Understanding AMR pathways in the Indian context

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Relevance of Antibiotics and Environment studies

- Present focus: Measurement of resistance in clinical settings only
- Antibiotics in aquatic environment as vital public health problem undiscovered
- Few studies in developing countries reported antibiotics in aquatic environment
- Increased use of antibiotics
- Insufficient wastewater treatment facilities
Antibiotic residues, metabolites and antibiotic resistance bacteria

Untreated hospital effluent
Seasonal and Temporal Variation in Release of Antibiotics in Hospital Wastewater: Estimation Using Continuous and Grab Sampling

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Diwan et al. BMC Public Health 2010, 10:414
http://www.biomedcentral.com/1471-2458/10/414

Antibiotics and antibiotic-resistant bacteria in waters associated with a hospital in Ujjain, India

Vishal Diwan*¹,², Ashok J Tamhankar³,⁴, Rakesh K Khandal⁵, Shanta Sen⁵, Manjeet Aggarwal⁶, Yogyata Marothi⁶, Rama V Iyer⁶, Karin Sundblad-Tonderski⁷ and Cecilia Stålsby- Lundborg¹
### Table 5: Levels of monitored antibiotics (μg/l) in waters associated with a hospital in Ujjain, India using LC-MS/MS

<table>
<thead>
<tr>
<th>Antibiotics</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ground Water</td>
<td>Municipal Water</td>
<td>At 10:00</td>
</tr>
<tr>
<td>Amoxicillin</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Amikacin</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Ofloxacin</td>
<td>--</td>
<td>--</td>
<td>4.5</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>--</td>
<td>--</td>
<td>2.2</td>
</tr>
<tr>
<td>Norfloxacin</td>
<td>--</td>
<td>--</td>
<td>6.4</td>
</tr>
<tr>
<td>Levofloxacin</td>
<td>--</td>
<td>--</td>
<td>5.0</td>
</tr>
</tbody>
</table>

-- = Below Detection Limit
Site 1 = Incoming safe water (received in hospital only once a day)
Site 2 = At the point of exit of inpatient wards of the hospital
Site 3 = 100 metres from the hospital in subsequent drains
**Table 1.** Concentration of antibiotic released/day/hospital (ng/L).

<table>
<thead>
<tr>
<th></th>
<th>CIP</th>
<th>LEV</th>
<th>OFL</th>
<th>NOR</th>
<th>FQ</th>
<th>MET</th>
<th>SUL</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CS</td>
<td>GS</td>
<td>CS</td>
<td>GS</td>
<td>CS</td>
<td>GS</td>
<td>CS</td>
<td>GS</td>
</tr>
<tr>
<td>Summer</td>
<td>155.5</td>
<td>–</td>
<td>472</td>
<td>35</td>
<td>96</td>
<td>–</td>
<td>–</td>
<td>191</td>
</tr>
<tr>
<td>Rains</td>
<td>694</td>
<td>1239</td>
<td>66</td>
<td>88</td>
<td>90</td>
<td>85</td>
<td>40</td>
<td>225</td>
</tr>
<tr>
<td>Winter</td>
<td>245</td>
<td>1836</td>
<td>578</td>
<td>1078</td>
<td>495</td>
<td>475</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>1095</td>
<td>3076</td>
<td>644</td>
<td>1638</td>
<td>620</td>
<td>656</td>
<td>40</td>
<td>225</td>
</tr>
<tr>
<td>Average (Total/3)</td>
<td>365</td>
<td>1025</td>
<td>214</td>
<td>546</td>
<td>206</td>
<td>218</td>
<td>13</td>
<td>75</td>
</tr>
</tbody>
</table>

**Notes:**
- CS: Continuous sampling, GS: Grab Sampling.
SEGREGATION OF HOSPITAL BIO-MEDICAL WASTE

GENERAL WASTE
Kitchen Waste, Paper & Tissues & Water Bottles & Cans

INFECTED PLASTICS
Syringes, Gloves & Plastic Waste

INFECTED WASTE
Soiled, Anatomical, Chemical Liquid, Cytotoxic, Laboratory Waste, Expired & Discarded Medicines

GLASSWARE
Antibiotic Vials, Metallic Implants, Glassware Material Except Cytotoxic

SHARPS
Needles & Cut Glasses

DISPOSAL
Secured Land Filling

Incineration

Auto Claving

Deep Burial

Plasma Pyrolysis/ Incineration

Auto Claving

RE-Cycler

Mutilate

Sharp Pit

Common Treatment Facility

Multiple – Approaches

Clinically Oriented Approaches

Behavior and Social Approaches

Environmental Approaches

To reduce the hospital associated infections and to preserve the effectiveness of Antibiotics
Constructed Wetlands
Hand Hygiene Interventions
Surveillance of Resistance and Residues in Hospital associated waters

• Starting Point
  • Start with at least 10 Hospital with more than 100 beds
  • Scale up as per resources

• Sampling
  • Four Times in a year (to study seasonality)
  • Hospital waste water
  • Hospital incoming water
  • Continuous or Grab Sampling
  • Hospital Environment (OT, Labour room, surfaces)

• Indicator Bacteria
  • *E.coli*
  • *Klebsiella spp*

Analysis
• CFU
• Antibiotic Residues (optional)
• AST Patterns, ESBL
• Antibiotic resistance genes (optional)
• Inpatient Hospital antibiotic use
Disposal of Pharmaceutical/ Antibiotic Waste in Community/ Household Settings
Top 5 municipal solid waste generators (annually) in world

<table>
<thead>
<tr>
<th>Country</th>
<th>2016 Estimate</th>
<th>2030 Projected</th>
<th>2050 Projected</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>277.1</td>
<td>387.8</td>
<td>543.3</td>
</tr>
<tr>
<td>US</td>
<td>263.7</td>
<td>311</td>
<td>359.9</td>
</tr>
<tr>
<td>China</td>
<td>220.4</td>
<td>295</td>
<td>335.8</td>
</tr>
<tr>
<td>Brazil</td>
<td>79.1</td>
<td>96.7</td>
<td>114.3</td>
</tr>
<tr>
<td>Indonesia</td>
<td>65.2</td>
<td>87.9</td>
<td>118.6</td>
</tr>
</tbody>
</table>

Waste generation per person (kg/day)

Waste Management – Global and National Response

1. ZERO HUNGER
   - Reduced food waste, more use of organic waste

2. GOOD HEALTH AND WELL BEING
   - Less disease caused by open dumping & burning

3. QUALITY EDUCATION
   - Environmental and health training and awareness

4. GENDER EQUALITY
   - Women often bear most of the impact of bad waste mgmt

5. CLEAN WATER AND SANITATION
   - Better SWM goes hand in hand with better WASH

6. AFFORDABLE AND CLEAN ENERGY
   - Bioenergy opportunities from organic waste

7. DECENT WORK AND ECONOMIC GROWTH
   - Waste management is the world’s largest industry

8. INDUSTRY, INNOVATION AND INFRASTRUCTURE
   - Recycling innovation is growing and scalable

9. REDUCED INEQUALITIES
   - The poorest are harmed the most by poor waste mgmt

10. RESPONSIBLE CONSUMPTION AND PRODUCTION
    - Need to shift from waste to resource management

11. SUSTAINABLE CITIES AND COMMUNITIES
    - Better SWM vital for healthy & resilient communities

12. CLIMATE ACTION
    - Reduced methane & CO2 from dumping & burning

13. LIFE BELOW WATER
    - Less plastic pollution in the oceans & sea life

14. LIFE ON LAND
    - Less pollution on the land, healthier environments

15. PEACE AND JUSTICE STRONG INSTITUTIONS
    - Producer responsibility and governance

16. PARTNERSHIPS FOR THE GOALS
    - Working together: formal & informal, wealthy & poor
Municipal waste water

30-90 per cent fraction of all antimicrobials being excreted unchanged

20-30 per cent of municipal waste water is treated

ARB and ARGs detected
Why we keep store Antibiotics /pharmaceuticals

• Lack of adherence to the prescribed treatment
• Storage for future use and reaching the expiry date
• Change of treatment plan
• Frequent change of prescription by doctors
• Same patient consult many hospital
• Patient death
• Buying medication because of advertisements
• Prescription of more medicines than required
• Cost/availability/ health system issues
Disposal Methods of Medicine

• Throwing away in a household trash (73%)

• Flushing in sewer water (20%)

• Burying in the ground (5.3%)

• Burning the medications (1.6%)

• Return to the pharmacy (6%)
Information about Pharmaceuticals / Antibiotics effects

**Aware**

• expired medicines can cause adverse drug reactions

**Not aware**

• Concept of drug resistance due to expired medicines
• Environmental impact of unused/expired medicine
Waste Management - Paradigm Shift

Hierarchy of Preferred Solid Waste Management Strategies

Paradigm Shift Required For the 21st Century
Door to Door Collection

Waste Transfer Station-cum-MRF Centres

Centralized processing facility
Disposal of Unused/ discarded/ expired medicine - Households/ Community

• Solid Waste Management Rules, 2016
• Source Segregation is compulsory
• Duty of Waste generators
• Three separate streams namely bio-degradable, non bio-degradable and domestic hazardous wastes
• Authorized waste pickers or waste collectors
### BASIC Segregation

<table>
<thead>
<tr>
<th>Biodegradable Waste (WET)</th>
<th>Non-Biodegradable Waste (DRY)</th>
<th>Domestic Hazardous waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry waste (Blue bin)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With further sub-segregation BASIC+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Food wastes of all kinds, cooked and uncooked, including eggshells and bones**

**Paper cardboard and cartons**

**Containers of all kinds excluding those**

**Rags, Rubber, Wood, Discarded clothing**

**Furniture**

**Metals, Glass (all kinds), Inerts, House sweepings**

**E-waste**

**Hazardous wastes**

**Household medical waste***

***Household Medical Waste: Thermometers and other mercury containing products, discarded medicines, injection needles and syringes after destroying them both, sanitary wastes and diapers (should be collected daily)***

**Juice, vegetable peels and other uncooked wastes**

**Compound packaging (tetrapak, blisters etc.)**

**Street sweepings**

**Batteries from flashlights and button cells. Lights bulbs, tube lights and Compact Fluorescent Lamps (CFL)***
What are the Solutions
Approaches and Interventions required

• Research

• Awareness

• Innovations

• Regulations
How to increase awareness?

• Starting point - Idea of expiration of drugs

• Starting point - non-consumption expired drugs

• Raises the query about how to dispose of them safely.
How to increase awareness?

• Awareness regarding the hazards of unsafe disposal

• Development of take back programs from households/community

• Information by Health care providers

• Inclusion of safe disposal practices/health effects – Education Curriculum
Waste Disposal and Health Hazards
Friends of Earth
Waste Segregation and Other benefits

- Doctor visits decreased
- No Fines and Penalties
- Healthy fruits & vegetables
- Savings
- Clean house and surroundings
- Discount on house tax cess if compost

HOSPITAL

Healthy fruits & vegetables

Savings

Clean house and surroundings

Discount on house tax cess if compost

$
Product Life Cycle

Resource used

Product

Recycled Product
Put Right Waste, in Right Bin

- Wet Waste
- Dry Waste
- Sanitary Waste
- Hazardous Waste
AMR and WASH

Lack of access to WASH driving Antibiotic Resistance

- Safely managed drinking water source for all households
- Individual Household Latrine
- Optimal water and sanitation at Healthcare Facilities
- Adequately functional Sewage Treatment Plants
- Proper disposal of sludge from sewage treatment

• Issues with any of the above, will drive ABR in a community
AMR and WASH

One Health Action on Antibiotic Resistance

- Human Dimension
- Agricultural Dimension
- Environment Dimension

Hygiene can impact all the dimensions
**ICMR-NIREH WASH SCHOOL DASHBOARD**

- Date will be uploaded on dashboard for visualization.
- Standard WASH service ladders
- Communication of Results - online/quarterly meeting

The report will include:
- Brief summary of indicators, area of immediate and long-term concerns and points for improvement; system

![Sanitation Coverage Graph](image)

Globally, 3 billion people do not have access to an improved sanitation facility.

Fig. 3.10: Number of people (in millions) without access to an improved sanitation facility in 2015, by WHO region.

Source: WHO/UNICEF/Program on Drinking Water and Sanitation 2016 Update.
Way Forward

- Important to focus on measurable change in behavior or practices
- AMR is still an invisible issue but the interventions/changes should be visible to people
- Assess how we can integrate the interventions into existing national structures
- Performance of the strategy in real-world scenario and cost-benefit analysis
THANKS