater treatment is **the most critical step in wastewater management** as the suitability of wastewater for reuse (or, even disposal) depends on the ability of treatment steps to reduce the contaminant load to the desired levels (standards).

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Effective Wastewater Management Cycle

➢ The prevention or reduction of pollution at the source (in terms of pollution load and volume of wastewater produced)

➢ The removal of contaminants from wastewater streams

➢ The use of wastewater (i.e. water reuse)

➢ The recovery of useful by-products

Source: http://unesdoc.unesco.org/images/0024/002471/247153e.pdf

Image Source: http://pubdocs.worldbank.org/en/326201521231539309/WB-WasteWater-Resource-infographic.pdf

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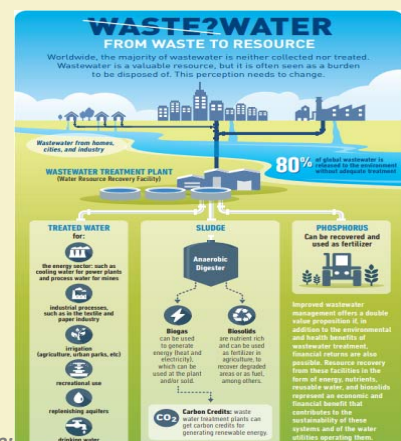
Wastewater Management: Recycling Perspective

Resources in excreta and wastewater	Resource management options	Technical system options	Multiple potential benefits
Water	**Water reuse and recycling** Potable and non-potable water / industrial use / recharge of water bodies	Centralized vs decentralized	Health protection
Nutrients	**Combined water and nutrient reuse** Agricultural irrigation / forestry irrigation / aquaculture	Waterborne vs non-waterborne excreta management	Environmental protection
Energy content	**Nutrient reuse or combined organic matter/nutrient reuse** Solid and liquid fertilizer and soil conditioner for agriculture and forestry	Separate greywater management	Livelihoods
	Energy generation Biogas generation / incineration / Biomas production	Sludge management	Gender equity
Organic matter	**Ecosystem services** i.e. constructed wetland	Off-site vs on-site treatment	Water security
Other		Wastewater treatment	Food security
	Other outputs i.e. protein feed for livestock / building material	Excreta and sludge treatment	Energy security
			Climate mitigation and adaptation

Source: http://unesdoc.unesco.org/images/0024/002471/247153e.pdf

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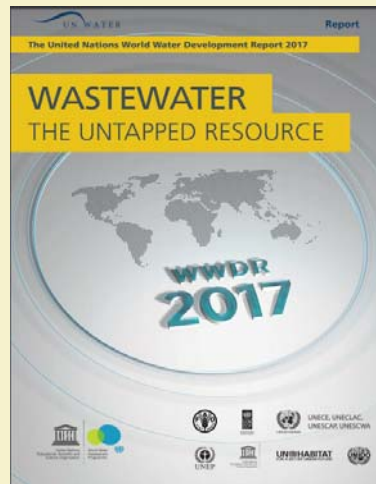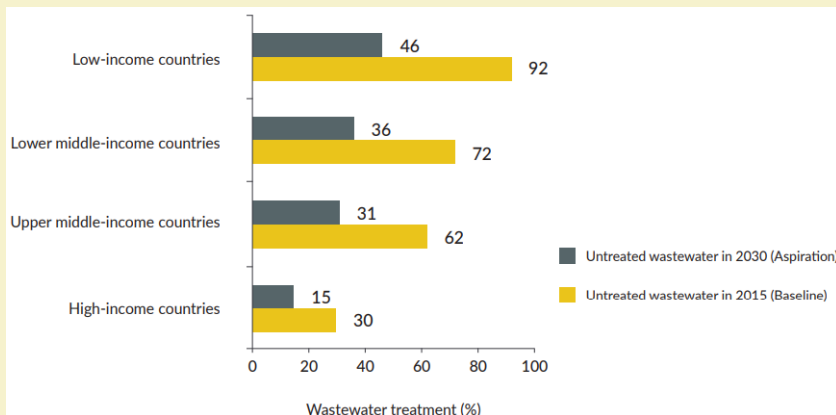**IIT KHARAGPUR** | **NPTEL ONLINE CERTIFICATION COURSES**

WASTEWATER TREATMENT AND RECYCLING
Wastewater Management: Issues and Challenges
Week 1- Lecture 5

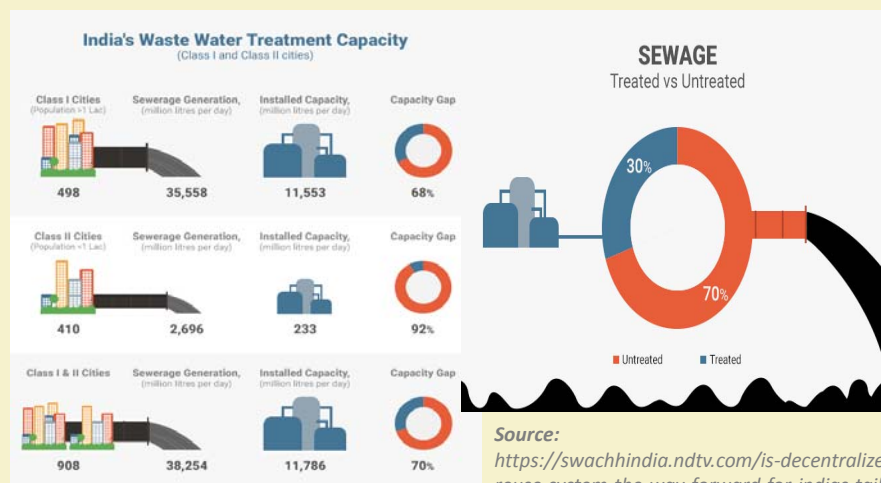## Dr. MANOJ KUMAR TIWARI
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Wastewater Management: Global Scenario

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Wastewater Management: Indian Scenario

Twelfth Five Year (2012–17) Planning Commission (now **NITI Aayog**) *Report* on Urban Development highlights that 4861 cities and towns in India lack even a partial centralized sewerage network and almost 50% of households in metropolitan city such as Bengaluru do not have sewerage connections.

Source:
https://swachhindia.ndtv.com/is-decentralized-waste-water-treatment-and-reuse-system-the-way-forward-for-indias-tail-end-sanitation-challenge-7358/

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Urban Sanitation Situation in India

Sewerage & Sanitation Services	Benchmark	Lowest	Highest
Toilet Coverage	100%	16.8	100
Sewerage network coverage	100%	4.2	100
Waste water collection efficiency	100%	2.8	99.3
Wastewater treatment adequacy	100%	2.5	178.9
Quality of wastewater treatment	100%	33.3	100
Extent of reuse & recycling of treated WW	20%	0.6	35.9
Cost recovery - waste water	100%	4.3	176.7
Collection efficiency	90%	18.7	97.1
Complaints redressal	80%	40	100

Source: Strategic Plan of Ministry of Urban Development for 2011-2016

With the launch of the Swachh Bharat Mission (Gramin) on 2nd Oct 2014, the sanitation coverage in rural India increased from 39 % in 2014 to 76 % in January 2018, (Economic Survey 2017-18)

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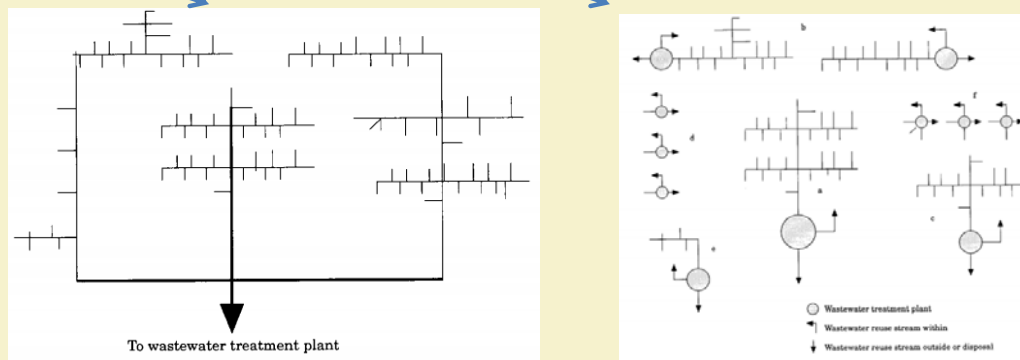# Issues and Challenges

✓ Increasing water demand and wastewater production with population growth, urbanization and industrialization.

✓ Emerging contaminants appearing in municipal and industrial wastewaters

✓ Pollution of freshwater resources due to wastewater disposal (nature's capacity to withstand pollution load has almost exhausted)

Wastewater recycling is becoming unavoidable

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Issues and Challenges

✓ **Centralized *vs* decentralized management**

To wastewater treatment plant

○ Wastewater treatment plant
↱ Wastewater reuse stream within
↓ Wastewater reuse stream outside or disposal

Source: *Wastewater Management Strategy: centralized v. decentralized technologies for small communities by Sharon Hophmayer-Tokich*

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Other Major Issues and Challenges

✓ Lack of awareness

✓ Lack of finance

✓ Lack of political will

✓ Environmental footprint

✓ Energy consumption

✓ Trained and skilled manpower

✓ Development of adaptable technologies

✓ Quality control of treated wastewater

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Thank You!!

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