

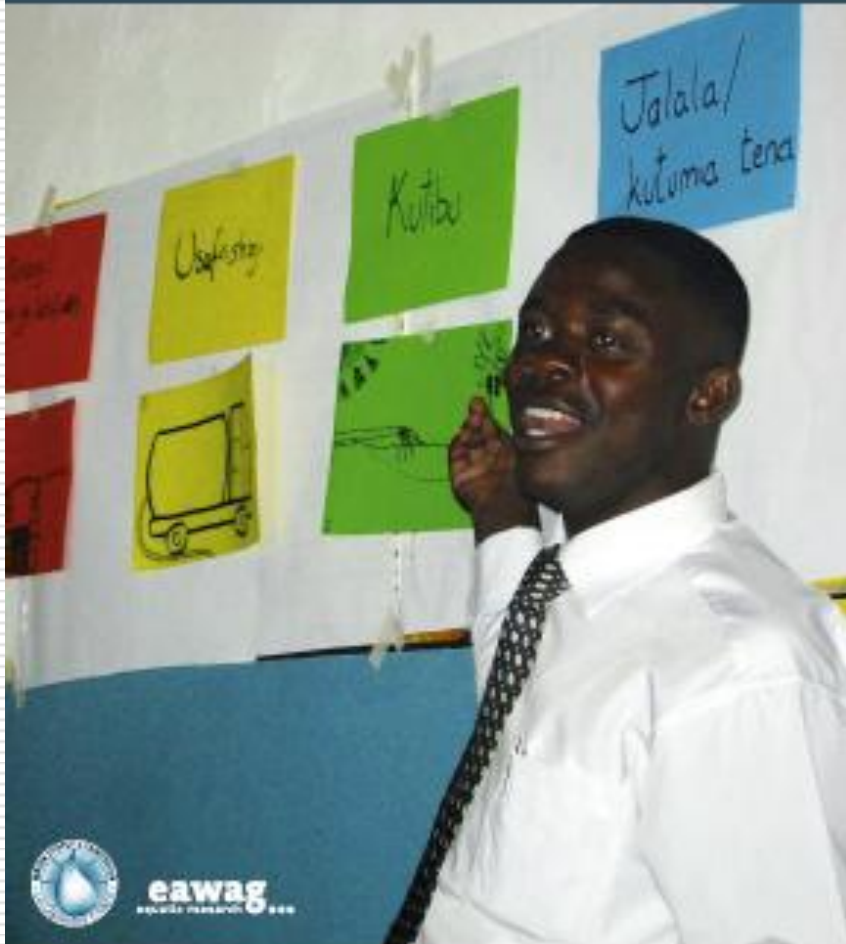
Sanitation Systems and their Functionality in Health Protection

Arno Rosemarin, PhD
Senior Research Fellow
Stockholm Environment Institute

Theme 1 - Water and Sanitation for Development
**Session 8 - Sustainable Sanitation and the Role of
Hygiene in the Value Chain**

4th Africa Water Week, Cairo
May 17, 2012

Compendium of Sanitation Systems and Technologies



"EAWAG Compendium", 2008



Stockholm Environment Institute, EcoSanRes Series, 2011-1



Microbial Exposure and Health Assessments
in Sanitation Technologies and Systems

Thor Axel Stenström, Razak Seidu,
Nelson Ekane, and Christian Zurbrügg

sustainable
sanitation
alliance

eawag
aquatic research

Sandec
Water and Sanitation in
Developing Countries



EcoSanRes

"SEI Health Compendium", 2011



WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater (2006)

World Health Organization

WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater

Third Edition

Volume 1: Policy and Regulatory Aspects
Volume 2: Wastewater Use in Agriculture
Volume 3: Wastewater and Excreta Use in Aquaculture
Volume 4: Excreta and Greywater Use in Agriculture

The third edition of the WHO Guidelines for the safe use of wastewater, excreta and greywater has been extensively updated to take account of new scientific evidence and contemporary approaches to risk management. The revised Guidelines reflect a strong focus on disease prevention and public health principles. They reflect the knowledge and experience of a unique group of scientists, regulators and public health specialists, from developed and developing countries worldwide, brought together by the Water, Sanitation and Health Programme of the World Health Organization.

This new edition responds to a growing demand from WHO Member States for guidance on the safe use of wastewater, excreta and greywater in agriculture and aquaculture. Its target audience includes environmental and public health scientists, researchers, engineers, policy-makers and those responsible for developing standards and regulations.

The Guidelines are presented in four separate volumes: Volume 1: Policy and regulatory aspects; Volume 2: Wastewater use in agriculture; Volume 3: Wastewater and excreta use in aquaculture; and Volume 4: Excreta and greywater use in agriculture.

Volume 1 of the Guidelines presents policy issues and regulatory measures distilled from the technical detail found in volumes 2, 3 and 4. Those faced with the need to expedite the development of policies, procedures and regulatory frameworks, at national and local government levels, will find the essential information in this volume. It also includes summaries of the other volumes in the series and an index for all four volumes.

Volume 2 of the Guidelines explains requirements to promote safe use concepts and practices, including health-based targets and minimum procedures. It also covers a substantive revision of approaches to ensuring the microbial safety of wastewater used in agriculture. It distinguishes three vulnerable groups: agricultural workers, members of communities where wastewater-fed agriculture is practiced and consumers. It introduces health impact assessment of new wastewater projects.

Volume 3 of the Guidelines informs readers on the assessment of microbial hazards and toxic chemicals and the management of the associated risks when using wastewater and excreta in aquaculture. It explains requirements to promote safe use practices, including minimum procedures and specific health-based targets. It puts trade-offs between potential risks and nutritional benefits in a wider development context. Special reference is made to food-borne zoonoses.

Volume 4 of the Guidelines focuses exclusively on the safe use of excreta and greywater in agriculture. Recent trends in sanitation, including ecological sanitation, are driven by rapid urbanization. The momentum created by the Millennium Development Goals is resulting in dramatic changes in human waste handling and processing. New opportunities enable the use of human waste as a resource for pro-poor agricultural development, particularly in periurban areas. Best practice to minimize associated health risks is at the heart of this volume.

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Meaning of Sanitation

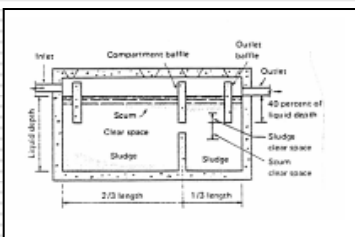
- Safe collection, storage, treatment and disposal / reuse / recycling of
 - human excreta (faeces and urine)
 - sludge and sewage effluent
 - grey water
 - solid waste
- Hygiene and behavior change
- Drainage and management of stormwater

What are the parts of a sanitation system?

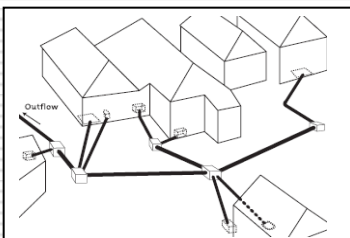
User Interface



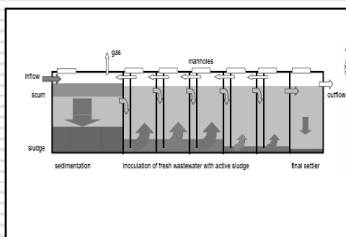
Collection and Storage



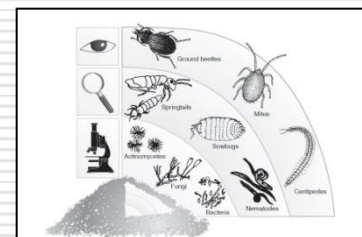
Conveyance



(Semi-) Centralised Treatment



Reuse and Disposal



- Dry toilet
- Urine diverting dry toilet
- Urinal
- Pour flush toilet
- Flush toilet

- Single pit
- Single pit VIP
- Alternating dry double pit
- Alternating wet double pit
- Double dehydr. vaults
- Aquaprivy
- Septic tank
- Composting chamber

- Manual emptying
- Mechanical emptying
- Simplified sewer
- Small bore sewer
- Conventional gravity sewer
- Jerry can/tank

- Imhoff Tank
- Anaerobic baffled reactor
- Anaerobic filter
- Trickling filter
- Waste Stabilization ponds
- Finishing pond
- Constructed wetland
- Co-composting

- Application of urine
- Application of dehydr. Faeces
- Compost
- Irrigation with wastewater
- Aquaculture
- Soak pit
- Leach field
- Incineration
- Land application
- Surface disposal

Exposure and Transmission Routes



ingestion of excreta from hands



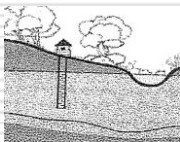
dermal -contact



contact with flies/mosquitoes



inhalation of aerosols and particles



contaminated groundwater/surface water
contact with overflowing/leaking contents

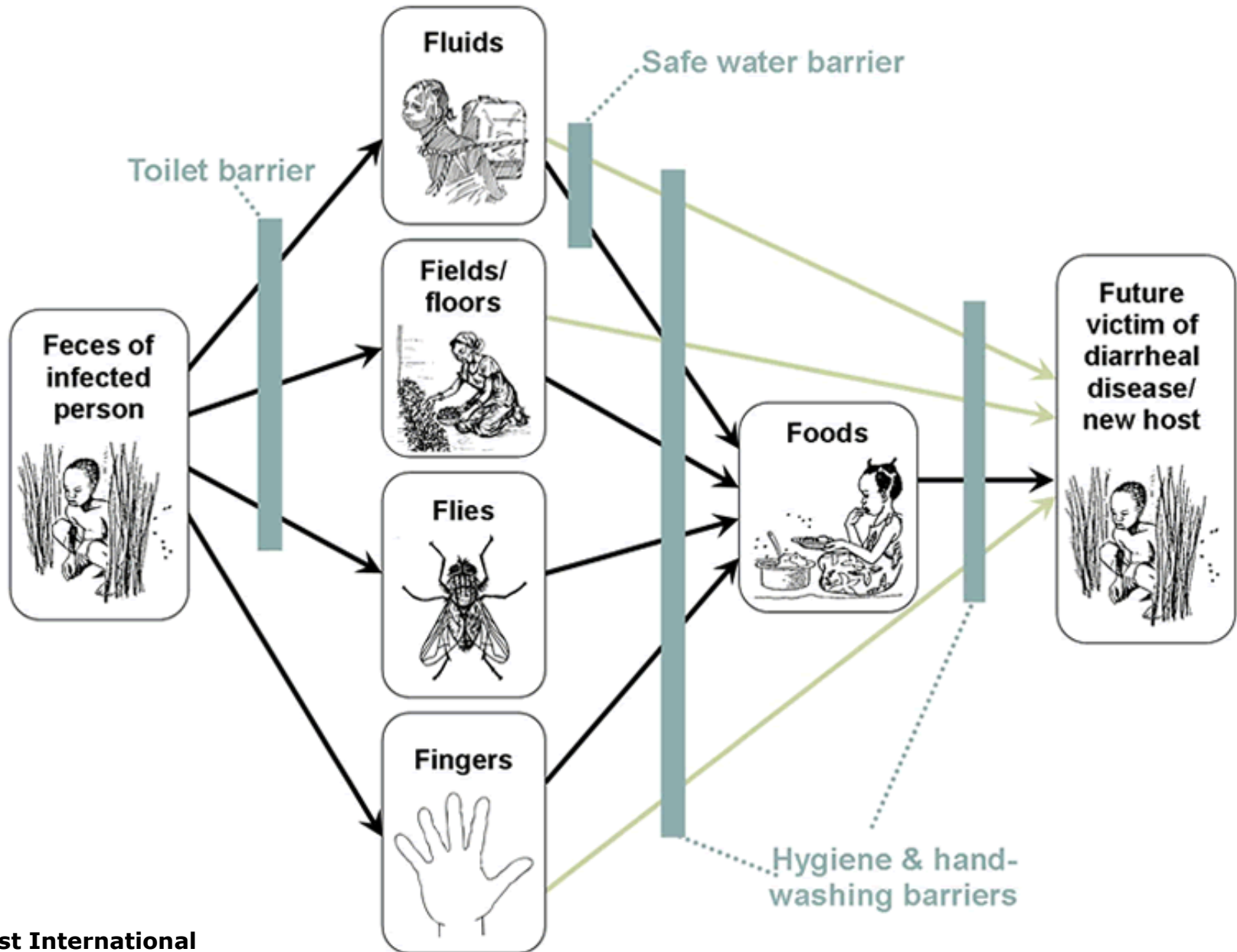


ingestion of excreta



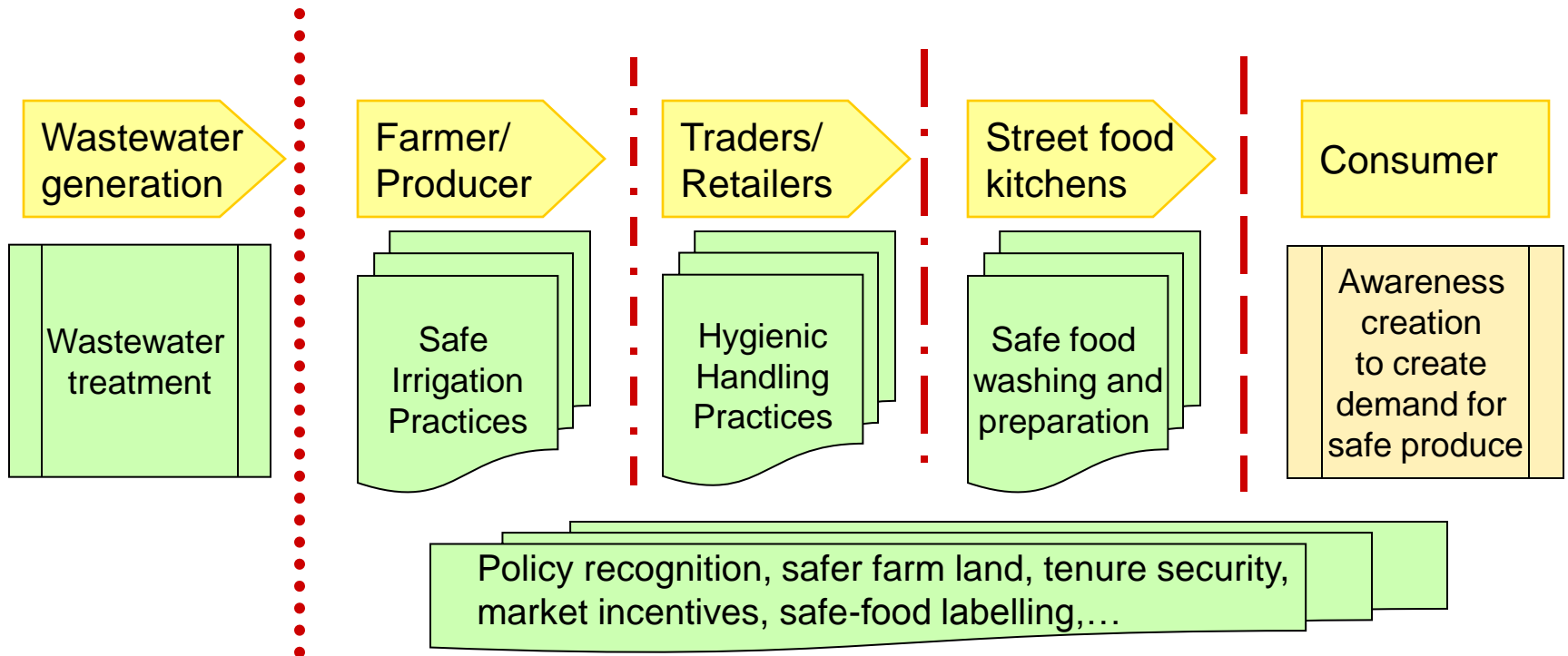
consumption of contaminated produce (vegetables)

Barriers to Prevent Spread of Pathogens: the "F-Diagram"



Risk reduction strategies

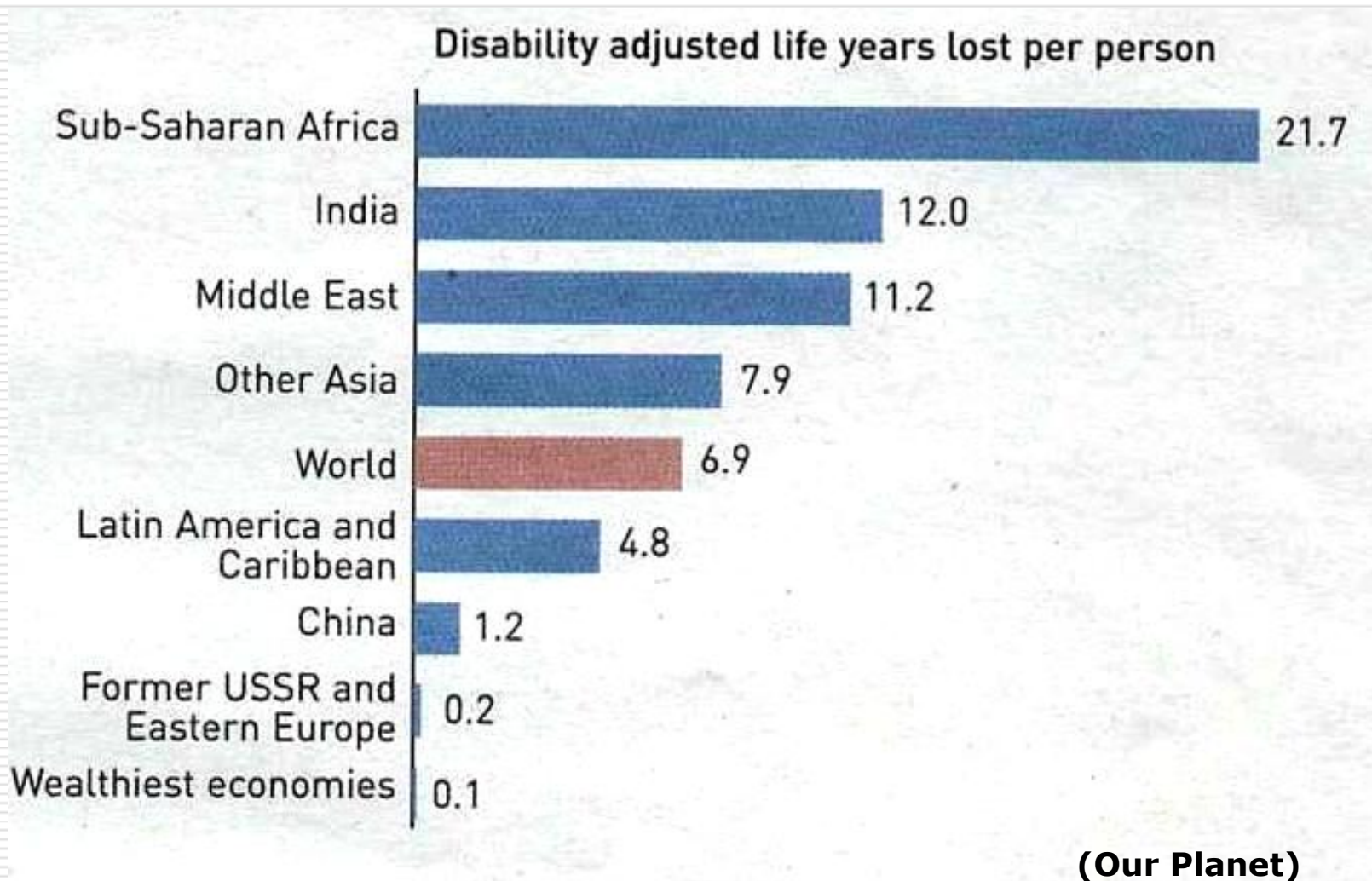
WHO's *multiple barrier* approach from "Farm to Fork"



Pathogens in faeces that can be transmitted through water and improper sanitation

Pathogen	Symptoms
Bacteria	
<i>Aeromonas</i> spp	Enteritis
<i>Campylobacter jejuni/coli</i>	Diarrhoea, cramping, abdominal pain, fever, nausea, joint pain, Guillain-Barré syndrome
<i>Escherichia coli</i> (EIEC, EPEC, ETEC, EHEC)	Enteritis
<i>Plesiomonas shigelloides</i>	Enteritis
<i>Salmonella typhi/paratyphi</i>	Fever - headache, malaise, anorexia, slow pulse, enlarged spleen, cough
<i>Salmonella</i> spp.	Diarrhoea, fever, abdominal cramps
<i>Shigella</i> spp.	Dysentery (bloody diarrhoea), vomiting, cramps, fever
<i>Vibrio cholera</i>	Cholera - watery diarrhoea, lethal if severe and untreated
<i>Yersinia</i> spp.	Fever, abdominal pain, diarrhoea, joint pains, rash
Virus	
Enteric adenovirus 40 and 41	Enteritis
Astrovirus	Enteritis
Calicivirus (incl. Noroviruses)	Enteritis
Coxsackievirus	Various, respiratory illness, enteritis, viral meningitis
Echovirus	Aseptic meningitis, encephalitis, often asymptomatic
Enterovirus types 68-71	Meningitis, encephalitis, paralysis
Hepatitis A	Fever, malaise, anorexia, nausea, abdominal discomfort, jaundice
Hepatitis E	Hepatitis
Poliovirus	Often asymptomatic, fever, nausea, vomiting, headache, paralysis
Rotavirus	Enteritis
Parasitic protozoa	
<i>Cryptosporidium parvum/hominis</i>	Watery diarrhoea, abdominal cramps and pain
<i>Cyclospora cayentanensis</i>	Often asymptomatic, diarrhoea, abdominal pain
<i>Entamoeba histolytica</i>	Often asymptomatic, dysentery, abdominal discomfort, fever, chills
<i>Giardia intestinalis</i>	Diarrhoea, abdominal cramps, malaise, weight loss
Helminths	
<i>Ascaris lumbricoides</i>	Generally no or few symptoms, wheezing, coughing, fever, enteritis, pulmonary eosinophilia
<i>Taenia solium/saginata</i>	
<i>Trichuris trichiura</i>	Unapparent through vague digestive tract distress to emaciation with dry skin and diarrhoea
Hookworm	Itch, rash, cough, anaemia, protein deficiency
<i>Shistosomiasis</i> spp	

Avg Health Burdens from Diarrhoeal Diseases



Current annual diarrhea cases in SSA:

1.2 billion which lead to 769.000 dead children, mostly under 5 years

Ascaris: Distribution of Disease Burden

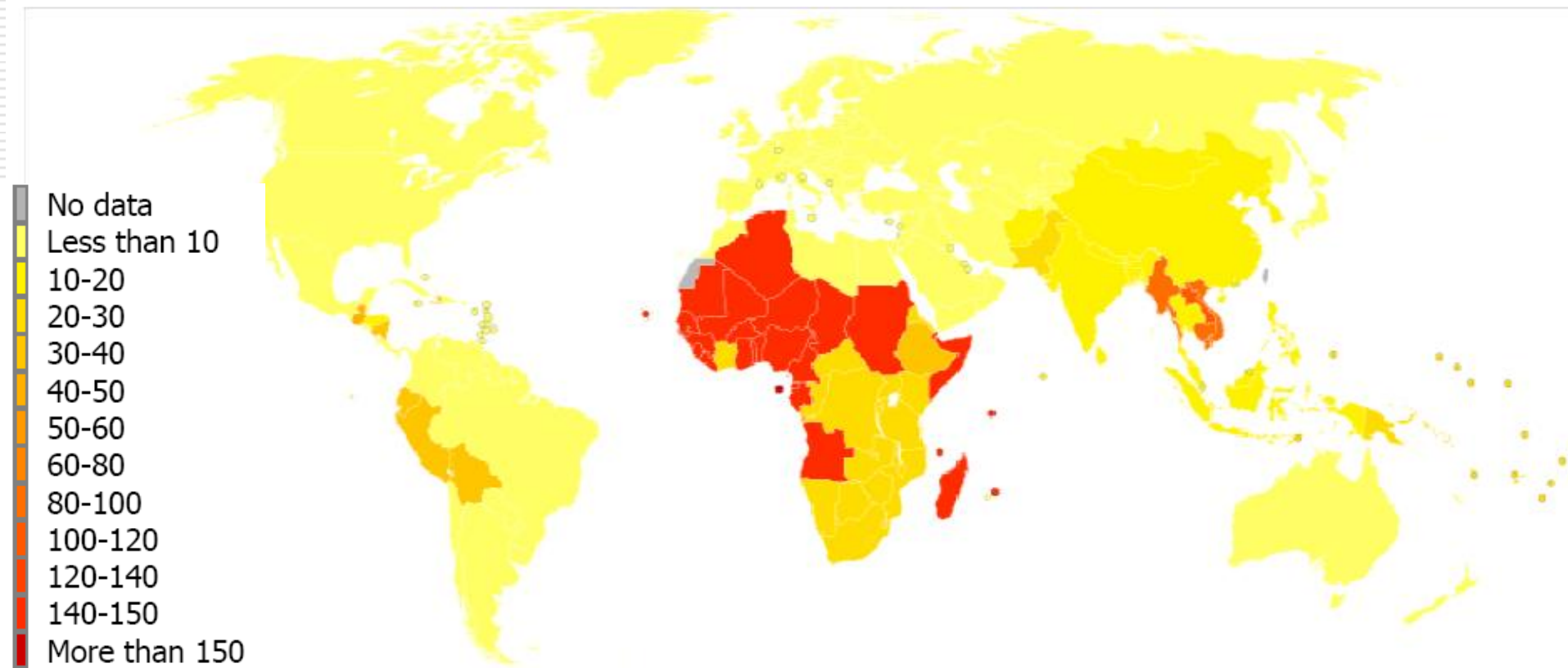


Figure 4: DALY factor for ascariasis per 100,000 inhabitants worldwide in 2002 (WHO, 2002)



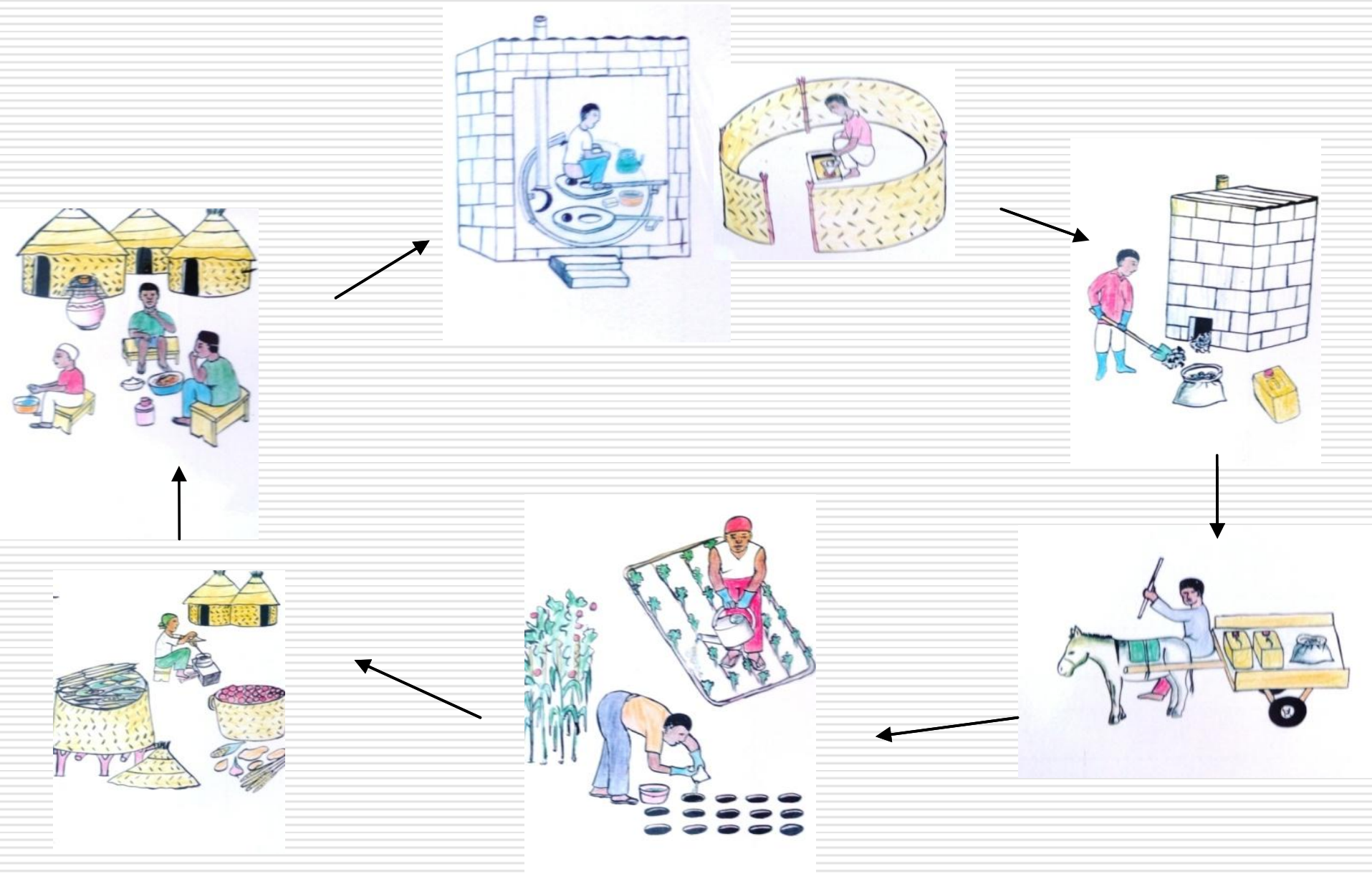
***Ascaris lumbricoides* blocking a 3-yr old child's intestine**

Dumping of Sludge= "Advanced Open Defecation"

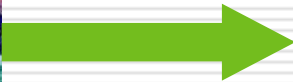
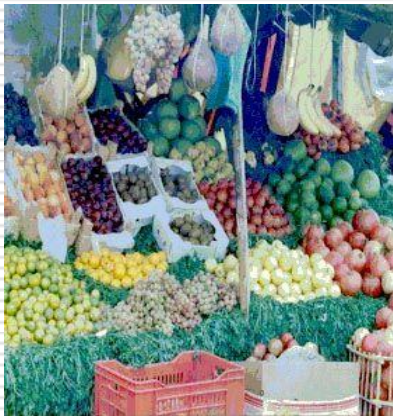


Understanding the Nutrient Loop

«What we take from the soil, we give back to the soil»



Productive Sanitation a neglected treasure



N = 2,8 kg
P = 0,4 kg
K ~ 1,3 kg
Per person
per year



N = 2,8 kg
P = 0,4 kg
K ~ 1,3 kg
Per person
per year



≈



Urea = 6 kg
TSP = 2 kg
KCL ~ 2,6
kg



Urine Collection in Niger

(SEI, 2009)



Storage and hygienisation of urine: "Takin Ruwa"



Participative Testing of “Takin Ruwa” in Niger





Safe and fertile crops



URINE

CONTROL

Construction of Composting Pit Latrines in Zimbabwe Schools

School children making concrete slabs, ringbeams and toilet houses in traditional material and bricks



(Morgan - Aquamor, Zimbabwe)



School Sanitation Garden Experiments

Children recording the results

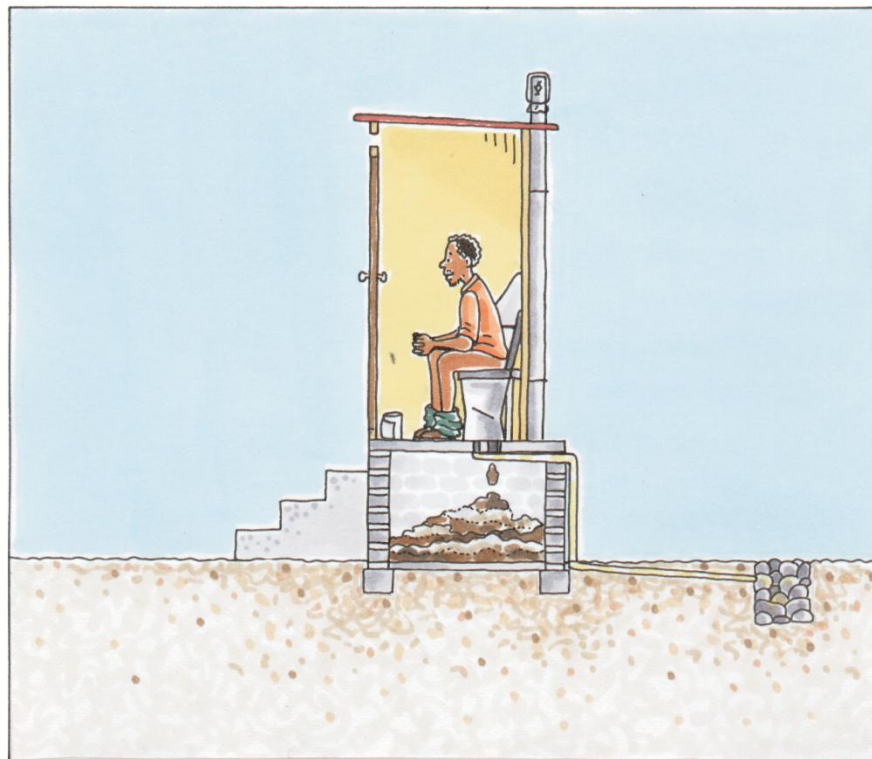
Taking measurements

Maize trials using urine fertiliser



Urine Diversion Dry Toilet

Separates urine and
faeces at source



School Sanitation Keeps Girls in Schools

(WRC, 2011)



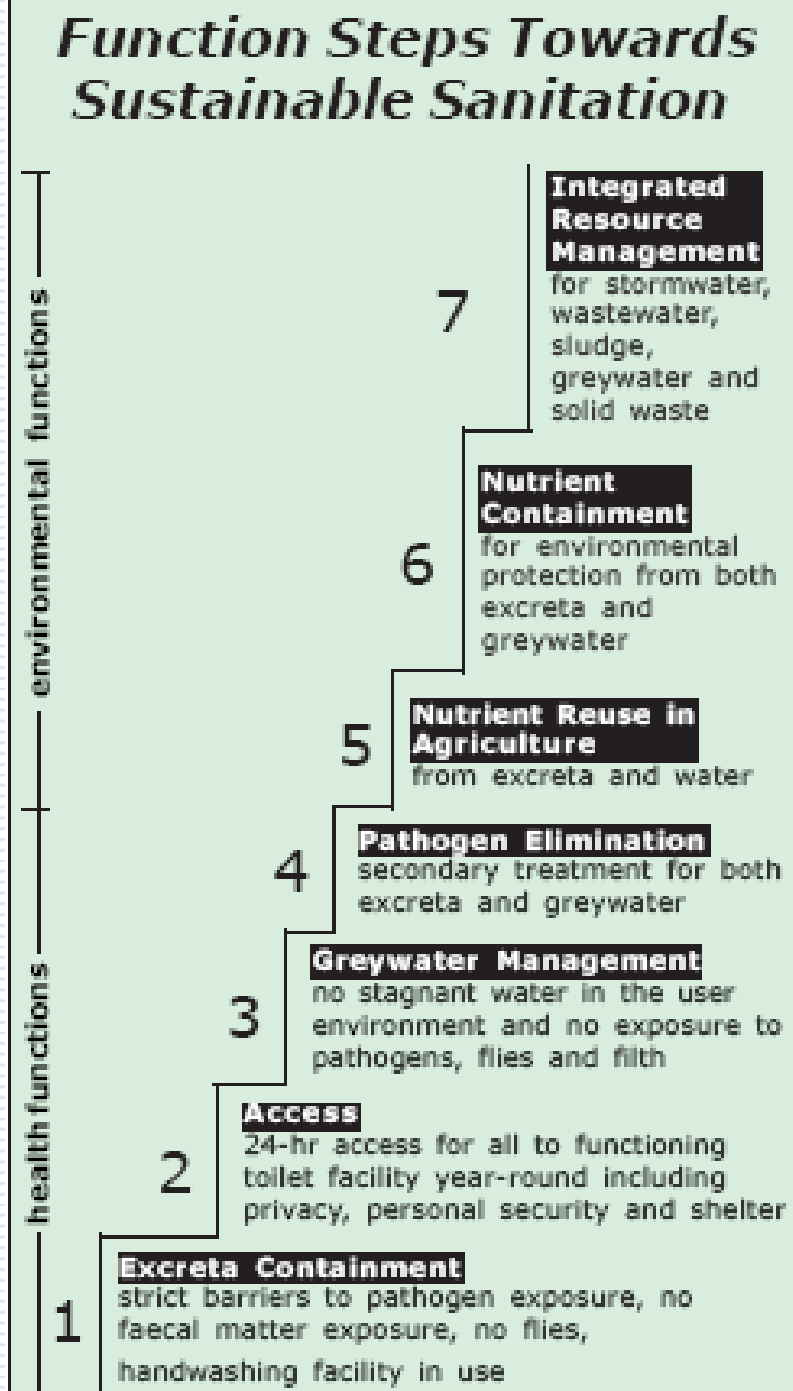
growing up
at school
A guide to
menstrual management
for school girls

Annie Kanyemba



The New Sanitation Ladder Based on Function

(Kvarnström et al 2010)



Safe Sanitation Made Possible

- ❑ Requires a systems approach – the value chain
- ❑ Affordable, functional, maintainable, appropriate and participative
- ❑ Design the entire chain including disposal and reuse
- ❑ Profits generated from health protection also can include energy (biogas), food production and water savings

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