Development of a procedure and apparatus to quantify pathogen reduction throughout an intermittent biosand filter

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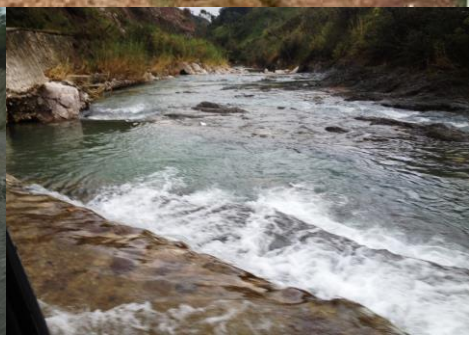
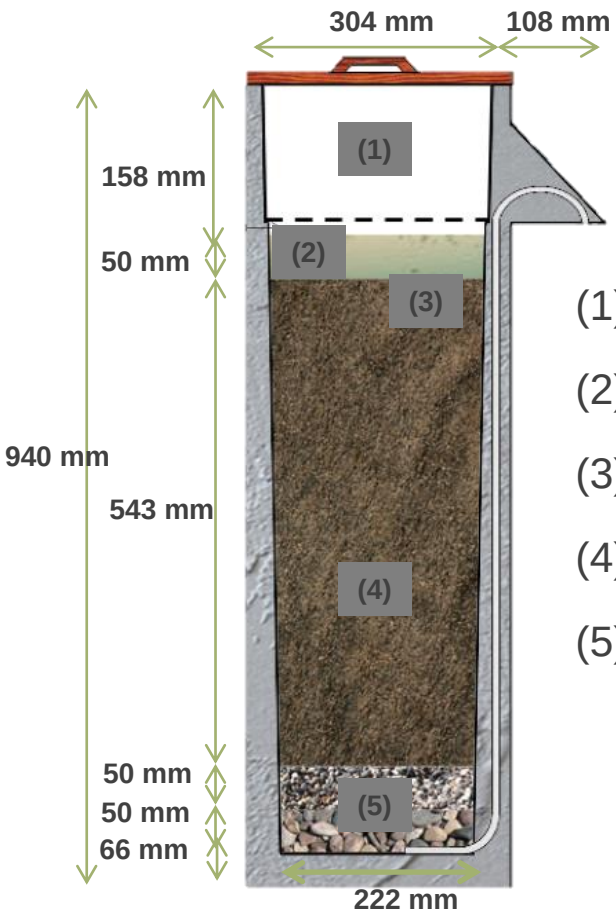
Duchity, Haiti



Duchity, Haiti – Water Quality

Intermittent biosand filter



(1) Reservoir Zone

(2) Standing water Zone

(3) Biological Zone

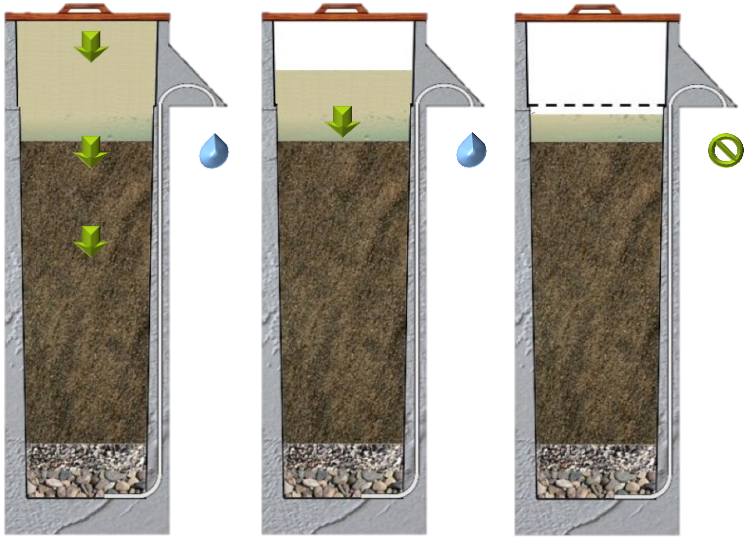
(4) Non-Biological Zone

(5) Gravel Zone

- Adaptation of a traditional slow sand filter
- Designed by Dr. David Manz (1991)
- Implemented in more than 70 countries
- Appropriate technology
  - Low cost
  - Materials availability
  - Operational simplicity

(1) CAWST Manual 2009

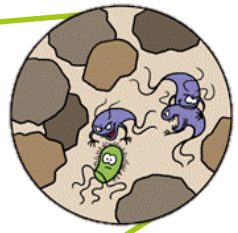
Biosand filter operation



- Biosand filter mechanisms

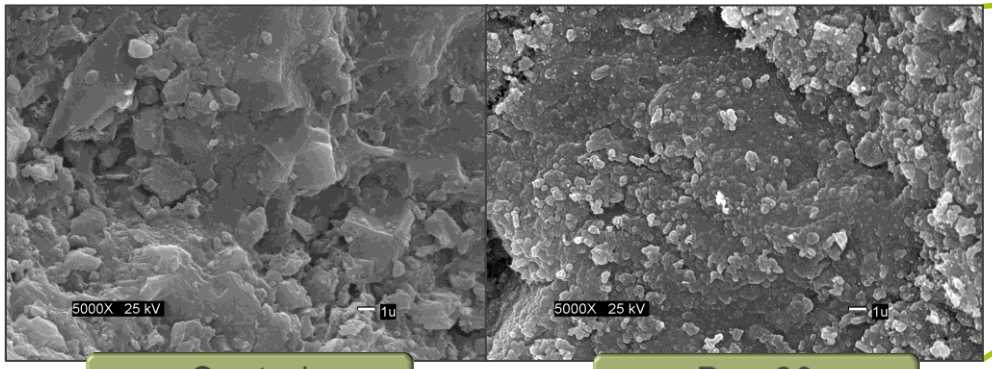
Mechanical trapping

Adsorption



Biological Activity

Lack of oxygen and nutrients



Control

Day 29

(1) CAWST Manual 2009

Technology comparison

Intermittent biosand filter	Traditional slow sand filter
Intermittent flow	Continuous flow
No mantinance cost	Municipal level
Household level	Volume of treated water
Simple operation	

Objectives

- Evaluate the impact and contribution of microbial activity and dissolved oxygen concentration in pathogen reduction as functions of medium depth and time.
  - Understand the filter mechanisms interaction
  - Improve filter design
  - Optimize materials use

Experimental Apparatus

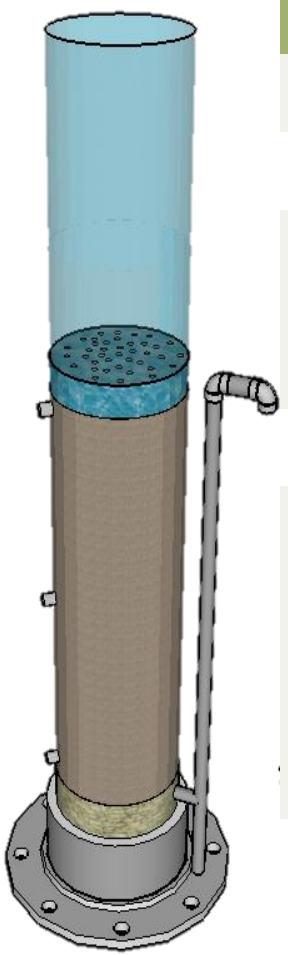


Table 1. Bench scale dimensions	
Diameter [m]	0.10
Total height [m]	1.0
Outlet tube	
Inside diameter [mm]	9.53
Outside diameter [mm]	6.35
Tube height [mm]	695
Effective volume [mL]	2,280
Media layers	
Sand [mm]	543
Porosity	0.44
Separation Gravel [mm]	50
Porosity	0.50
Drainage Gravel [mm]	50
Porosity	0.55
Diffuser	
Perforation diameter [mm]	3.2
Distance between perforations [mm]	12.7

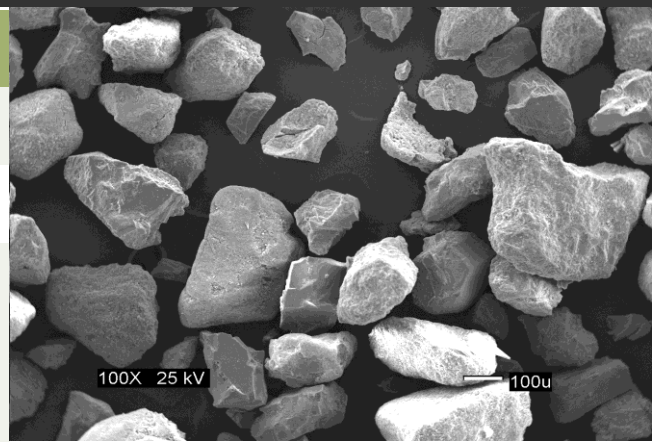
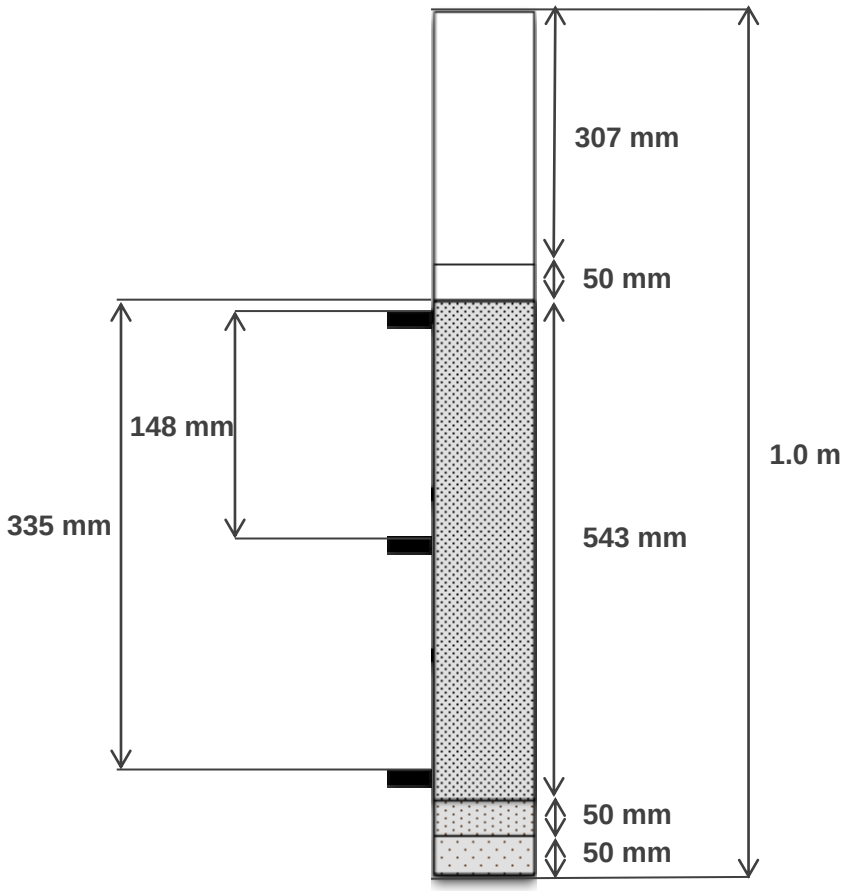


Table 2. Haiti local sand	
Particle size [mm]	0.7 - 0.1
Effective size [mm]	0.13
Uniformity Coefficient	2.5
Minerals	
Quartz	SiO_2
Calcite	$CaCO_3$

Sampling Ports



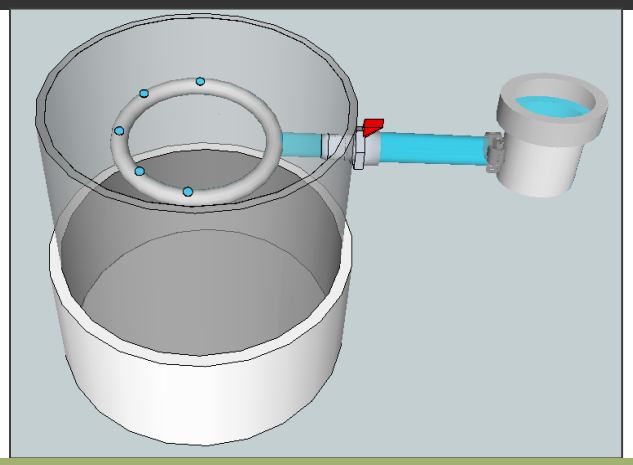
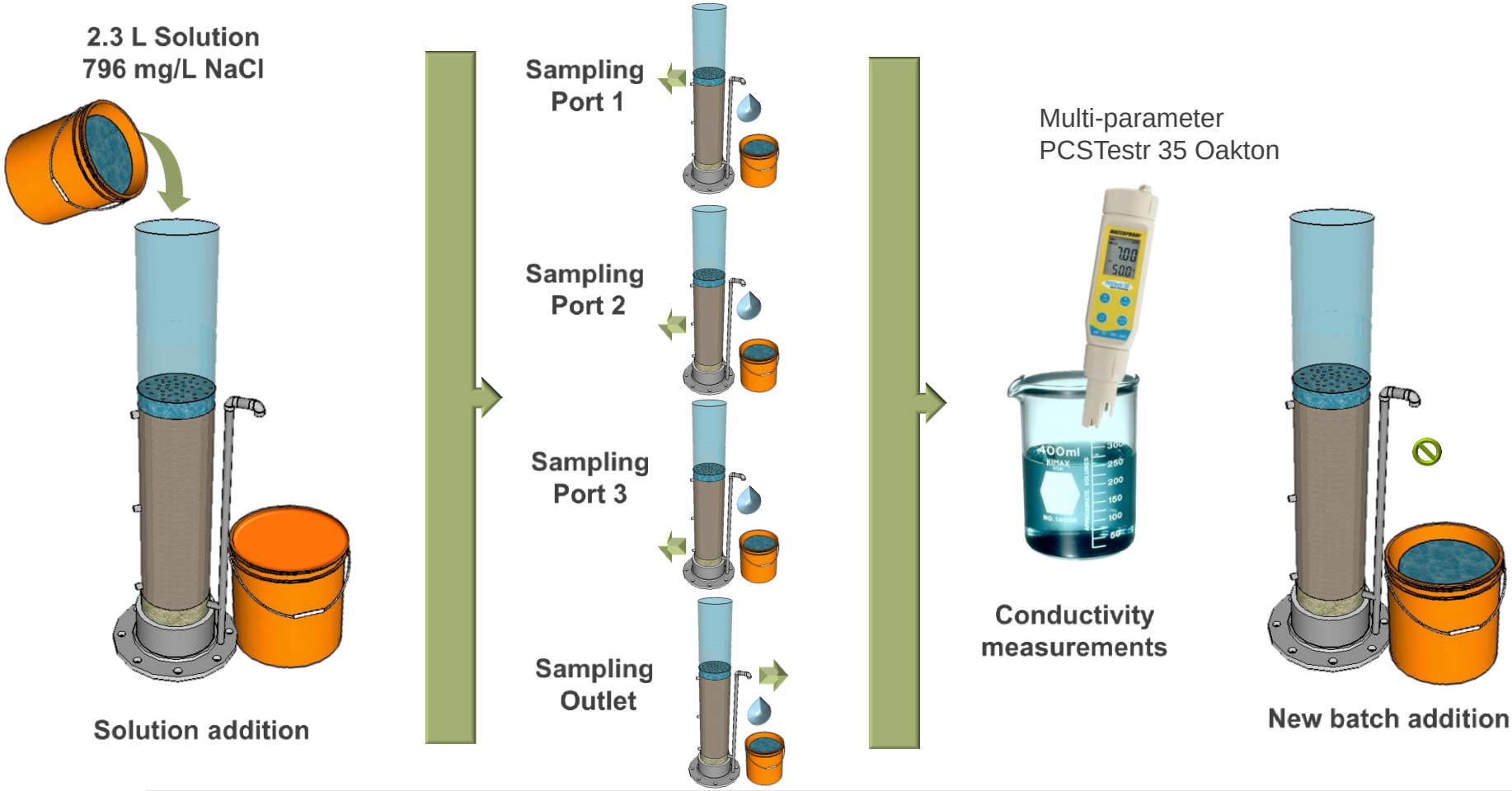
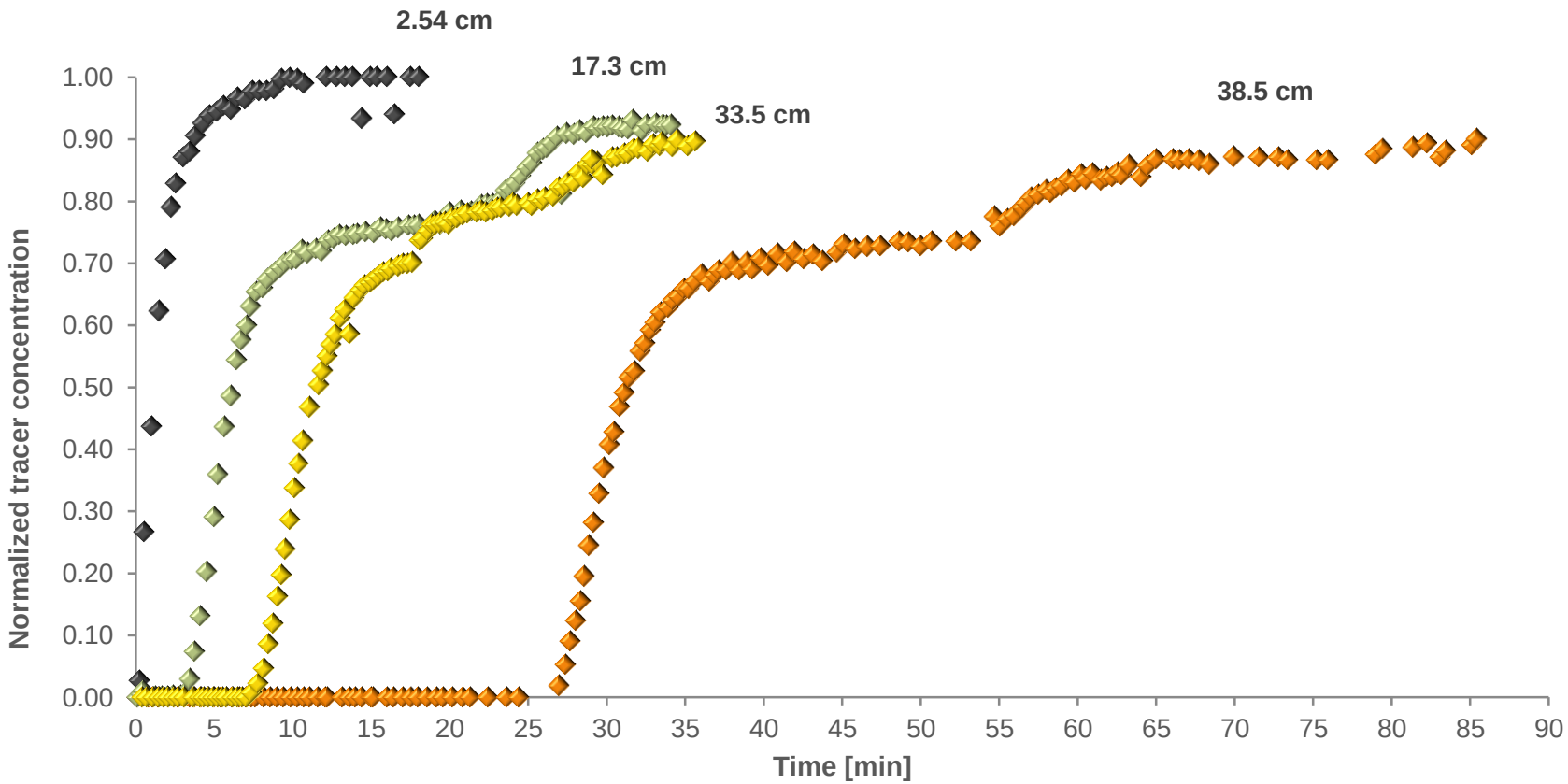


Table 3. Sampling ports dimensions	
Ring diameter [mm]	50
Wall distance [mm]	25.4
Tube	
Outside diameter [mm]	9.53
Inside diameter [mm]	6.35
Perforations quantity	5
Mesh	
Opening size [μm]	105

Methodology



Results: Tracer test

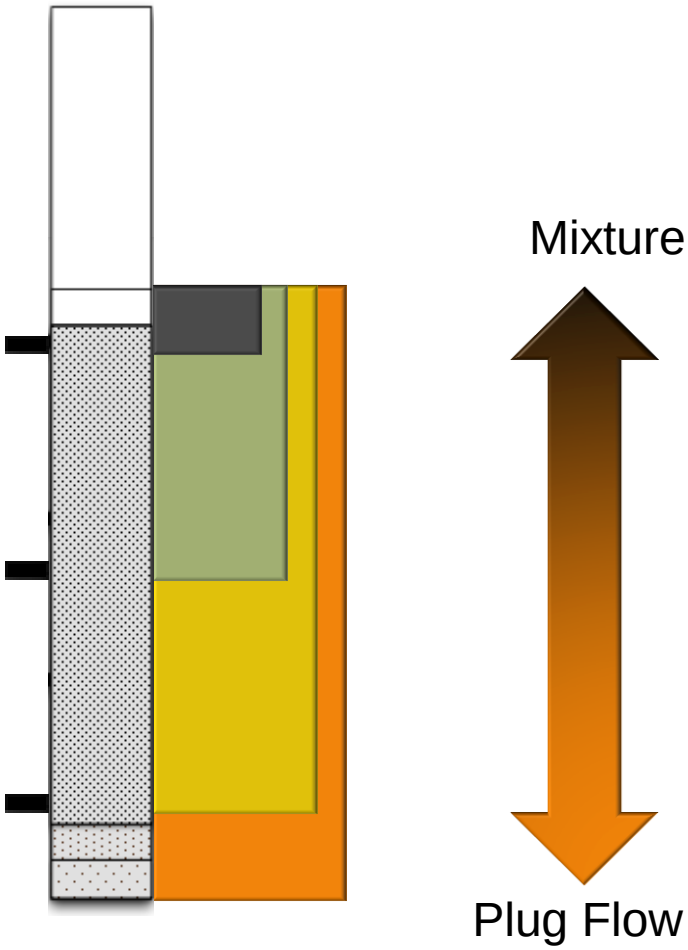


Results: Tracer Test

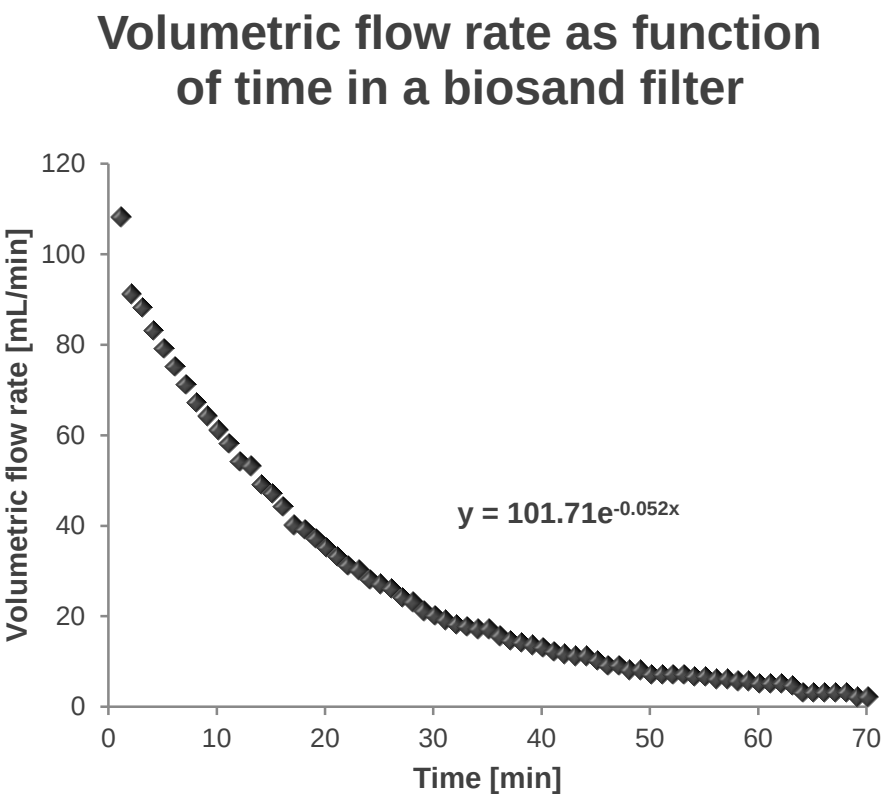
Morrill Dispersion Index

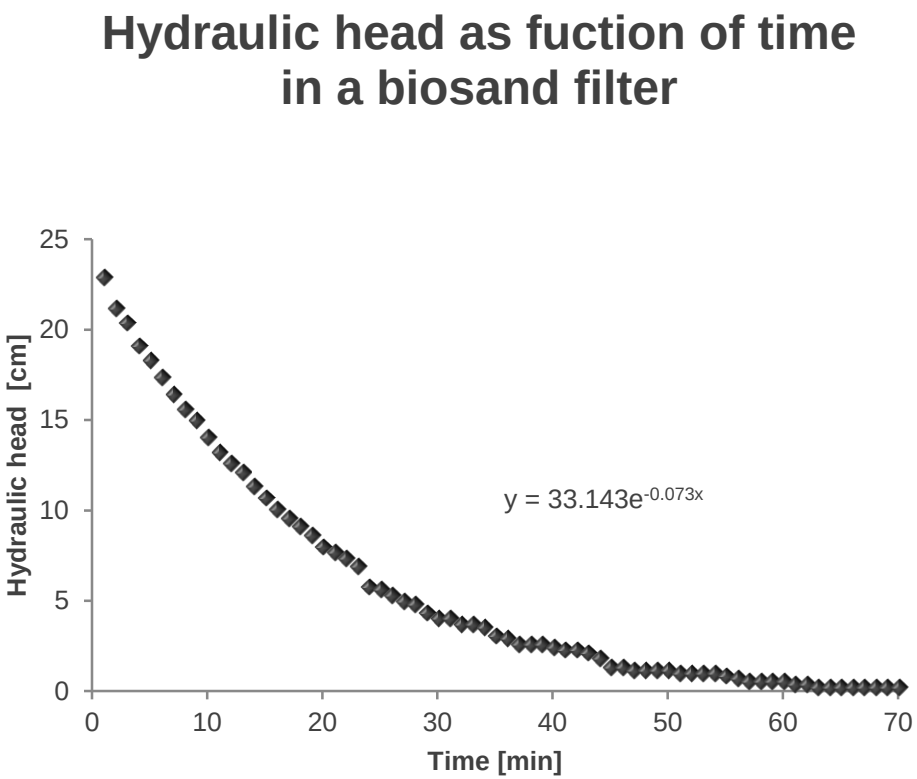
$$MDI = \frac{T_{90}}{T_{10}}$$

- MDI = 16
- MDI = 7
- MDI = 4
- MDI = 3



Volumetric flow rate and hydraulic head





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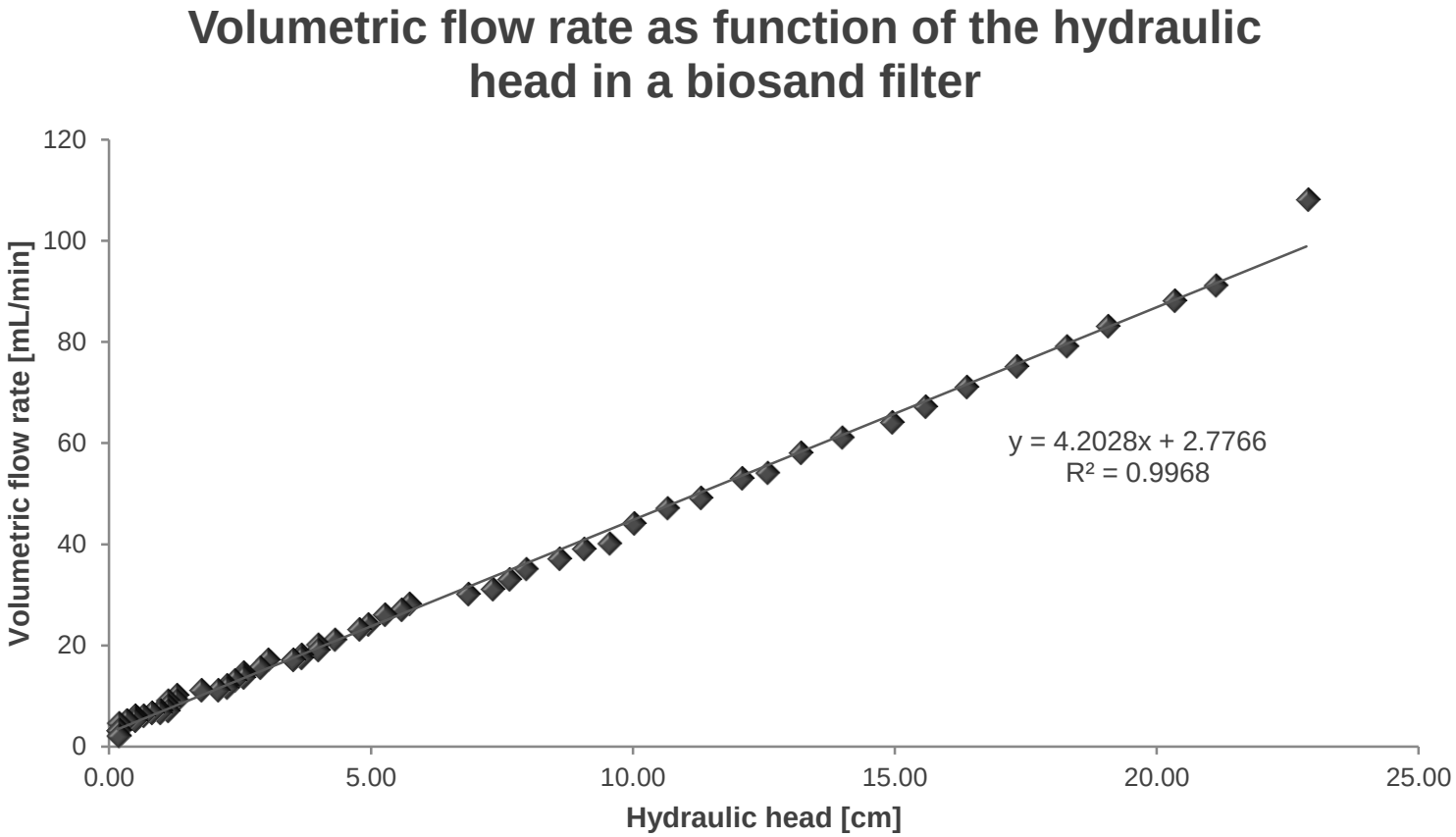
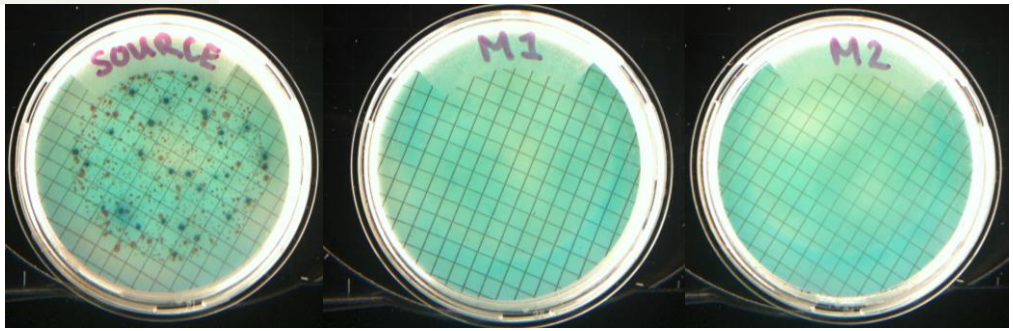


Future Work

- Develop concentration profiles as a function of depth and time
  - Total coliform
  - *Enterococcus spp.*
  - Dissolved oxygen
- Evaluate the impact in the bacteriological quality of the biosand filter effluent with a modified zeolite treatment.
- Conduct a person-to-person survey in Duchity, Haiti.

Table 4. Preliminary Results

Sample	Treatment time	*E-coli* CFU/100 mL	Total coliform CFU/100 mL
Source	0 hr	3,100	66,900
Control	1 hr	3,600	56,500
	2 hr	3,400	53,700
Non-modified zeolite	1 hr	400	13,000
	2 hr	100	9,700
Modified zeolite	1 hr	0	0
	2 hr	0	0



Acknowledgements
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