Modelling fecal pathogen flows and health risks in urban environments to inform sanitation planning

UNC Water & Health Conference 2018

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Key messages

1. Public health risks need to be **better taken into account** in deciding between sanitation improvement options
2. Using a **source-pathway-receptor** conceptual approach, it is possible to estimate the pathogen flows across a city, exposure to these pathogens and related health risks
3. Comparing options on the basis of relative health risk may point us to ***different* sanitation solutions** as compared with commonly assumed solutions

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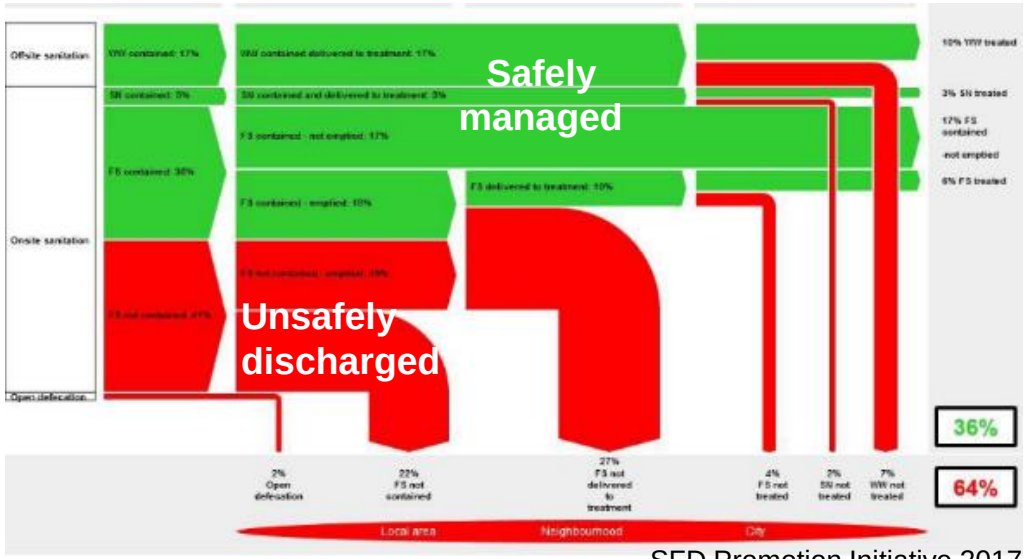
Why pathogen flows in matter for developing country cities

Poor management of sanitation

Failures across the service chain release untreated faecal waste into the environment



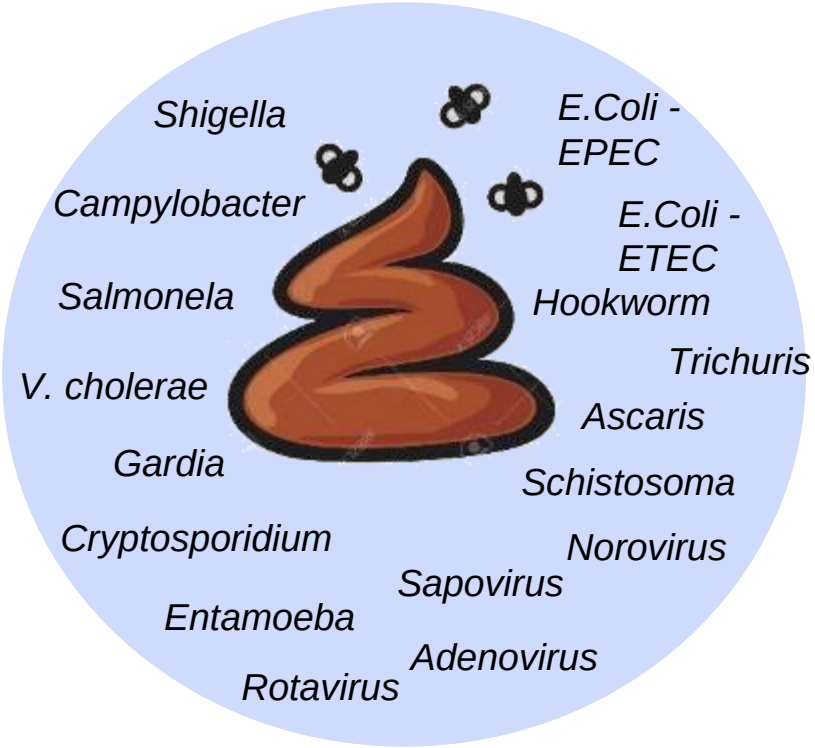
SFD Promotion Initiative 2017

Household **Community** **City** **Downstream**

Connected but unclear exactly how

High number of infectious pathogens

- Pathogens excreted in high numbers
- Numerous and varied types
- Persist in the environment



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However, investments rarely consider pathogen flows

Current decisions often based on:

- Capital cost
- Assumed benefits of individual technologies or practices
- Environmental discharge standards
- Protection of downstream environment

Rather than an understanding of:

- Where the most significant public health risks lie?
- What failures in sanitation systems or services are the source of pathogens?
- Which improvement options will best address these?

Urban sanitation planning raises many questions about how we protect public health

Which option: Will a regular desludging program reduce health risks?
Or do we need to also improved containment?

Which exposures to pathogens are most significant in terms of the health risks (in waterways, groundwater, food, etc.)?

Which of the "unsafe" flow paths or which faecal waste discharges are of most concern?

With limited resources, **what data should be collected** if we want to find out how to best improve health outcomes?

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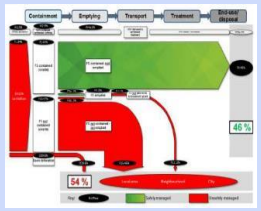
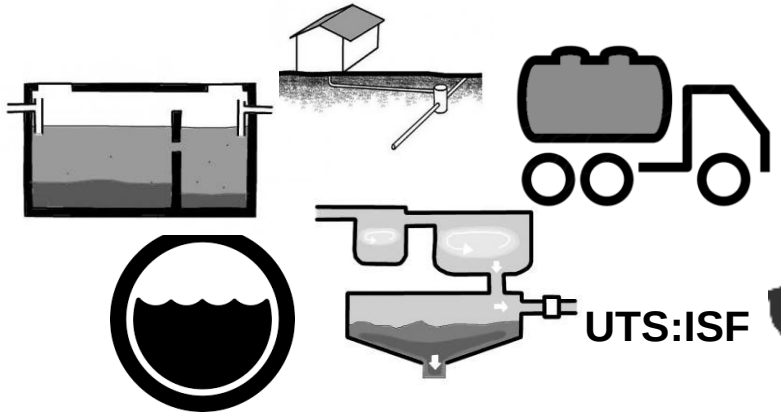
Aim: to build on existing data, tools and knowledge to develop an approach to inform sanitation options



Sanitation tools: Various mapping and assessment tools exist which assess the status of the sanitation service chain or unsafe discharge of faecal waste.

Health and exposure: GWPP compilation of pathogen data and knowledge plus various tools to inform exposure and health risk assessments.

Sanitation options: Increased consideration of the need to consider a range of sanitation solutions across the service chain and the multiple objectives or cross cutting benefits of sanitation investments.



1. Developed a conceptual approach to bring together sanitation and health assessments to inform decision making

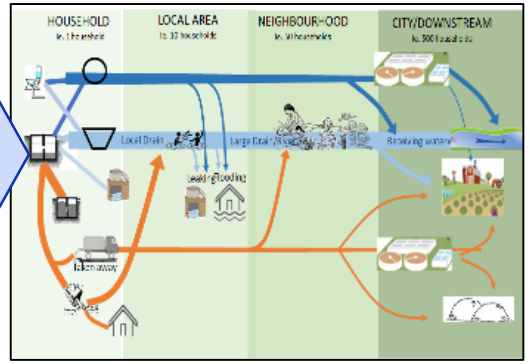
1. Set up the system, assess the faecal waste pathways and identify exposure points

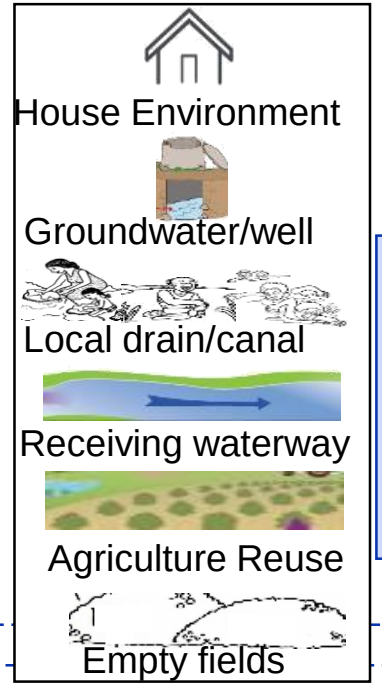
2. Calculate pathogen load and flows along the service chain

3. Calculate pathogen concentrations from various flows at each exposure point

Findings from most significant exposure pathways can inform initial sanitation improvement options to be assessed

Input Data
- Pathogen load
- Local Data:
  - Sanitation types
  - Wastewater flows
  - Service chain status
  - Drainage/flooding
  - Soil/groundwater
  - Prevalence of disease





4. Calculate the relative heath risk for each exposure point

5. Develop and test improvement options considering the service chain and compare with base case

Input exposure quantity, frequency and population exposed suitable to local context. Apply dose-response models, illness/infection and DALY ratios from literature.

Model new scenarios by changing setup or inputs and compare the change in health risks with base case

Input pathogen log reduction for system and flow paths, consider type and performance. Add dilution based on local conditions

Validate with literature or local data to adjust model

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2. Applied the approach to a hypothetical example

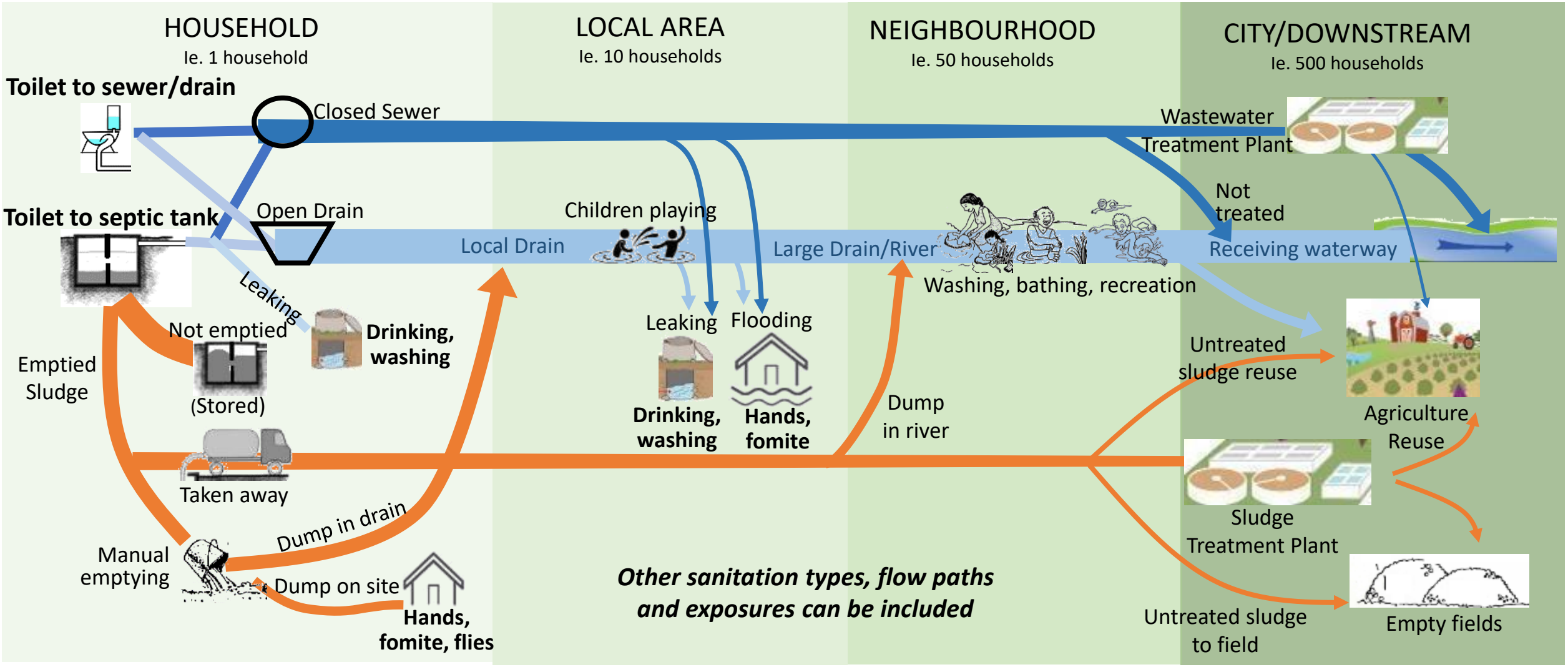

Image - Mills et al 2018

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3. Developed and tested improvement options

Sanitation improvement option	Household Environment	Groundwater	Local Drain	Community Drain	Downstream Waterway	Fresh Produce	Downstream Environment	TOTAL
1a. Reduce leakage from sewer and drain into groundwater (as 25% population assumed to use groundwater daily for drinking)	0%	↑	0%	0%	↓	0%	0%	↑
1b. Reduce groundwater use for drinking by half by providing an alternative water supply	0%	↑↑	0%	0%	0%	0%	0%	↑
2. Cover local drains	0%	0%	↑↑	0%	0%	0%	0%	↑↑
3a. Toilet and septic tank effluent to sewer (not drain)	↓	0%	↑↑	↑	0%	↑	0%	↑
3b. Improve conveyance (reduce flooding and leakage)	↑↑	↑	[illegible]	↓	↓	↓	0%	↑
3c. Increase sewer discharge that reaches treatment plant	0%	0%	0%	0%	↑	↑↑	0%	↑
3d. Improve wastewater conveyance (3a, 3b and 3c)	↑↑	↑	↑↑	↑	↑	↑	0%	↑↑
4a. Increase sludge emptying	↑	0%	↑	↑	0%	↑	↓	↑
4b. Increase sludge emptying and its delivery to sludge treatment plant	↑	0%	↑	↑	0%	↑	↑↑	↑
5. Improve faecal sludge treatment and wastewater treatment	0%	0%	0%	0%	↑	↑	0%	↑
6. Cover drains, reduce groundwater use, discontinue reuse of untreated sludge and wastewater for food production	0%	↑↑	↑↑	0%	↑	↑↑	↑	↑↑

Improvement

↑ Small change from base case

↑↑ High change

↓ **Worsen health risk**

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Key limitations and uncertainties remain…

Preliminary model phase only

- Preliminary stage for demonstrating use of the conceptual approach
- Validation and sensitivity testing needed
- Trade offs –complexities vs ease of use for practitioners.
- Does not yet include time and spatial considerations

Research data gaps and uncertainties

- Empirical research on the impact of sanitation improvements on pathogen discharge
- Fate of different pathogens in urban environments and treatment technologies
- Further application of emerging methods to monitor multiple pathogens in the environment (e.g. qPCR) particularly in developing country contexts
- Develop improved decision making frameworks to support multiple objectives: economic, health, environment

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What was achieved and where to next

- Modelling provides **a way forward** in the face of data constraints that are typical in developing country urban contexts.
- Highlights the need to widen our consideration of health risks and exposure and to consider **how to prevent pathogen entry** to the environment.
- Further **empirical research** in specific locations is now required to refine the approach and address data gaps

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Thank you

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Paper: Mills, F., Willetts, J., Petterson, S., Mitchell, C., & Norman, G. (2018). Faecal Pathogen Flows and Their Public Health Risks in Urban Environments: A Proposed Approach to Inform Sanitation Planning. *International journal of environmental research and public health*, 15(2), 181.

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