WSUP | Water & Sanitation for the Urban Poor

Modelling faecal pathogen flows in urban environments: a proposed approach to inform sanitation planning

Policy Brief | January 2018

Quick read...

- This Policy Brief summarises an initial research study which developed a conceptual model of faecal pathogen pathways in urban environments
- The proposed model uses a "source-pathway-receptor" approach: it considers *release* of pathogens into the environment, *transport* in the environment, and eventual human *exposure*
- The model can potentially provide a framework for comparing the relative impacts of different sanitation options on health; the next step should be to test the approach in a real city

This Policy Brief summarises the findings of an initial desk-based research study that developed a conceptual model for structured analysis of the relationships between sanitation improvements and health.

Rationale

An increasing body of research makes clear that just "improving toilets" or "improving pit emptying" is unlikely to be sufficient for reducing faecal-oral disease in slum communities, because of the complexity of faecal pathogen pathways in the environment. The SaniPath project has generated extensive information about some pathways of exposure, using E. coli as indicator. Meanwhile, the Shit Flow Diagram model has proved an influential framework for top-level analysis and advocacy, highlighting that city sanitation requires consideration of the entire sanitation chain. Nonetheless, many investments in sanitation continue to be made on the basis of simplistic assumptions about likely impacts on disease transmission. There has not yet been any significant attempt to create a practically applicable methodology by which city-level decisions about sanitation investment can be supported by understanding of pathogen flows.

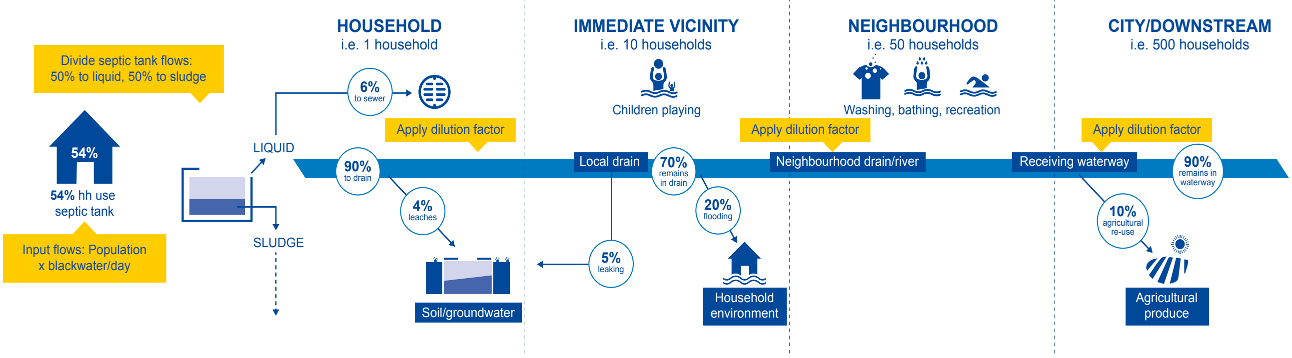
Urban Sanitation Research Initiative

This report is produced under the Urban Sanitation Research Initiative, a 2017-2020 programme of rigorous research designed to drive pro-poor sector change in urban sanitation in Bangladesh, Ghana and Kenya and globally. www.wsup.com/research

Methods

This was a concept-stage desk study, based on literature review (including review of existing models and tools), expert consultation and analysis to develop the basic skeleton of a conceptual model. The researchers built a prototype model in spreadsheet form, using data for a hypothetical urban context together with values from the global literature.

Figure 1: Schematic representation of the volumetric flow model for one particular sanitation type (pour-flush to septic tank).



Findings

This was a complex study, with in-depth consideration of multiple complexities which cannot be covered in any detail in this Policy Brief: interested readers should consult the open-access journal article in IJERPH. Here, we present a simplified summary of the steps of the proposed model:

1. Identify the main original sources of faecal pathogens, and for each pathway **estimate volumetric flows** along the service chain, as in the example shown in Figure 1.
2. Using published or local data on pathogen loads in excreta, and estimates of rates of die-off in treatment systems and the environment, **estimate pathogen flows** (on the basis of the volumetric flow estimates). This is done separately for different major pathogen groups.
3. By summing the pathogen flows estimated for each source, **estimate resulting pathogen concentrations at each exposure point** (in Figure 1: groundwater; household environment; local drain; neighbourhood drain; fresh agricultural produce; receiving waterway).
4. Use a QMRA methodology to **estimate the disease impact** (in disability-adjusted life years lost = DALYs lost) from each pathogen via each exposure point, on the basis of pathogen concentration (applying a dose-response model) together with expected frequency of exposure, and proportion of population exposed.

The model can then be varied by introducing changes corresponding to **candidate sanitation improvements**: for example, what happens if we move 10,000 people from septic tanks to sewer; or if we increase sludge removal rates by 25%; or if we reduce groundwater use by half? [See Figure 2.]

In conclusion: evidently, a model of this type requires multiple input parameters (based on published data and/or local data collection and/or expert opinion). Just as evidently, in many low-income contexts there is limited technical capacity to handle complex models, and limited political will to act on recommendations. But without considering the whole system in a holistic way, there is a clear risk that sanitation investment decisions will be ineffective for improving health.

Figure 2: Example tabular output from the model, illustrating the type of guidance that a model of this type could provide. Arrows represent projected change in DALYs lost via each pathway: green arrows represent a reduction in health risk, red arrows an increase. The results shown are illustrative of model application only, and should not be interpreted as real findings.

Improvement option	Household environment	Groundwater	Local drain	Community drain	Downstream waterway	Fresh produce	Downstream environment	TOTAL	Explanation of the results
Reduce leakage from sewer & drain into groundwater (as 25% population assumed to use groundwater daily for drinking)	0%	↑	0%	0%	↓	0%	0%	↑	A very small change in leakage flows from sewer and drain (2% change) resulted in an overall reduction in health risk due to pathogens in groundwater, despite a slight risk increase in relation to downstream waterways.
Cover local drains	0%	0%	↑	0%	0%	0%	0%	↑	Covering drains reduced exposure and related health risks through this pathway, and resulted in a major overall reduction in health risk due to significance of this pathway.
Toilet and septic tank effluent to sewer (not drain)	↓	0%	↑	↑	0%	↑	0%	↑	Reduction of faecal flows to open drain reduced subsequent exposure at local and community drains, but moved pathogen flows so increased risk at household due to no improvement in the sewer overflow/flooding.

Policy implications

Investment decisions about how to improve urban sanitation (by governments and other in-country actors, or by international agencies) should be based on a better understanding of pathogen flows. Pathogen flows are complex, and this research supports the view that simple judgements (e.g. "regular de-sludging will improve health outcomes") may be inadequate: understanding in any given context will require some sort of whole-system analysis. But modelling of complex systems is very challenging, and WSUP is considering the possibility of further research, in a specific city, to assess the extent to which the approach outlined here can generate reliable and useful guidance at reasonable cost, whether within an existing approach (e.g. Sanitation Safety Planning) or as a self-standing analysis.

Funded by

Credits: This research was led by the University of Technology Sydney (UTS). See open access: Mills, F., Willetts, J., Petterson, S., Mitchell, C. and 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 **http://mdpi.com/journal/ijerph/**