

An aerial photograph showing a coastline with a mix of blue water and brownish land. The water has a textured, wavy appearance. The land is a mix of light and dark brown tones, suggesting different types of terrain or vegetation.

# **Moving Sanitation Science into Practice**

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**MICHIGAN STATE**  

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**UNIVERSITY**

# Investment in R&D: Moving knowledge to practice

Move to Pathogen Monitoring filling data gaps.

Characterize the range of pathogens in untreated sewage: Use new methods.

Advance our understanding of treatment removals at full-scale and this MUST include the disinfection process.

Use combination of molecular and cultivation methods

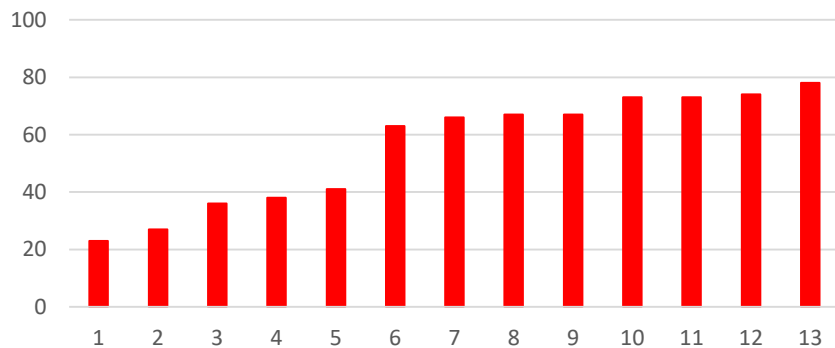
Use a Risk-based framework for decision making



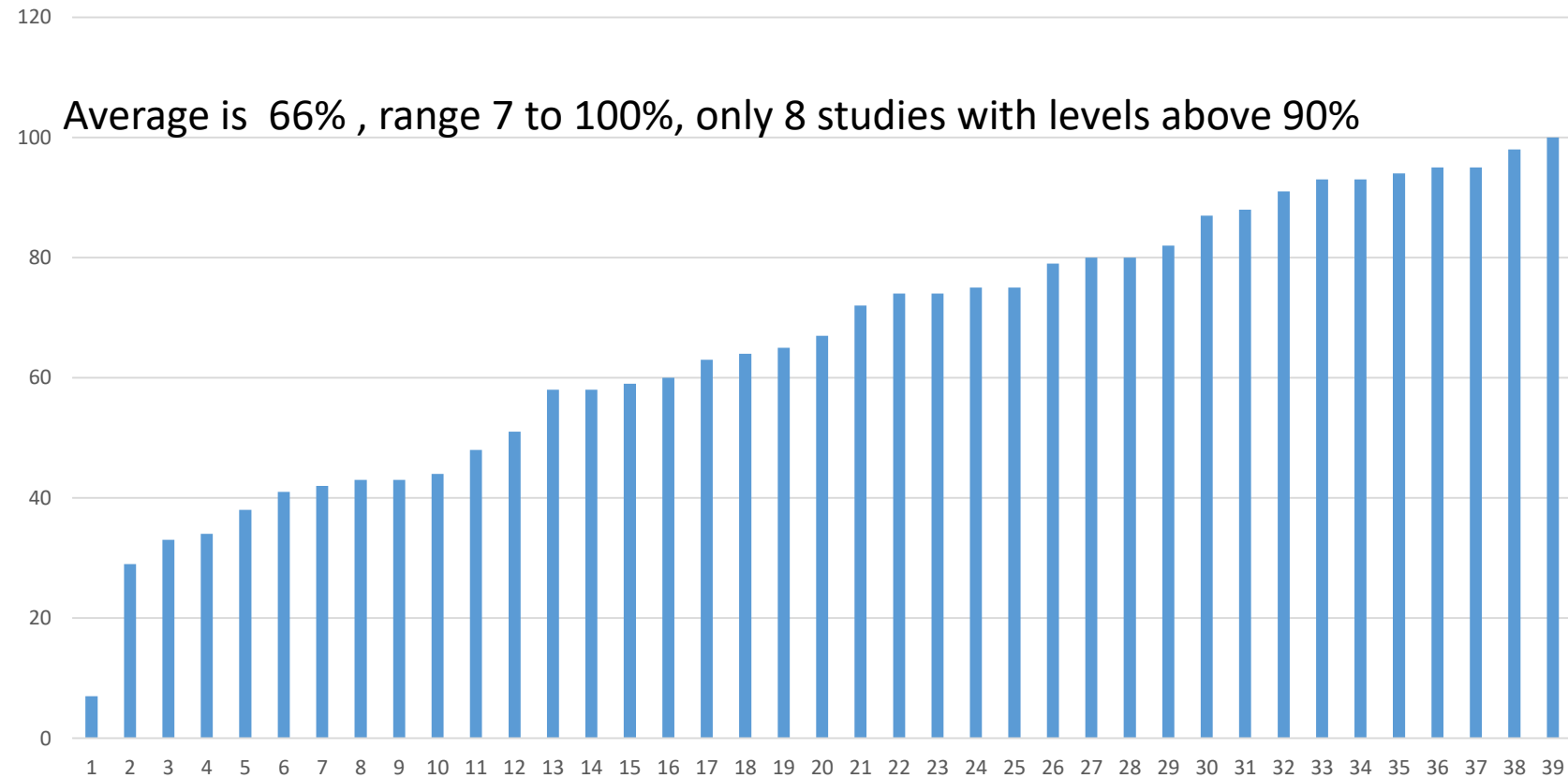
# The impact of sanitation interventions on latrine coverage and latrine use: A systematic review and meta-analysis Garn et al.2017 INTERNATIONAL JOURNAL OF HYGIENE AND ENVIRONMENTAL HEALTH,Volume: 220, Issue: 2, Pages: 329-340

- Average coverage was 66%
- Average usage was 56%

### Sanitation Usage



### Sanitation Coverage



# Pathogens in Biogas effluent tanks

Exposure to biogas wastewater in Ha Nam province, Vietnam  
Assessment of diarrhea risk

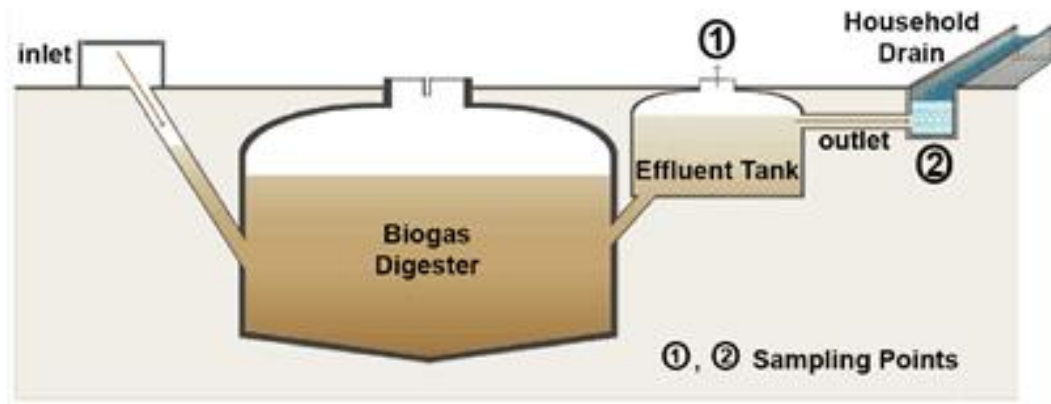
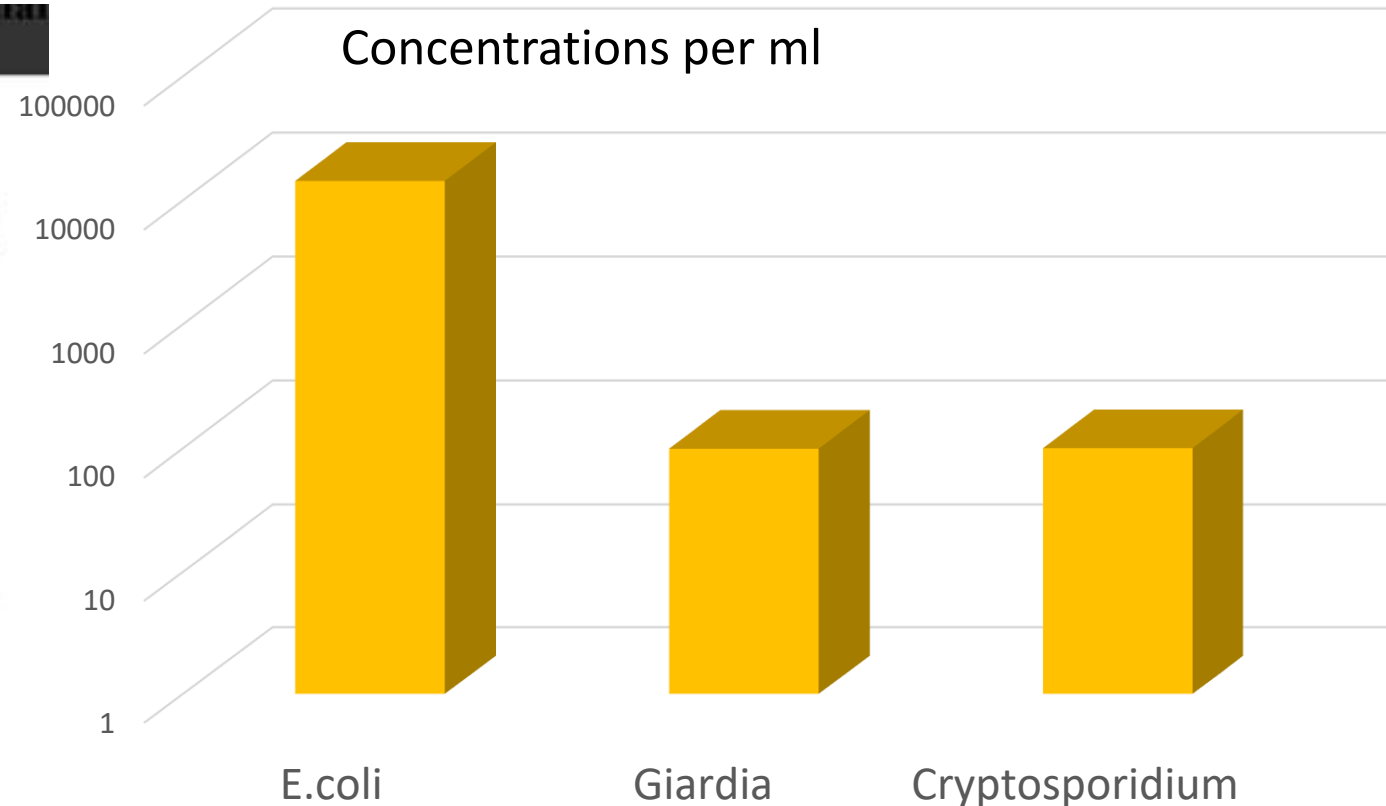


Fig. 1 Scheme of a biogas plant and the two sampling points

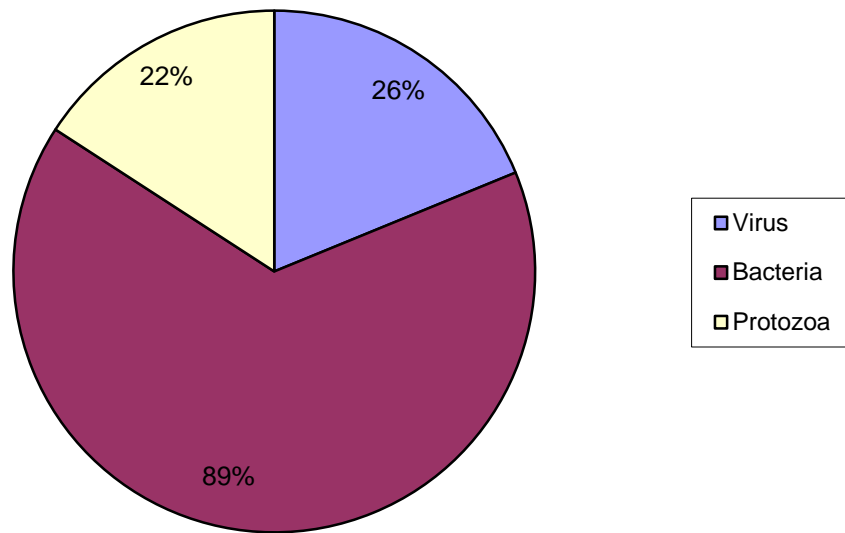
(Source: Adapted from (Tilley et al. 2014))



Thu Le-Thi, Phuc Pham-Duc, Zurbrügg, C., Toan Luu-Quoc, Huong Nguyen-Mai, Tu Vu-Van and Hung Nguyen-Viet. 2017. Diarrhea risks by exposure to livestock waste in Vietnam using quantitative microbial risk assessment. International Journal of Public Health 62(Supplement 1): 83–91.

# Enteric pathogens from fecal wastes are the major cause of waterborne disease

Implicated pathogen in 74 disease outbreaks during extreme weather events



- Data from a meta-analysis of > 100 articles for extreme water-related weather events and waterborne outbreaks from 1910 to 2010 found the majority were associated with heavy rainfall, flooding and severe storms. 78% were disinfection sensitive.

# Global Challenge: Advancing Sanitation Science

- Hundreds of disease causing organisms are found in sewage
- These are causing acute and chronic disease
- Poor data base on occurrence, distributions, persistence and removal efficacy by wastewater treatment and disinfection practices
  
- **NEED A MAJOR INVESTMENT IN SANITATION SCIENCE**
- **NEED DATA TO PROMOTE BETTER DECISION MAKING**
- **NEED PILOT TESTING**

## Pathogen Data on Concentrations in Feces and Raw Sewage

In a study on composting of excreta (Sossou et al., 2014, from Burkina Faso) the mean numbers (n= 30 samples) in raw feces were as follows:

*A.lumbricoides* (204 eggs/g)

*Trichuris trichiura* (117 eggs/g)

*Ancylostoma duodenale* (65 eggs/g)

*Schistosoma mansoni* (53 eggs/g)

*Hymenolepis nana* (34 eggs/g)

*Enterobius vermicularis* (12 eggs/g)

*Strongyloides stercoralis* (12 eggs/g)

WORMS ARE NOT IMMEDIATELY INFECTIOUS HAVE LATENT PERIODS FROM 5 DAYS TO 4 WEEKS

Most protozoa are immediately infectious and numbers in feces (Sossou et al., 2014, from Burkina Faso) were on average (n=30):

*Entamoeba coli* (1256 cysts/g),

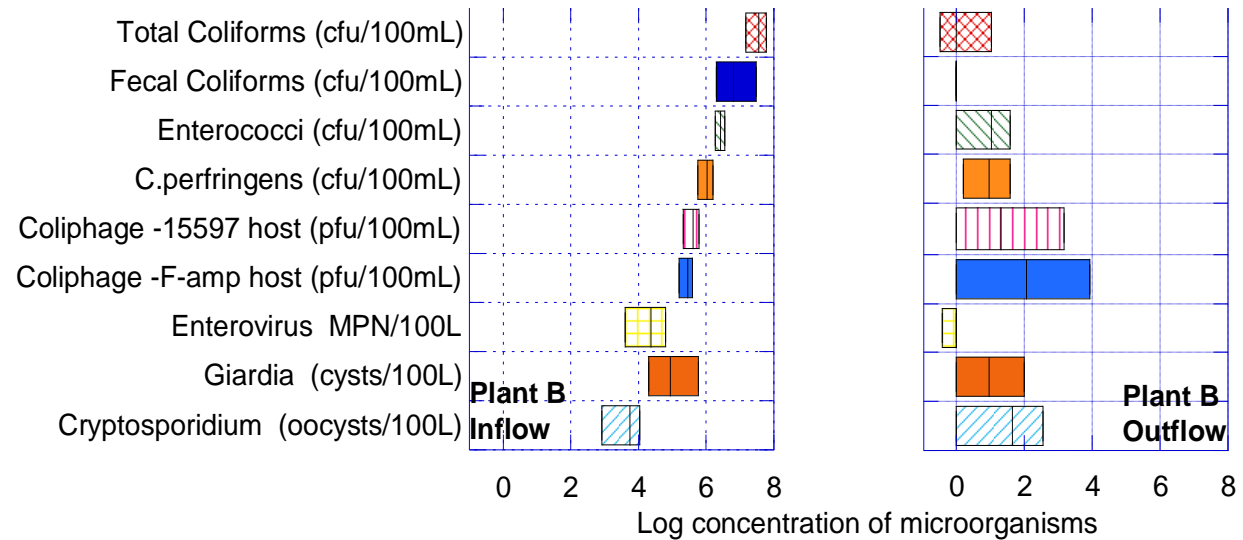
*Entamoeba histolytica* (854 cysts/g)

*Giardia lamblia* (56 cysts/g)

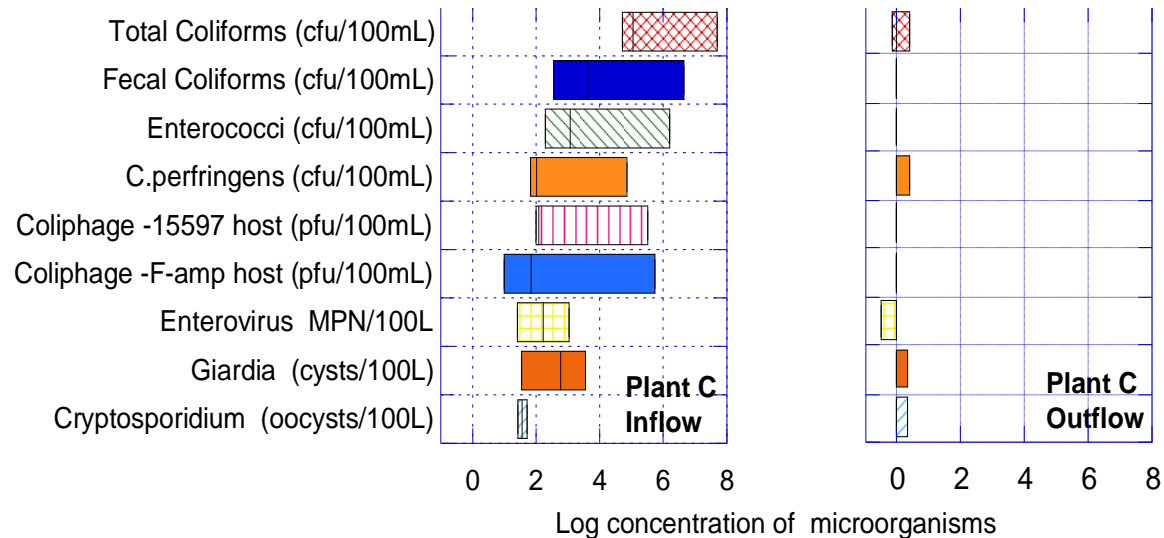
Feces produced per day around the globe varies an average of 32 grams (g) per capita per day (with a range of 4 to 102g of excreta) Rose, C.A. 2015 ES&T

Microorganism	Concentra-tions/g in feces	Concentra-tions/L In raw sewage	Notes regarding sewage data	References
<b>Pathogens<sup>a</sup></b> (often in feces represents those infected at max excretion)				
<i>Cryptosporidium</i>	10 <sup>6</sup> to 10 <sup>7</sup>	10 to 10 <sup>2</sup>	From 6 wastewater plants in USA. Review from 12 countries South and North America, Asia, Europe and Africa High as 6X10 <sup>4</sup>	Nasser 2016 Rose et al, 2005 Gerba, 2001
<i>Giardia</i> ( <i>Entamoeba</i> could be higher)	56 to 5x10 <sup>6</sup>	1.35x10 <sup>4</sup>	18 studies includes Africa, Europe, North and South America.As high as 10 <sup>5</sup>	Guimarães et al. 2017 Gerba, 2001
<i>Ascaris</i>	2x10 <sup>3</sup> to 6x10 <sup>3</sup> Not infectious needs ~10 days to mature	46 to 204	In sewage as high as 6.0x10 <sup>2</sup> N=30 Burkina Faso	Sharafi et al., 2015; Sossou et al., 2014
Adenoviruses	10 <sup>11</sup>	9.1x10 <sup>9</sup>	13 studies Africa, Europe, USA, South America, New Zealand	Allard and Vantakarīs, 2017
Rotavirus	10 <sup>10</sup> to 10 <sup>12</sup>	5.87x10 <sup>7</sup>	5 studies includes data as High as 2.9x10 <sup>8</sup>	Da Silvia et al., 2016, Gerba, 2001

# Understand Variability and Control of Pathogens



b) Boxplot of distribution of pathogens and indicators in influent and effluent samples from wastewater reclamation plant B. Samples collected under peak flow conditions.

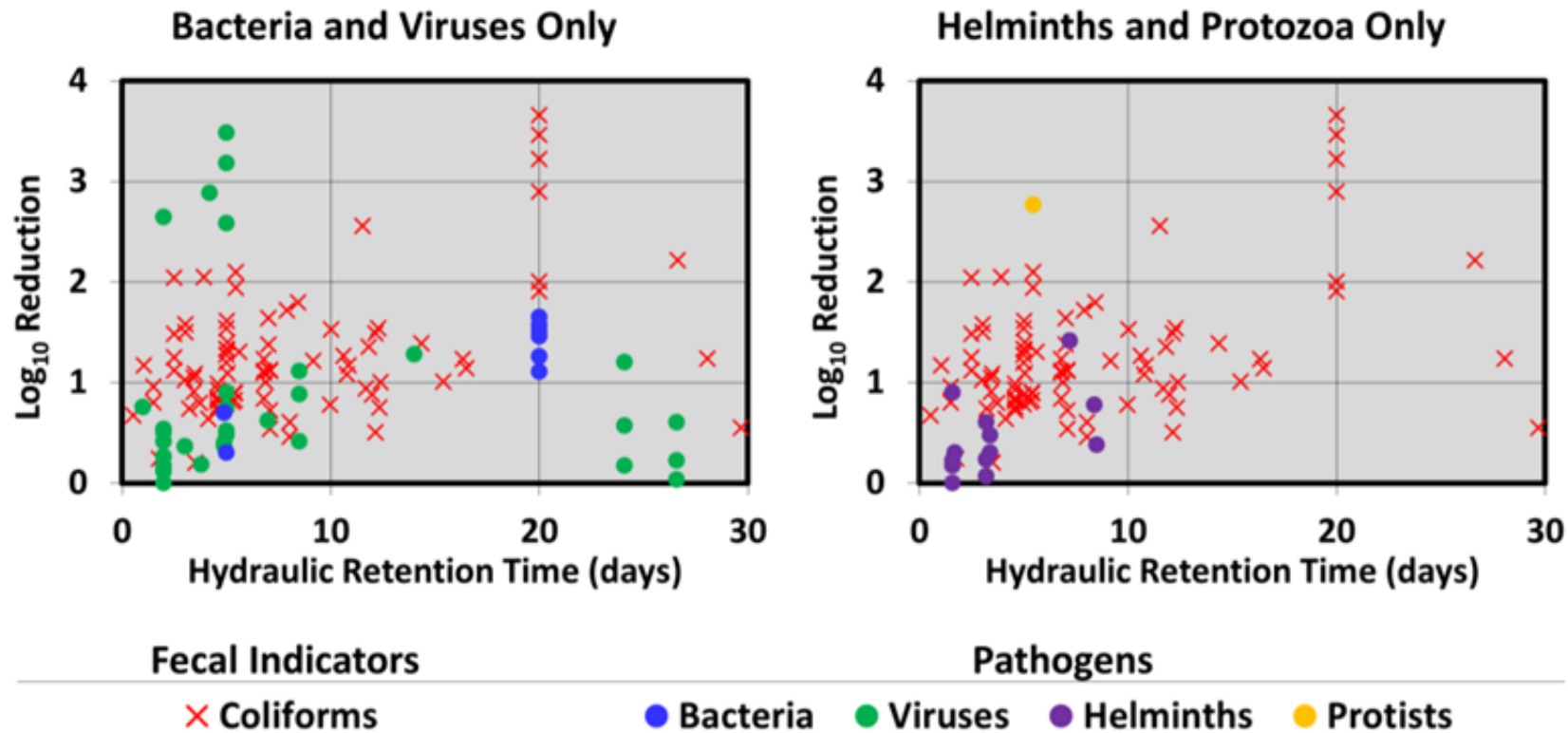


c) Comparison of distribution of pathogens and indicators in influents and effluents from wastewater reclamation plant C. Samples collected under peak flow conditions.



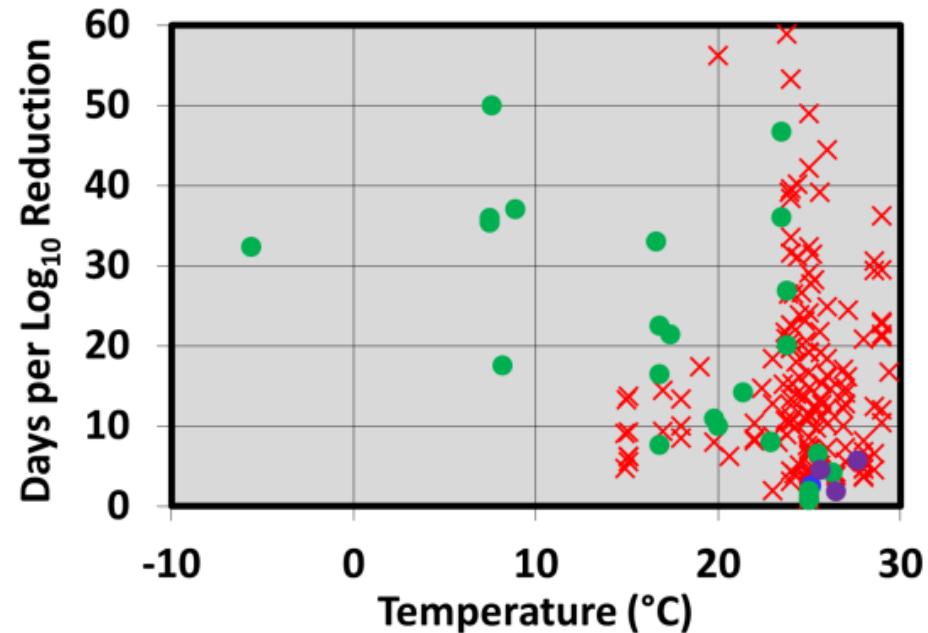


# Example of Technology Data: Showing Pathogens in Relation to Indicators (Matt Verbyla)



# Data for Waste Stabilization Ponds: Showing the Impact of Key Factors (Temperature) (Matt Verbyla)

## Waste Stabilization Ponds



Fecal Indicators

× Coliforms

Pathogens

● Bacteria

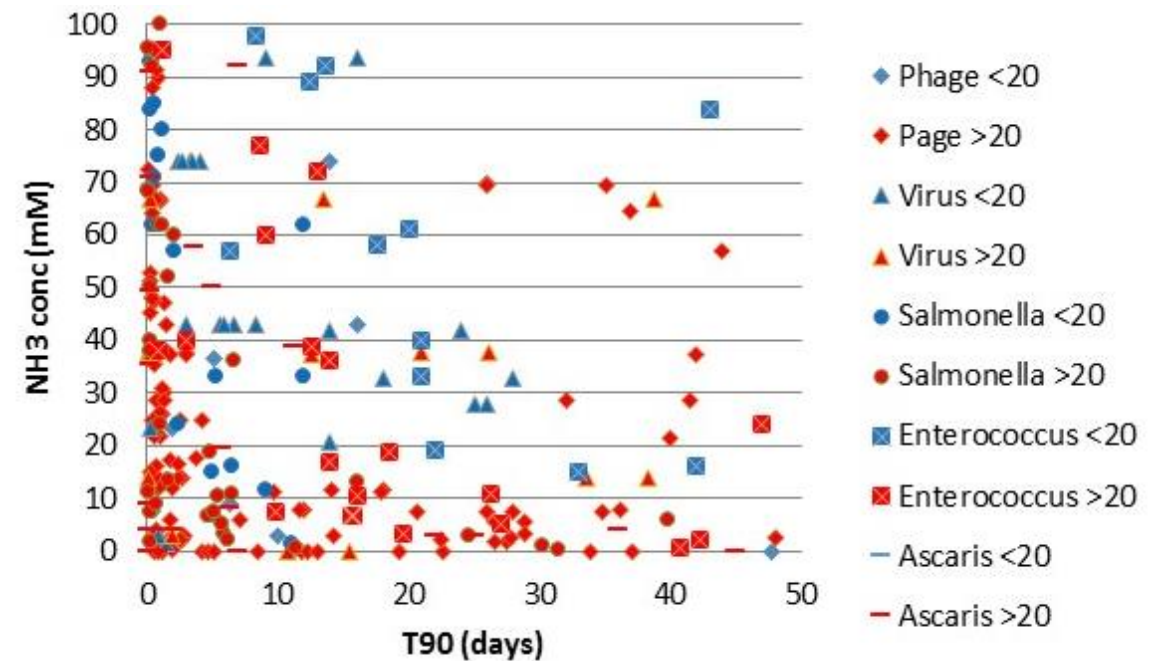
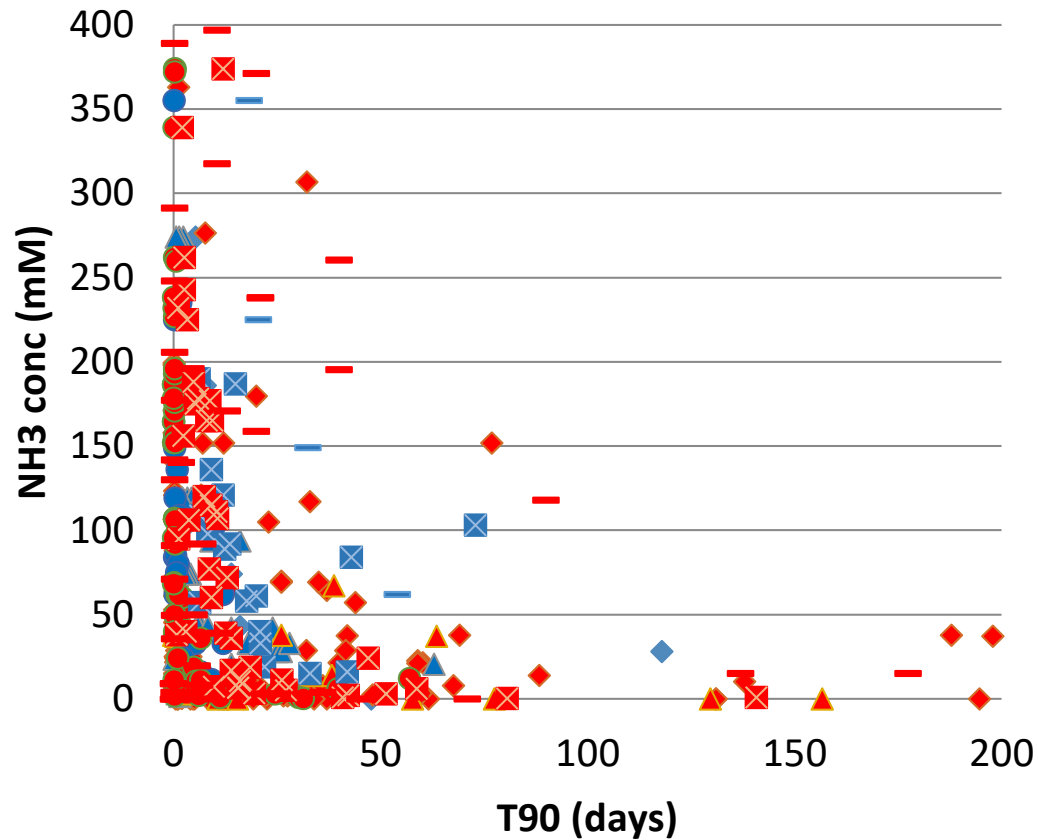
● Viruses

● Helminths

● Protists

# Identify indicator

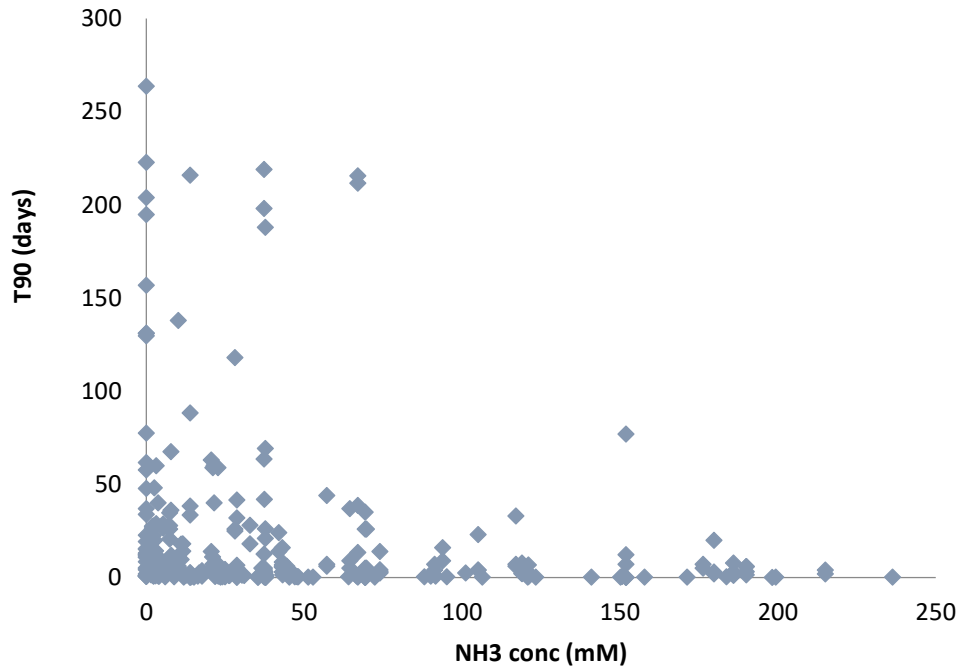
This plot allows to identify the “hardest” organism, which may serve as a conservative indicator. Here, Ascaris is the hardest. However, it is not always a relevant organism to treat, so Enterococcus or a phage may be a better indicator.



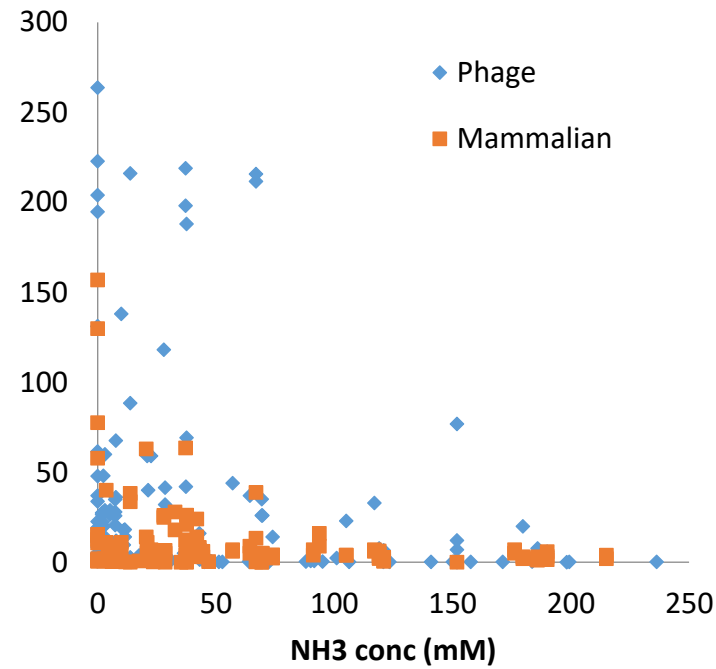
# identify problematic species or subgroups

Such a series of plots could help identify critical (i.e., most resistant) species within a pathogen class.

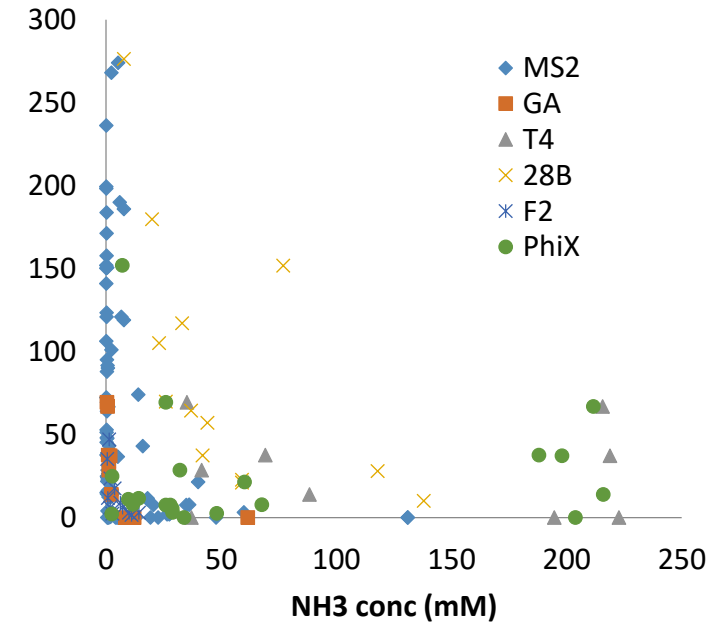
### All virus



### Phage vs mammalian



### Individual Phages



**QMRA should be used to examine wastewater treatment**

**How much treatment is needed?**

**What is safe?**

**Virus Concentration in Untreated Sewage (virus/L)**

Reductions by various treatment →

← Reductions by various dilutions

Water use for washing; To Hand Transfer Efficiency; Hand To Lip Transfer Efficiency

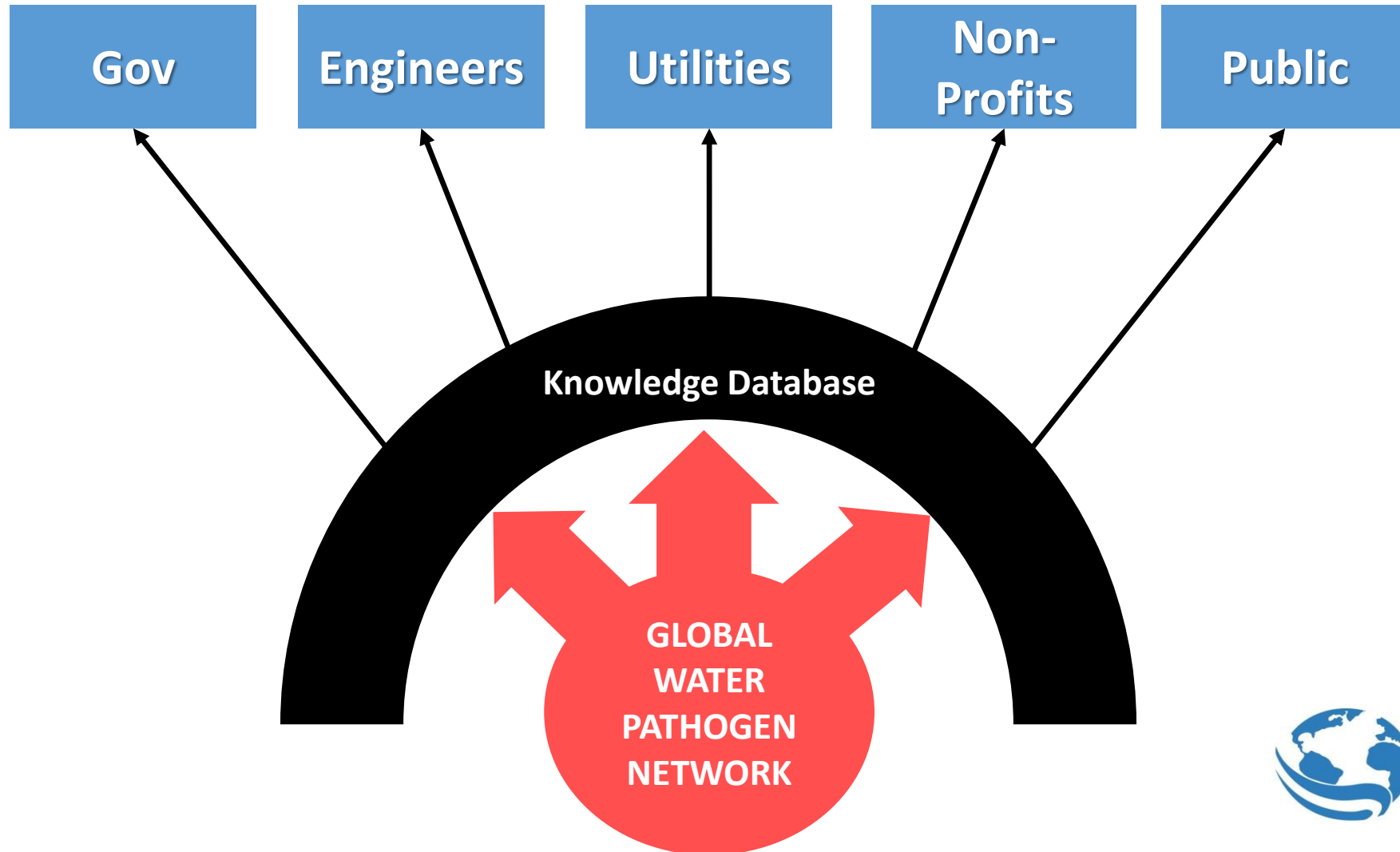
Dose with Bathing 30 ml

← Drinking Water 1 to 2 Liter per day with or without reductions for potable water treatment

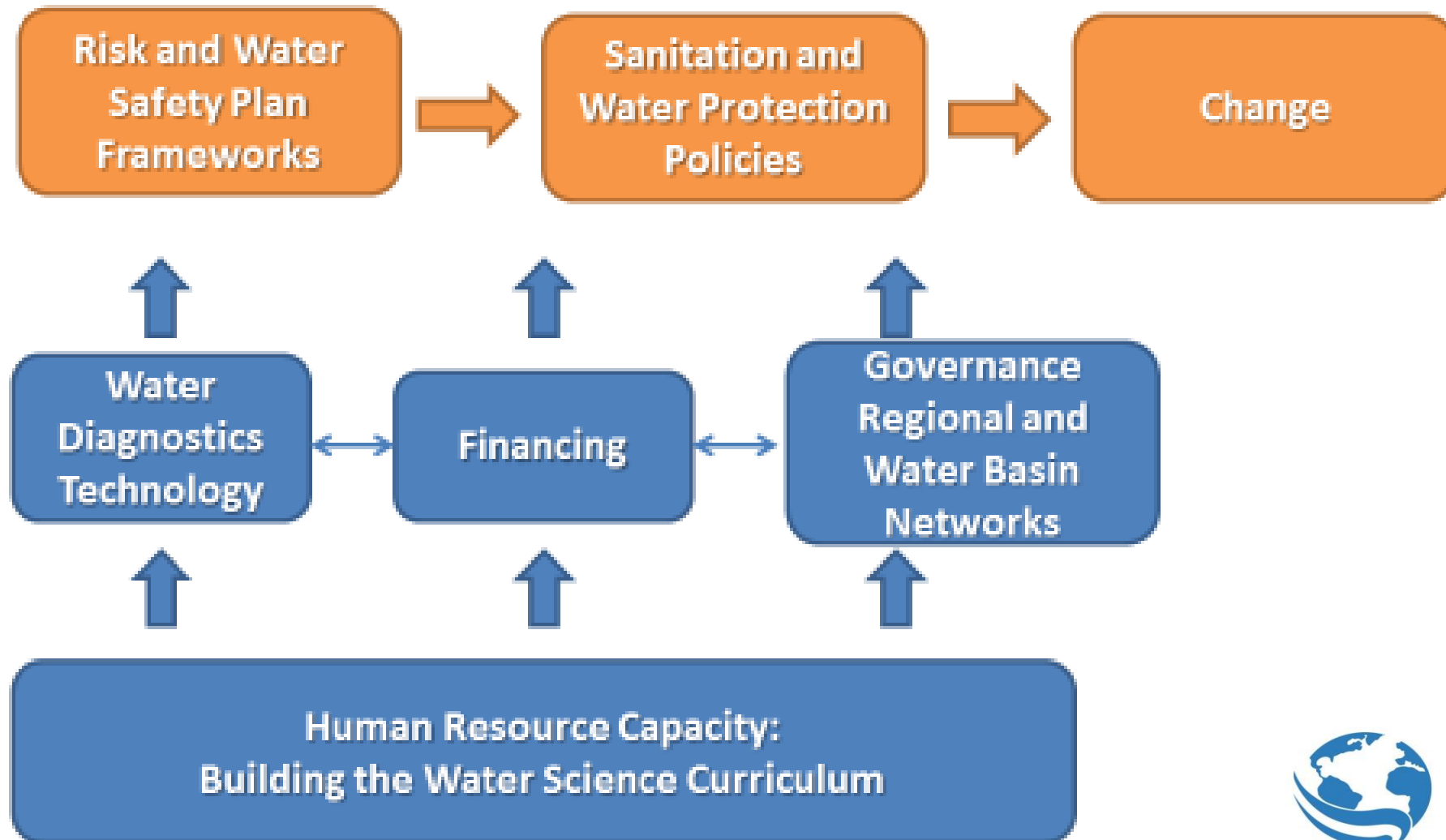
Dose Response Equation

Risk Assessment

# Philosophy: Creating the knowledge hub



# Knowledge path for interfacing science, technology and policy to meet water quality goals



# Global Water Pathogen Project: Passionate science moving to action

www.waterpathogens.org

Apps Michigan State Univ Electronic Resources Google QMRWikisite Center for Advancing Global Water Pathogen Web of Science [v.5.1] Global Water Pathogen

**GWPP**  
Global Water Pathogen Project

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The GWPP mission is to be a knowledge resource and hub on water pathogens which will guide the goals for sanitation and achieving safe water around the world using the power of new information technology and tools. [Read more...](#)

Science Links  
GAHI GLOBAL ATLAS OF RELEVANT INFECTIONS

Events

- 28 August *Stockholm World Water Week*
- 11 September *12th Annual Meeting of the International Water Resource Economics Consortium (IWREC)*
- 13 September *5th Food and Environmental Virology Conference*
- 9 October *6th International Calicivirus Conference*

All events

Our Twitter feed

GWPP Retweeted  
ChildrenWithoutWorms @CWWDirector  
How Worm Warriors Are Beating An Unbeatable Worm n.pr/2aGqwYZ via @NPR  
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[www.waterpathogens.org](http://www.waterpathogens.org)

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**GWPP**  
Global Water Pathogen Project





# Thank you!

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