Arsenic Removal by Granular Iron Hydroxide-based Adsorbent

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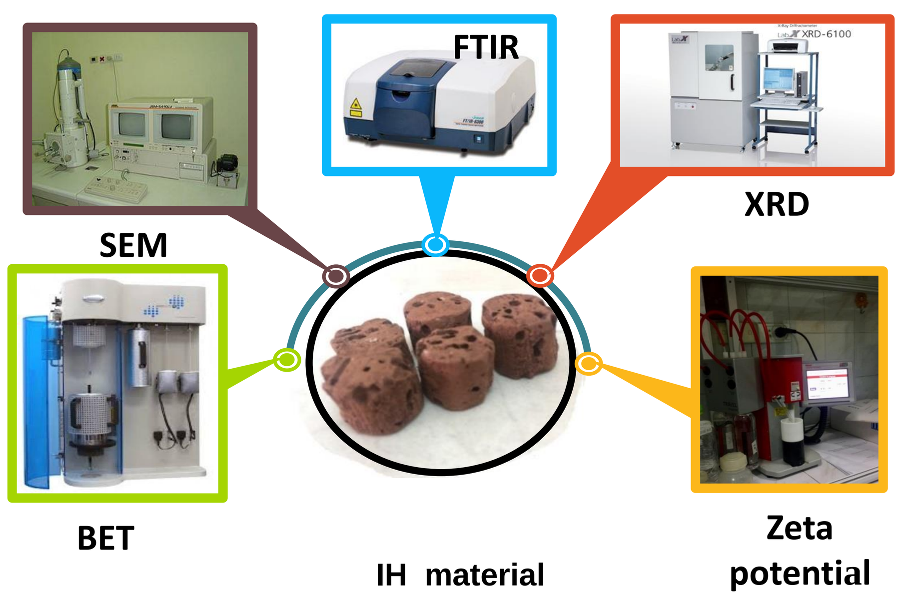
1 Introduction

21% Vietnam's population using As contaminated water (2010), particularly in Red and Cuu Long river delta regions.

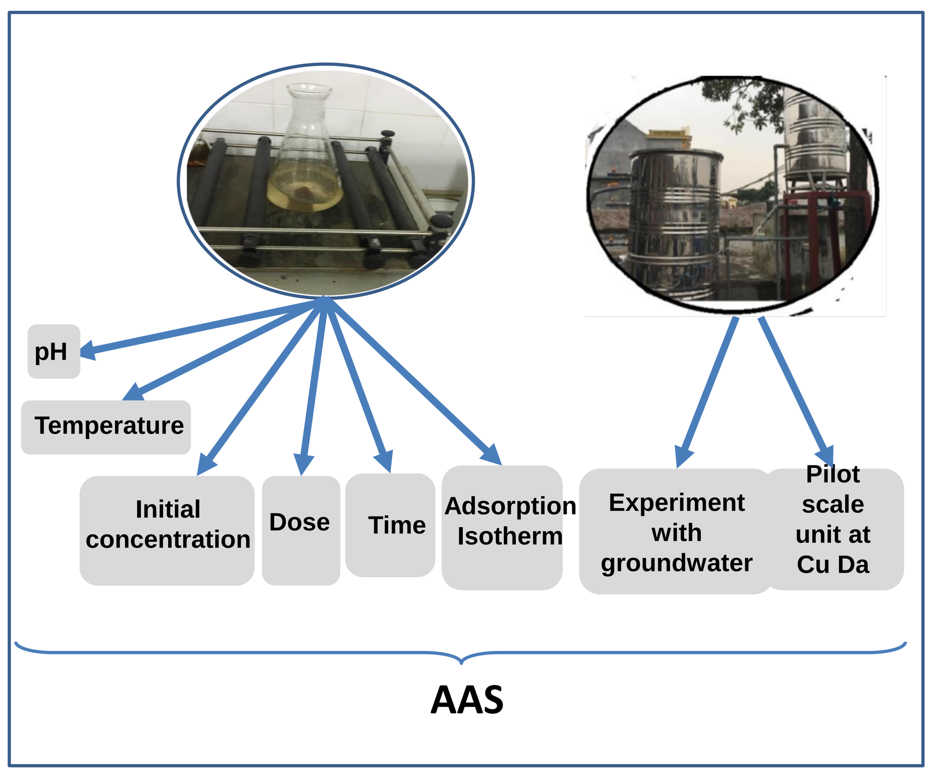
The solution to remove As from groundwater with low-cost adsorbent
Granular adsorbent is easy to apply in fixed bed column treatment system

2 Materials and methods



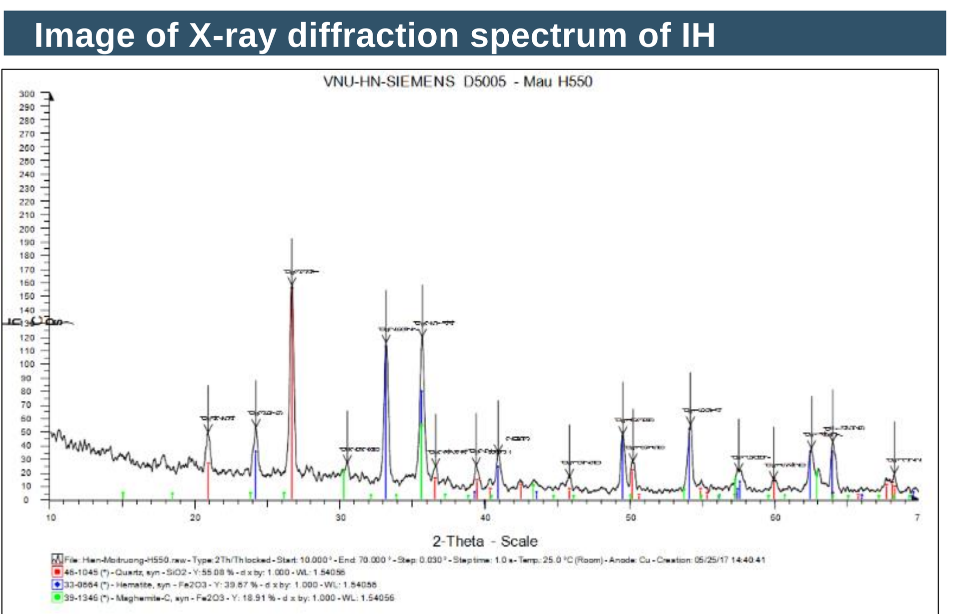
Iron hydroxide, Kaolin, bentonite, Alumium oxide

→ Mixed, created granular form, heated at 500˚C for 10 hours

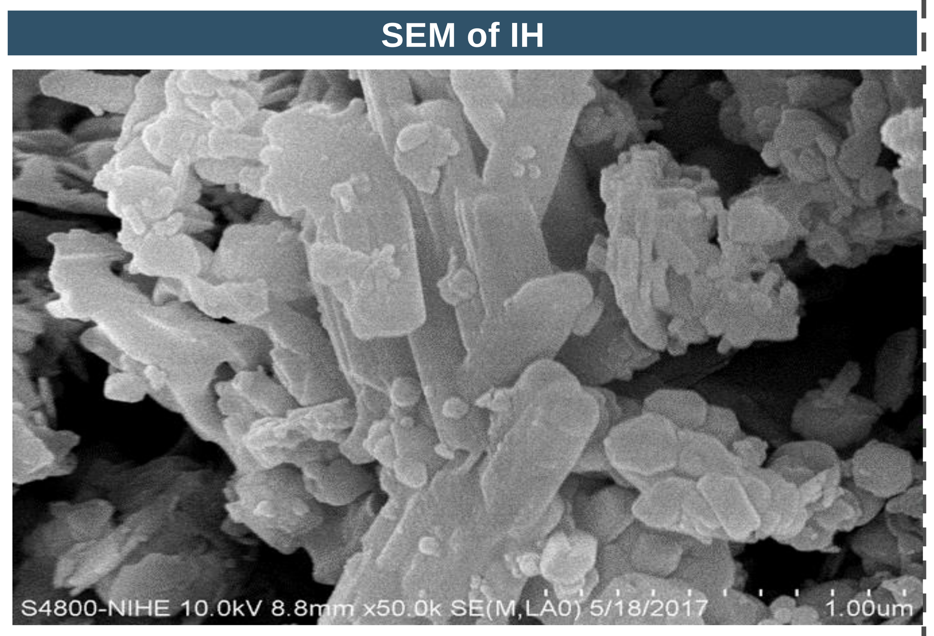


3 Results and discussion

Image of X-ray diffraction spectrum of IH



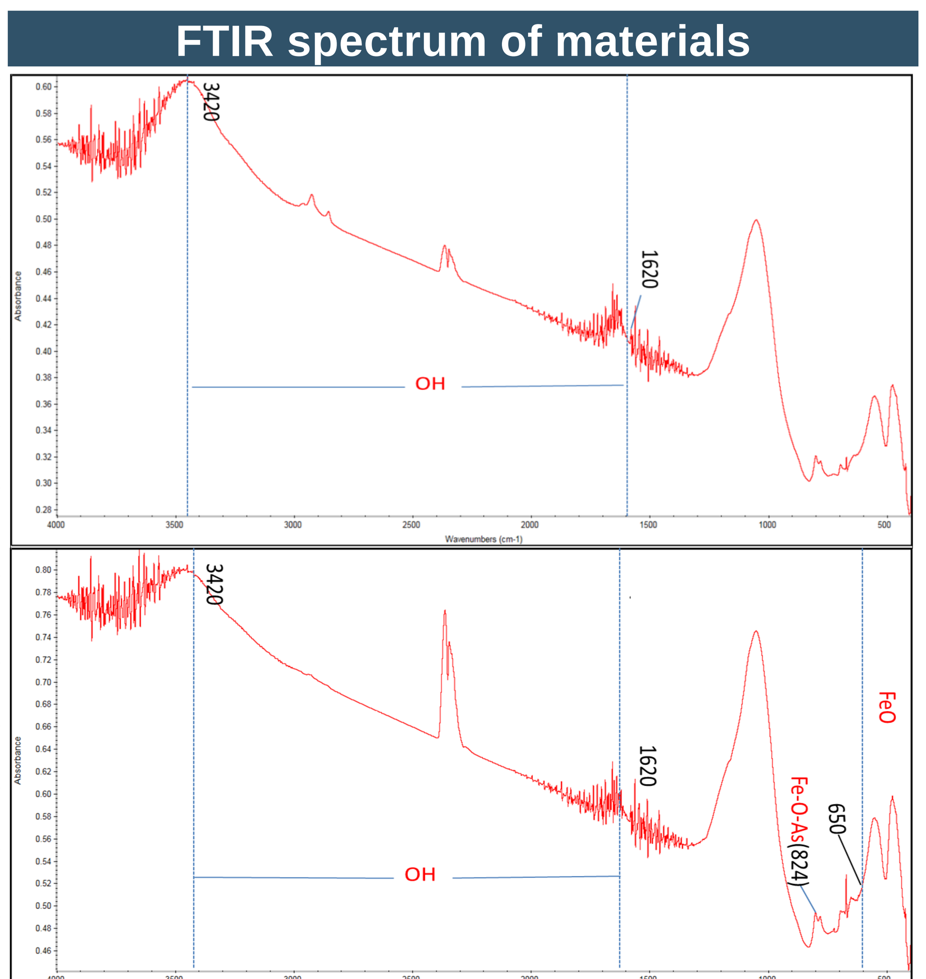
SEM of IH



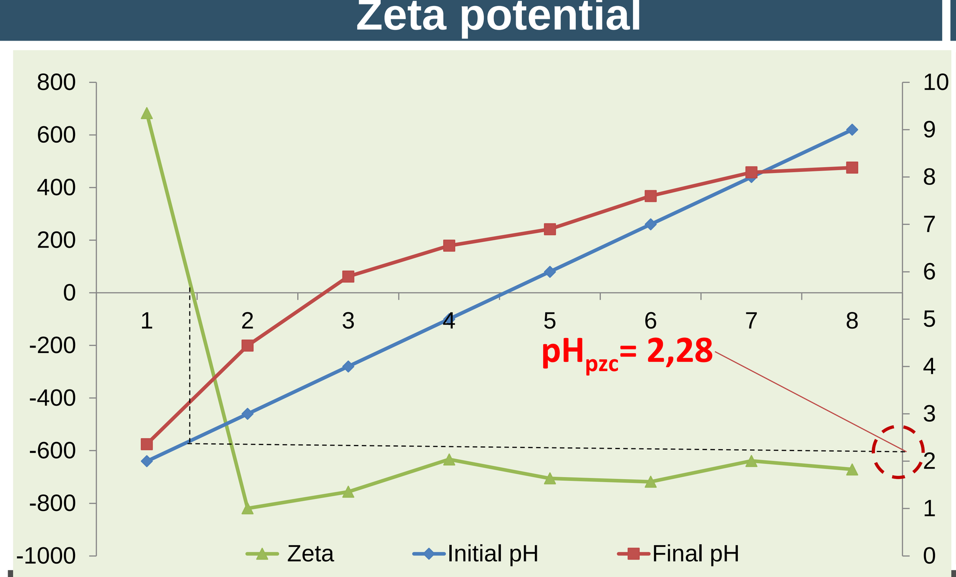
Surface area of the material

Material	Area (m²/g)	Source
IH before adsorption	22.6909	This research
IH after adsorption	22.0304	This research
Fly ash	0.8	Diamadopoulos et al.,1993
Iron Zero valent	1.8	Sasaki et al., 2009
Manganese sand(IOCMS)	9.18	Wu et al., 2007
Kaolin	33	Mohapatra et al., 2007
$Fe_x(OH)_y$-Montmorillonite	165	Lenoble et al., 2002
Iron activated carbon	723	Chen et al., 2007
Activated carbon	1125	Lorenzen et al., 1995
C- from coir	1200	Lorenzen et al., 1995
Diatomite rock changes the surface	50-55	Wu et al., 2005

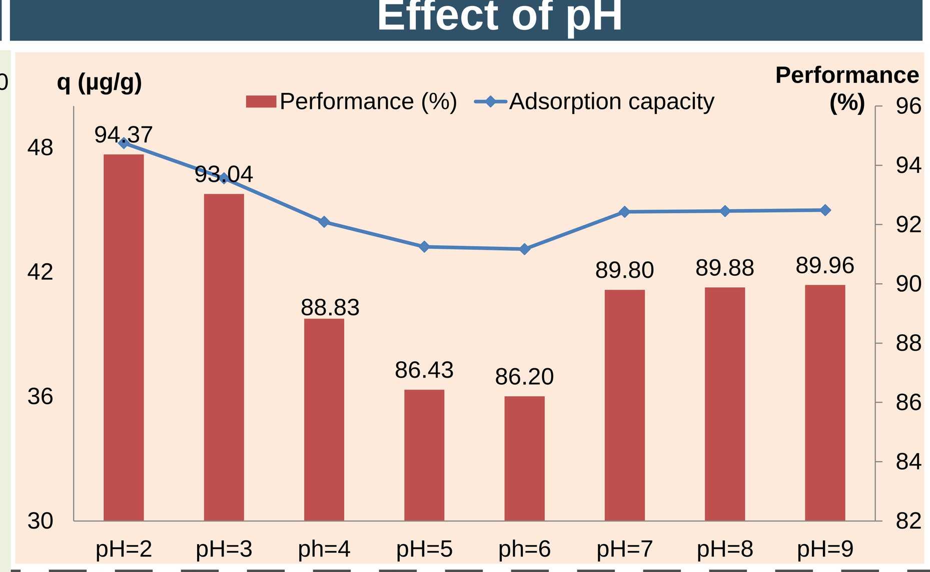
FTIR spectrum of materials



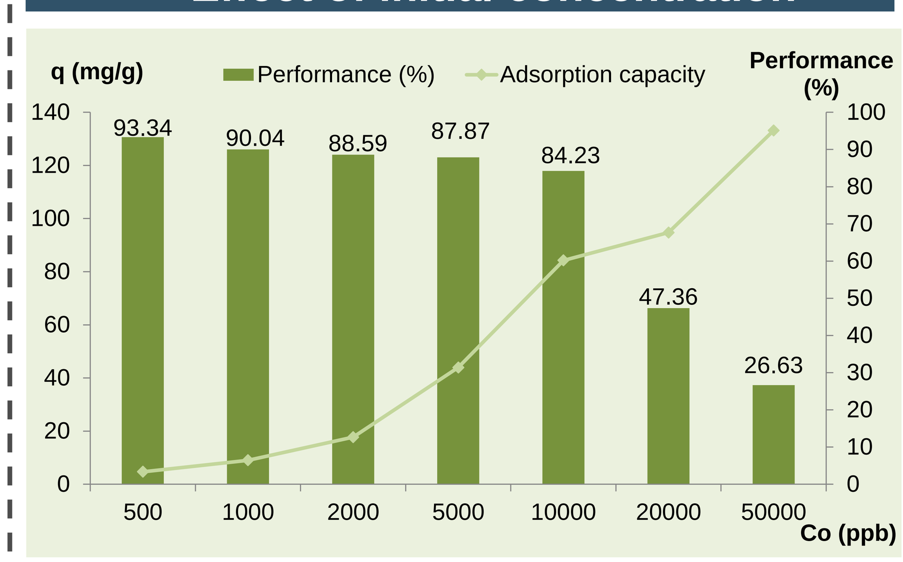
Zeta potential



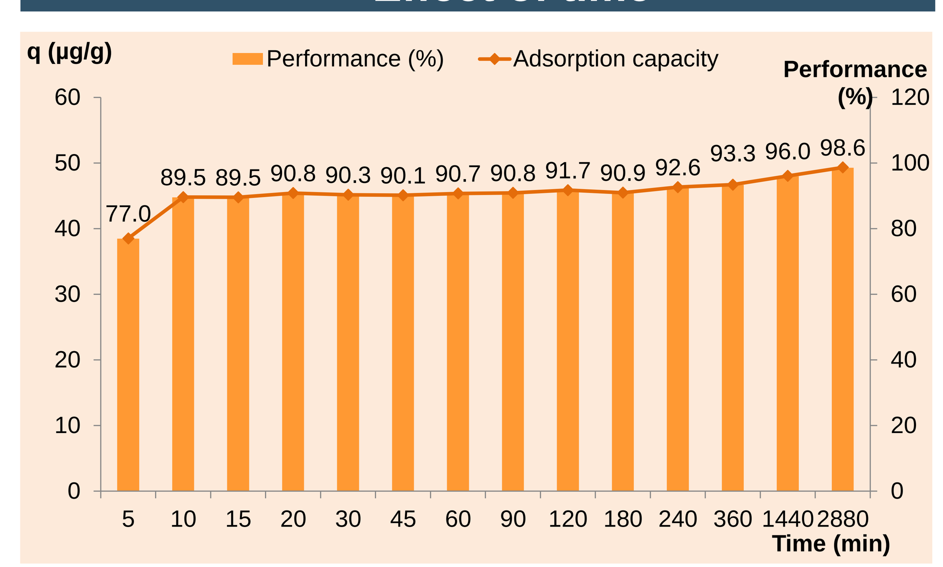
Effect of pH



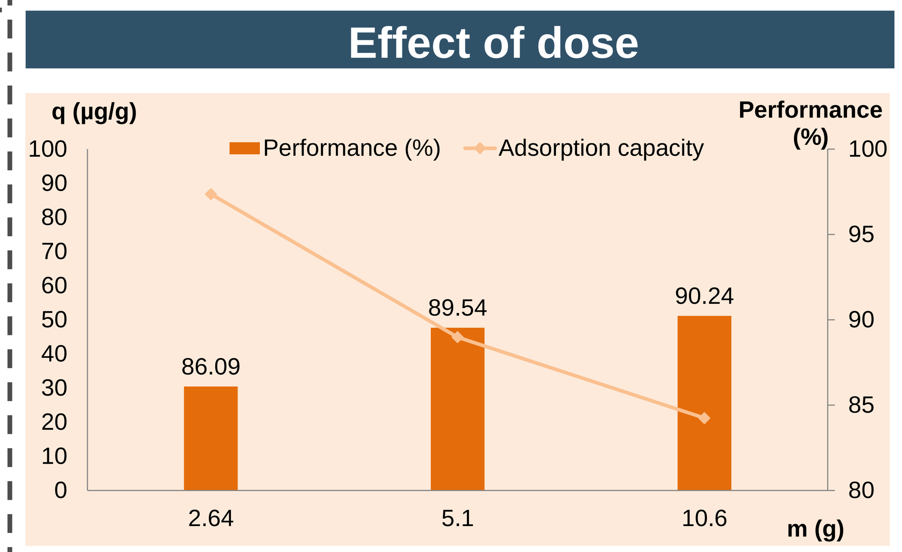
Effect of initial concentration



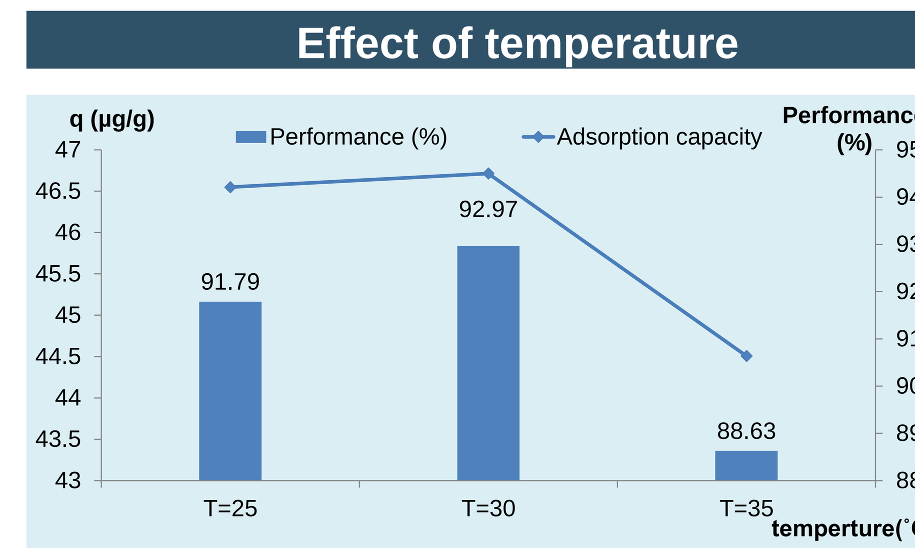
Effect of time



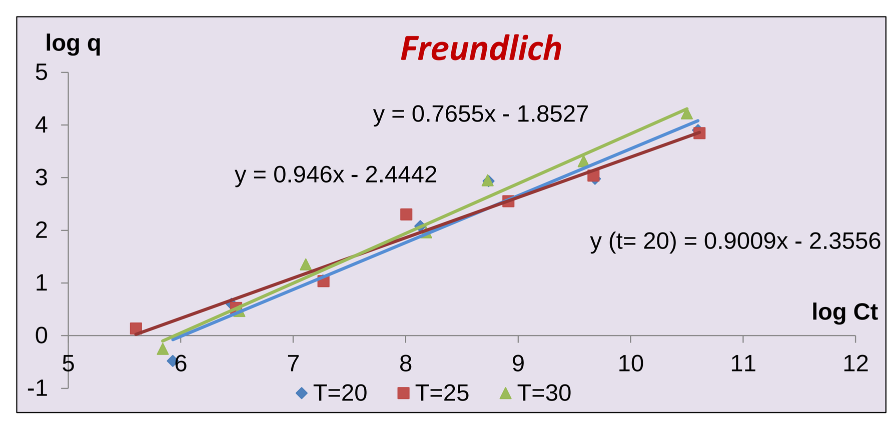
Effect of dose

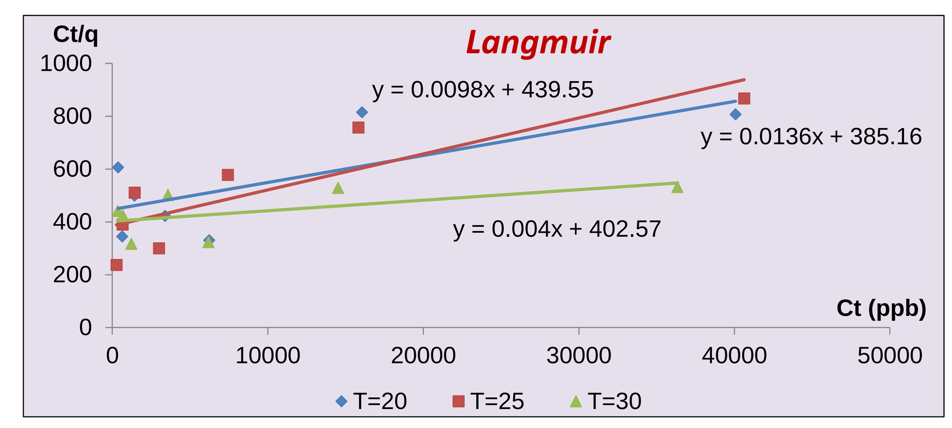


Effect of temperature



Adsorption Isotherm

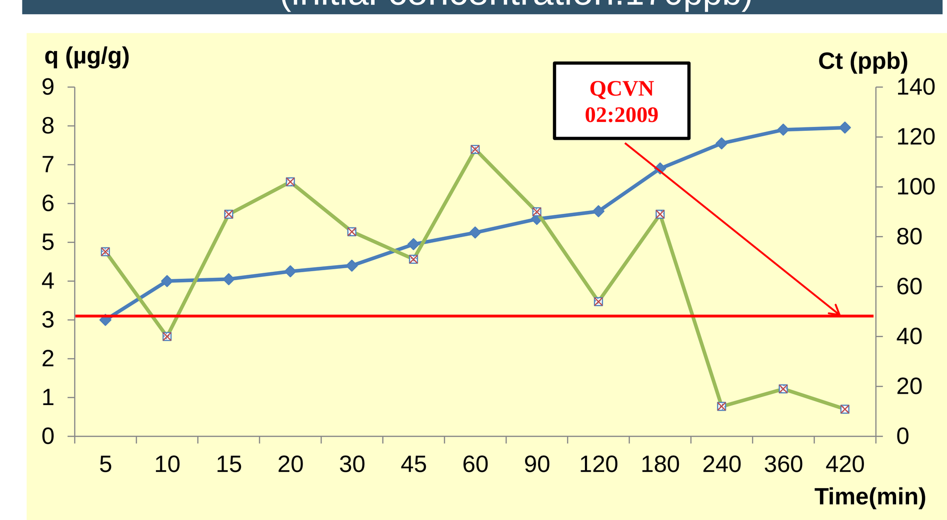




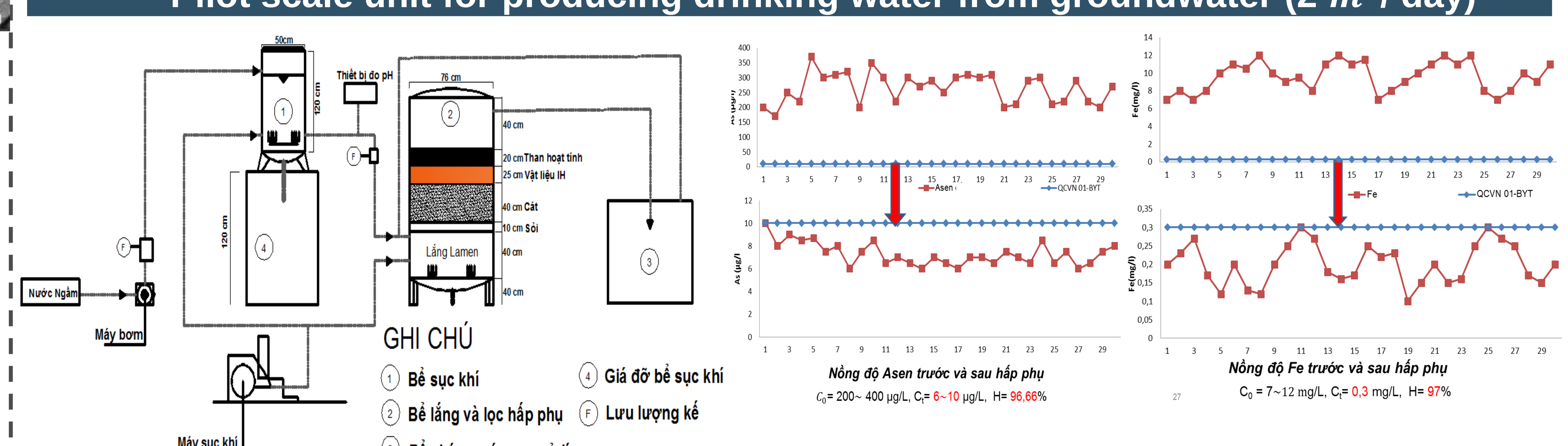
Adsorbent	q_{max} (µg/g)	Source
Granular IH	250	This research
Powdered IH	2896.9	This research
Zero valent Iron	1920	Wu et al., 2007
Manganese sand	5452	Wu et al., 2007
Kaolin	860	Mohapatra et al., 2007
$Fe_x(OH)_y$-Montmorillonite	4000	Lenoble et al., 2002
Iron activated carbon	5130	Chen et al., 2007
Denatured Corn protein	1950	Sineephan et al., 2016
Activated carbon	1725	S.P. Dubey et al., 2015
Lemon peel	474	Marin-Rangel et al., 2012

Experiment with groundwater at Cu Da

(initial concentration:170ppb)



Pilot scale unit for producing drinking water from groundwater (2 m^3/ day)



Evaluation of arsenic removal efficiency

- T= 30 days → V = 60 m³
- Input: m_{Fe} = 600g, m_{As} = 18g
- Output: m_{Fe} = 18g, m_{As} = 0,6g
- **60%** The amount of As is removed by sand filtration and natural precipitation → Adsorbent treated 36.66% of arsenic.
- Maximum adsorption capacity of the material (q_{max}) is **0,00025** kg As/kg adsorbent, $m_{adsorbent}$ = 100 kg → m_{As} = **0,025kg** = **25g**
- $q_{(1\ month)} = \frac{17,4*36,66\ \%}{25} = 25,52\%\ q_{max}$

→ **T Material replacement frequency: one per 4 months.**

Cost	mass/ kg material (kg)	Cost (VNĐ)	Total amount(VNĐ)
Kaolin	0,24	800	192
Alumium oxide	0,1	13.000	1.300
Bentonite	0,075	5.000	375
Iron hydroxide	0,4	15.000	6.000
Labour			1.500
Electricity			1.000
Material loss			100
IH			10.467

Cost of 1 m³ water

Electricity cost /day:

- Pump : P=100W, t=2h
- Aerator : P=370W, t=1,5h

⟶ Electric consume : 0,755 kWh/ 2m³ = 0,3775 kWh/m³ → **528** VND/m³

Replace materials costs:
Activated carbon (50kg): 1 time/ year , Adsorbent (100kg/time): 3 times/ year→ **Replace materials costs** : **3.740.000 VND/year**
Amount of water processed in 1 year: V=730m³

→ Material replacement costs for 1m³: **5.123 VND**

Capital cost: **8.390.000 VND** for water treatment system, lifetime: 10 years

→ Invest cost 1m³ = 8.390.000/ 7.300= **1.142** VND

→ **Total amount for 1M³: 6.793 VND**

Conclusion

- Large surface area, high porosity. On the surface having good arsenic adsorption functional groups.
- Equilibrium time: 10 min, (H = 89.5%). Optimal conditions: pH = 2, dose: 50 g/L, T = 30˚C. The adsorption process of IH material follows the model Langmuir, q_{max} = 250 µg/g.
- Working well with groundwater in short time, after 5 minute reduce 56,5%. After 4 hours, Adsorption capacity stable and concentration of arsenic output reach QCVN 02:2009/BYT (<50 µg/L).
- Materials are made from low-cost, local-available materials with easy preparation process. In compassion with other materials, IH is cheaper and have overcome some of their disadvantages.

Research orientation:

- Further research to widely apply IH
- Improving the process of adsorbent preparation
- Developing method fo desorption and reusing IH material.

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