Importance of low-cost affordable waste management technologies for AMR containment

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Increase in Antibiotic Resistance

Antibiotic Resistance of *Escherichia coli*

Antibiotic Resistance of *Klebsiella pneumoniae*

Antibiotic Resistance of *Acinetobacter baumannii*

Antibiotic Resistance of *Pseudomonas aeruginosa*

http://www.resistancemap.org
Double burden - conventional and emerging hazards

Traditional hazards: water-borne diseases from inadequate water supply & sanitation
Modern hazards: exposure to agro-industrial chemicals

Disability-adjusted life year (DALY), a time-based measure combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health.
Pathways of AMR exposure into the environment
India

16% of world population with 4% of world water resources

Total utilizable water resource in the country
1123 BCM (690 BCM - surface water and 433 BCM - ground)

70-80% water supplied gets generated as wastewater (CPHEEO)

Sewage generation
38354 MLD
(only 30% gets treated)
Industrial wastewater 13468 MLD
(only 60% gets treated)

Overall water analysis indicates:
• Coming year reduced freshwater availability and increased wastewater generation will be a major problem.
• Health costs relating to water pollution- INR 470-610 billion ($6.7-8.7 billion) per year.

Fig. Projected water demand different sectors (CWC, 2010)
Sewage treatment in Delhi

Major contributors
- Hospital Effluents
- Household Discharge
- Agricultural run-offs
- Industrial Effluents

Transporters → Drains → WWTP

Amplifiers
- WWTP

Receivers
- Yamuna River

50% → WWTP

River Pollution
- Increased ARB and ARGs
- Community
- Environment
Sampling Sites

- Hospital
- STP
- River
- Drain
Abundance of coliforms and ARB in the samples collected from hospitals, drains, STPs and the river Yamuna

Lamba M, Ahammad SZ et al. Environmental Science and Technology 2017, Chemosphere 2017
Abundance of ARGs in the samples collected from hospitals, drains, STPs and the river Yamuna

Lamba M, Ahammad SZ et al. Environmental Science and Technology 2017, Chemosphere 2017
CRE abundance in Delhi

**Summer**

- < log (3.0) CRE/ml
- < log (3.0 to 5.0) CRE/ml
- < log (5.0) CRE/ml

**Winter**

- < log (3.0) CRE/ml
- < log (3.0 to 5.0) CRE/ml
- < log (5.0) CRE/ml

Pipl. Density (per sq. km):
- < 10000
- 10001 - 20000
- 20001 - 30000
- > 30001

Legend:
- STP
- Hospital
- Yamuna river
- < log (3.0) CRE/ml
- < log (3.0 to 5.0) CRE/ml
- < log (5.0) CRE/ml
Hospital vs Community

Summer

Winter

CRE

bla\textsubscript{NDM-1}

int1

int3

Lamba M, Ahammad SZ, Environmental Science and Technology 2017
Upper Ganga: Extent of ARG abundance and transmission

ARG abundance increases due to increase in untreated sewage generated by increased population

- Improvement of treatment capacity

Ahammad et al. *Environmental Science and Technology* 2014
Conventional Treatment Technologies

Typical Scheme for Wastewater Treatment

Secondary Treatment Systems

Traditional WWTPs are to remove suspended solids, organic matter, nitrogen and phosphorus from wastewater, but the process does not remove ARB and ARGs.

Neither designed for nor capable of removing ECs

Tertiary Treatment Technologies
Upper Ganga: Extent of ARG abundance and transmission

- Log gene abundance (copy no./16S rRNA gene)
- NDM1, OXA, tetM, tetW, tetQ

- Rishikesh-Haridwar
- Delhi

- February
- June
Mitigation of ARG proliferation

- Attached-cell anaerobic treatment systems are preferred
  - Energy economy
  - Better ARG removal

Ahammad et al. *Environmental Science and Technology* 2015
Typical Scheme for Wastewater Treatment

Raw Wastewater

Conventional Treatment Technologies

Secondary Treatment

Tertiary Treatment

Treated Water

UV O₃ Cl₂ UV O₃ Cl₂ UV O₃ Cl₂
UV Treatment

UV light passes through the cell of bacteria and it adsorbed by the DNA creating thymine dimer.
Ozonation

(lakovides et al, 2019)
Effect of Tertiary treatment technologies on ARB

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Mode of Action

(Lamba et al, 2017)

Effect of Tertiary treatment technologies on ARGs

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(Lamba et al, 2017)
Membrane Based technology

- Ultrafiltration (UF) and reverse osmosis (RO) are advanced water treatment technologies that are widely used in wastewater, drinking water, and surface water treatment.

- UF can effectively remove particulate matter in wastewater through separation mechanisms such as size/space exclusion, hydrophobic adsorption and electrostatic repulsion.

- RO, with a smaller membrane pore size than UF, only allows some atoms and molecules to pass through.

- Compared with traditional biochemical wastewater treatment, membrane filtration has many advantages.

- For example, it is cleaner (no secondary pollution), more efficient (short hydraulic retention time), and unaffected by season and temperature.

(Liang et al, 2021)
low-cost adsorption process
Change of perspective

One World: World without boundaries

Cost of life: Putting a Dollar Value on Life? Invaluable?

Helping each other for a better and safe world
Thank you!