Screening filter materials for use as substrate in constructed wetlands for enhancing the removal of phosphorus from swine wastewater

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Introduction

The excessive loading of phosphorus (P) in swine wastewater is a major cause leading to eutrophication, which threats to water resources. To prevent water pollution from eutrophication, P should be removed from wastewater before being discharged into the environment. Constructed wetland has known as a green technology for P removal. However, P removal efficiency in CWs is still low, because of using conventional materials. Therefore, to improve P treatment performance, filter materials should have high adsorption capacity. This study aims to search the potential materials use as substrate in CW for enhancing P treatment performance.

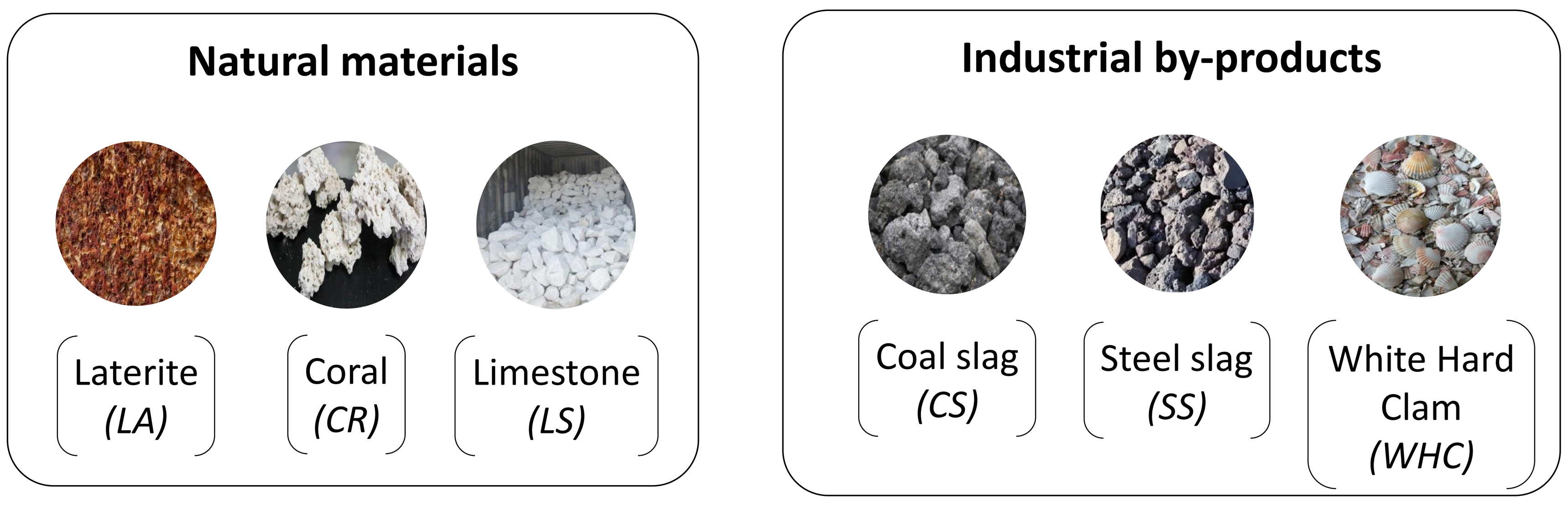
Objectives

- To identify the potential filter materials for being used as substrate in CWs
- To characterize the selected filter materials
- To design and operate a hybrid CW-adsorption treatment system with the selected filter materials

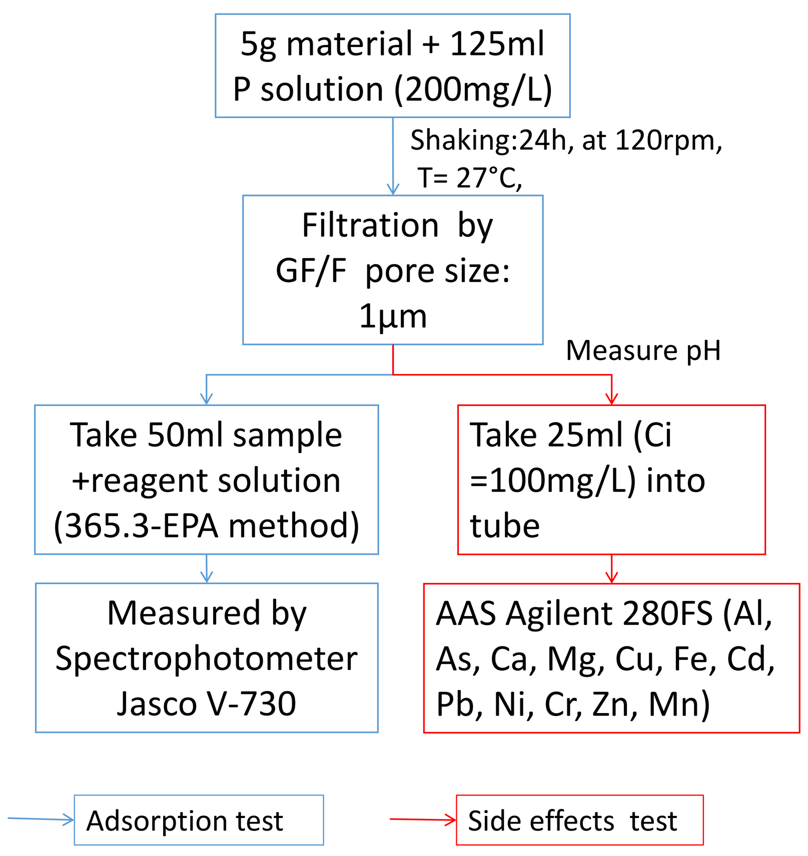
Materials and Methods

Materials selection

5 selection criteria: abundant availability, high adsorption capacity, good water conductivity, low cost, less side effects



P adsorption and side effects test



Permeability

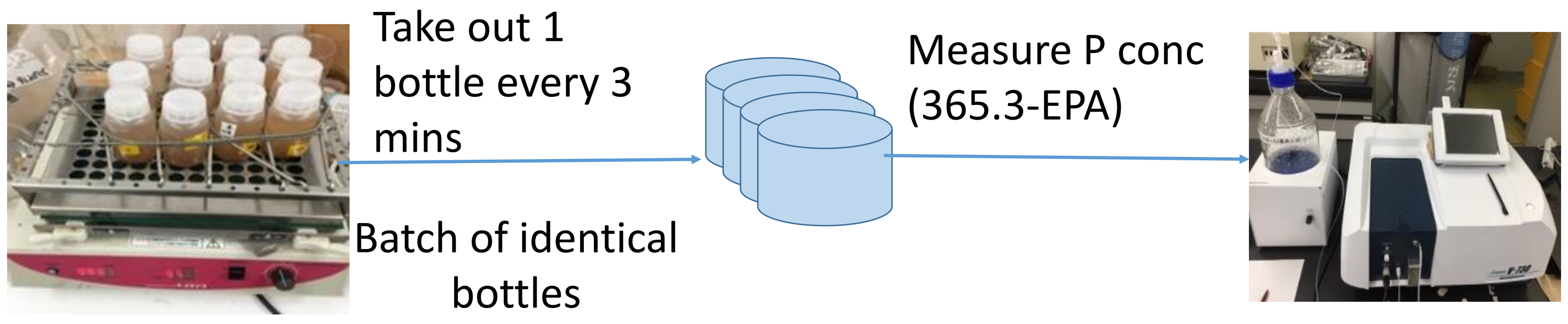
Based on Darcy's Law to find permeability constant of materials

$$Q = KA\frac{\Delta h}{L}$$

Q: Fluid flow (cm³/s);
K: Permeability constant (cm/s);
A: Cross sectional area (cm²);
Δh: Difference in height of water (cm);
L: Flow length (cm)

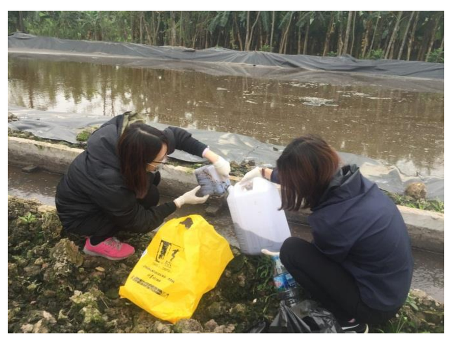
Kinetic batch experiment

3 g of granular materials is added with 75 mL of synthetic P solution (C_i = 200mg/L) for phosphorus adsorption over time



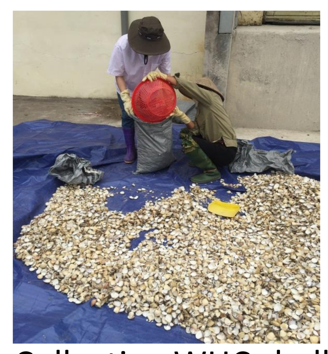
Results

Fieldtrip

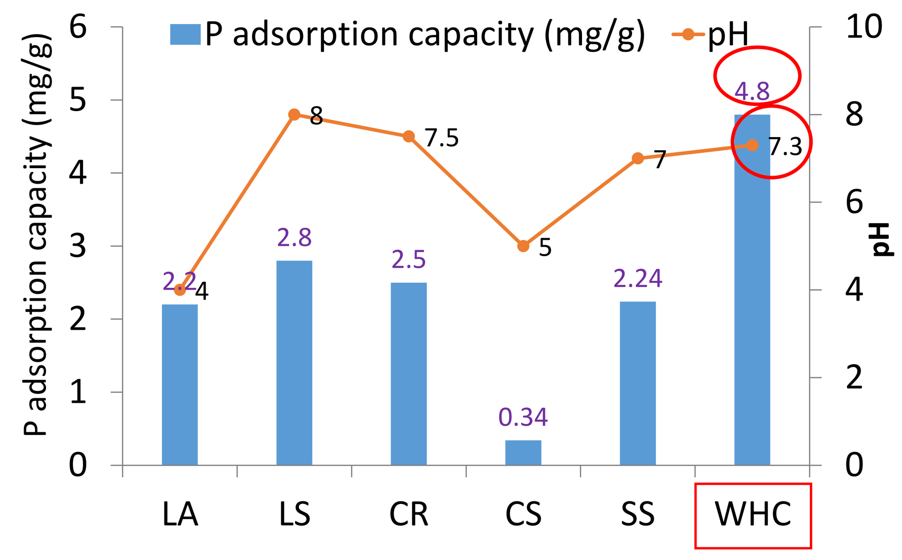

Sampling


Visiting real-scale CW system


Dumping site of WHC shell


Collecting WHC shell

Lab-experiments



P adsorption capacity and pH of post-adsorption solution of investigated materials

Permeability of investigated materials and gravel, coarse sand

Sample	Permeability constant (K) (cm/s)
LA	2.1
CS	4.2
LS	1.2
WHC	2.8
SS	2.2
Gravel	1.0
Coarse sand	0.1 – 1
	(Size: 1.4 – 2.2mm)

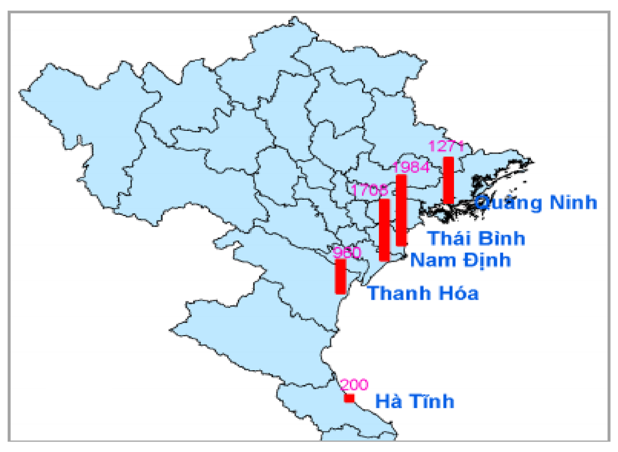
Heavy metals release in post-adsorption solutions

Samples	As	Cd	Cr	Cu	Mn	Ni	Pb	Zn	Hg	Fe
WHC	<0,002	<0,002	0,005	<0,002	0,005	0,011	<0,002	0,116	<0,0002	0,475
SS	<0,002	<0,002	0,005	0,011	0,374	0,009	0,007	0,088	<0,0002	1,11
LS	<0,002	0,002	0,003	<0,002	0,013	0,003	0,012	0,108	<0,0002	0,79
CS	<0,002	<0,002	0,012	<0,002	0,067	0,029	0,003	0,348	<0,0002	0.104
LA	0,021	<0,002	0,006	<0,002	0,033	0,009	0,002	0,162	<0,0002	0,59
QCVN (mg/L)	**0.05**	**0.1**	**1**	**2**	**1**	**0.5**	**0.5**	**3**	**0.005**	**5**

=> Heavy metals release were lower than permissible levels

Among investigated materials, **WHC** shows the highest P adsorption capacity, good water conductivity, and less side effects.

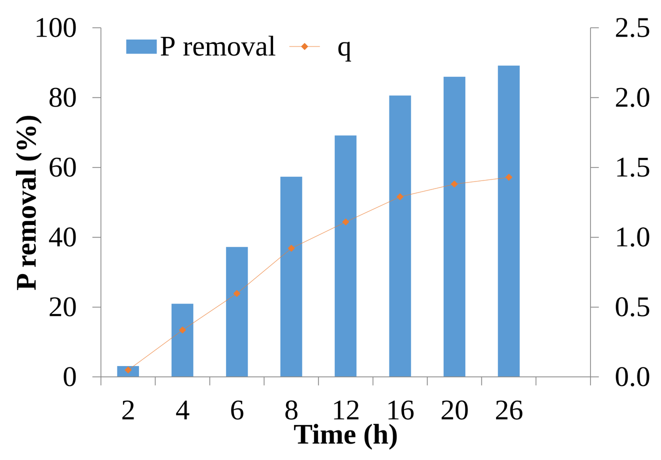
Characteristic of WHC


Distribution of WHC in Northern Vietnam

Quantity of WHC in coastal provinces in the north region

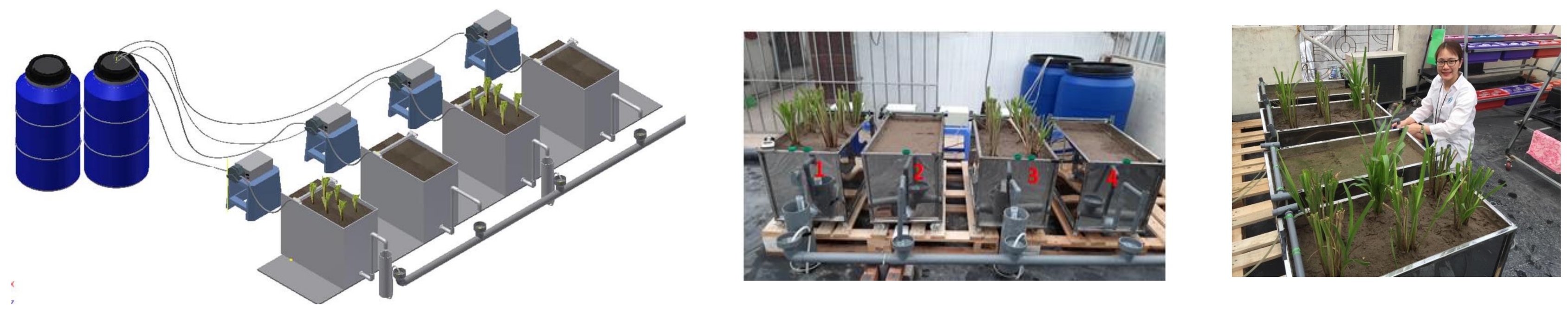
	Quantity (ton/year)		
Province	**Lowest**	**Highest**	**Average**
Quang Ninh	0.6	60	9.2 ± 1.8
Thai Binh	**30**	**700**	**137.5 ± 20.5**
Nam Đinh	10	1000	144.7 ± 20.5
Thanh Hoa	3.5	200	46.5 ± 5.5
Ha Tinh	2.5	250	35.7 ± 7.2

⇒ Area and output of WHC in Vietnam are 32,960 ha and 430,700 tons, respectively.
⇒ WHC shell composed mainly of $CaCO_3$, is an abundant non-hazardous waste material.
⇒ Recycling clamshell in P removal is a good way in both economy and environment protection sides



Kinetic test of WHC

Design and operate CW systems


Integrated WHC based CWs-adsorption systems

Conclusions

➢ This research trip aimed to have a face-to-face discussion with my research group, do experiments, and visit some constructed wetlands in Vietnam. Although having some difficulties in traveling because of the covid 19 pandemic, our research group still has achieved some excellent results:
- Experienced in operating the actual application of constructed wetland.
- Found the WHC shell as a potential material for use as substrate in CW for P removal.
- We installed integrated CWs-adsorption systems based on WHC in Vietnam Japan University.

➢ <u>Further works</u>: Operating the system with real swine wastewater to evaluate entirely the treatment performance of the CW-adsorption systems.

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