WaSH and Global Public Health - Sanitation Approaches in Developing Countries

Thursday, June 1, 2017

12:00 – 2:00pm Eastern

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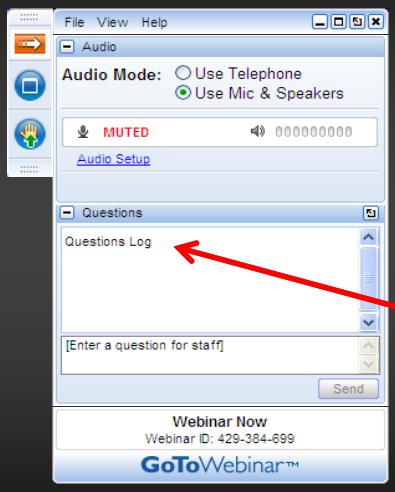
How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

Today's Moderator

Djanette Khiari, Ph.D.

Research Manager

Water Research Foundation

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Today's Speakers

- Sophie Boisson, Ph.D., World Health Organization
- Dr. Michael Templeton, Imperial College, London
- Dr. Joël Nkiama N. Konde, University of Kinshasa
- Gary A. Toranzos, Ph.D., University of Puerto Rico

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WASH and Health:
Sanitation challenges and opportunities in the sustainable development agenda

Sophie Boisson, PhD
Water, sanitation, hygiene and health Unit
World Health Organization

World Health Organization

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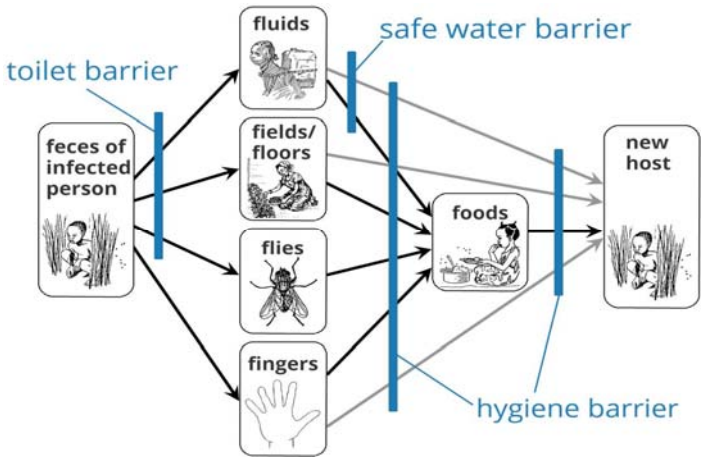
Transmission of faecal pathogens



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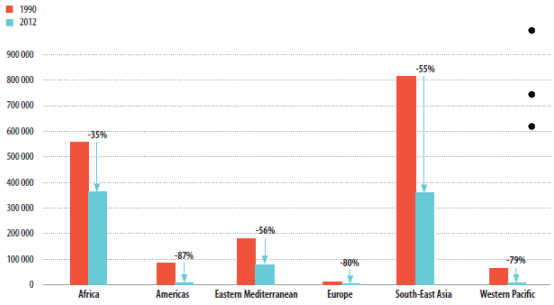
Diarrhoeal diseases

Diarrhoea deaths related to poor WASH are declining, but:

Figure 16. Decline in diarrhoea deaths attributable to inadequate WASH in LMICs in 1990 and 2012



- 842 000 diarrhoea-related deaths each year in LMIC
- Children < 5 most affected
- Cholera outbreaks

Source: WHO 2015 Preventing diarrhoea through better water sanitation and hygiene

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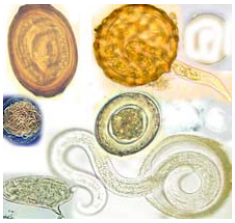
Neglected Tropical Diseases

- More than 1 billion people affected in 149 countries
- Include:
  - Soil-transmitted helminths and schistosomiasis– undernutrition, school absenteeism and impaired cognitive development.
  - Trachoma – leading infectious cause of blinding
  - Lymphatic filariasis – disability, stigma



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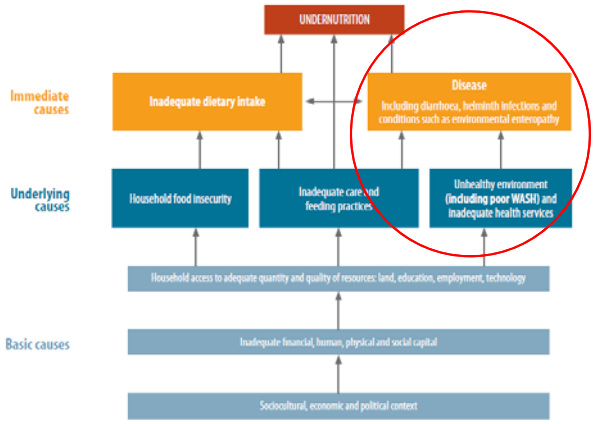
Undernutrition

155 million children <5 are stunted

52 million are wasted

17 million are severely wasted



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Health 'state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity'

- Harassment, threats
- Shame embarrassment
- Stress and anxiety
- Absenteeism

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Household access to water supply and sanitation 1990-2015

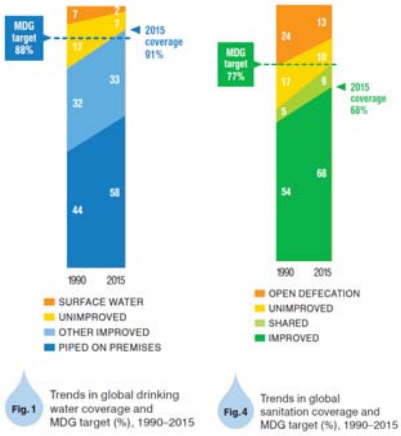

Fig.1 Trends in global drinking water coverage and MDG target (%), 1990–2015

Fig.4 Trends in global sanitation coverage and MDG target (%), 1990–2015

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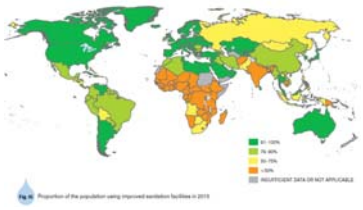
Large inequalities

Between regions and countries



Urban / Rural

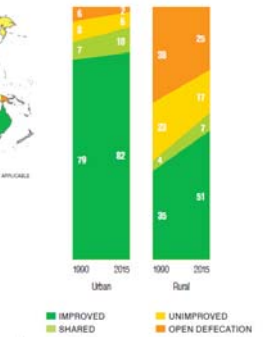


Fig.20 Urban and rural trends in sanitation coverage (%)

Richest / Poorest

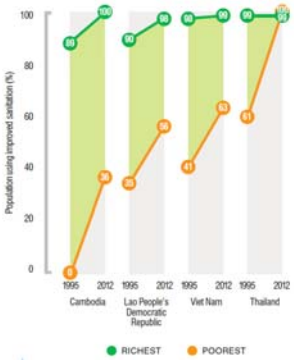


Fig.30 Trends in use of improved sanitation in the richest and poorest urban wealth quintiles, 1995–2012

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Accelerating progress on WASH

- Human rights to drinking-water and sanitation
- UN Deputy Secretary General's call on eliminating open defecation by 2025
- SDG 6: Ensure availability and sustainable management of water and sanitation for all

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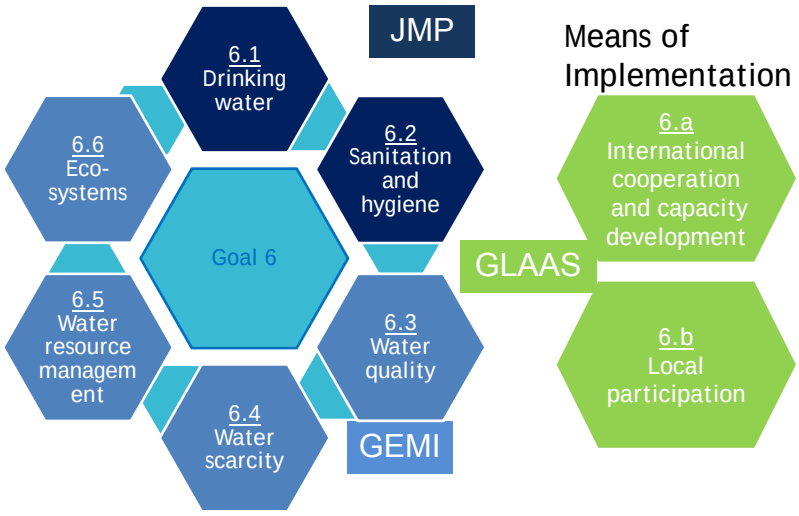
Goal 6: Ensure availability and sustainable management of water and sanitation for all



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Target 6.2: Sanitation and hygiene

*By 2030, achieve access to **adequate** and **equitable sanitation** and **hygiene** for all, and **end open defecation**, paying special attention to the needs of **women and girls** and those in **vulnerable situations***

6.2.1: Population **using safely managed sanitation services** including a handwashing facility with soap and water

Definition: Pop. using an improved sanitation facility which is:

- not shared with other households and where
- excreta are safely disposed in situ or
- transported and treated off-site

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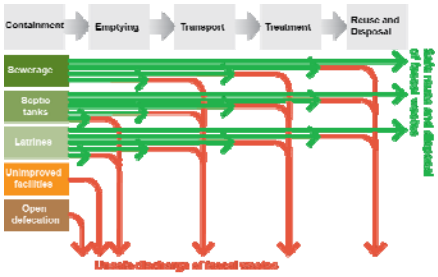
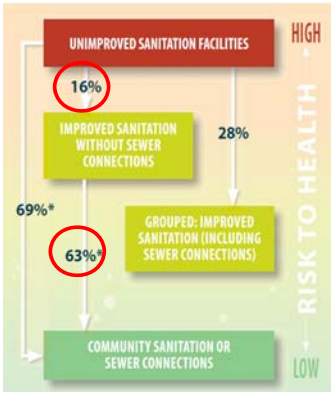
Addressing the entire sanitation chain

A **safely managed sanitation system** prevents human contact with excreta at all steps of the sanitation chain.



Safely managed = higher health gains



Source: WHO 2015 Preventing diarrhoea through better water sanitation and hygiene

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Eliminating open defecation

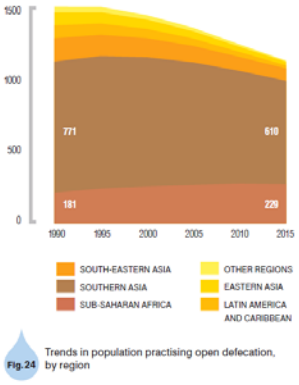
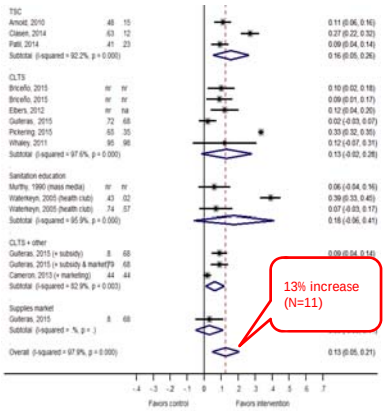


Fig. 24 Trends in population practising open defecation, by region

Change in use



Source: The impact of sanitation interventions on latrine coverage and latrine use: a systematic review and analysis (Garn et al.)

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Hygiene

6.2.1: Population using safely managed sanitation services, **including a handwashing facility with soap and water**

Emerging data on handwashing show that the presence of facilities with water and soap varies widely between countries and regions

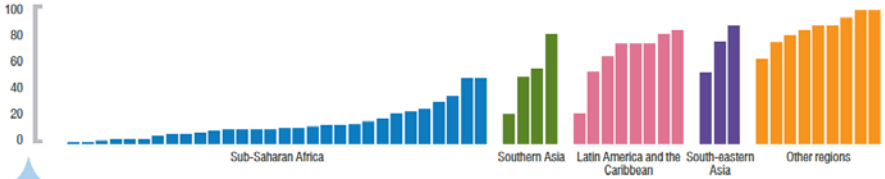

Fig. 40 Proportion of the population with a handwashing facility with soap and water (2009-2014)

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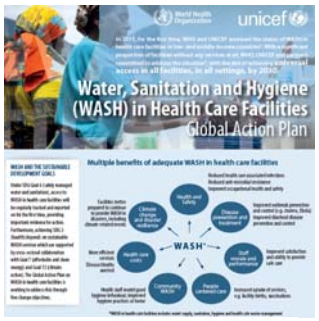
Healthcare facilities and schools

Healthcare facilities

Data from 54 countries:

- 38% do not have any water source
- 19% do not have improved toilets
- 35% do not have water and soap or alcohol -based hand rub for hand washing



World Health Organization unicef

TACKLING ANTIMICROBIAL RESISTANCE:
Supporting national measures to address infection prevention and control and water, sanitation and hygiene in health care settings

Antimicrobial resistance (AMR) presents a significant threat to human health. World leaders have agreed that tackling AMR will require addressing both health and agriculture concerns with a focus on prevention. Improving infection prevention and control (IPC) and water, sanitation, and hygiene (WASH) is one of the five objectives in the World Health Organization's (WHO) AMR Global Action Plan. Nowhere is reducing infection more important than in health care facilities. Joint, immediate action to address IPC and WASH is essential.

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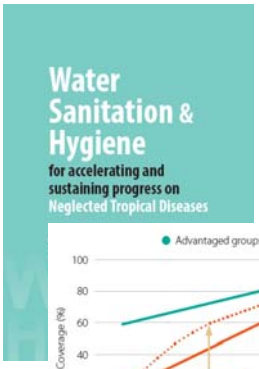
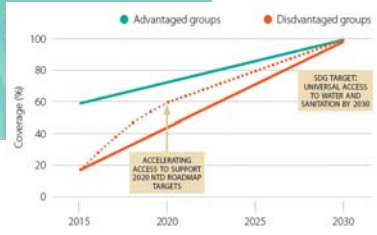
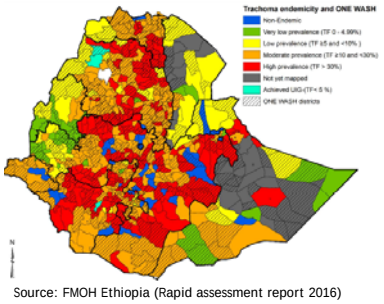
Greater focus on inequalities





Linking with disease programmes to improve targeting of WASH services to the most vulnerable

Ethiopia: Trachoma endemicity and ONE WASH implementation



Source: FMOH Ethiopia (Rapid assessment report 2016)

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Safe use of wastewater

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Understanding the enabling environment

- National WASH budgets are growing, but slowly
  - 80% of countries report insufficient financing to meet national WASH targets
- WASH infrastructure is not receiving enough investment
  - 50% countries say that household tariffs are insufficient to recover from operation and maintenance costs
- Foreign aid commitments for WASH have declined
  - While international aid spending on WASH increased from US$ 6.3 to 7.4 billion between 2012-2015, Future commitments declined from US$ 10.4 to 8.2 billion
- Vulnerable groups are still left behind
  - 70% countries have specified plans to reach low-income communities but 25% of WASH aid was spent on basic systems for unserved people, particularly in rural areas

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Take away messages

- Sanitation is critical for disease prevention, social well-being and economic development.
- Sanitation under the spotlight– opportunity to accelerate progress:
  - Safely managed services
  - Eliminating OD
  - Hygiene
  - Beyond household – Healthcare facilities, schools
  - Inequalities
  - Understanding enabling environment
- Collaboration between multiple sectors is essential.

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Thank you

For more information:
www.who.int/water_sanitation_health

World Health Organization

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Dr Michael Templeton

Reader in Public Health Engineering

Department of Civil and Environmental Engineering

Imperial College London

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Safe and sustainable onsite sanitation for developing countries

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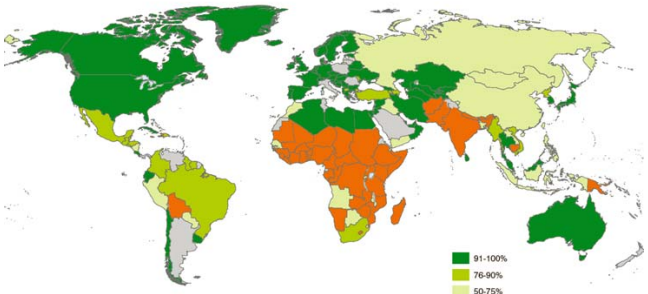
Water and sanitation challenges

- Globally, we did pretty well with regard to the Millennium Development Goal for access to safe drinking water, ~92% in 2015 (though that still leaves ~660 million people without access!)
- Not so for access to improved sanitation – ~32% still didn't have it in 2015



Proportion of the population using improved sanitation in 2010

Image credit: Progress on drinking water and sanitation 2012 update, WHO, UNICEF

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Sustainable Development Goals

- Set on 25 September 2015, 17 goals, 169 targets, adopted by 193 countries, to achieve by 2030

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SDG Goal 6: Clean water and sanitation (excerpts)

- **6.2** By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
- **6.3** By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

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SDG Goal 6: Clean water and sanitation (excerpts)

- **6.a** By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies

- **6.b** Support and strengthen the participation of local communities in improving water and sanitation management

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What do we mean by 'sanitation'?

- Toilets, but not necessarily like the ones that you're accustomed to using
- A means of isolating human waste from human contact, safely and sustainably
- The most common form is a basic pit latrine

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Safe and sustainable sanitation

- 'Safe' – hygienic; promoting a clean environment; in a safe location
- 'Sustainable' – long-lasting; affordable; maintainable; equitable; acceptable

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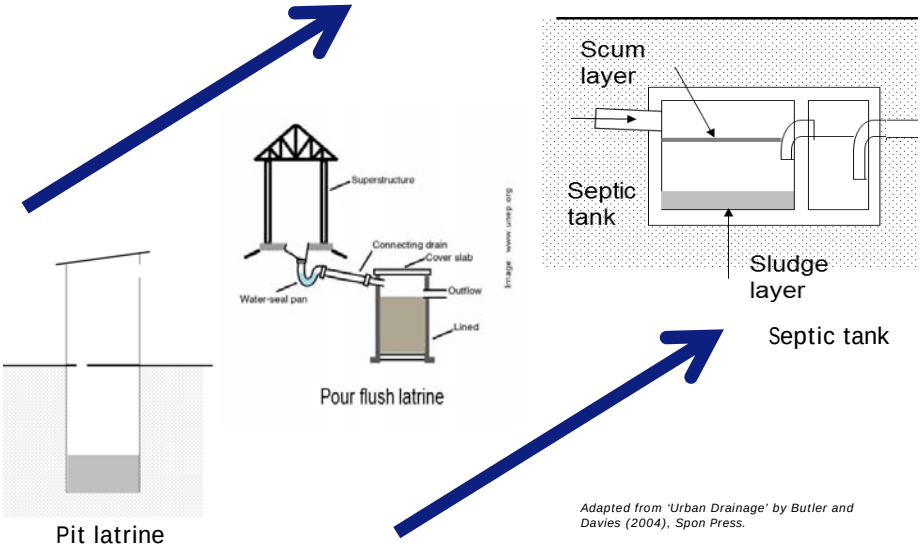
What's the problem with pit latrines?

- They can become unhygienic and unpleasant
- They fill up eventually
- They may contaminate soil and groundwater
- They may be too expensive for the intended users
- Their design sometimes does not consider the range of users nor user preferences
- Better alternatives are still needed
- Many people aspire to climb the 'sanitation ladder'

The 'sanitation ladder'



Adapted from 'Urban Drainage' by Butler and Davies (2004), Spon Press.

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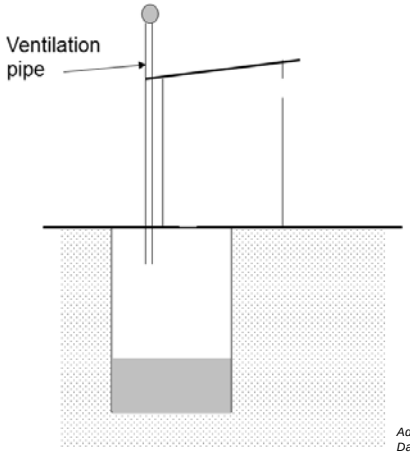
A clever, cheap adaptation: the VIP latrine



Adapted from 'Urban Drainage' by Butler and Davies (2004), Spon Press.

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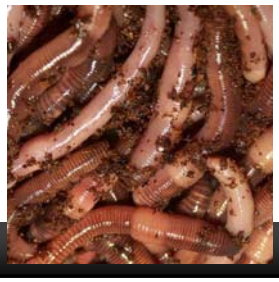
Innovation example: The 'Tiger Toilet'

- Arose from a collaboration with the London School of Hygiene and Tropical Medicine, funded by the Bill and Melinda Gates Foundation
- The target was an affordable, longer lasting, locally available alternative to a septic tank
- The neat idea: a latrine in which tiger worms degrade the waste, lengthening the time between required emptyings and other benefits



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The sanitation challenge

- Not a problem that any single discipline can solve alone!
- Community-led approaches can be effective
- There can also be benefits of thinking of the whole 'sanitation chain', not just giving people toilets
- There are now interesting business models for services using mobile, container-based sanitation systems
- Try to monitor and quantify the benefits of sanitation (as much as possible) – e.g. health, time-saving
- Capacity-building and knowledge transfer should be core objectives of any sanitation project

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Take-home messages

- Sanitation and clean water are still major global challenges, captured in SDG 6 but also impacting other SDGs
- Sanitation is currently often unsafe and unsustainable
- Better alternatives are needed, e.g. the Tiger Toilet
- Improving sanitation is not just about giving people toilets


Environmental Science
Water Research & Technology

PERSPECTIVE

Pitfalls and progress: a perspective on achieving sustainable sanitation for all

Michael R. Templeton

Why is it that so many people in our world still lack access to a toilet? Many developing countries have met their Millennium Development Goal target for access to clean water but still lag far behind their goal for access to improved forms of sanitation, especially in the rural and unplanned peri-urban settlements that

Cite this: Environ. Sci.: Water Res. Technol., 2015, 1, 17

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Dr Joël Nkiama N. Konde

Associate Professor
Department of Environmental Health
University of Kinshasa School of Public Health

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Treatment of fecal sludge and septage from onsite sanitation facilities in developing countries

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Sanitation challenges for developing countries

- The world as a community has missed the MDG target for sanitation
- Most of least developed countries located in Sub-Saharan Africa, Oceania, and Southern Asia made limited or no progress to achieve this target
- Globally, 2.4 billion people still lacked access to improved sanitation facilities in 2015

MDG Target achievement for sanitation

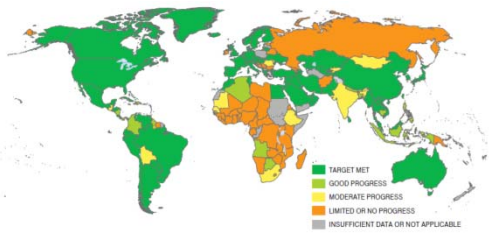

Image credit: 25 Years Progress on Sanitation and Drinking water 2015 Update and MDG Assessment, JMP WHO and UNICEF

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Advantages of onsite sanitation systems

- Technically accessible
- Low operation and maintenance costs
- Affordable treatment technologies for emptying materials (fecal sludge and septage)
- Respond to the paradigm shift in waste management strategies encouraging resources recovery

Source: CAWST
https://www.cawst.org/blog/bydate/2016/09/4-objectives-of-fecal-sludge-treatment/

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Problems with onsite sanitation systems

- Risk of water and soil contamination
- Unsafe and unsustainable disposal of emptying material
- Risk of contamination of surface waters, open drain, agriculture lands, and remote open lands by emptying products
- Environmental insult and threat to public health

Causes of indiscriminate dumping of fecal sludge and septage

- Lack of information on the related hazard
- Lack of political will to regulate
- Necessity of profit maximization for operators
- Low purchase power of households
- Lack of infrastructures in some areas

Treatment objectives for fecal sludge and septage from onsite

- To ensure protection of public health and the environment
- To ensure resources (organic matters and nutrients) recovery from treatment resulting biosolids for their safe reuse

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Targets of Treatment Technologies for fecal sludge and septage

- Solids content increase
- **Pathogens reduction**
- Stabilization of resulting biosolids
  - **Biosolids:** nutrient-rich organic materials resulting from the treatment of domestic sewage, fecal sludge or septage in a treatment facility. When treated and processed, these residuals can be recycled and applied as soil conditioner or fertilizer to improve and maintain productive soils and stimulate plant growth.
- Safe reuse of biosolids as soil conditioner or fertilizer

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Criteria for Pathogen inactivation

- Land application of sludge require restrictions for environmental and public health protection
- Restrictions for biosolids that are:
  - applied to land
  - placed in a surface disposal site
  - or burned in an incinerator
- Standards (codes, regulations, guidelines) set:
  - pollutant concentration limits
  - and operation/management guidelines

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Part 503 Criteria for Pathogens

- Based on pathogen reduction, USEPA classifies biosolids as Class A or Class B
  - Class A: no restrictions for end use as fertilizer, or soil conditioner, or in a reclamation project
  - Class B: restrictions imposed on the end use

Microbes	CLASS A	CLASS B
Fecal coliforms	< 10^3 MPN/g TSS	< 2 x 10^6 MPN/g TSS
Pathogens		
Bacteria (salmonella)	< 0.75 MPN/g TSS	2 log reduction
Viruses	< 0.25 MPN/g TSS	2 log reduction
Helminthes Eggs	< 0.25 viable eggs/g TSS	NA

Source: USEPA, 1993

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Stressors affecting pathogen inactivation in fecal sludge

- 3 categories of stressors: physical, chemical, and biological factors
  - Physical: temperature, cavitation, desiccation, and irradiation (gamma and beta)
  - Chemical: pH variation, exothermal production of energy, oxidation, reduction, or oxidation-reduction reactions, production of non-charged disinfectants
  - Biological: auto thermal biological activity, reduction of the degradable organics, production of biocidal agents
- At least 4 to 7 stressors affect pathogen in each disinfection process

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Biosolids disinfection process and stressors

Biosolids Disinfection Process	# of stressors	Exposure time	pH	Irradiation	Temperature	Solids content	Ammonia (NH_3)	Organic by-products	Drying	Cavitation/Ultra sound
Composting	6	+	-	-	+	+	±	+	+	-
Anaerobic digestion	6	+	-	-	+	+	+	+	-	+
Aerobic digestion	4	+	-	-	+	+	-	-	-	+
Lagoon storage	5	+	-	-	+	+	+	+	-	-
Air & Heat drying	5	+	-	+	+	+	-	-	+	-
Alkaline stabilization	7	+	+	-	+	+	+	-	+	-
High energy irradiation	6	+	-	+	+	-	+	-	±	+

Legend: + Effective; ± variable effect; - not effective

Source: Reimers, R.S. et al., 2001; Acquisto, B.A. et al., 2006

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Criteria for Treatment technologies selection

Choice based on an holistic approach accounting for:

- Treatment goal
- Simple design and operations
- Safe management alternatives stressing reclamation of resources
- Social, economic and environmental characteristics
- Promotion of sustainability

Treatment technologies for fecal sludge and septage

The choice should be towards natural treatment systems:

Dewatering/Stabilization

- Settling/Thickening tank
- Drying bed (Unplanted/Planted)
- Settling ponds
- Anaerobic digestion
- Co-treatment with sewage sludge
- Co-treatment with wastewater
- Lagoon storage

→ **Treatment of Solid fraction**

→ **Treatment of Liquid fraction**

Treatment technologies for fecal sludge and septage (1)

Liquid fraction treatment

- Stabilization ponds
- Co-treatment with wastewater
- Constructed wetlands

Receiving water body

Solid fraction treatment

- Co-composting with organic solid waste
- Unplanted drying bed
- Natural solar drying
- Solar oven drying
- Lime/Ammonia addition
- Vermicomposting with larvae of black soldier flies (tiger worms)

Safe reuse in Agriculture/ on reclamation sites

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Treatment technologies for fecal sludge and septage (2)

Lagoon storage of septage for 12 to 15 months:

- Disinfection and stabilization of septage
- Resulting biosolids are safe for reuse

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Hygiene promotion

- Hygiene promotion integrated in the effort for water supply and sanitation provision
- Simple messages stressing water container cleaning and hands washing
- Households and schools should be encouraged to have handwashing stations close to sanitation facilities
- Sustainable systems should be privileged

WASH to achieve Global Health …

- **Water, sanitation, and hygiene act in a synergistic manner**
- Holistic approaches in the choice of WASH technologies :
  - For water supply: Low-cost decentralized schemes are cost effective particularly in peripheral urban and rural areas
  - For sanitation: Natural onsite treatment systems providing safely reusable end products
  - For hygiene: water container cleaning at filling and handwashing at critical times will maximize the return on investments in WASH
- **Global Health can not be achieved without WASH**

MICROBIAL INDICATORS IN THE 21ST CENTURY

ERA OF MOLECULAR METHODS

WHICH INDICATORS TO USE, HOW AND WHY?

Gary A. Toranzos, Ph.D.

Professor of Microbiology

University of Puerto Rico

gary.toranzos@upr.edu

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Current Monitoring Approach Leads to Errors

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Science Questions that drove EPA Research

1. What is the risk to human health from swimming in water contaminated with human fecal matter vs. swimming in water contaminated with non-human fecal matter?
2. Do culture and molecular methods for various indicators correlate with swimming-related illnesses?
3. **Are indicators, methods and models suitable for use in different types of waters and for different CWA programs?**

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Other EPA Indicator/Method Efforts

- Developing Approaches to Bring Additional Indicator/Methods into Criteria
  - Establish scientifically defensible "**equivalency**" of indicator/methods with an unknown health relationship to indicator/methods **with an established health relationship.**
- Developing Options for Incorporating New Technologies and Methods
  - Identify analyses and techniques we could use to incorporate alternative indicators and novel methods into standards and guidelines.

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WHAT DO INDICATORS "INDICATE"?

1. Indicators are tools depending on what we need them for (TX efficiency, water quality)
2. Current Indicators **are not "pathogens"** and therefore their presence **does not indicate "real and present danger"**
3. Indicators indicate a **statistical probability of risk** to the user/consumer
4. Presence of **indicators indicate their presence**, which is then statistically correlated to a certain level of risk.

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Known unknowns

- Traditional fecal indicators (FIBs????)
  - Sources are fecal and non-fecal
  - **<u>Less indicative of health risk</u>** when sewage is not a significant **or obvious** source
  - Spatial & temporal variability differs from pathogens
- Newer indicators (e.g. *Bacteroidales,* enterophages)
  - Ecological sources & behavior not understood
  - So still reliant on **<u>sound sanitary understanding</u>**

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CONTAMINATION DETECTION AND SOURCE TRACKING

FC/FS ratio (first attempt, Ed Geldreich et al., ca. 1966)
- *Bifidobacterium* spp, *Bacteroides fragilis* phages

F-specific RNA, DNA and somatic Coliphages
- 4 subgroups of F+ RNA coliphages

Human Enteric Viruses (Adenovirus)

Chemical methods:
- Caffeine, Coprostanol, Whiteners

Molecular methods:
- PCR, Q-PCR, Ribotyping, Host-specific markers

Microbial Antibiotic Resistance

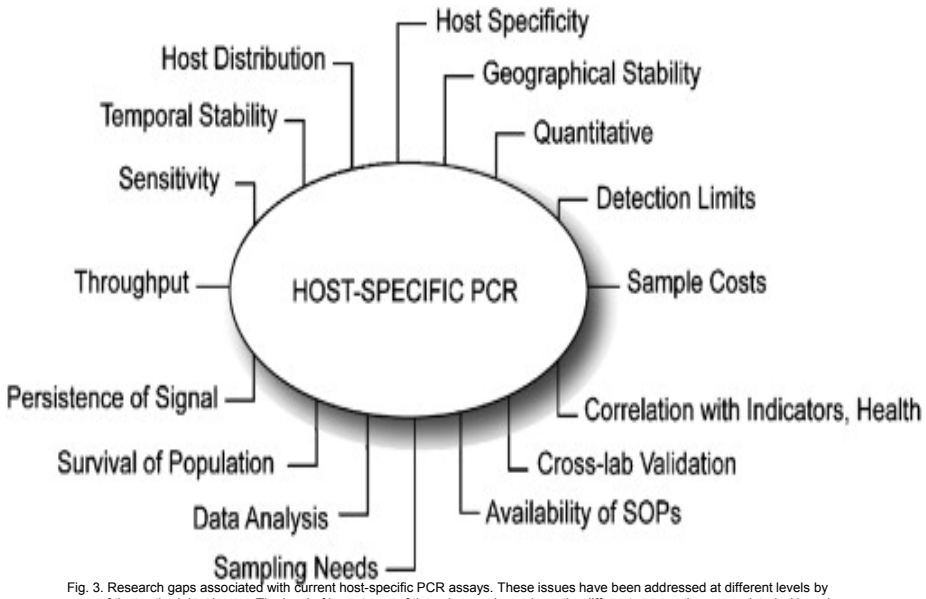

Fig. 3. Research gaps associated with current host-specific PCR assays. These issues have been addressed at different levels by some of the method developers. The level of importance of these issues depends on the different perspectives associated with end use...

Water Research, Volume 41, Issue 16, 2007, 3539–3552

VIRUSES AS INDICATORS

- Phages:
  - Male Specific F+RNA Coliphages
  - Somatic Coliphages
  - *Bacteroides* phages
  - Enterophages

Teshoviruses (porcine, one strain SSRNA, picornavirus)

Enteroviruses

Polyoma viruses (Ovine, Bovine, Human)

Papilloma viruses

Parvoviruses (Chicken, Turkey, sheep)

Adenoviruses (human, porcine, bovine)

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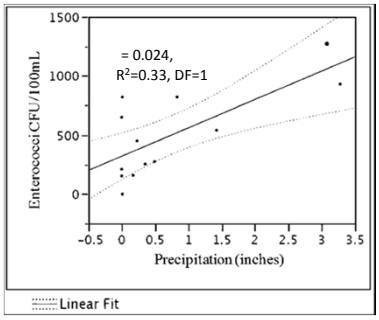
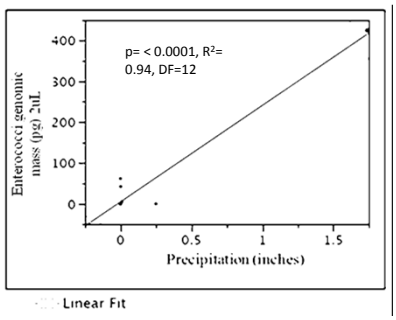
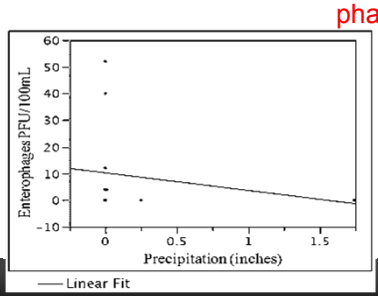
Correlation with Precipitation

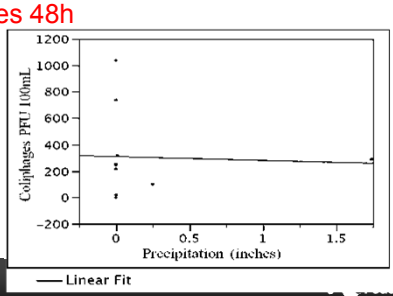
enterococci



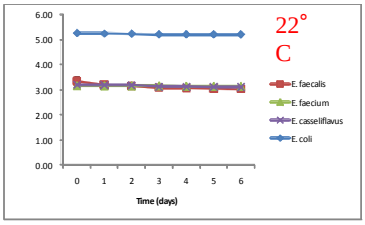


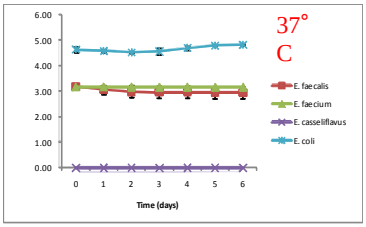
phages 48h

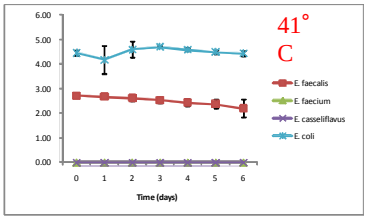




Inactivation Rate of enterophages and coliphages in sewage at 4°C







• There is no significant difference in the inactivation rate of *E. faecalis*, *E. faecium*, *E. casseliflavus* and *E. coli* phages in sewage at 4° C, obviating current guidelines of processing samples 4-6h post-collection.

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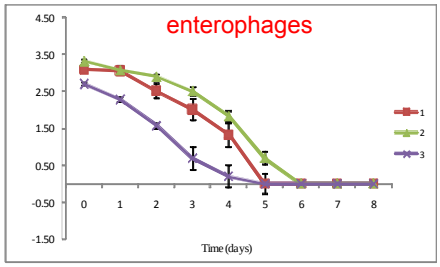
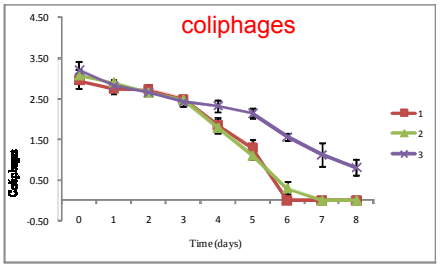
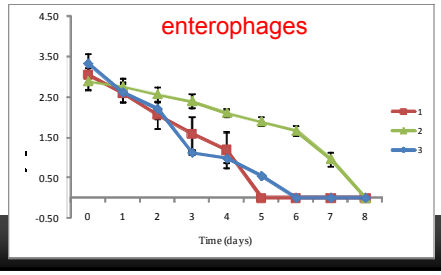
Survival of phages in Fresh Waters

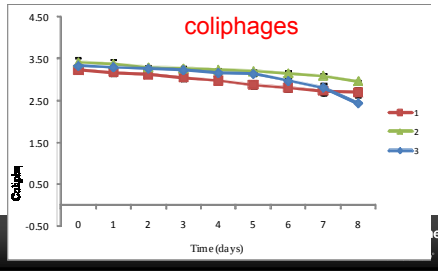
NO RAINFALL





MORE RAINFALL





Current regulations and phages

U.S. Environmental Protection Agency. 2006. National primary drinking water regulations: ground water rule; final rule; 40 CFR parts 9, 141, and 142. Fed. Regist. **71:**65574–65660.

Anonymous. 2001. Loi sur la qualité de l'environnement: réglement sur la qualité de l'eau potable c. Q.-2, r. 18.1.1. Gazette Officielle du Québec 24, 3561. Government of Quebec, Montreal, Quebec, Canada.

Queensland Government – Environmental Protection Agency. 2005. Queensland Water Recycling Guidelines. Pp 84.

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FINAL THOUGHTS AND CONCLUSIONS

1. There is no "universal" indicator. We may have to rely of different ones, but mostly: **KNOW YOUR WATERSHED, KNOW YOUR SEWAGE AND KNOW YOUR TREATMENT EFFICIENCY**
2. **Phages** are perhaps the **most promising candidate** indicators for most types of waters (ground-, recreational, reused as well as drinking as well as treatment efficiency, **VERY INEXPENSIVE**)
3. Need to know the BIOLOGY and ECOLOGY of phages.
4. Need to test more phages as indicators of health risk and/or do equivalency measurements to include phages as part of a TOOLBOX

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ありがとう!

EFHARISTO,
GRACIAS,
THANK YOU
شكرا

PREGUNTAS?
QUESTIONS?
質問？
الأسئلة

For More Information:

P.O. Box 23360
San Juan, Puerto Rico 00931-3360
gary.toranzos@upr.edu

http://upr-rp.wix.com/microbiologyuprrp

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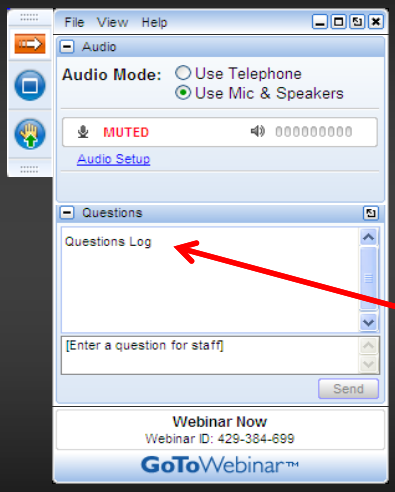
Questions?



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