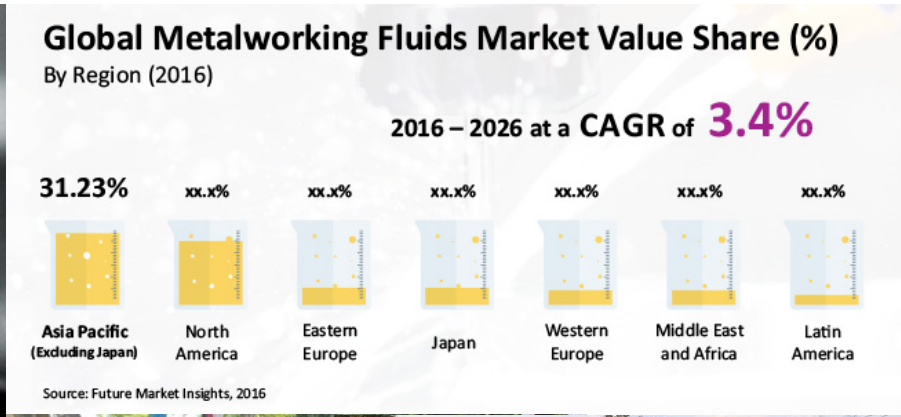

ACID-ASSISTED RECYCLING OF $FE(OH)_3$ SLUDGE AS COAGULANT FOR METALWORKING FLUID WASTEWATER TREATMENT

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Tanapon Phenrat

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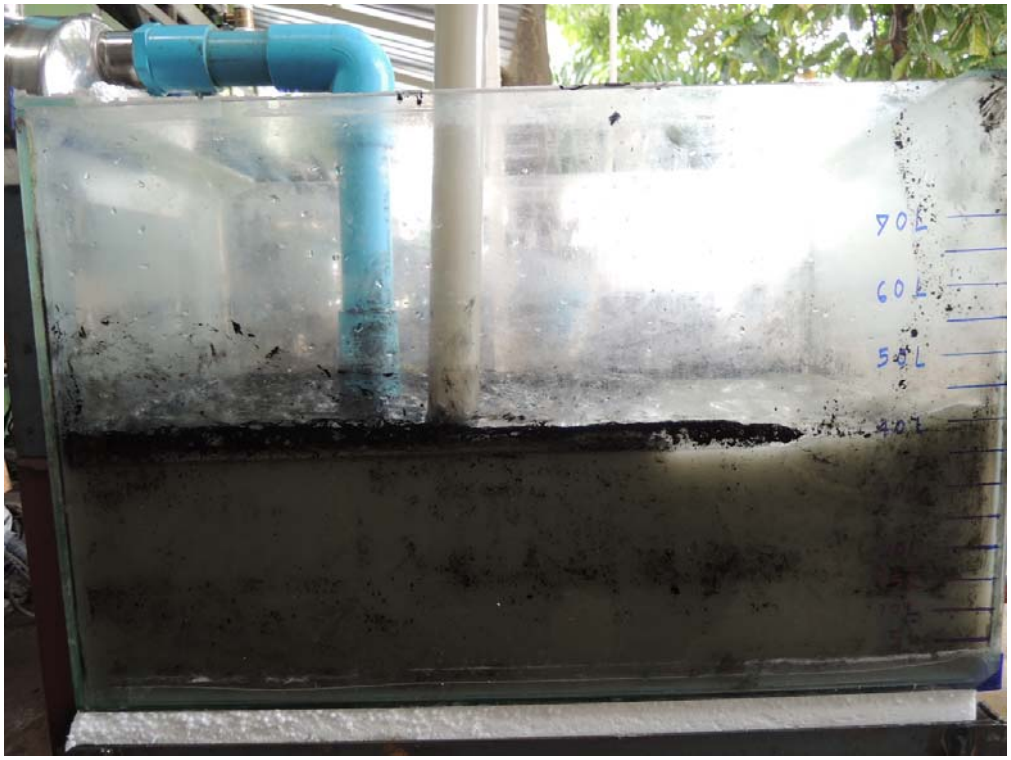
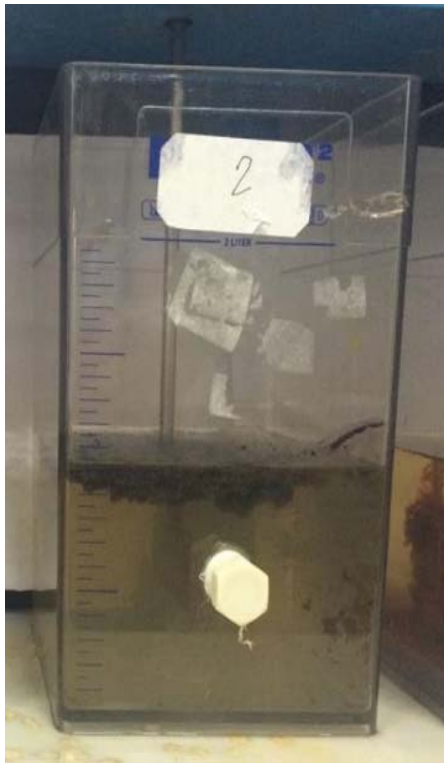
CIRCULAR ECONOMY: WASTE TO RESOURCE

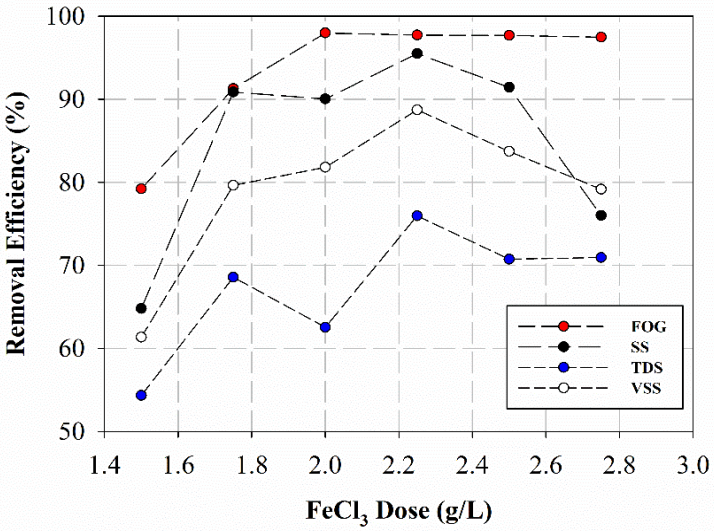


COAGULATION FOR OIL SEPARATION/FURTHER TREATMENT

FeCl3 without polyacrylate

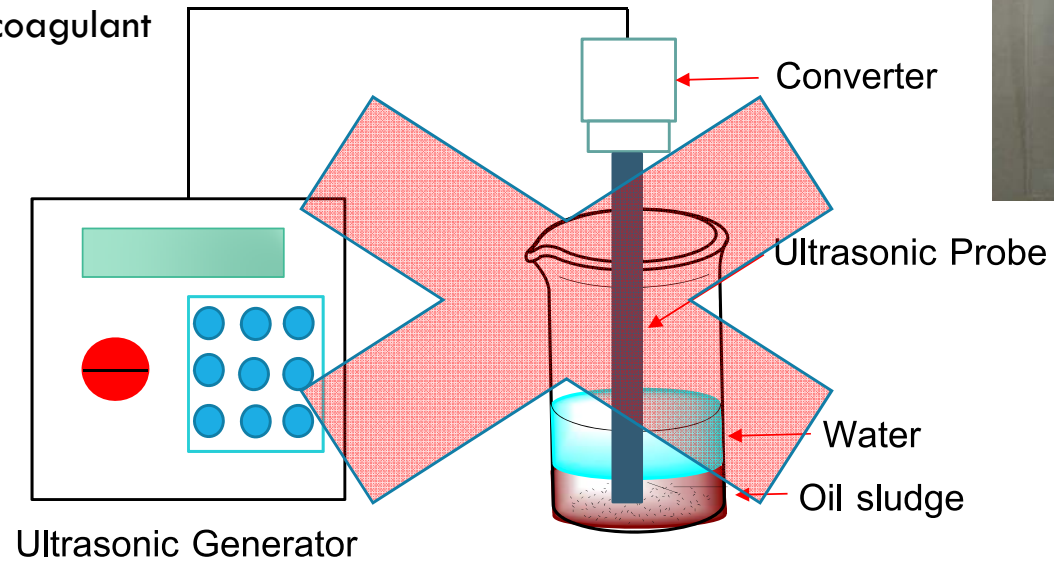
FeCl3 with polyacrylate





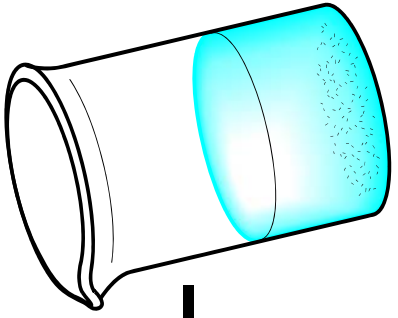
OIL-CONTAMINATED FE(OH)3 SLUDGE

- To treat 1 m^3 of MWF wastewater,
  - ✓2.25 kg of FeCl3 is used
  - ✓generates 19.36 kg of dewatered oil-contaminated $Fe(OH)_3$ sludge.
- The cost of a conventional treatment would be 58.00 THB
  - ✓48.40 THB for land disposal
  - ✓9.60 THB for fresh coagulant
  - ✓1 USD = 31 THB



ACID RECOVERY OF IRON COAGULANT AND OIL

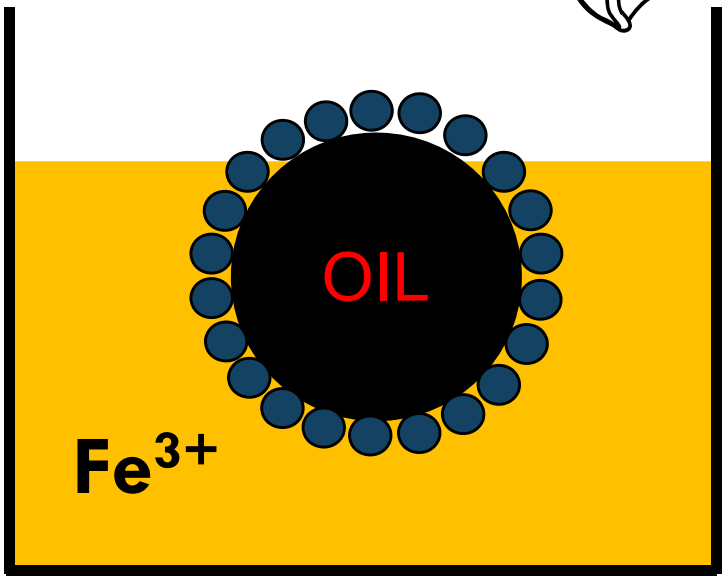
$Fe(OH)_{3(S)} + 3\ HCl \rightarrow Fe^{3+} + 3Cl^{-} + 3H_2O$

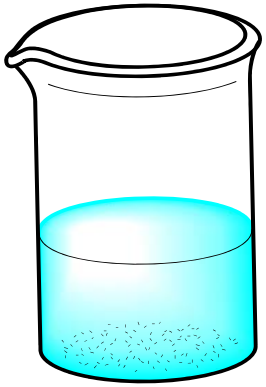


Oil

Fe^{3+}

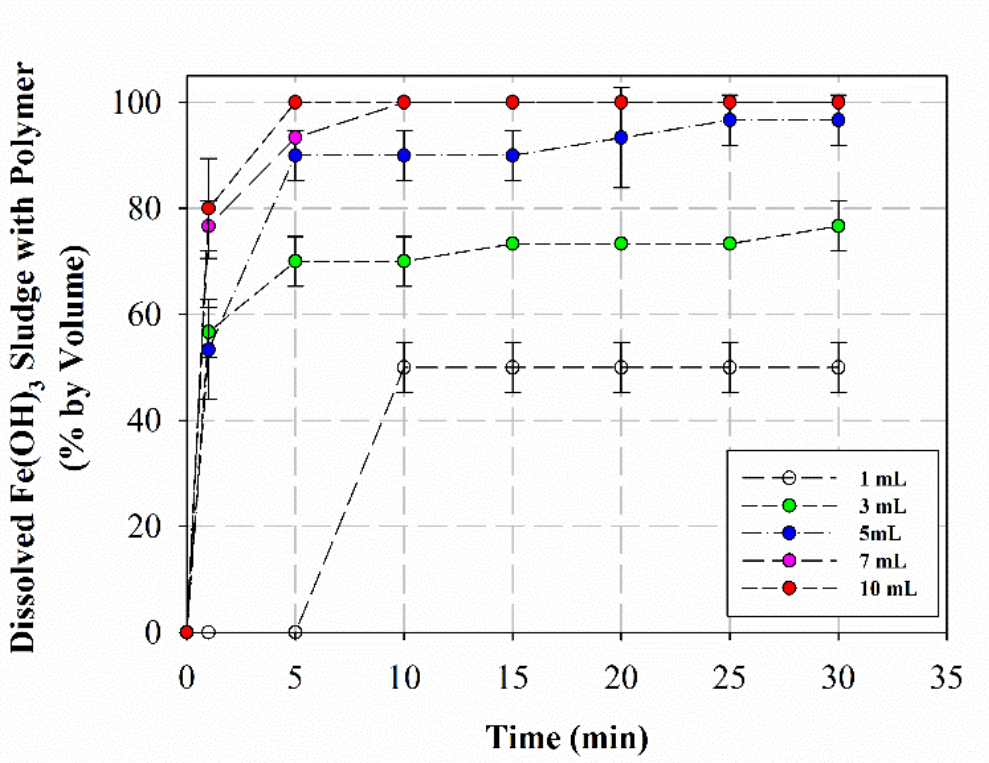
Oil

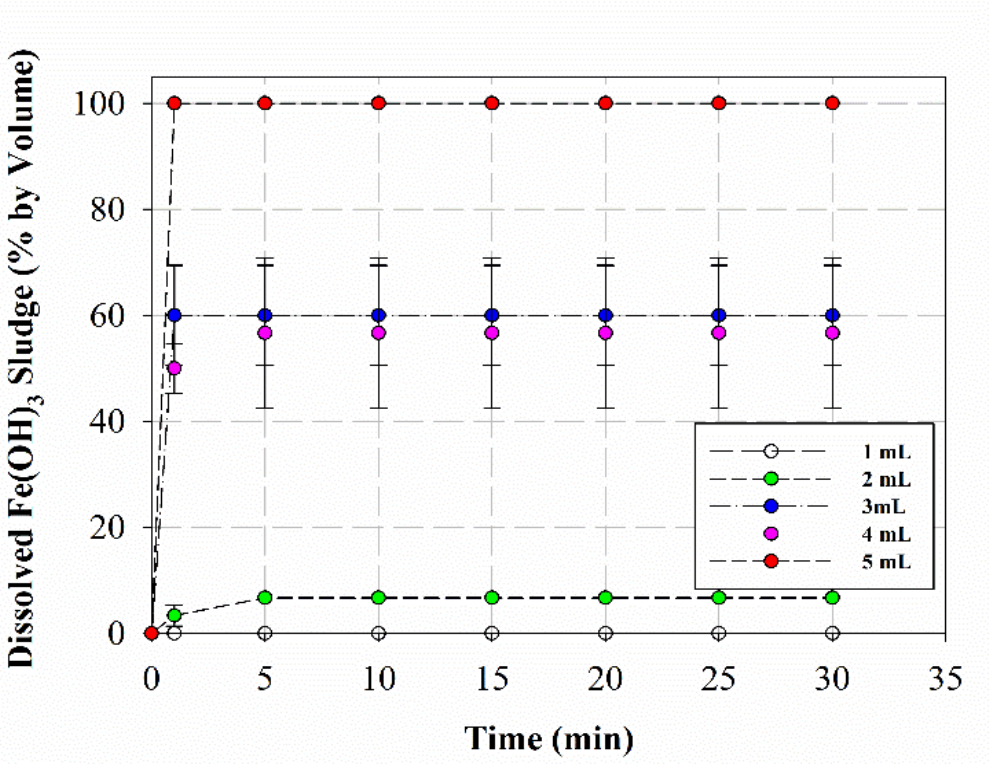




HCl

CONTROL EXPERIMENTS

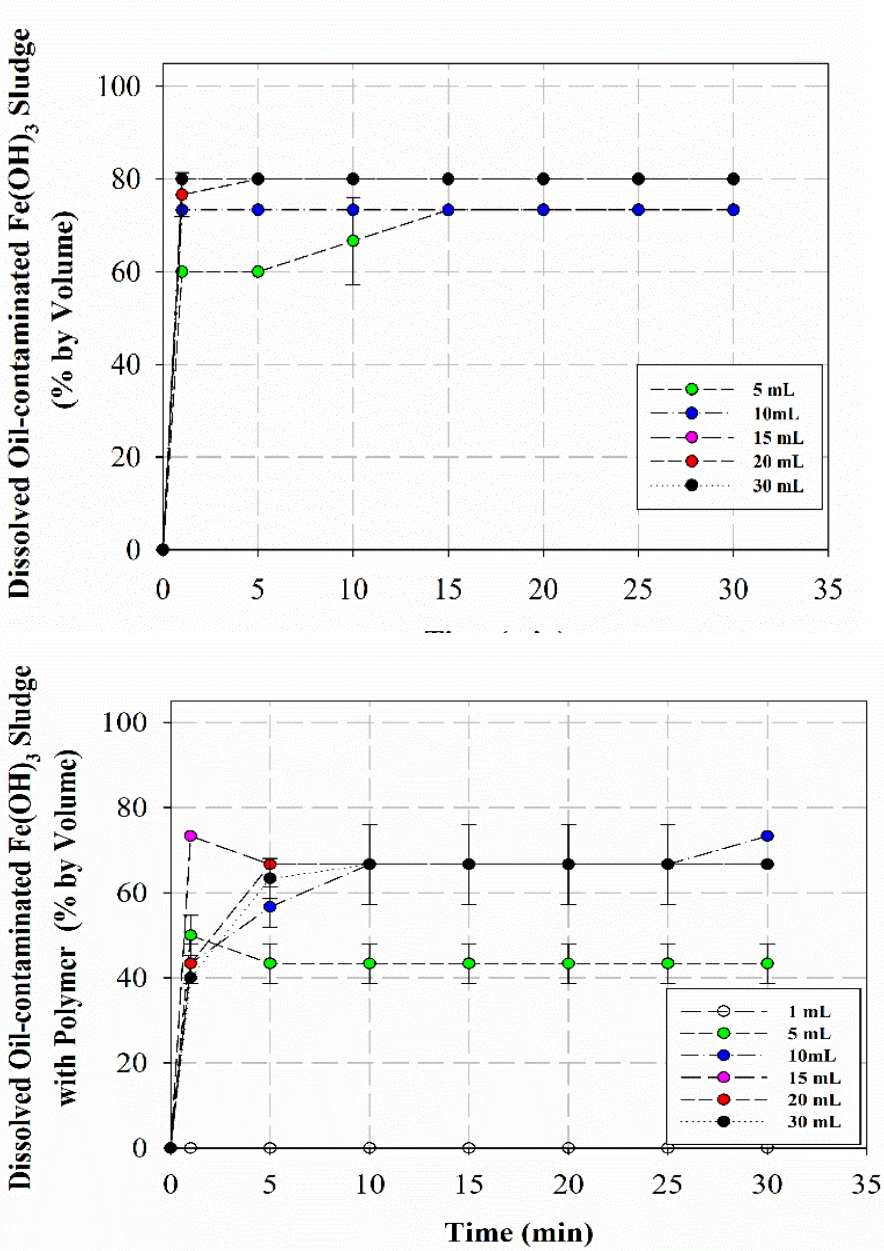




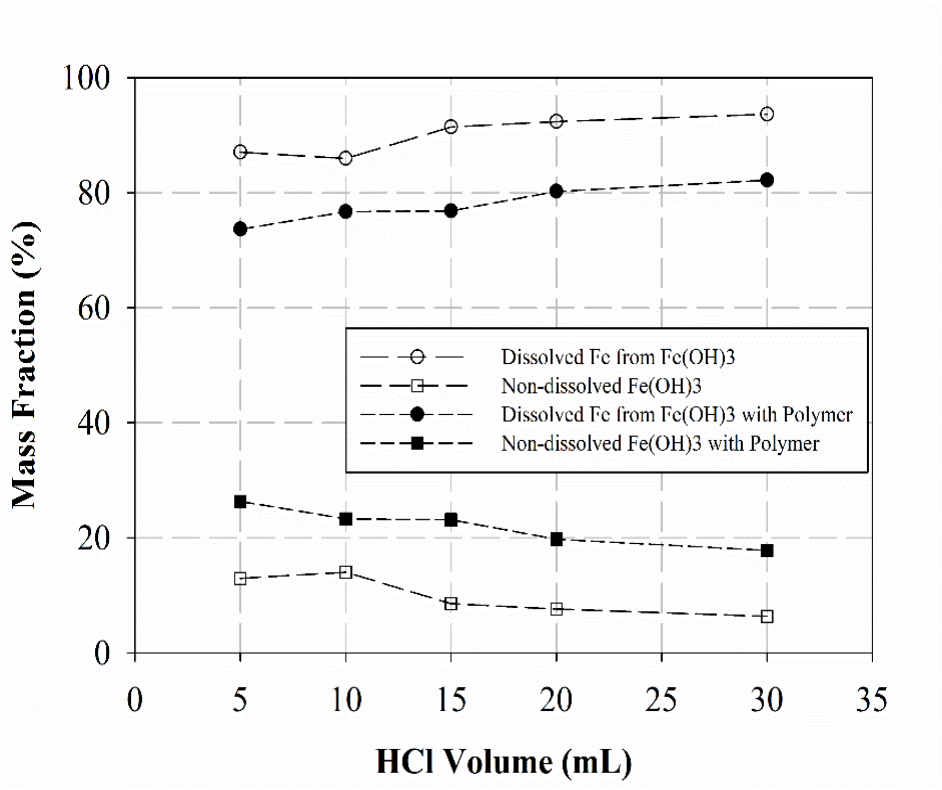
- Without MWF contamination, the $Fe(OH)_3$ to HCl ratios of 3:1 and 3:2 were required to completely recover the $Fe(OH)_3$ sludge without and with the anionic polymer, respectively, in less than 5 min

ACID RECOVERY OF MWF OIL-CONTAMINATED SLUDGE

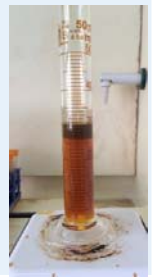
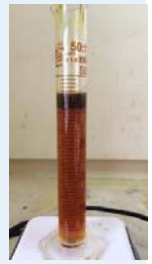
- The presence of MWF oil on the sludge substantially decreased acid recovery of $Fe(OH)_3$.
- Even at 30 min, the $Fe(OH)_3$ to HCl ratios of 3:1 and 3:2 could recover only 87.07% and 73.69% by mass of the iron for the cases without and with the polymer, respectively.
- This coagulant recovery process also yielded 4 L of recovered MWF oil from 19.36 kg of dewatered oil-contaminated $Fe(OH)_3$ sludge.



MASS OF ACID RECOVERY OF IRON COAGULANT



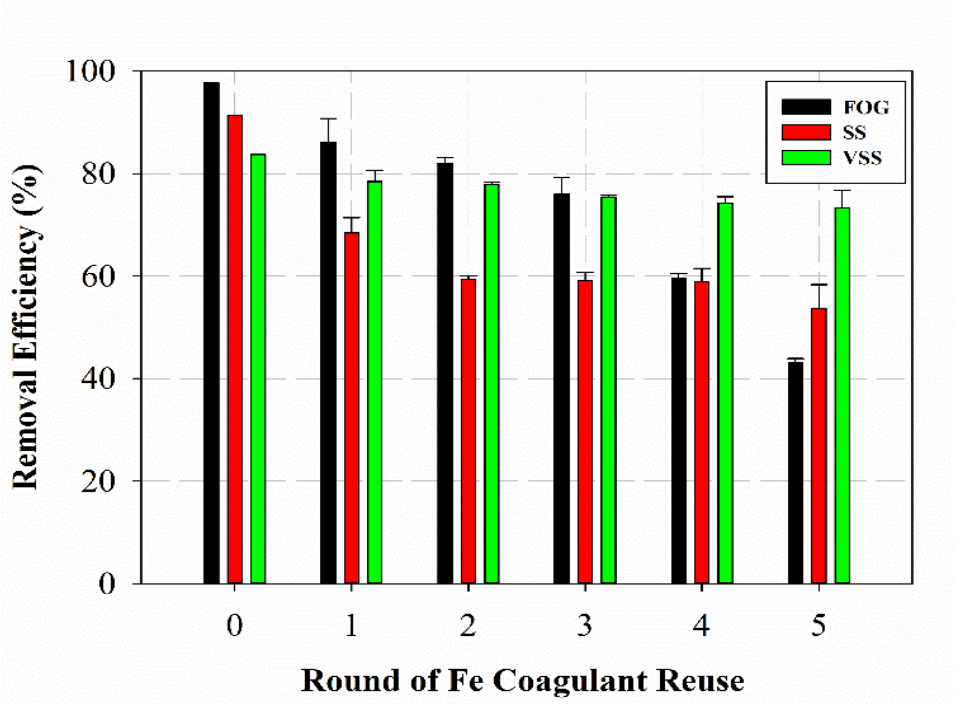
FeCl3 without polyacrylate

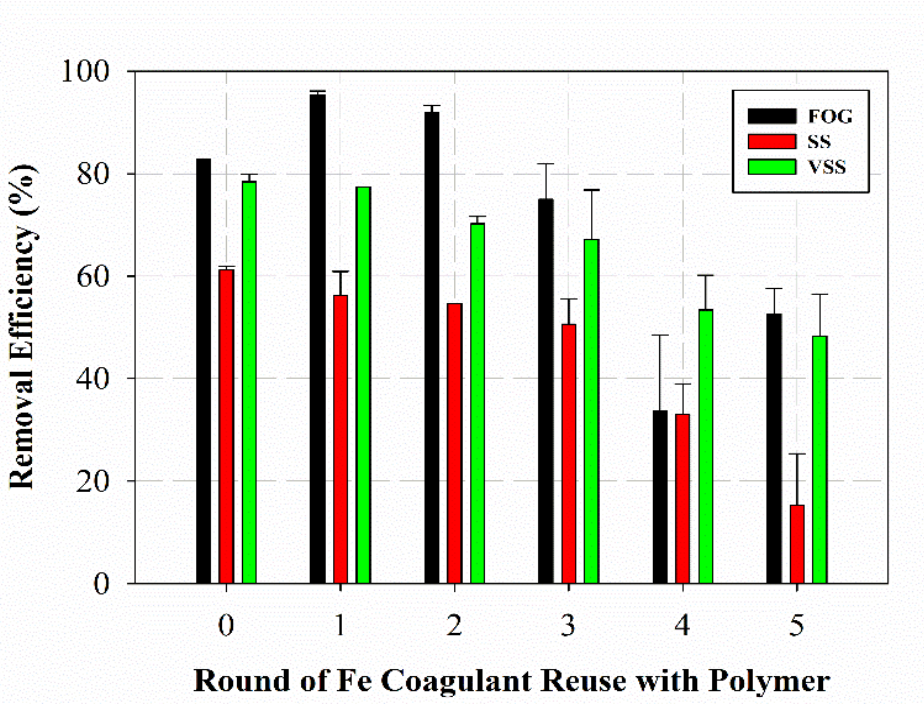
Time	Vol (HCl) Conc. 37%					
	1 ml	5 ml	10 ml	15 ml	20 ml	30 ml
30						

FeCl3 with polyacrylate

Time	Vol(HCl) Conc. 37%					
	1 ml	5 ml	10 ml	15 ml	20 ml	30 ml
30						

FIVE –CYCLE REUSE OF ACID RECOVERED IRON COAGULANT





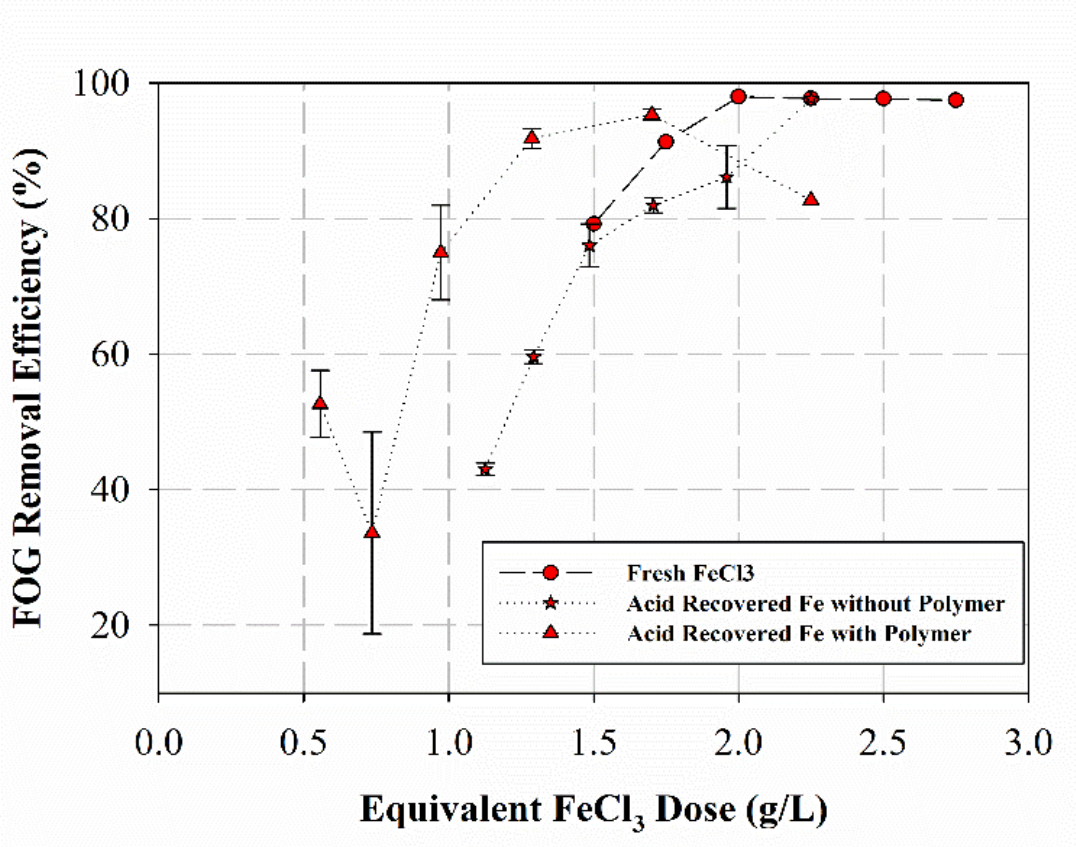
COAGULATION EFFICIENCY PER RECOVERED COAGULANT DOSE

Without Polymer

- the reuse of acid-recovered iron coagulant at the same iron mass = similar treatment efficiency as the fresh FeCl3.
- the decrease of the treatment efficiency = the depletion of Fe coagulant from each subsequent cycle of the acid recovery

With Polymer

- the reuse of acid-recovered iron coagulant with polymer at the same iron mass = better treatment efficiency than the fresh FeCl3.
- the decrease of the treatment efficiency = the rapid depletion of Fe coagulant from each subsequent cycle of the acid recovery



OPERATIONAL COST

- Four cycles of reuse of the acid-recovered iron coagulant without polymer
- we treat 4 m^3 of the MWF wastewater.
- the total cost of treating 4 m^3 of the MWF wastewater using the acid-recovered iron coagulant is 354.85 THB
- 152.45 THB for HCl, 154 THB for NaOH, and 48.40 THB for land disposal of the final sludge)
- while the conventional approach will require 232 THB.
- This recovered oil can be sold at 1 THB per L, gaining 16 THB per 4 m^3 of the treated wastewater.
- Thus, the net cost (total cost minus the benefit) of treating 4 m^3 of the MWF wastewater using the acid-recovered iron coagulant is 338.85 THB

ENVIRONMENTAL COST OF $FECL_3$??

Table 3
A comparison of the CML primary impact characterisations between 1 kg ferric chloride and 1.23 kg ferric sulphate production systems.

Environmental impacts	$FeCl_3$ (1 kg)	$Fe_2(SO_4)_3$(1.23 kg)
Acidification potential (kg SO_2 eq.)	0.0042	0.0011
Eutrophication potential (kg Phosphate eq.)	0.003	0.001
Freshwater aquatic ecotoxicity potential (kg 1,4 Dichlorobenzene (DCB) eq.)	0.5894	0.1764
Global warming potential (kg CO_2 eq.)	0.8343	0.2153
Human toxicity potential (kg DCB eq.)	1.1424	0.3778
Marine aquatic ecotoxicity potential (kg DCB eq.)	1658.4144	486.5444
Ozone layer depletion potential (Carbon trichlorofluoride eq.)	1.05×10^{-6}	1.12×10^{-8}
Photochemical oxidant creation potential (kg Ethylene eq.)	0.0003	7.67×10^{-5}
Terrestric ecotoxicity potential (kg DCB eq.)	0.0332	0.0063

BEST FOR WASTE TREATMENT FACILITY WITH ACID WASTE

- If a waste treatment company also has acid waste, it can be utilised to replace fresh HCl for the acid solubilisation of the sludge.
- With this waste combination approach, the total cost of treating 4 m^3 of the MWF wastewater using the acid-recovered iron coagulant is 186.40 THB which becomes substantially cheaper than the conventional approach.

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