Household Water and Wastewater Treatment

GEF Pacific IWRM 3rd Regional Steering Committee Meeting

Why?

- WHO attributes 88% of diarrhoea deaths worldwide to unsafe sanitation and drinking water
- About 2,800 people die each year in the Pacific Region from diarrhoea

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Fiji Times
Attributed to dirty water in rainwater tanks
Cause of the outbreak contaminated water
Empty bottles and pieces of wood were found floating inside many tanks

What killed the baby?
Poisons?
Pathogens?
Heavy metals?
Oil and hydrocarbons?
How significant are the bottles and sticks?
In every tank?
Pollution sources

What are the problems?

• Pathogens
• Metal pollution
• Toxins

• Also nutrients (which are not normally directly toxic)
Wastewater Nutrients

• Impacts
  – Algal blooms
  – Fish kills (Solomon Islands)
  – Ciguatera
  – Ecosystem collapse

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What are pathogens?

- Organisms that call illness in people
  - Bacteria
  - Protozoa
  - Viruses
  - Helminths

- “Papa why don’t you just call them Germs”
- They all behave differently and a tapeworm is a bit big to call a germ

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<table>
<thead>
<tr>
<th>Pathogen type</th>
<th>Pathogens</th>
<th>Illness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td><em>Salmonella</em></td>
<td>Gastroenteritis, reactive arthritis</td>
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<tr>
<td></td>
<td><em>Campylobacter</em></td>
<td>Gastroenteritis, Guillain–Barré syndrome</td>
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<tr>
<td></td>
<td><em>Pathogenic Escherichia coli</em></td>
<td>Gastroenteritis, haemolytic-uraemic syndrome</td>
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<tr>
<td></td>
<td><em>Shigella</em></td>
<td>Dysentery</td>
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<tr>
<td></td>
<td><em>Yersinia</em></td>
<td>Gastroenteritis, septicaemia</td>
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<tr>
<td></td>
<td><em>Vibrio cholerae</em></td>
<td>Cholera</td>
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<tr>
<td></td>
<td><em>Atypical Mycobacteria</em></td>
<td>Respiratory illness (pneumonia, fever)</td>
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<tr>
<td></td>
<td><em>Legionella spp</em></td>
<td>Respiratory illness (pneumonia, fever)</td>
</tr>
<tr>
<td></td>
<td><em>Staphylococcus aureus</em></td>
<td>Skin, eye, ear infections, septicaemia</td>
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<tr>
<td></td>
<td><em>Helicobacter pylori</em></td>
<td>Peptic ulcers</td>
</tr>
<tr>
<td>Viruses</td>
<td><em>Enterovirus</em></td>
<td>Gastroenteritis, respiratory illness, nervous disorders, myocarditis</td>
</tr>
<tr>
<td></td>
<td><em>Adenovirus</em></td>
<td>Gastroenteritis, respiratory illness, eye infections</td>
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<tr>
<td></td>
<td><em>Rotavirus</em></td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td></td>
<td><em>Norovirus</em></td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td></td>
<td><em>Hepatitis A</em></td>
<td>Infectious hepatitis</td>
</tr>
<tr>
<td></td>
<td><em>Coronavirus</em></td>
<td>Gastroenteritis</td>
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<tr>
<td></td>
<td><em>Coronavirus</em></td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td>Protozoa</td>
<td><em>Cryptosporidium</em></td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td></td>
<td><em>Giardia</em></td>
<td>Gastroenteritis</td>
</tr>
<tr>
<td></td>
<td><em>Naegleria fowleri</em></td>
<td>Amoebic meningitis</td>
</tr>
<tr>
<td></td>
<td><em>Entamoeba histolytica</em></td>
<td>Amoebic dysentery</td>
</tr>
<tr>
<td>Helminths</td>
<td><em>Taenia (T. saginata)</em></td>
<td>Tapeworm (beef measles)</td>
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<tr>
<td></td>
<td><em>Ascaris</em></td>
<td>Roundworm</td>
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<tr>
<td></td>
<td><em>Trichuris</em></td>
<td>Whipworm</td>
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Indicators

• Often too many pathogens to test
• Use one or two indicator organisms
• Usually E. Coli. Or Enterrococcus
• Only an indicator – generally not the most dangerous pathogen (except 0157)
• Commonly used and broadly understood

Wastewater

• Pathogens (germs)
  – Cause people to get sick
Wastewater

• How many *E. Coli*?
  – In one toilet flush more E. Coli than:
    • The world population?
  – ~ $10^{10} – 10^{12}$
  – Or about 1,000,000,000 per 100 mL
Pathogen Treatment

• 1,000,000,000 fcu per 100 mL
  – What does a 99% (2 log) reduction mean?
• 10,000,000 fcu per 100mL
  – What does a 99% (2 log) reduction mean?
• 100,000 fcu per 100mL

• For Drinking Water: min 99.99999999% reduction
• For swimming: min 99.99999999% reduction
• Margin of error?

Reductions Required

<table>
<thead>
<tr>
<th>Activity</th>
<th>Campylobacter</th>
<th>Cryptosporidium</th>
<th>Rotavirus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking Water</td>
<td>8.1</td>
<td>8.5</td>
<td>11.2</td>
</tr>
<tr>
<td>Toilet Flushing</td>
<td>6.3</td>
<td>6.7</td>
<td>9.4</td>
</tr>
<tr>
<td>Laundry</td>
<td>5.3</td>
<td>5.6</td>
<td>8.4</td>
</tr>
<tr>
<td>Fire Fighting</td>
<td>5.3</td>
<td>5.6</td>
<td>8.4</td>
</tr>
<tr>
<td>Showering</td>
<td>5.8</td>
<td>6.2</td>
<td>8.9</td>
</tr>
<tr>
<td>Cooked Food</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

• Different pathogens require different amount of treatment (log reductions)
Pathogen Treatment

- Need a treatment ‘train’
- Each aspect of treatment train improves the quality

Wastewater Treatment Train

Influent → Primary Treatment → Secondary Treatment → Tertiary Treatment → Disinfection → Effluent

Water Quality improved
Nutrients Reduced
Organic Matter Reduced
Pathogens marginally reduced

Disposal / Reuse

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Treatment Types I

- **Primary Treatment**
  - Settlement of solids. Includes septic tanks

- **Secondary treatment**
  - Treatment to reduce organic loads (BOD) by about 80%.
    Includes trickling filters, sand filters and biological nutrient removal (BNR) systems

- **Tertiary Treatment**
  - High level treatment to remove majority of remaining nutrients and organic matter. Includes membranes, ion exchange and micro- / ultra-filtration systems

- **Disinfection**
  - Treatment to specifically remove pathogens. Includes chlorination, ozonation and UV light

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Treatment Types II

- **Lagoon storage**
  - Storage contributes to pathogen die-off through holding times and natural UV light. Would require community-level collection

- **Wetlands Subsurface flow**
  - Flow through a designed planted gravel bed. A very rough approximation to soil seepage processes.

- **Aquifer transport**
  - Pathogen die-off due to travel times in the groundwater

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Septic Tanks

- Typically achieve up to 1 log reduction
- 10,000,000,000 fcu to 1,000,000,000 fcu
- About 97 - 99% of the water going into a septic is discharged as effluent
- Nutrients and BOD about 20 - 30% reduction
- Septics are generally not the solution but are a way of controlling the wastewater
Wastewater Treatment

- Biological process (although some high tech alternatives)
- Treating organic matter, balancing carbon and nutrients
- To improve generally:
  - Increased time
  - Increased contact with micro-organisms
  - Warm temperature
  - Balance of food
  - Don’t kill it

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Sanitation Options: Septic Tank

Sanitation Options: Irrigation
Sanitation Options:
Common Septic

Sanitation Options:
Advanced Treatment
Sanitation Options:
Advanced Treatment

Sanitation Options:
Sand Filter
Sanitation Options:
Sand Filter

Sanitation Options:
Ecotrench
Sanitation Options: Composting Toilet

Sanitation Options: Baffled Reactor

principal longitudinal section
Actual number of chambers optional

provision for gas release

settle

baffled reactor

Length of Settle
Length of Chamber
Length of Chamber
Length of Chamber
Length of Chamber
How to choose?

- Engage the stakeholders yesterday
- Technical input (engineering/trades)
- Start with what you want to achieve
- Be specific about objectives:
  - Not “improve the water quality”
  - Be able to safely drink / swim in / wash with the water
  - Remove nutrient loads to lagoon to allow recovery

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Making Decisions

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Values

- Understand the stakeholder values:
  - Protecting the water for all uses?
  - Protecting coastal waters for swimming and shellfish collection?
  - Are land tenure issues likely to be negotiable?
  - Is land availability an issue?
  - Protecting coastal ecosystems: degradation and increased ciguatera / shellfish poisoning?
  - Ongoing annual costs and maintenance?
  - Total life-cycle costs?

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<thead>
<tr>
<th>Groundwater Use / Environmental Impact</th>
<th>Treatment Process</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
</tr>
<tr>
<td>Drinking¹</td>
<td>✗</td>
</tr>
<tr>
<td>Showering, food preparation, laundry</td>
<td>✗</td>
</tr>
<tr>
<td>Toilets</td>
<td>✓</td>
</tr>
<tr>
<td>Coastal Ecosystem</td>
<td>✓</td>
</tr>
<tr>
<td>Coastal Swimming⁴</td>
<td>✗</td>
</tr>
<tr>
<td>Shellfish and fish harvesting⁵</td>
<td>✗</td>
</tr>
</tbody>
</table>

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Talk and Negotiate

- Which values are negotiable
- Ask the engineer the same question
- Will payment address some concerns
- If there is no solution that meets the needs, then the needs have to change or be innovative
- Wastewater Treatment has limitations

Appropriate technology

- Achieves the objectives
- People are comfortable with the technology
- It can be maintained locally with local materials
- Low risk of failure (limited complexity)
- Low cost (or targeted cost)
- Appropriate not cheap
Taking it to the people

• How do we change this to be the norm?
• For Outer Islands?
• How do we transfer the technology?

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Household Water

• Focus on rainwater tanks
• Significant misconceptions
• These can be dangerous, pointing people to less safe options

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• What is people’s response to this?

Are Rainwater Tanks Safe?

• Yes – numerous studies showing that diarrhoea rates comparable with treated mains water and bottled water
• Maybe – however it depends on the household situation
• Rainwater is as safe as the tank and catchment
What are the risks?

- Anything on or above the roof – animals including birds; paint; settled dust; airconditioning condensate; anything you put there
- Pathogens – faecal matter from birds, lizards, cats, dogs, cows(!), people or even cross connections in 2 story houses
- Toxins – paint (old leaded), pesticides sprayed around house, dust containing toxins, anything else on your roof

What are the other risks?

- Tanks below ground level (even partially) or with subsurface pipes leading to the tanks are a much higher risk
- Cleaning tanks actually presents a risk because people commonly enter the tank
- Children often don’t understand the importance of protecting the water and may pollute it intentionally or otherwise
- Transfer of water with poor hygiene
- Boiled water sitting uncovered
What are the other risks?

- Nearby industry
- Copper piping
- Overhanging trees or material to attract birds
- Preservative treated wood (e.g. CCA)
- Taps exposed to animals or close to sanitation facilities
- Increased handling increases risks associated with poor hygiene
- Notably all of the above should be manageable

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How do I manage the tank?

- Do a survey to check for risks outlined above
- Address the risks (remove overhanging branches, etc)
- Where possible install a valve or plug at the lowest point of the tank to enable draining of sludge (if buying – buy one with a sump)
- Inspect the tank every three months if practical
- Clean gutters regularly (divert drains during clean)
- Ensure that no pollutants enter the roof (paints, pesticides, water from airconditioners or heaters)
- A first flush device is good practice

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First flush device

Do I need to Clean the tank?

- Why?
  - To check for leaks; although this can achieved through other tests if the tank is above ground
  - To keep the water healthy – not generally unless specific risks are identified in the survey that need managing
  - If the water tastes bad? Inspect first and then drain off sludge if possible. Speak to local authorities. Treat with hydrogen peroxide. As a last resort, clean the tank – it is often difficult to do this without damaging the tank
Do I need to boil the water?

- Generally no – if the tank is maintained properly and if there are pathogen risks identified (birds or bats overhead)
- Generally yes if there are babies or vulnerable people in the house (old, sick or immunocompromised) – or during disease outbreaks
- However, always follow local health authorities advice

How do I assess the problem?

- Sampling and monitoring – although this is always retrospective and a confirmation or verification approach
- Do a sanitary survey – Are there source of pollution, particularly faecal pollution? Do they present a real risk? How?
- Speak to your health authorities or SOPAC for guidance
- SOPAC / consultants / universities may be able to provide more detailed assessment / assistance – eg. Southern Cross University
How do we mainstream appropriate technology

- Engage appropriate authorities
- IWRM nationally to engage Outer Islands and vulnerable groups
- Consistent messages – e.g. boiling water
- Work with SOPAC WASH
- Link into NGOs and National AID organisations – these are often the groups delivering on the ground
- Education processes with LLEE, WASH, etc
- IWRM provides platform for this process – make it work

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How do we really mainstream appropriate technology?

- Which tools?
  - Guidance documents / toolkits
    - Technical
    - Selection
    - How much further to go?
  - Communication
  - Education / awareness
- Which stakeholders?
  - Political
  - Community
  - Government Agencies

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