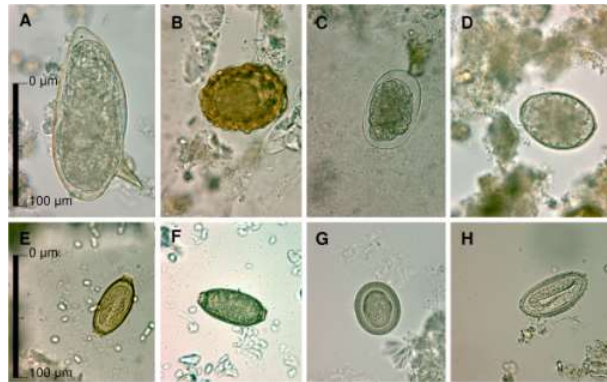


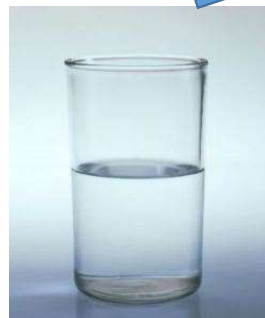
Tracking the culprits: Parasite eggs movement and sedimentation in waste stabilization ponds (WSP)



Larvae: up to 350 μm



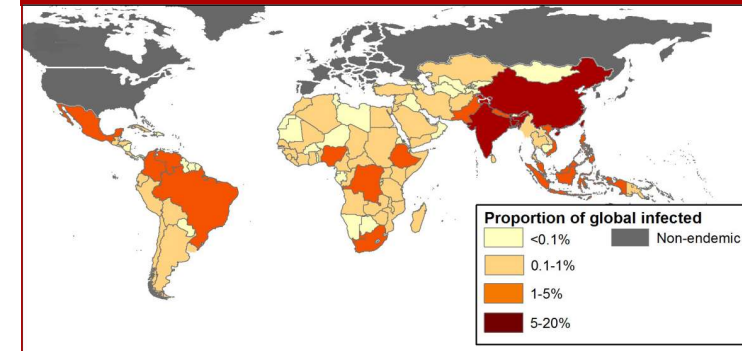
Helminths eggs (size: 20-80 μm)
A-*Schistosoma mansoni*; B- *Ascaris lumbricoides*; C-hookworm; D-*Diphyllobothrium latum*; E- *Trichuris trichiura*; F- *Capillaria* ; G- *Taenia*; H-*Enterobius vermicularis*.



Potential source of infection: contaminated water and vegetable and fruits grown using contaminated water

Factsheet:

- Approximately 1.5 billion people (24% of the world's population) are infected with soil-transmitted helminths worldwide (WHO 2017).
- Estimated annual deaths ~ 135,000 (Lustigman, 2010)
- Disability-adjusted life years (DALYs) ~ 5.2 million (GAHI, 2017) (<http://www.thiswormyworld.org/worms/global-burden>)



The proportion of the global population infected by country (Pullan et al., 2010)

By Fides Izdori, Paolo Perona and Andrea Semiao

Helminth infection routes

Different treatment systems have different capacities for retention of parasite eggs: **WSP are best**

A sick person excretes parasite eggs in large quantities



Treated wastewater is a good source of irrigation water



Produce from irrigated fields



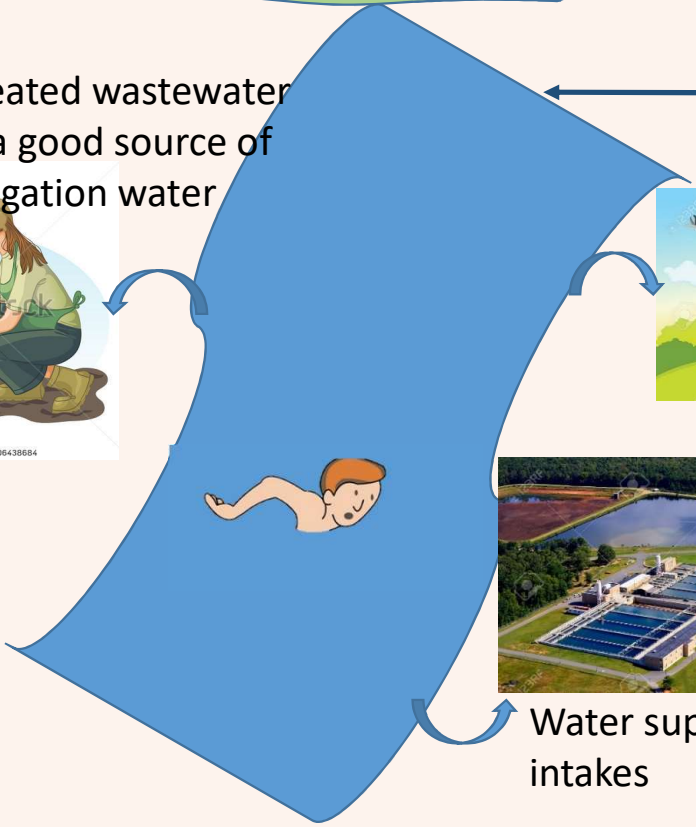
Eggs in the effluent of treatment systems are a source of environmental contamination



Fields receive effluent discharges eg irrigation



Water supply intakes



- Effects:**
- Physical and mental impairment to children
 - Anaemia
 - Reduced work productivity to adults
 - Adverse pregnancy outcomes
 - Speed progression of other diseases eg TB, AIDS

Problem

- Wastewater particles have sizes between 0.001 to more than 1000 microns, among which are helminth eggs (cysts).
- The egg sizes are between 20 to 80 μm and have specific gravity between 1.056 and 1.3 hence are removed by sedimentation in waste stabilization ponds (WSP), with a hydraulic retention time (HRT) of about 20 days providing complete removal.
- However, helminth eggs have been found in effluents, even for WSP with a HRT higher than 20 days.
- Literature shows that particles in wastewater can interact with helminth eggs and affect their sedimentation, but it is not clear how as both reduced and increased settling velocities of eggs in wastewater have been observed.
- Since sedimentation leads to modification of particle size distribution (PSD), studies on how particles sizes vary inside the pond may be used to study the sedimentation process in the ponds.

Methods

Study Area: Buguruni WSP

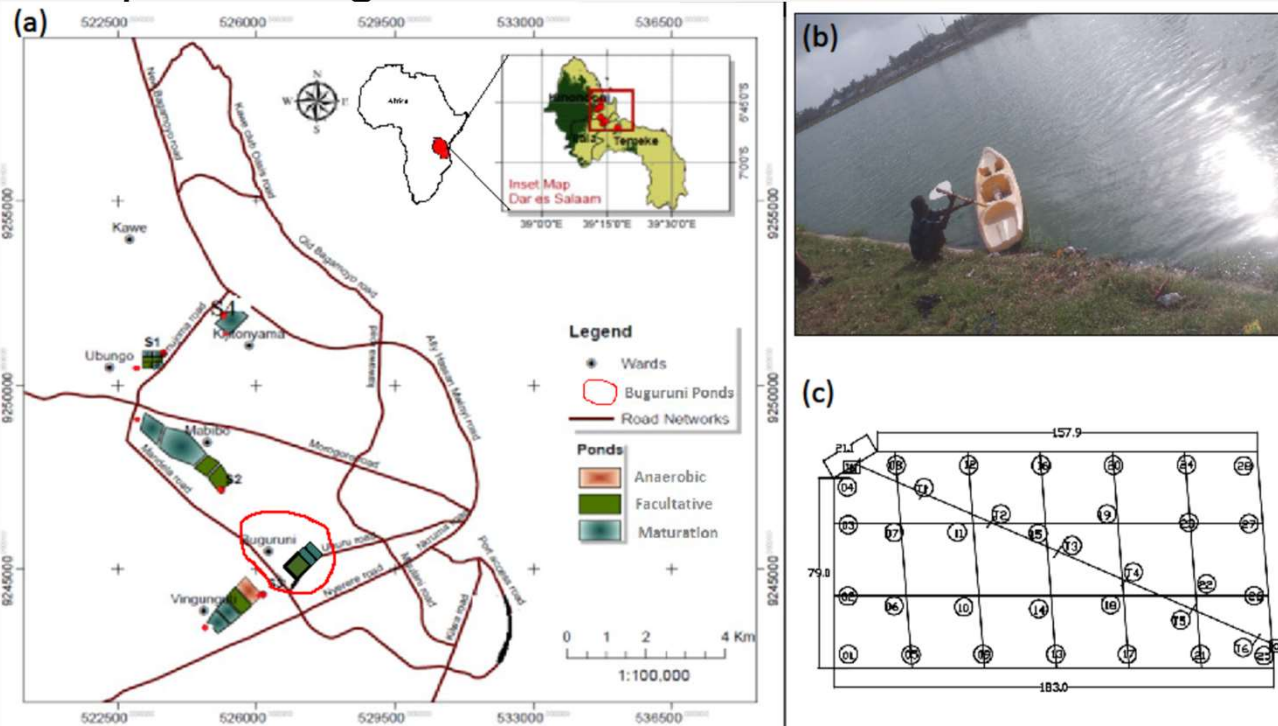


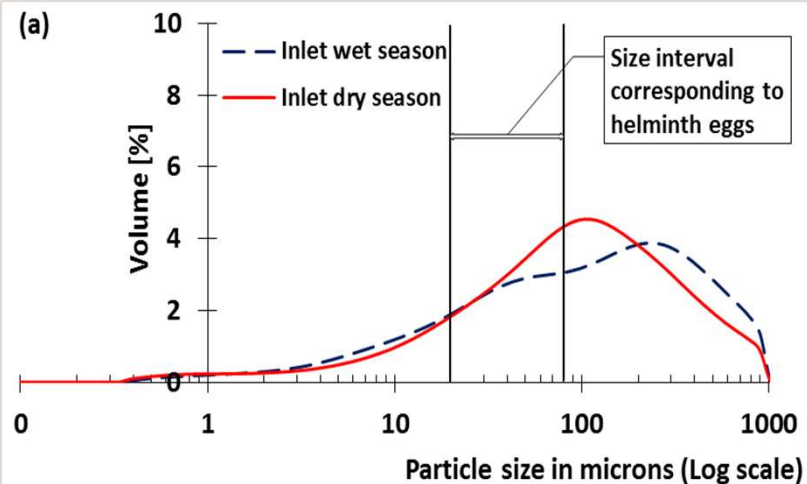
Figure 1a: Buguruni WSP from the inset map of Africa and Dar es Salaam city (modified from Kihampa (2013)). Figure 1b: Photo of the pond taken during a sampling campaign in December, 2016. Figure 1c: sampling points (node numbers in circles).

- Water samples were collected from the facultative pond in dry and wet seasons using a 6.2 L water sampler.



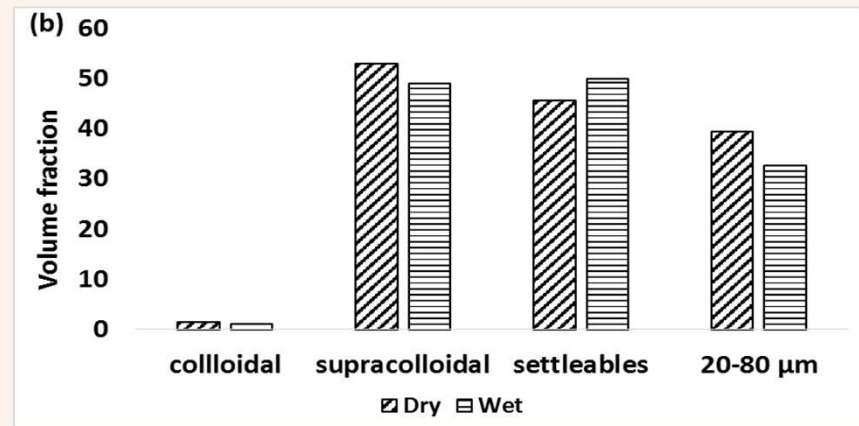
- Particle size distribution (PSD) analysis was done by using the Malvern 2000 Mastersizer
- The volume of particles corresponding to a prescribed size interval was obtained by calculating the area under the curve between the size intervals

Results: Inflow volume fraction Particle Size Distribution

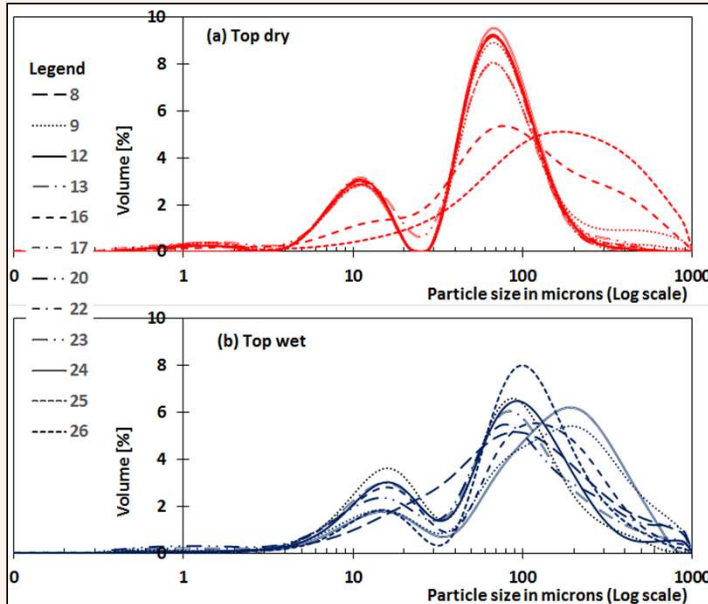


- The PSD in terms of diameter of volume-equivalent spherical particles at the WSP inlet for both seasons is **unimodal** distribution skewed towards larger particles of 100 microns or more.
- The values for dissolved, colloidal, supracolloidal and settleable fractions are 0, 1.5, 52.9, 45.6 % and 0, 1.1, 48.9, 49.9 % in dry and in wet weather, respectively

- More than **one-third** (30 percent) of inflow particles fall within size class of **helminth eggs** (20-80 microns).
- Efficient sedimentation of these particles will guarantee an efficient removal of helminth eggs.

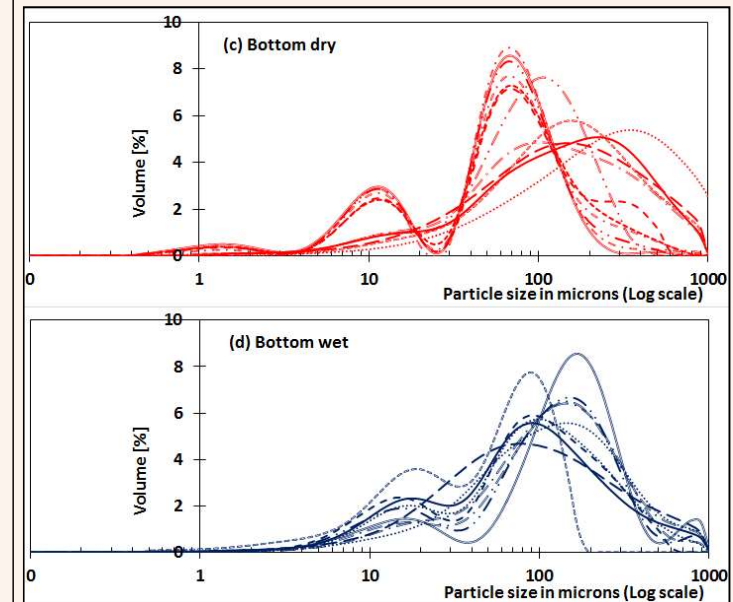


Results: In-pond PSD



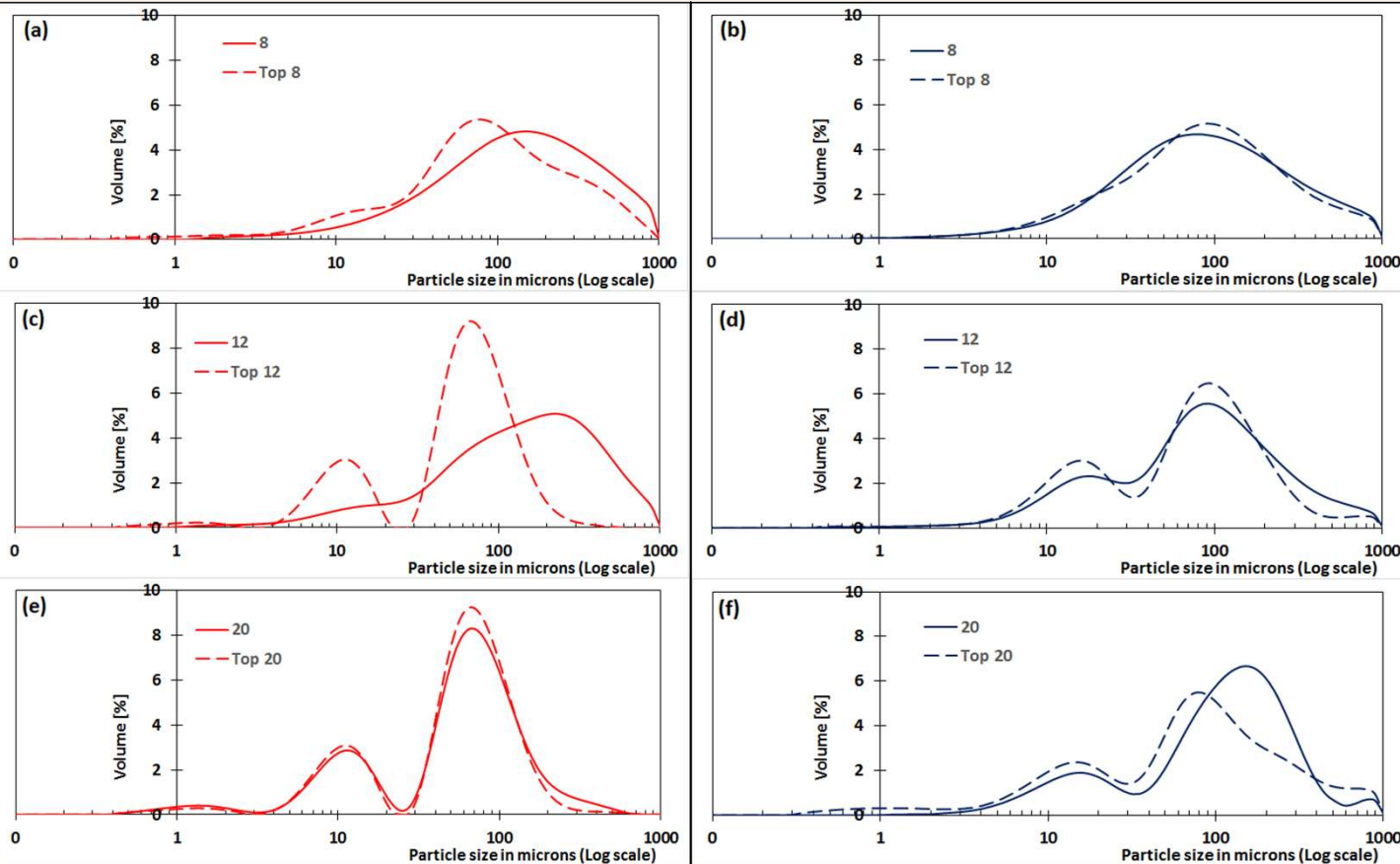
Samples collected at the top for dry (a) and wet(b) season

- Two types/ groups of PSDs exist inside the pond for both wet and dry season, as well as top and bottom
- A **unimodal** distribution mainly for samples collected at the bottom hence **sedimenting** particles
- A **bimodal** distribution mainly for samples collected at the top hence **suspended** particles



Samples collected at the bottom for dry (c) and wet(d) season

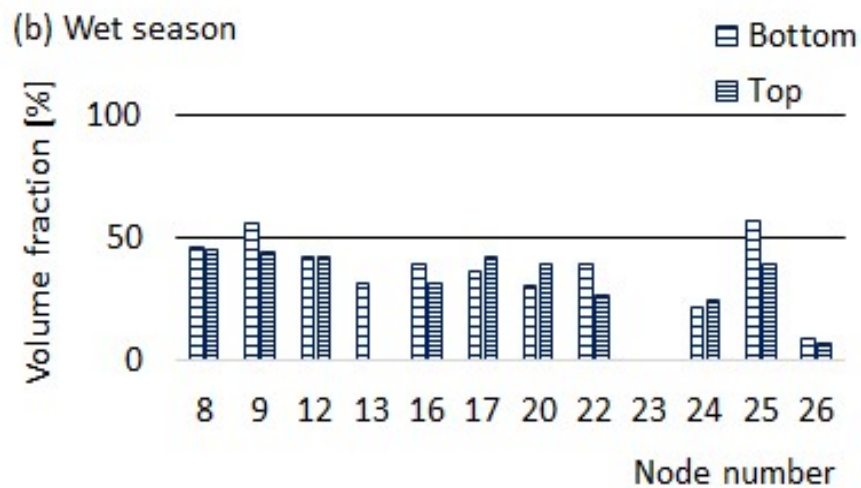
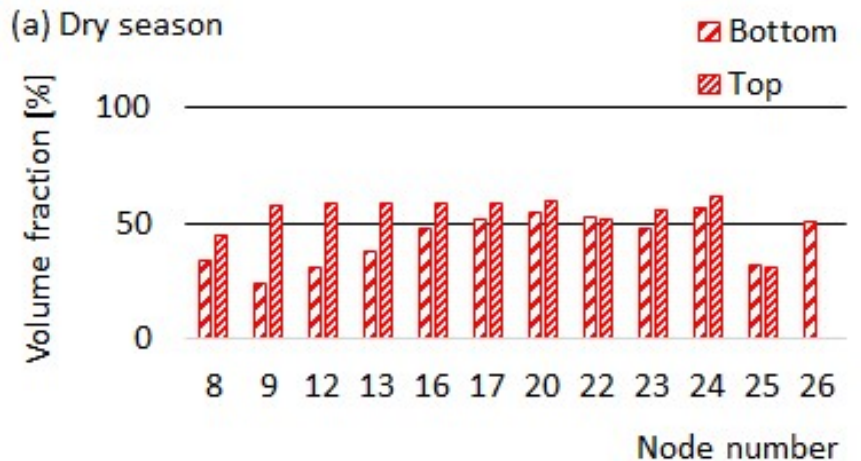
Results: Comparison of top and bottom PSD



Three major areas were identified:

- 1) Area with resuspension of particles: unimodal distribution at both top and bottom (figures a & b)
- 2) Areas with sedimentation: bimodal distribution at the top while the bottom has a unimodal distribution (figures c & d)
- 3) Areas with no sedimentation: bimodal distribution at both top and bottom (figures e & f)

Results: Particles with size between 20 and 80 microns



- These particles appear throughout the pond both at top and bottom, with an increased volume compared to that of the incoming particles indicating that some are generated inside the pond (Figures a & b).
- No trend in their volumes at different locations, but their volumes are consistently higher at the top especially during dry weather
- Analysis for helminth eggs for water samples collected at the bottom was done using the formol-ether concentration method but very few eggs (only two eggs in 12 samples) were recovered

Conclusion

- Particles coming into the pond are mainly supracolloids and settleables, although information about their densities is missing.
- Inside the pond, PSD split into settling and suspended PSDs, with indication of particle breakage as shown by the increased volume of smaller particles and hence appearance of a bimodal distribution for suspended particles.
- Sedimentation takes place in the first half part of the pond, while the remaining part has suspended particles only.
- Particles with size between 20-80 microns (size of helminth eggs) as well as settleable particles (> 100 microns) are in abundance in suspension. Although these may not necessarily contain helminth eggs, they indicate a large potential for the eggs to remain in suspension and be carried out of the system.

Future work: Research on particle density variations inside the pond which will enable tracing of the eggs based on their characteristics.