Circularity and Recovery of Value from Wastewater Treatment,

E. Nandakumar – CEO
International Centre for Clean Water

27-June-2024

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INTERNATIONAL CENTRE FOR CLEAN WATER

AN INITIATIVE OF IIT MADRAS

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ICCW- Value Streams


RESEARCH
Low-cost Sensors
Real-Time Monitoring;
Materials & Processes to minimize footprint


ANALYSIS
Testing, Training,
Validation,
Wastewater analysis


COMPUTATIONAL
Modelling & Visualization Simulations
Hydroinformatics


INNOVATORS


IMPLEMENTATION
Consultancy
Technology interventions
O & M Support


OUTREACH
Interactive sessions
Capacity Building
Publications


START-UPs
Grand Challenges
Incubation
Accelerator
Financial & Technical Support

IMPACTORS

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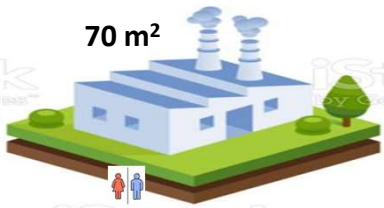
Proposed Micro-Green Factory

Solar, Animal, biogas, fuel

Eco Farming local Herbal oils

Ecofriendly packaging

70 m²



30 minority women

Semi-Automation Machines + Hand made Technology Transfer

Quality Assurance

Water, Zero Liquid Discharge (ZLD)

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Envisaged SDG benefits

- The project offers funders a unique opportunity to contribute to women's empowerment, sustainable manufacturing, and community well-being, while advocating WASH awareness and environmental responsibility.
- It has the potential to scale across the country creating a lasting impact on lives, industries, and the environment.
- **Eight SDG'S will get addressed**

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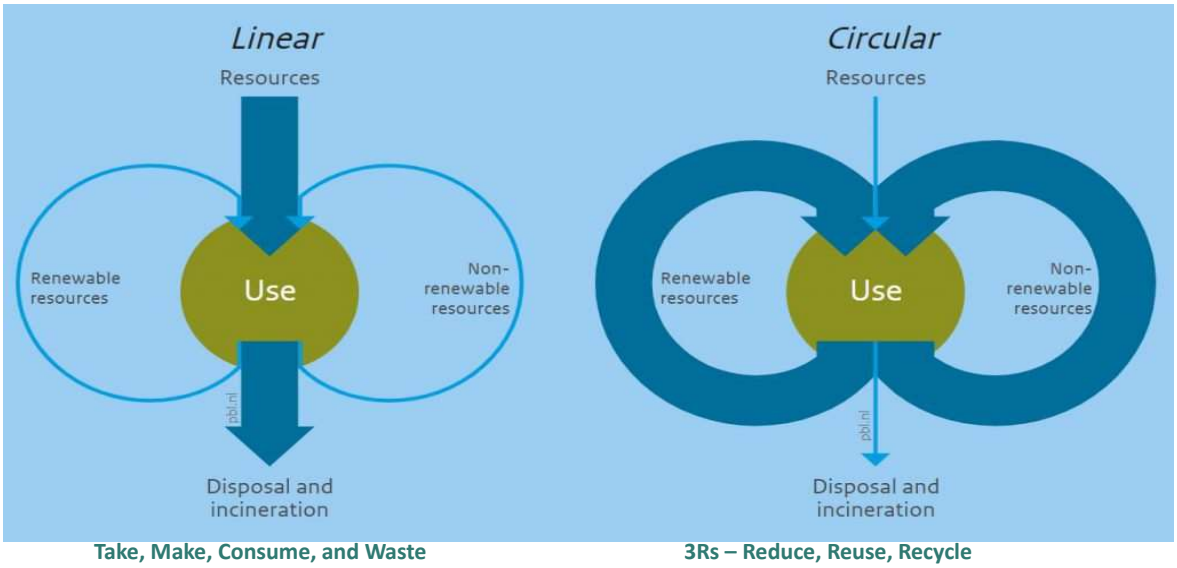
Linear vs Circular Economy



Take, Make, Consume, and Waste

3Rs – Reduce, Reuse, Recycle

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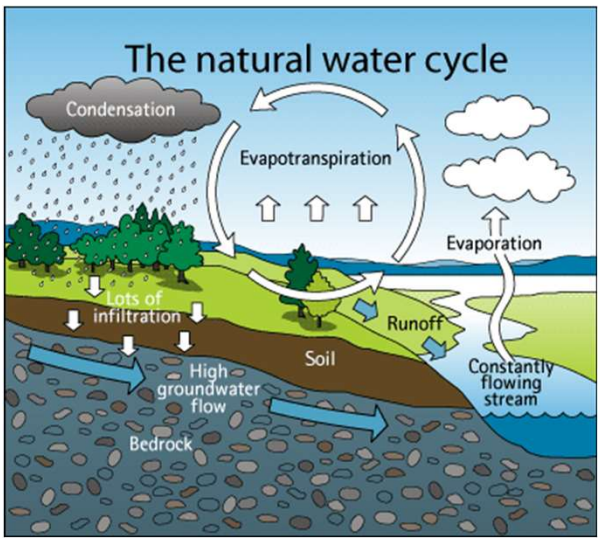
Economy ~~vs~~ and Ecology



Technology is at crossroads.

We need innovations to not only solve a problem economically, but also reduce carbon and water footprint and promote life on the planet.

Economy = f (Ecology)

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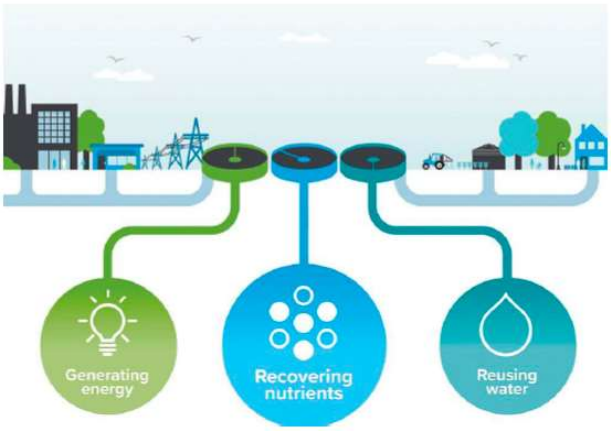
"Wastewater" as a Resource



Treatment plants are productive resources

Wastewater has been perceived as a growing problem – as a source of pollution that needs to be treated and disposed of.

But a paradigm shift is underway

- to seek **value** from wastewater
- to seeing treatment plants as water resource recovery facilities that can produce **clean water**, **recover nutrients** and **reduce fossil fuel** consumption

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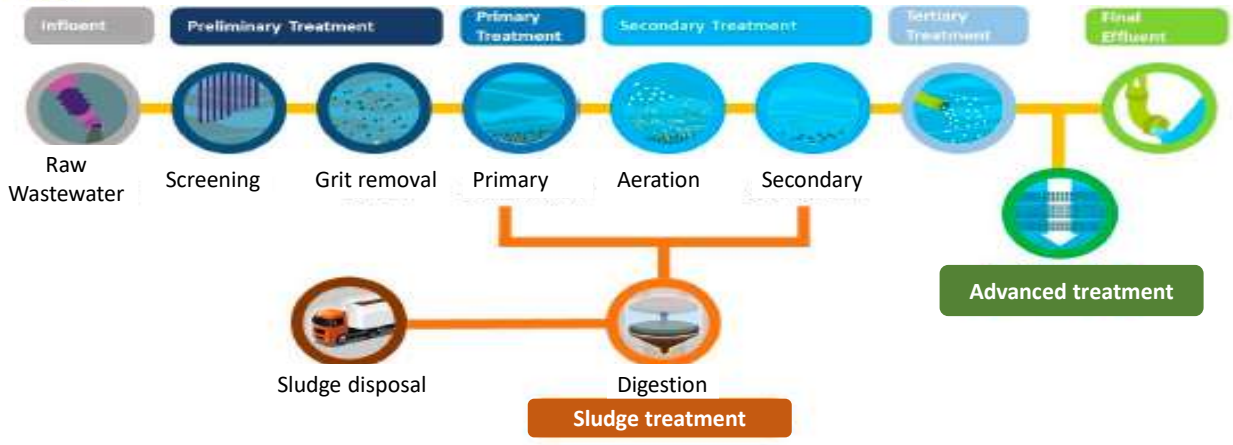
Wastewater treatment process



Several separate and sequential stages of physical, chemical and biological processes to remove contaminants.

A truly circular process attempts to reuse the contaminants removed at each stage and provides feedback to minimize their generation

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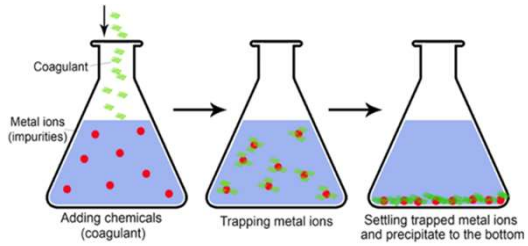
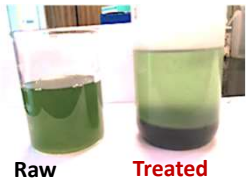
Localized water and material recovery

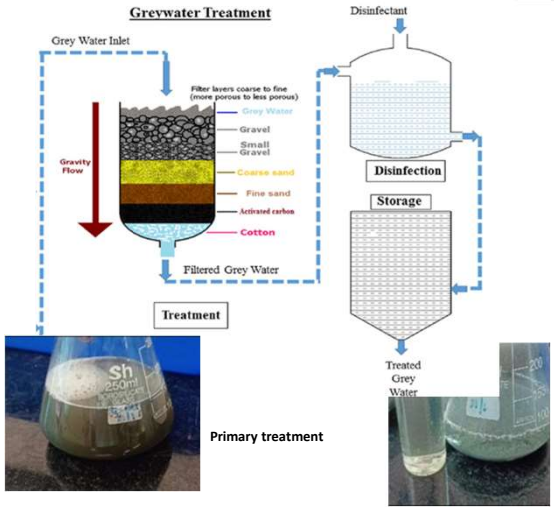
Metal recovery from ETP





Raw Solution **Treated Solution**

Recovery of copper from electroplating effluents



Recycling of greywater for automobile industry

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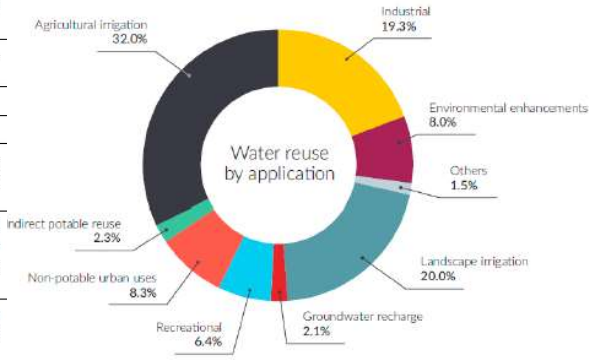
Potential end-uses of recycled water

DEFINITIONS	
Reclaimed water / water reuse	Wastewater that has been treated to meet a specific water quality standard corresponding to its intended use.
Non-potable reuse	Use of reclaimed water not meeting drinking water standards for non-potable purposes.
Potable reuse	Use of reclaimed water for drinking water supply.
Indirect potable reuse (IPR)	Augmenting natural sources of drinking water with recycled water.
Planned IPR	Using reclaimed water to augment a natural water source (river, groundwater basin or reservoir) so that the blended water can be used for drinking water supply.
Unplanned IPR	Unintentionally adding reclaimed water to a water resource that is subsequently used for the production of drinking water. Generally, in these cases the reclaimed water is treated to a lower standard than reclaimed water intended for planned indirect potable reuse.
Direct potable reuse (DPR)	The injection of reclaimed water directly into the potable water supply distribution system, either upstream or downstream of the water treatment plant.



https://www.eib.org/attachments/publications/wastewater_as_a_resource_en.pdf

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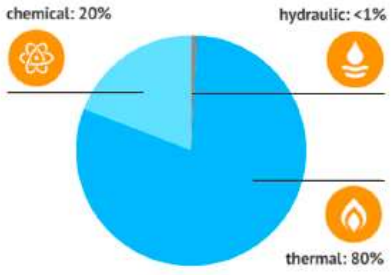
Energy embedded in wastewater



Source: Energy from Wastewater ENER6C13-Factsheet

Wastewater treatment plants are major consumers of energy.

Studies have, however, demonstrated that wastewater contains nearly **five times** the amount of energy that is needed for the process of treating it. *

Wastewater treatment facilities have the potential
- to produce the energy needed to treat the wastewater
- to help heat and power the cities that produce it
- contribute to the economy's decarbonisation.

Wastewater → Biogas →Electricity→ energy for operations

1. Coca Cola 20% energy
2. Dhampur Sugar Mill 25% energy
3. GCMMF – 60% energy (incl cow dung)
4. Arvind Mills – 80% water; 50% of steam

(*)Tarallo, Shaw, Kohl, & Eschborn, A Guide to Net-Zero Energy Solutions for Water Resource Recovery Facilities. IWA Publishing (2015)

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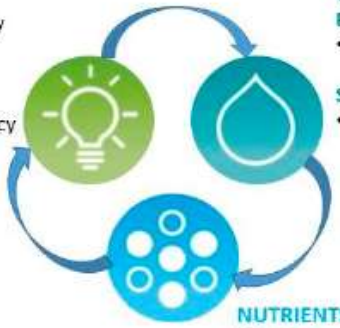
Cost recovery and sustainability

ENERGY
Revenue:
- Sale of biogas or electricity

Savings:
- Using own generated electricity
- Improving energy efficiency



WATER
Revenue:
- Sale of treated wastewater (especially in water scarce areas)

Savings:
- Discharge fees/taxes

NUTRIENTS and BIOSOLIDS
Revenue:
- Sale of phosphorus as fertilizer
- Sale of biosolids as compost

Savings:
- Sludge transport cost and landfill fees

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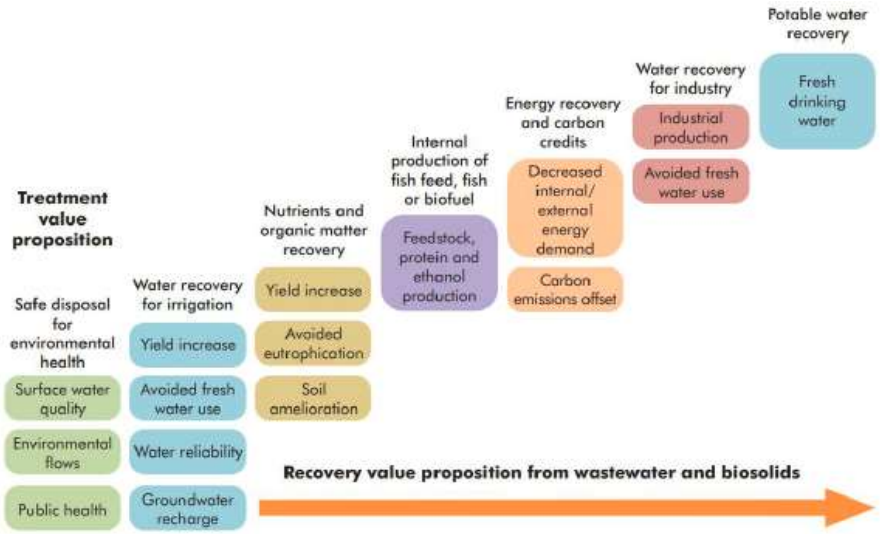
Ladder of value propositions



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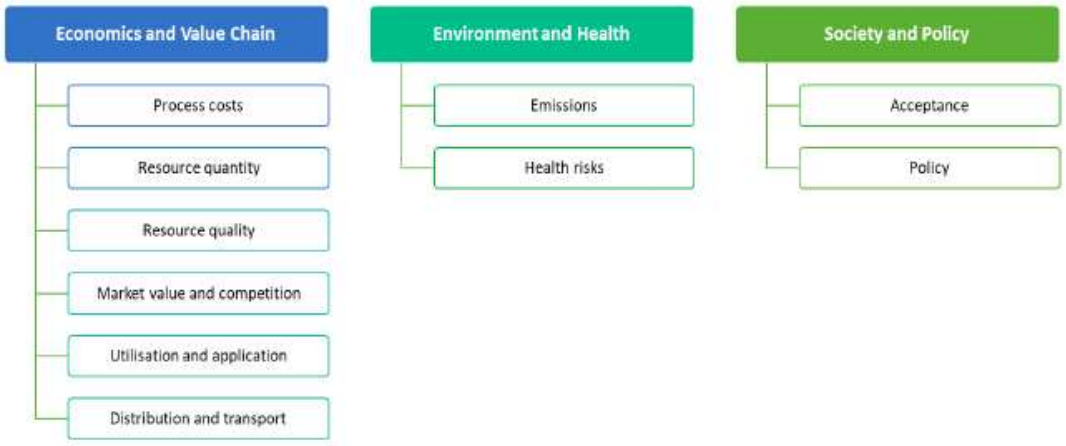
Bottlenecks to successful resource recovery



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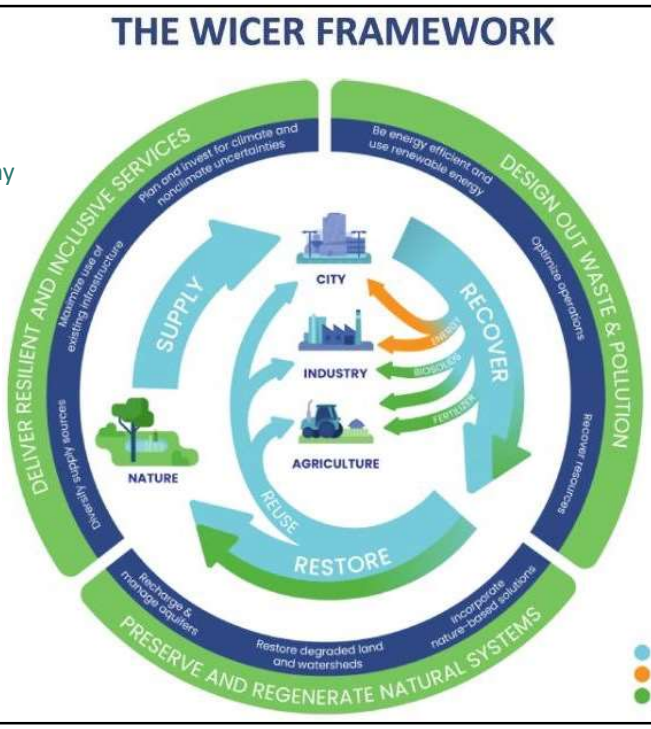
Water in Circular Economy and Resilience



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Case studies

Govt – 1 no

Startup – 2 nos

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Chennai Metro Water and Sewage Board

Industry use of Secondary-treated Wastewater

Note: CMWSSB = Chennai Metropolitan Water Supply and Sewerage Board.

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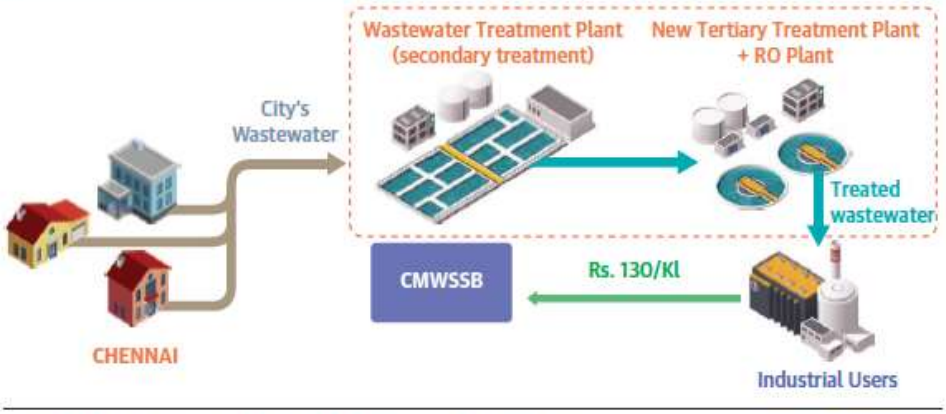
Chennai Metro Water and Sewage Board

Industry use of Tertiary-treated Wastewater



Notes: CMWSSB = Chennai Metropolitan Water Supply and Sewerage Board; RO = reverse osmosis.

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Chennai Metro Water and Sewage Board

Cost comparison of different water sources

S. No.	Source	Capital cost (Rs millions/MLD)	Operating cost (Rs/kl)
1.	Desalination	153	55
2.	Tertiary treatment + reverse osmosis (supply of treated wastewater to industries)	40	36
3.	Tertiary treatment + ultrafiltration + water treatment plant	35	18
4.	Distance surface-water source (~250 km from the city)	77	23

Source: CMWSSB 2019.

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Waste to Value using Algae Processes

Very low Life Cycle Costs and Opex	**Lowest LCC/capex ratio of** 0.2, with payback of ~2 years
	Low operating expenses: ₹ 15/KL
	The only revenue generating solution: ₹ 12,000/KL/yr
Truly Environment Friendly Solution	**Circular Economy:** full utilization of waste streams
	Carbon Negative: 1.8 kg CO_2 sequestered & 1 kg O_2 per KL water treated
	Chemical Free
No-risk Commercialization	**Modular Design For Easy Scale-Up:** 2KL to 1 MLD
First-of-its-kind Aesthetical STP	**Odor Free STP**
	Mini-forests in Urban Jungles

Agromorph's algal photobioreactor

Courtesy Agromorph

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AgroMorph enables Profit from Waste utilization

25 m³ WWT plant → can capture 3 tons of CO_2 → generate 1.5 tons of algae → to give ~$400 in profits

1. **Engineered low footprint & high growth algae strains** *(increasing algae's efficiency by 50x)*
2. **Secured customers for sale of end product** *(e.g. Biofertilizer @ $2000/ton)*
3. **Concept validation via projects with large scale operators** *(Larsen & Toubro, Gov't of Inda)*

Courtesy Agromorph

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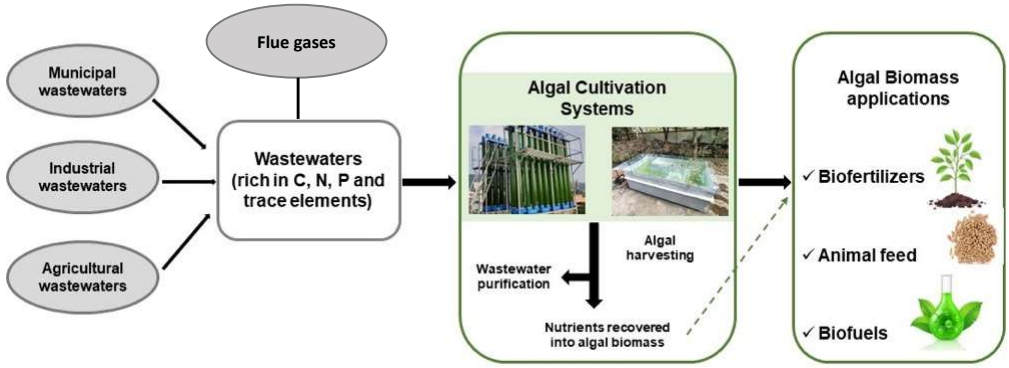
AgroMorph is an algae-based CO2, nutrient and water recycling company that has applied its concept in multiple industries



Tangible benefits

- ✓ On-site **CO_2 capture & conversion**
- ✓ **High revenue from CO_2** ~ $1,000+/ ton of CO_2
- ✓ Flexibility to **utilize wastewater** for process
- ✓ **Low risk** via **modular reactors** installed **phase-wise**

Other major ESG benefit → Green capture of CO_2 with release of 1 ton O_2 / ton of CO_2

Courtesy Agromorph

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Recycling in shrimp farms for value add

Issues addressed

 # 1: Large quantities of nutrient rich brackish water used in shrimp farming and discarded into sea

 # 2 NO_2 and CO_2 GHG emissions from production unit

 # 3 Water treatment is an added cost; yields no benefit

AgroMorph's Algal Photobioreactor Solution ; Conducted at pilot scale

W

1300 million liters of shrimp farming wastewater containing urea, ammonia and sulfur

Agromorph's algae-based technology

ENVIRONMENTAL IMPACT

E1 — **~3640 megatons CO_2** sequestered by algae

E2

E3 — **~ 1300 M liters water** recycled; **~9360 tons/yr** of nutrient-rich biomass; superior to control

ECONOMICAL IMPACT

C1 — Annual savings of **~$0.35 M** of water costs & generation of **~ $50,000** revenue through biomass

C2

W Waste streams
E Environment conservation
C Cost reduction

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DigitalPaani data-driven operations for water assets

Troublesome STP/WTP/ETP operations?

Even when you spend lakhs every month on them?

- Risk of non-compliance and fines
- Unnecessary and costly breakdowns - choked UF membranes, blower breakdowns, and more
- Low quality, unusable treated water
- Bad odour from plant
- Safety risks like poisonous gas production and flooding risk
- Unreliable and ever changing manpower onsite

Courtesy Digital Paani

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Managing ETPs/ZLDs can be complex

- Variations in load
- Excess sludge / oil and grease spilling over to the treatment process

- DO and MLSS not maintained

- Choked RO membranes

Pre treatment	Primary treatment	Secondary	Tertiary	Desalination	
Inflow → OGT/Scum Trap	Physio-chemical/Anaerobic treatment/both	Single/Two stage aerobic treatment	Filtration/UF/ Softener/Ozonaton	Single/Multiple stage RO	→ Outflow
Screen Chamber	• Excess chemical dosing	Sludge removal	• Biofouling / Frequently choked systems	ZLD (MVR/MEE/ATFD)	
Collection tank		• Suboptimal sludge removal		• Frequent scaling problem	

Courtesy Digital Paani

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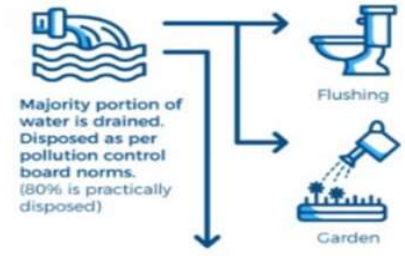
BOSON WATER IS GOD PARTICLE — Existing urban infrastructure

Apartments and malls

IT parks

Sewage Treatment Plant



PROBLEM → ***2 Billion litres /Day of Partially treated waster water sent to Drain – 13 Lakes / Month***

A City of 20 Million People will need 4 Billion litres of water every day

Courtesy Boson

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Preventing borewell exploitation

Apartments and malls

IT parks

Sewage Treatment Plant

All applications

Potable Water

Industries, IT Parks, Malls etc.

To cater to 5% of Bangalore's (1 Indian City) Water Requirement by 2030 – Aligning to UN SDG Goal 6, 11, 17.

Courtesy Boson

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Summary

Wastewater - whether industrial effluent or sewage - is a powerful resource not only for mitigating water stress, but also to provide value through recycled nutrients, chemicals and energy recovery that will pay for the capital operating expenditure thereby creating a virtuous cycle of economic, ecological and social prosperity

6 CLEAN WATER AND SANITATION

Wastewater recycling can unlock huge economic benefits

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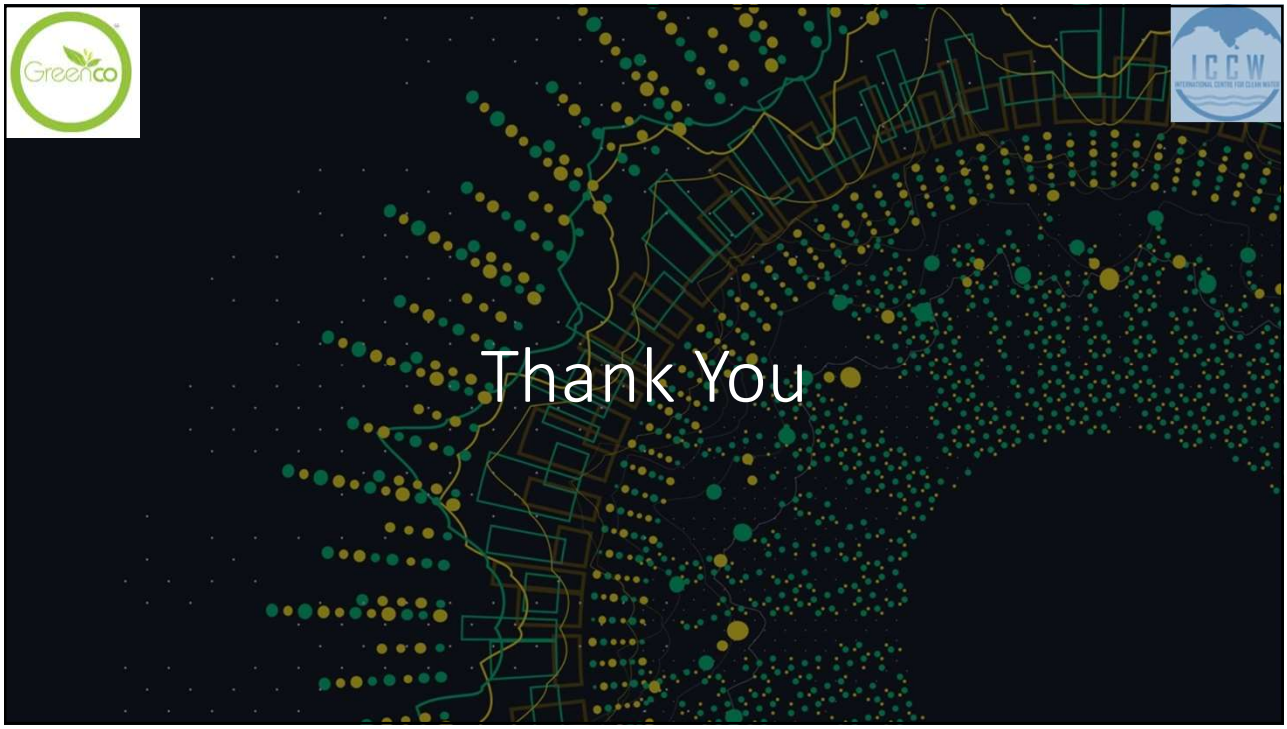

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