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Removal Of Manganese Using Polymer Gel Composites

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The accumulation of Manganese (Mn) may cause hepatic encephalopathy.

Almost 50% area of Bangladesh contains groundwater with Mn concentrations greater than the World Health Organization (WHO) health-based drinking water guidelines.

After Arsenic (As), Mn is the most concerning component in most of the rivers and groundwater in Bangladesh.

As and Mn were among the most critical pollutants for drinking water in the South African region.

Simultaneous removal of As and Mn is urgently required

Previous studies

Iron hydroxide (γ-FeOOH)

◎ Adsorbed Mn effectively.

✓ But Mn could be adsorbed at controlled (higher) pH level.

✓ Studies were not performed at the natural water conditions.

Sung et al. *Geochimica et Cosmochimica Acta* **1981**, *45*, 2377–2383

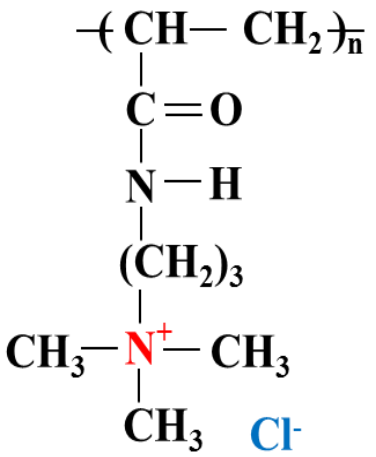
Composite of cationic / non-ionic polymer gel and iron hydroxide

Cationic gel **(DMAPAAQ)** + Iron Hydroxide **(γ-FeOOH)**

or

Non-ionic gel **(DMAA)** + Iron Hydroxide **(γ-FeOOH)**

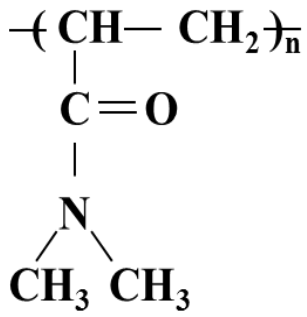
→ **Adsorption of Arsenic + Adsorption of Manganese**



Structure of *N,N'*-dimethylamino propylacrylamide, methyl chloride quaternary **(DMAPAAQ).**

Objectives

- ✓ To compare the cationic and non-ionic polymer gel composites for the removal of Mn from water.
- ✓ To study the adsorption of Mn at the natural water conditions.
- ✓ To study the simultaneous adsorption of As and Mn, for the first time.



Structure of *N,N'*-Dimethyl acrylamide **(DMAA).**

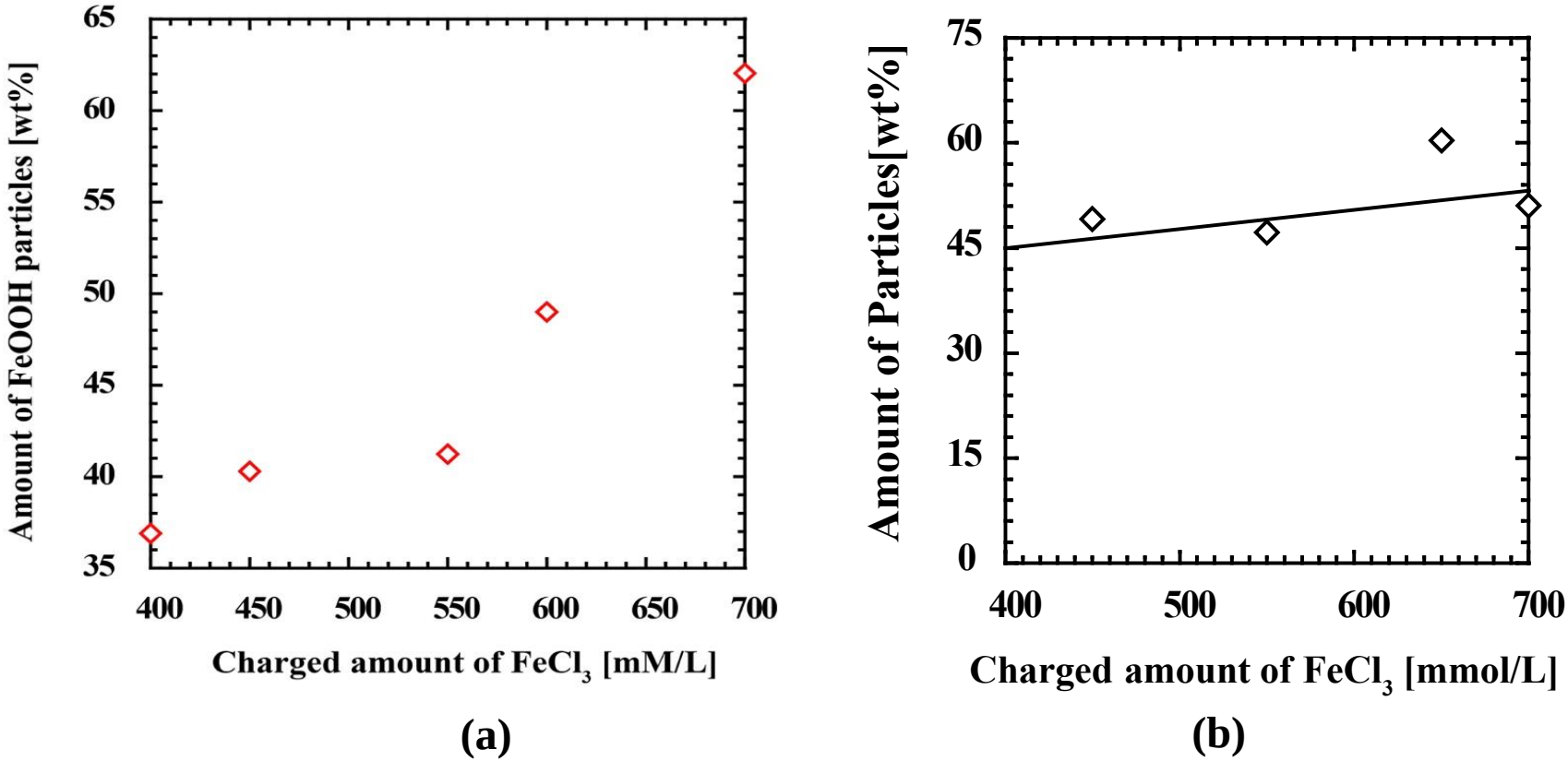


Fig. Thermogravimetric analysis to analyze the Content of FeOOH in **(a)** DMAPAAQ+FeOOH gel composite and **(b)** DMAA+FeOOH gel composite.

Safi et al. *Scientific Reports* **2019**, *9*, 11909

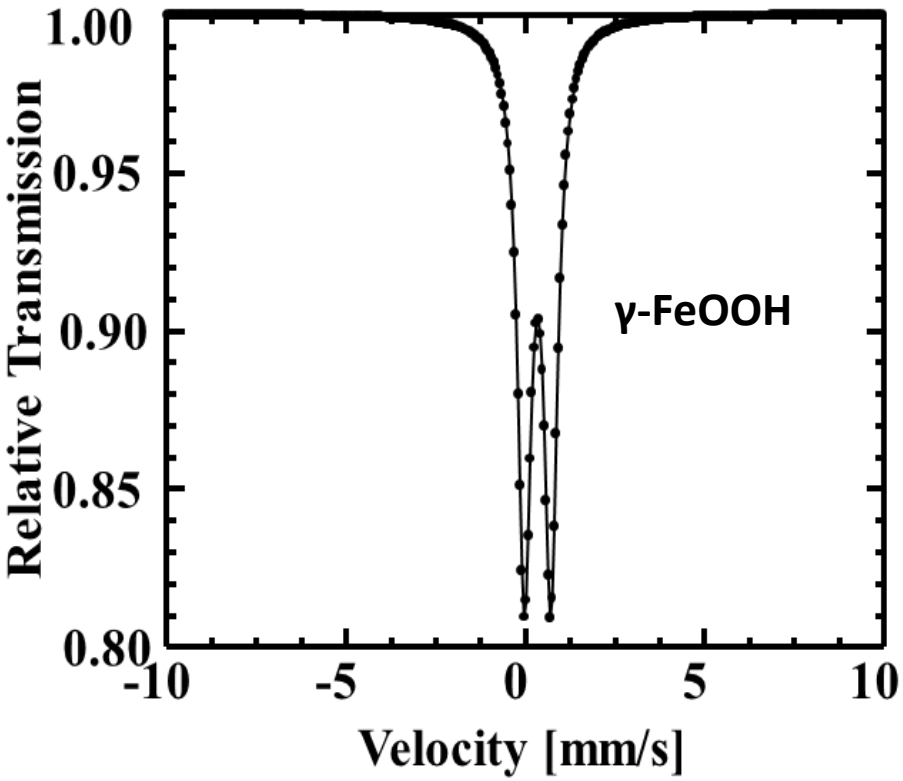
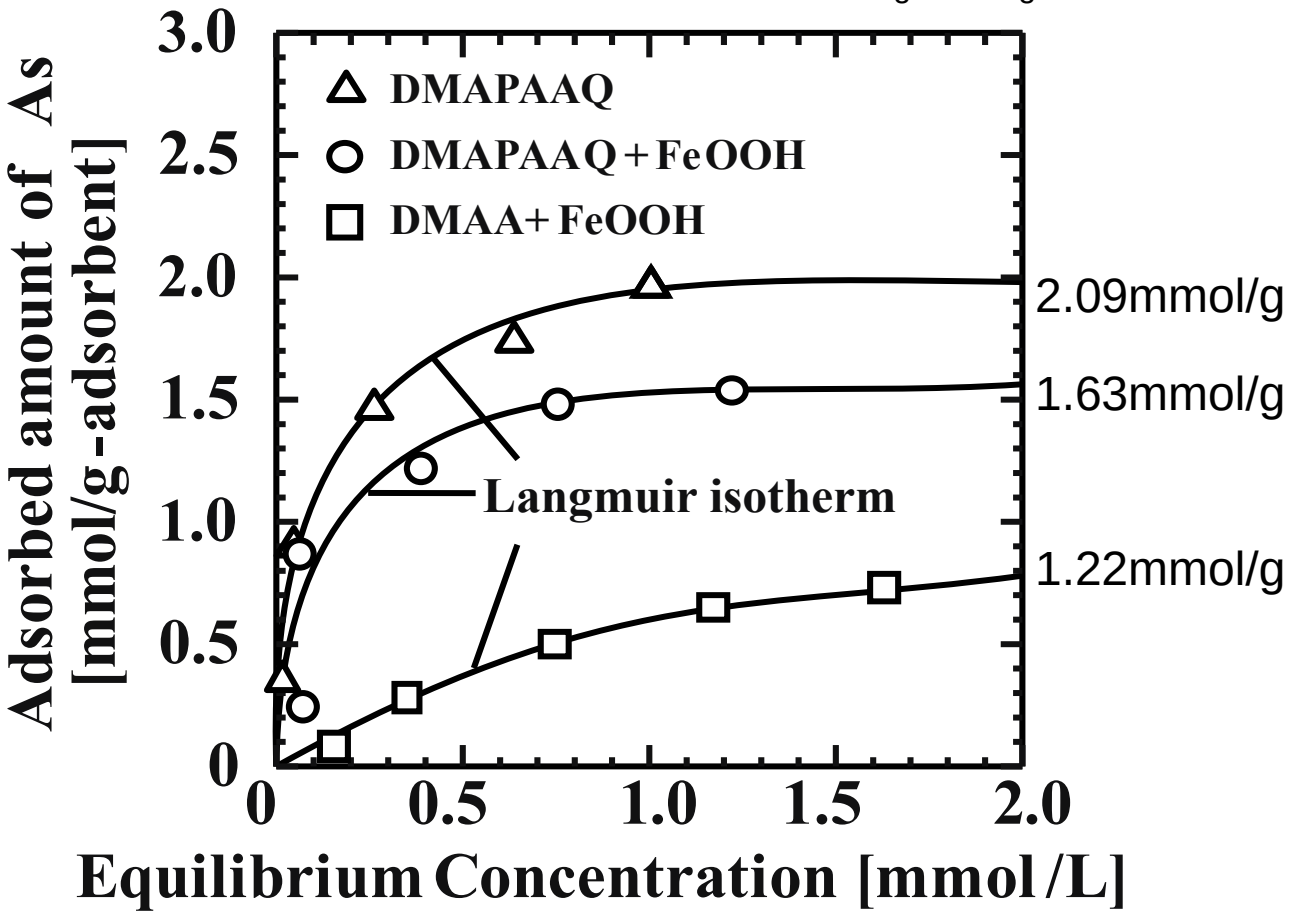


Fig. Mössbauer spectroscopy of DMAPAAQ+FeOOH gel composite shows the type of FeOOH particles in the gel was γ-FeOOH .

Safi et al. *Scientific Reports* **2019**, *9*, 11909

Research Background : Arsenic Adsorption Performance

Adsorption period: 24hr
Temperature: 20℃
Volume of As: 40ml
Gel weight: 20mg



Safi et al. *Chemosphere* **2019**, *217*, 808–815

Methods: Preparation of the Gel Composites

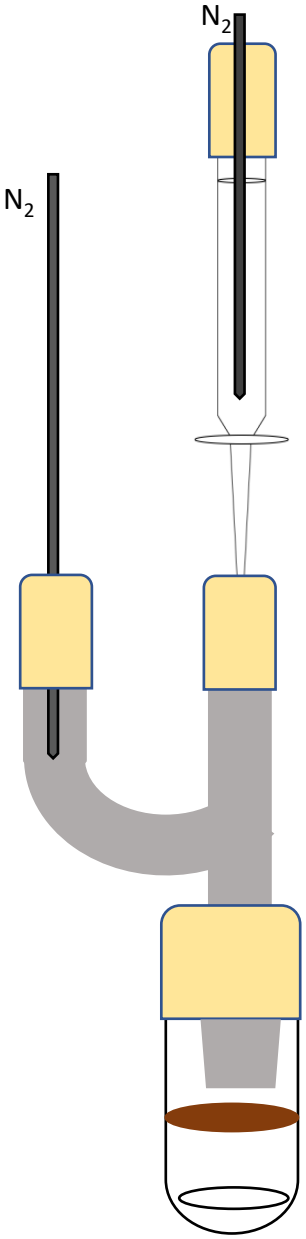
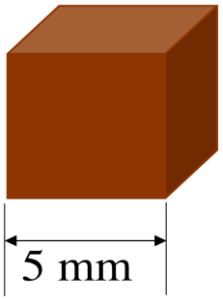


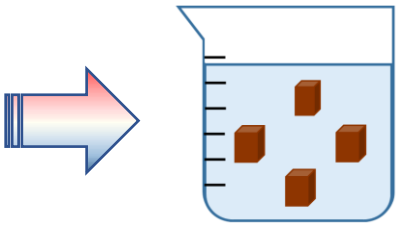
Table. Composition of cationic gel and Iron hydroxide

	Chemicals	mol/m³
Monomer	DMAPAAQ, DMAA	375
Crosslinker	N,N'-Methylene bisacrylamide (MBAA)	50
Accelerator	Sodium Sulfite	80
	Sodium Hydroxide (NaOH)	2100
Initiator	Ammonium peroxodisulfate (APS)	30
	Ferric Chloride ($FeCl_3$)	700

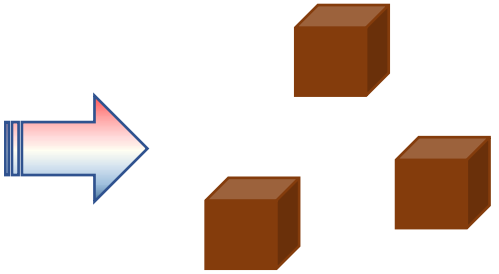
Solvent : Water	Temperature : 10℃	Reaction time : 4 hours	N_2 Synthesis: 10 minutes



Gel Composite



Cleaned the Gel with distilled water for 24 hour

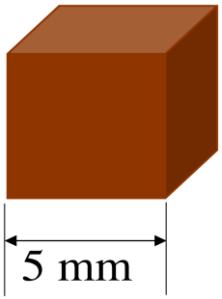


Dried in oven at 50℃ for 24 hour

$FeCl_3 + 3NaOH \rightarrow Fe(OH)_3 + 3NaOH$

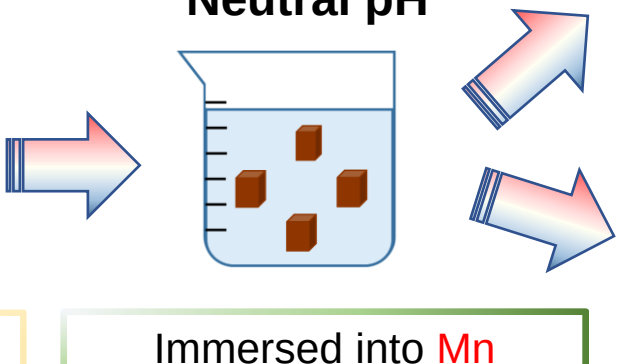
Safi et al. *Chemosphere* **2019**, *217*, 808–815,
Safi et al. *Journal of Visualized Experiments* **2019**, e59728

Methods: Adsorption Experiment

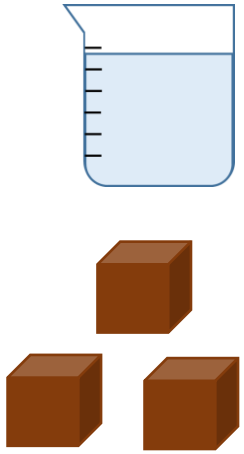


DMAPAAQ+ FeOOH Gel Composite

24 h, 25℃
Neutral pH



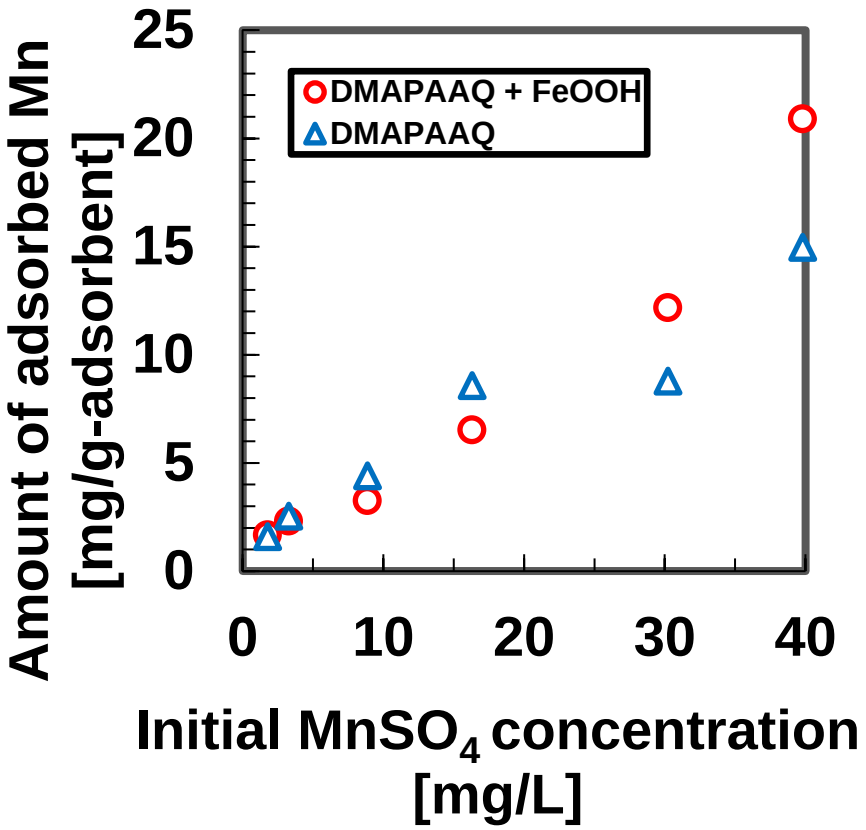
Immersed into Mn solution for adsorption



Mn-free water

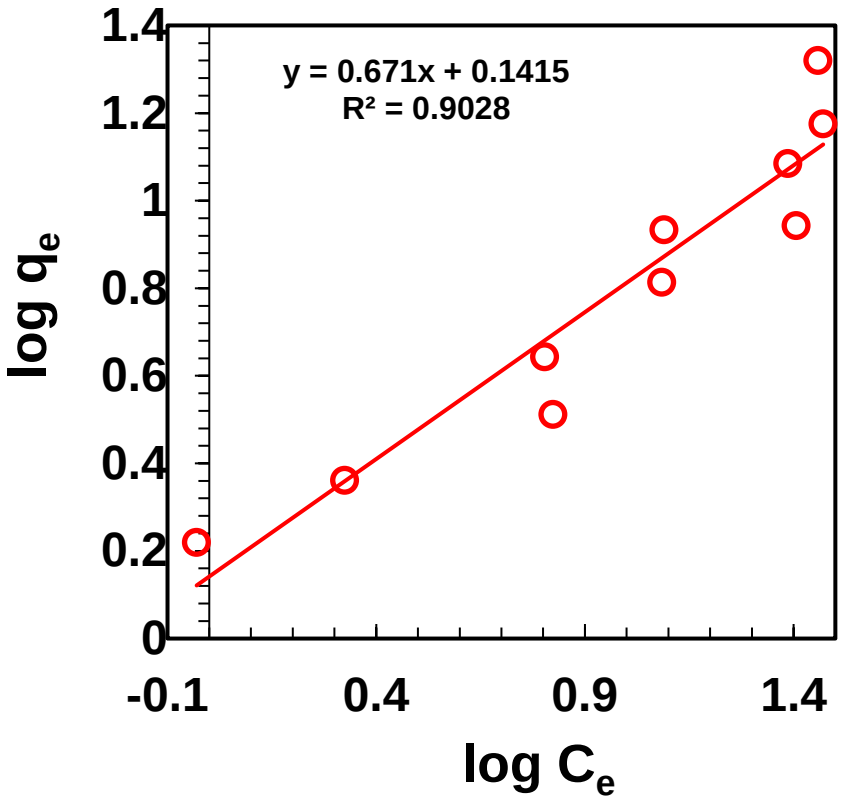
The Gels carried Mn out of water.

Result : Adsorption Of Mn Using Cationic Gels

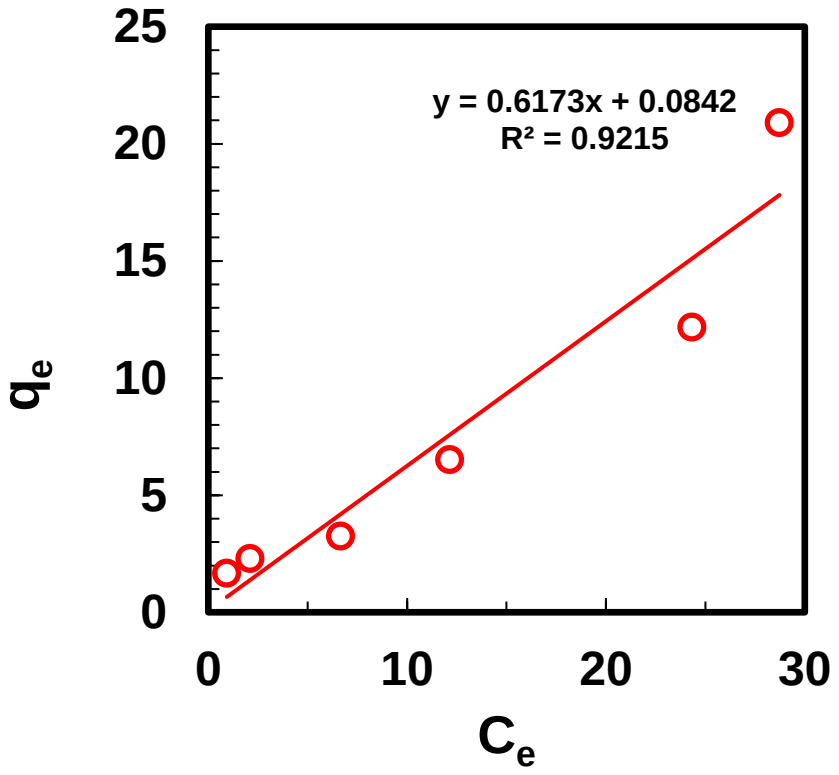


- The removal of Mn could be achieved effectively by both the cationic gel, DMAPAAQ, and the cationic gel composite, DMAPAAQ + FeOOH.
- The adsorption of Mn by DMAPAAQ + FeOOH was higher than that of DMAPAAQ.
- The highest amount of adsorption of Mn by DMAPAAQ and DMAPAAQ + FeOOH were 14.96 and 20.89 mg/g respectively.

Result : Adsorption Of Mn Using Cationic Gels



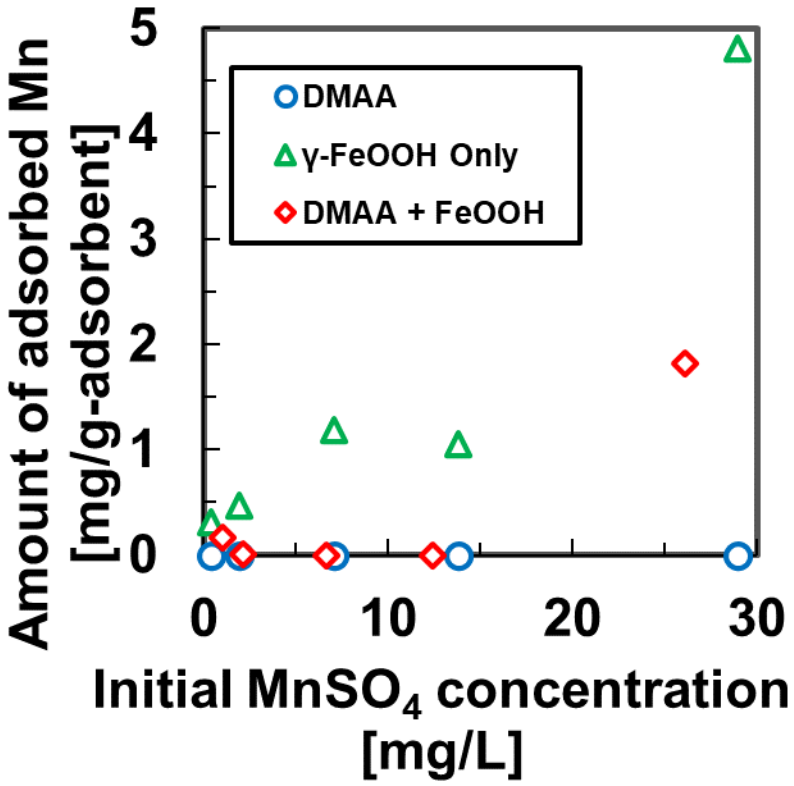
Freundlich isotherm



Langmuir isotherm

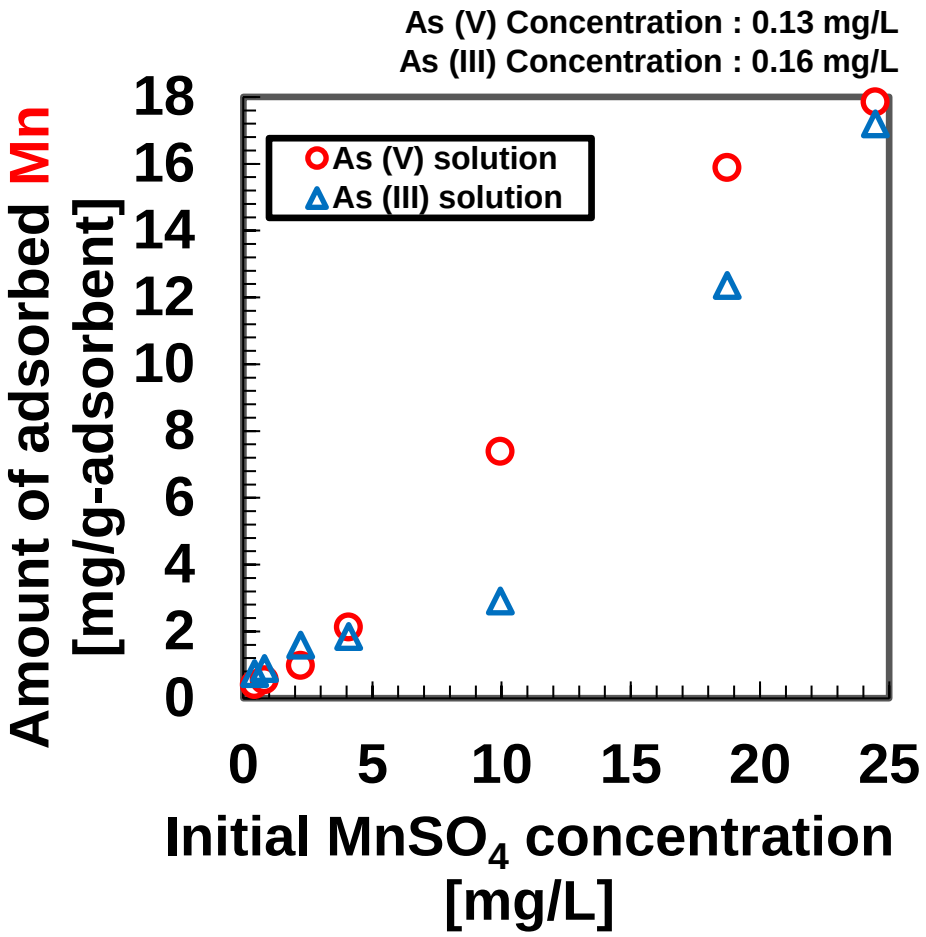
- The adsorption of Mn by DMAPAAQ + FeOOH gel followed both Freundlich and Langmuir isotherms with R^2 values of 0.9 and 0.92 respectively.
- Hence, the adsorption isotherm fits better with Langmuir isotherm.

Result : Adsorption Of Mn Using Non-ionic Gels



- The adsorption of Mn by a non-ionic gel was not possible unless the gel was impregnated with γ-FeOOH.
- The adsorbed amount of Mn by DMAA + FeOOH, γ-FeOOH and DMAA gel were 0.78, 2.4 and 0 mg/g respectively.
- Because of the presence of γ-FeOOH in the DMAA + FeOOH gel structure, 0.78 mg/g adsorption of Mn could be achieved.

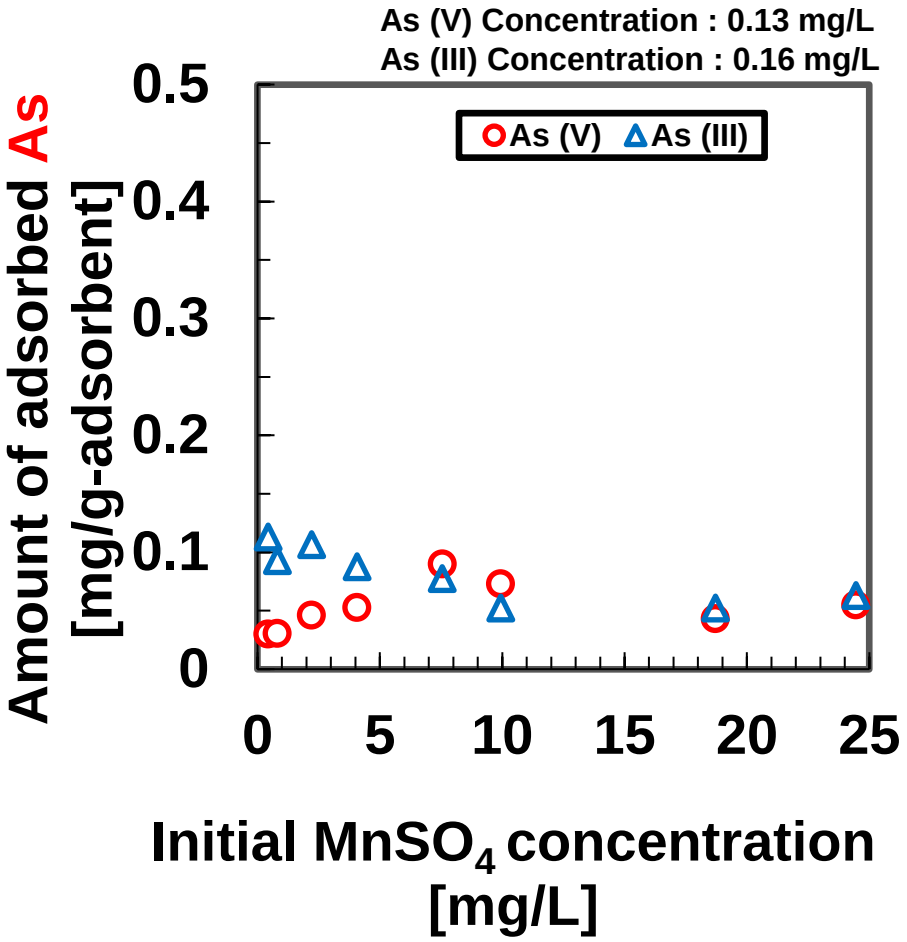
Adsorption of Mn in the presence of As



- The adsorption of Mn had almost no deviation due to the presence of arsenic, when the results were compared with the values of Mn adsorption with the same adsorbent when As was not added in the solution.

Result : Simultaneous Adsorption of As and Mn

Adsorption of As in the presence of Mn



- The adsorption of As (III) and As (V) almost remained constant despite the variation in the concentration of Mn solution.

Conclusions

- Mn could be effectively removed by DMAPAAQ gel, DMAPAAQ + FeOOH gel composite, DMAA + FeOOH gel composite, and γ-FeOOH at the natural water conditions.
- The highest amount of adsorption of Mn could be achieved was 20.89 mg/g by DMAPAAQ + FeOOH gel composite.
- For the first time, we performed the study of simultaneous adsorption of As and Mn because removing an anion and a cation using a cationic adsorbent was not done previously.
- Both As and Mn could be removed simultaneously as the DMAPAAQ polymer adsorbed As by ionic exchange and γ-FeOOH components adsorbed Mn.