“Zero Liquid Discharge” Concept for Efficient Management of Urban Waters & Wastewaters

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Water Scenario in Developing Countries

- Inadequate water supply and poor water quality
- Increasing demand for water for domestic, agriculture, as well as industrial purposes
- Available water resources continuously getting deteriorated

Causes

- Discharge of partially treated or untreated wastewater/effluents into water reservoirs
- Agricultural and Urban runoff
- Increasing water demand
- Excessive water withdrawal prevents dilution of pollutants
Wastewater Treatment in India

- Wastewater Generated (MLD)
- Wastewater Treated (MLD)

[Source: CPCB, 2009]
Trends of Wastewater Treatment and Management in India

(Source: CPCB, 2009)
The Imminent Challenges in Management of Water Resources

- Pollution due to disposal of untreated (or partially treated) sewage and sullage into natural watercourses and
- Pollution caused by disposal of industrial wastewater into sewers and watercourses
One usually encountered solution is to treat the sewages and wastewaters to regulatory standards and then dispose them off into receiving bodies!
The other less favored solution is to treat the sewages and wastewaters to much HIGH standards and then reuse / recycle them!
Reclamation of Wastewaters for Recycling and Reusing: A New Horizon

- The treated effluent is used as a water resource for beneficial purposes
  ------ New and assured water source

- The effluent is kept out of streams, lakes, and beaches;
  ------ Reduces pollution of natural water reservoirs
Reuse:
To extend the life of resource/product by using it again, repairing it, modifying it or creating new uses for it

Recycle:
Collecting and reprocessing already manufactured materials for remanufacture either as the same thing or as part of a different product

Reduce:
To bring down use of resource/material to a smaller extent, size, amount or quantity
Solution – Water Recycling

Advantages:

- Achieving 24 x 7 water supply
- Reduced consumption of potable water
- Elimination of pollution of watercourses
- Reducing the cost of wastewater treatment
Points for Immediate Action

- The installation and operating costs of existing technologies are rather high and hence are **ill-afforded** by the communities.

- The available technologies are often complex, require **heavy machinery** that are **capital intensive** as well as **energy intensive** during operation and operation.

- The technologies usually rely upon **expensive chemical inputs** (such as chlorine, alum, lime, poly-electrolyte, etc.) and generate sludges that may be hazardous in nature and difficult to de-water and dispose.
What is “Appropriate”?

- Low cost with Minimum possible Mechanization
- Simple in Operation
- Suitable for Incremental improvement and Recycle and Reuse oriented
Decentralized Solutions are Appropriate

- Effective and low-cost

- NTSs Utilize plants and their associated rhizospheric microorganisms

- Natural synergistic relationship
  - plants
  - soil
  - microorganisms and water
Community Is the Key!

- Natural treatment systems require local dedication, support and cooperation.
- Eventually, the community will assume project ownership and
- Ultimately, benefits must be enough for the community to want to keep the project intact.
Classification of Natural Treatment Systems

- Intrinsic
  - Stressed
  - Self-sustaining
- Engineered
  - Bioremediation
  - Hybrid

(Source: Chaturvedi et al., 2008)
The most common NTSs include

- **Waste Stabilization Ponds (WSPs)**
- **Hyacinth and Duckweed Ponds (DPs)**
- **Fish Ponds**
- **Oxidation Ponds and Lagoons**
- **Algal-bacterial ponds**
- **Polishing Ponds (PPs) and**
- **Constructed Wetlands (CWs) etc**
Physico - Chemical (Primary)

- Oil and Grease Removal
- Screen and Grit Removal
- Coagulation and Flocculation
- Sedimentation
- Plate Settlers and Tube Settlers
- pH Adjustment
- Sludge Thickeners
- Vacuum Filters
- Centrifuges
Physico - Chemical (Advanced)

- Ion-exchanging
- Membrane Separation (RO)
- Membrane Filtration (UF, MF, NF)
- Sorption (PAC, GAC)
- Solvent Extraction
- Molecular Sieves
Classification of Biological Systems

- Aerobic
- Anaerobic
- Combination
Classification of Aerobic Biological Systems

Suspended Growth
- Activated Sludge Process
- Membrane Bioreactor
- Aerobic Lagoons

Attached Growth
- Trickling Filters
- Rotating Biological Contactors

Combination
- Fluidized Bed Biofilm Reactor (FBBR)
Classification of Anaerobic Biological Systems

Suspended Growth
- UASBs
- Anaerobic Filters

Attached Growth
- Anaerobic Sludge Digester
- Anaerobic Contact Reactors
- Bio-gas Reactors (Gobar gas)

Combination
- Expanded Bed Reactor
Classification of Biological Systems

- Aerobic
  - Facultative Lagoon
  - Sequential Bio-Reactor
  - SSND Process

- Anaerobic

- Combination
Zero Discharge? Near-Zero Discharge?

• Zero discharge differs from pollution prevention from the perspective of converting all the wastes to useful materials.

• Zero Discharge is the final destination of the journey towards preventing pollution.

• In reality, absolute zero discharge condition may not be always possible to achieve - but, near zero discharge can be achieved!
Zero Discharge…  

• In its broadest sense, "zero discharge" means no discharge or emissions to any media (say, river, lake, reservoir, creek or estuary)

• More commonly, “zero discharge” focuses on the Zero Liquid Discharge (ZLD)

• The time has come for insisting the inclusion of other kinds of wastes including gases, sludges vapors and even irrigation of treated wastewaters under “zero discharge” discussion!
Theoretical Zero Discharge

No emissions?

Value Added Products (S/L/G)

Production Plant

S
L
G

Products (S/L/G)
Zero Liquid Discharge

Production Plant

Scrubbing or Detoxification

Products (S/L/G)

ETP

S

L

S

L

G

S

L

G

Products (S/L/G)
Technological Options for Zero Liquid Discharge (ZLD)

- Reverse Osmosis
- Thermal/Vacuum Evaporation
- Electrodialysis
- Ion Exchange
Constructed Wetland Research in IIT Bombay
Contaminant Removal Mechanisms: Multiple Processes At Work

O₂ through plants to root zone

Planting Substrate

Influent

BIOLOGICAL

PHYSICAL

CHEMICAL

Treated Water

Source: Ian Markiewicz
Types of Contaminants Removed

N - P - K
Laboratory CW Reactors Installed for Investigation
Collection and Analysis of Biomass from Field

Typha latifolia

Canna indica

Typha latifolia

Canna indica
Establishing CW Research Stations on IITB Campus

Research Station: Water Prospects

- CW-1
- CW-2
- CW-3
- Field Lab
- Sewage Sump
- Pump House

Research Station: Water Blessing

- CW-2
- Cattle Barn
- Septic Tank
- Devi Temple & Priest Quarters
Success Story of Rejuvenation of Mansagar Lake, Jaipur
Man Sagar Restoration Model...success through INNOVATION

Reviving Art - Culture - Environment
Success through Eco-System based Scientific approach…

Multidisciplinary team
- Environmental Scientists
- Environmental Engineers
- Hydrologist
- Chemical Engineer
- Botanist
- Environmental Activist
- Landscape Architects
- Local flora and fauna experts
- And more…

...revived Man Sagar Lake habitat has been widely excepted by Nature and its creations…
Jal Mahal has been abandoned for more than a century...picture from late 1800’s
Jal Mahal created around 1730’s to celebrate Man Sagar by Raja jai Singh.
Summers of 2003, 2004, 2005...
Summers of 2009, 2010, 2011...
Heavy pollutants load existed on lake bed
Systematic desilting operations cleared the lake bed of substantial pollutant load.
Migratory Birds at Mansegar lake
DIRECTIVE PRINCIPLE [Art. 48-A]

“The state shall endeavor to protect and improve the environment and to safeguard the forests and wildlife.”
What Should Be Our Mission? [... continued]

FUNDAMENTAL DUTY [Art. 51-A(g)]

“The "FUNDAMENTAL DUTY" of every citizen is to protect and improve the natural environment including forests, lakes, rivers, and wildlife and to have ecological compassion.”
Thank you!

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