Considering pathogen flows and health risks in sanitation investment planning

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Planning urban sanitation raises many questions about how we protect public health!

Which exposures to pathogens are most significant in terms of the health risks (in waterways, groundwater, food etc.)? Where in the sanitation chain should improvement options be directed?

Will our new desludging program reduce health risks? Or do we need to also improved containment?

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

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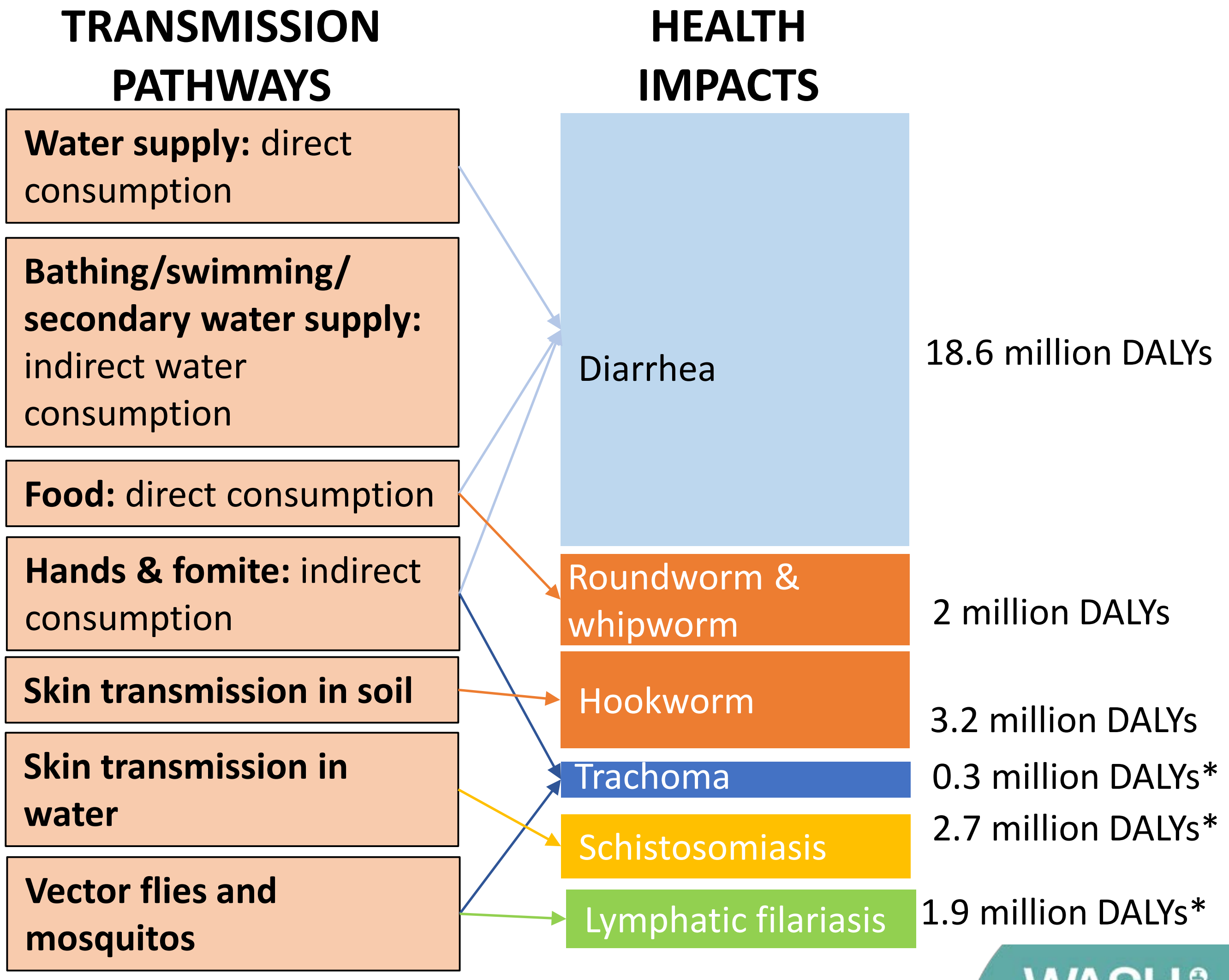
Key messages

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

Public health benefits often drive sanitation improvements

- Public health benefits of reducing exposure to faecal pathogens are not disputed
- Inadequate sanitation is associated with various health impacts, not just diarrhea
- Numerous types of pathogens and various pathways of transmission from inadequately managed sanitation in urban environments.



* based on WASH (not sanitation alone)

DALY = Disability Life Adjusted Years

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 sanitation system or service failures are the source of pathogens
- which improvement options will best address these

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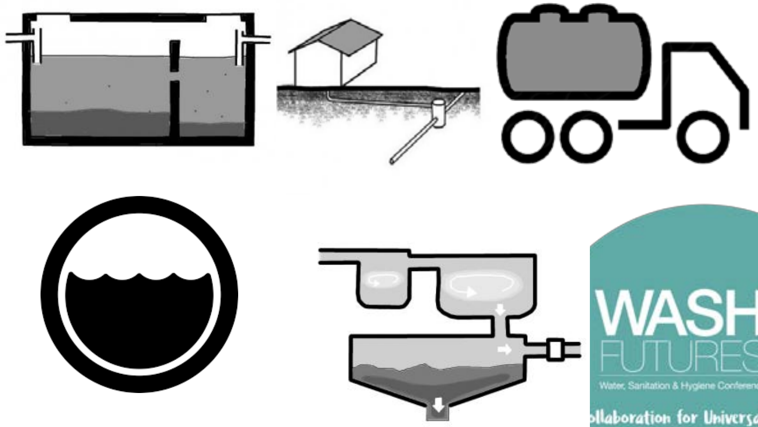
Can we develop an approach to better consider health in urban sanitation decision making?

Leveraging from existing mapping and assessment tools and global pathogen data, can we **estimate the faecal waste discharged** to various **exposure points**?

Considering which pathways and pathogens pose the greatest health risk, can we link the **estimated pathogen concentrations** with **exposure data** and use quantitative microbial risk assessment (QRMA) to estimate the relative **health risks**?

Can we identify and compare which **improvements in the sanitation chain** best **reduce pathogens or pathways** associated with **priority diseases** specific to the city's existing context?



1. Reviewed existing tools and assessments

- Various tools exist to inform and assessment sanitation status, planning, health risk and exposure (e.g. Shit flow diagram, Sanipath)
- No existing tools explicitly linked an existing sanitation situation with health risks to directly inform sanitation planning.
- Identified gaps:
  - ➢ assessment of **source** of pathogens entering the environment
  - ➢ **relative significance** of the different faecal waste discharges
  - ➢ **variability** in removal of different pathogen classes (helminths, protozoa, bacteria, viruses)
  - ➢ health risk assessment **situated** within the city context and considering the full sanitation service chain (rather than only in relation to standalone 'technologies')

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2. Developed a conceptual approach

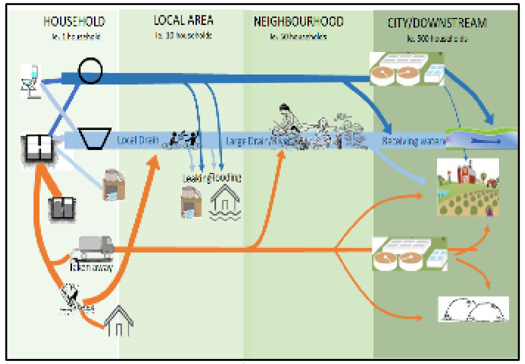
1. Set up the system, assess the faecal waste pathways and identify exposure points

2. Calculate pathogen load and flows along the service chain

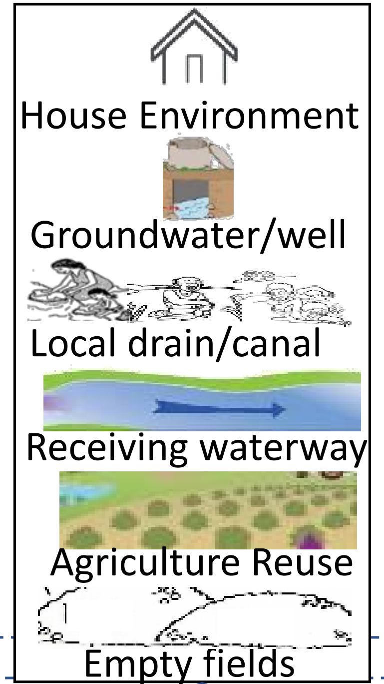
3. Calculate pathogen concentrations from various flows at each exposure point

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



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

4. Calculate the relative heath risk for each exposure point

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

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

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

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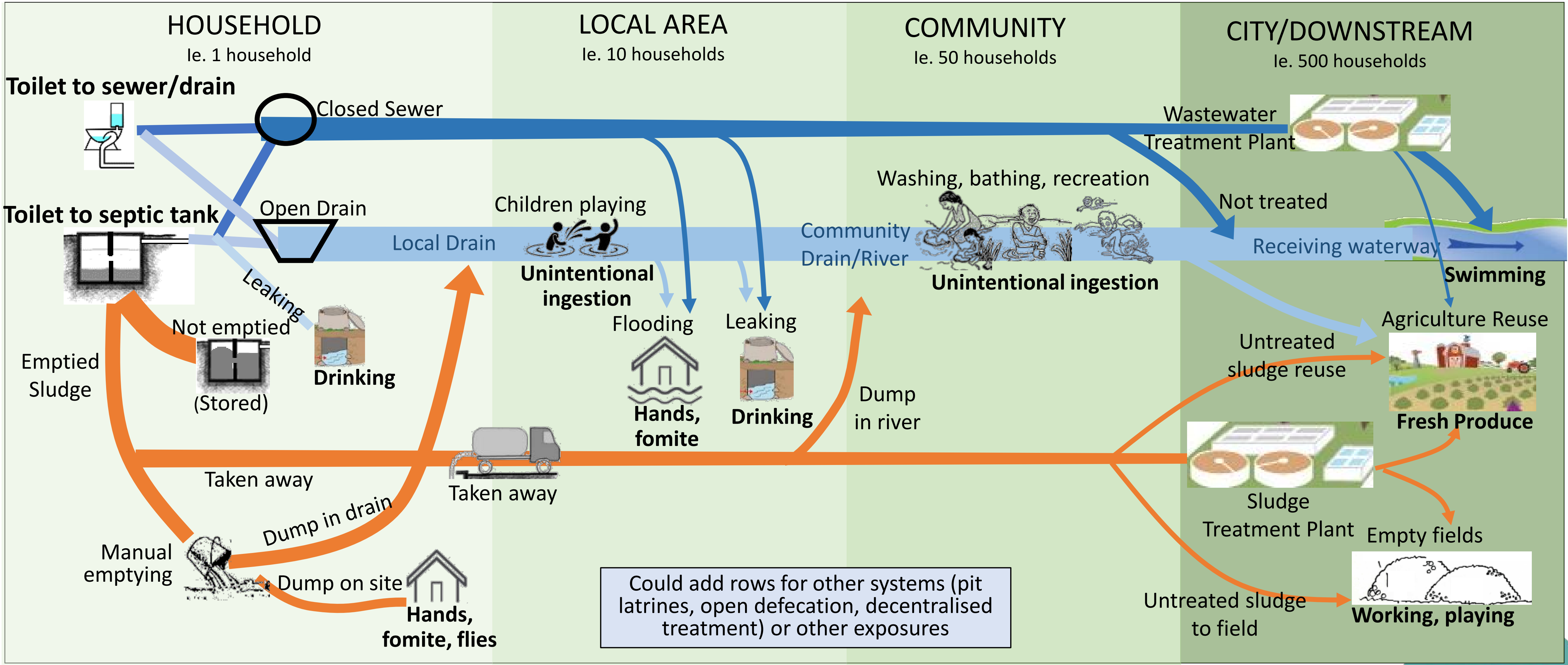
3. Applied approach to a hypothetical example



Could add rows for other systems (pit latrines, open defecation, decentralised treatment) or other exposures

4. 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)	↑	↑	0%	↓	↓	↓	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%	↑	↑	↑	↑

Key limitations and uncertainties remain…

- Pathogen data gaps
  - GWPP* not complete
  - Pathogen $\log_{10}$ reduction in all systems for all pathogens
  - Apportioning pathogens in septic tank
  - Behaviour in drains/waterways
- QMRA approach questioned
  - Applicability of dose response model
  - Exposure data context dependent
  - Suitability QMRA for high pathogen environments
  - Benefits of more complex modelling: stochastic and sensitivity analysis
- Balancing complexity with usability
  - Trade off – inherent complexities vs ease of use for practitioners.
  - Does not yet include time and spatial considerations
  - Dilution approach needs further thought
  - Primarily useful to guide researchers and sanitation experts

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*GWPP: Global water pathogen project www.waterpathogens.org

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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

Key messages

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THANK YOU

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References:
Mills, F., Willetts, J., Petterson, S., Mitchell, C., Norman, G. *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, 2018, Vol 15(2) p181. http://www.mdpi.com/1660-4601/15/2/181/html

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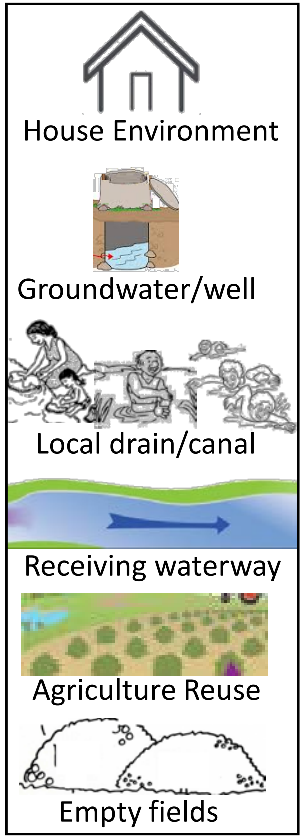
3. Linked exposure with probability of illness and resultant health risk (disability-affected life years- DALY)

Pathogen concentration at point of exposure



Volume consumed/ time exposed

- **Water consumption**
- **Indirect water consumption**
- **Food consumption**
- **Fomite & Hands**
- **Soil to Skin**
- **Water to Skin**
- **Vector flies**

Based on literature, SaniPath, Participatory Risk Assessment

= Dose of each pathogen consumed per person per day

QMRA Approach to calculate DALY

- Dose response relationship for each pathogen
- Risk of illness of each pathogen
- Frequency of exposure and proportion population exposed
- DALY for each pathway and overall

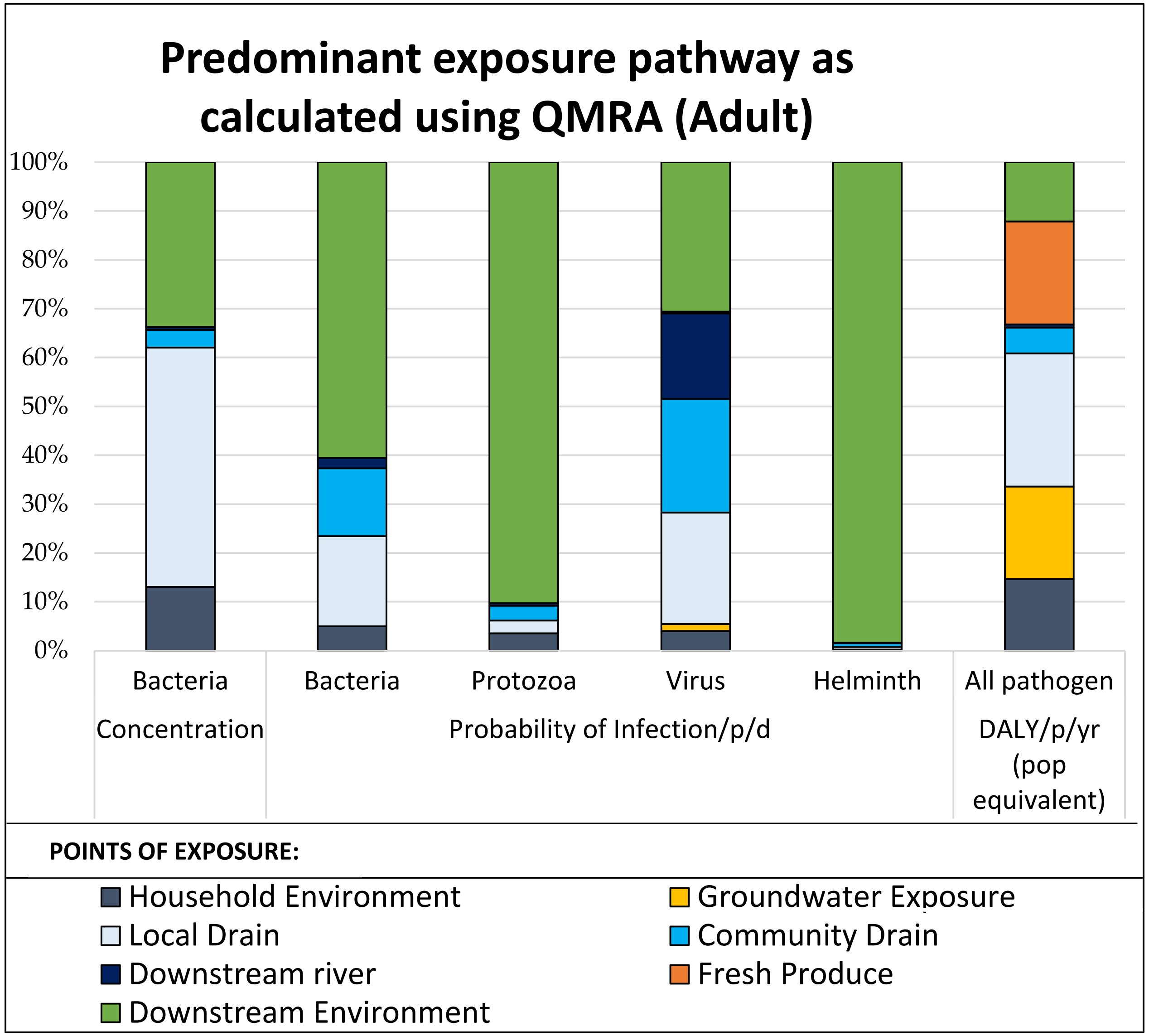
Based on literature

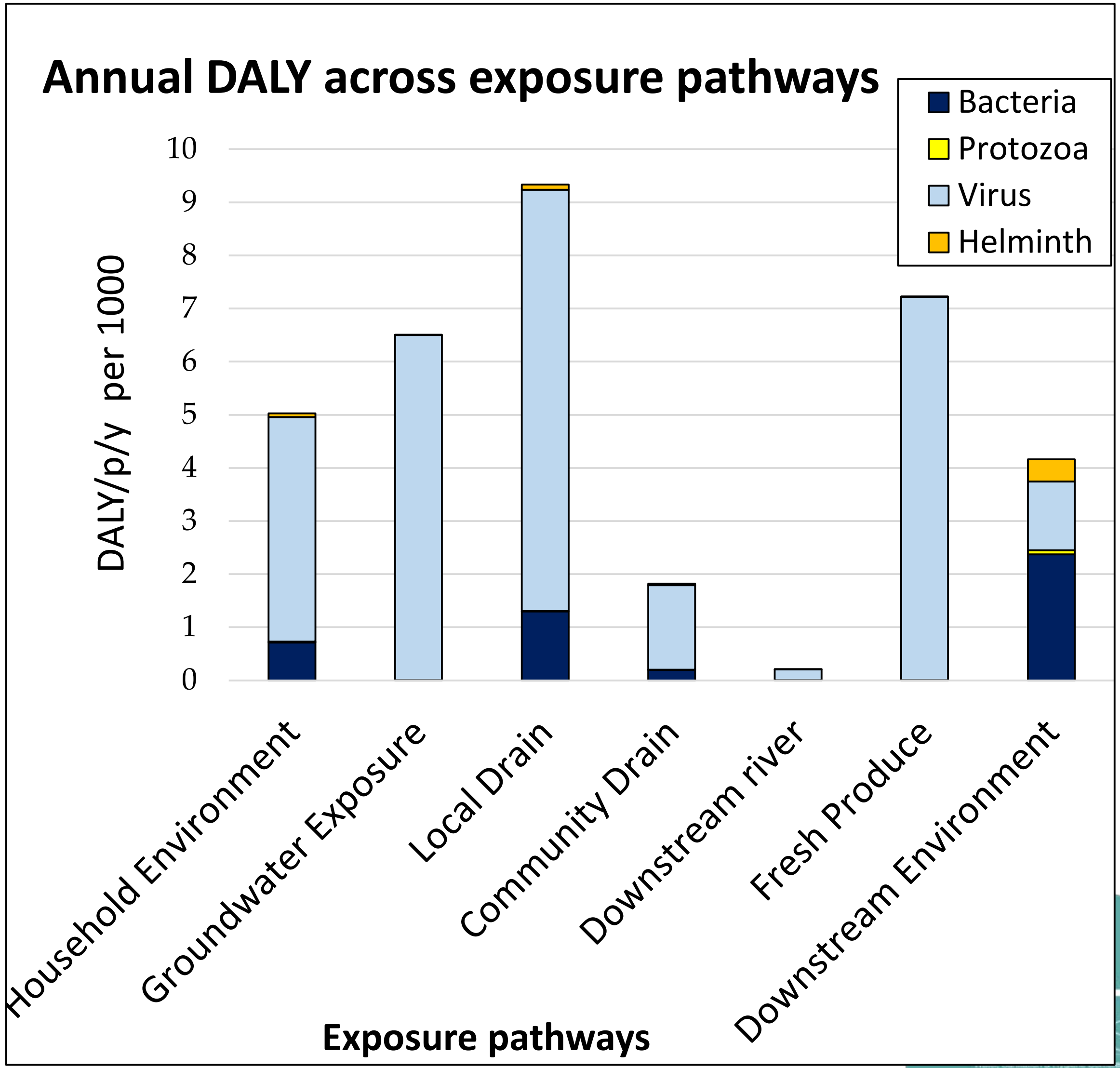
Apply the model to different scenarios to assistt with decision making

Test different improvement to the sanitation system

Compare how DALY changes for different exposure pathways and overall

3. Base case: example model outputs





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