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Proceedings

5-27-2018

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# ANALCIME GEOPOLYMERS AS SORBENTS IN WATER TREATMENT

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## Introduction

### ❖ Analcime

- ✓ Zeolite mineral [$Na_{16}(Al_{16}Si_{32}O_{96})\cdot 16H_2O$] formed in mining industry as lithium carbonate is produced from spodumene ($LiAlSi_2O_6$)
- ✓ Zeolite structure possess aluminosilicate framework and pores are occupied by water and exchangeable cations
- ✓ Zeolites act as cation exchangers → applications as sorbents in water treatment

### ❖ Geopolymers

- ✓ Geopolymers (GP) consist of an anionic framework of corner-sharing $SiO_4$ and $AlO_4$
- ✓ GP are x-ray amorphous unlike zeolites
- ✓ Exchangeable cations are located in the voids same way as in zeolites → excellent sorbent materials in water treatment for e.g. $As^{3+}$ ,$Cu^{2+}$, $NH_4^+$, $Ni^{2+}$
- ✓ The ion-exchange capacity of analcime at room temperature is quite low → in this study, analcime was geopolymerized to increase adsorption capacity towards $NH_4^+$

## Materials and Methods

GP were produced with silicate and/or NaOH to improve the sorption properties of analcime. Metakaolin was used as a blending component. Detailed production steps are presented in Table 1.

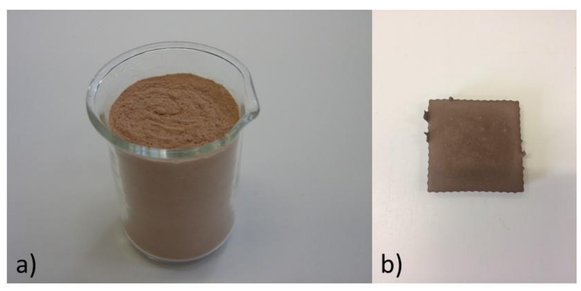


*Figure 1. a) Analcime and b) produced analcime geopolymer.*

Table 1. Production conditions for GPs.

| Pretreament | Drying | Raw material + Calcination | Geopolyme-rization chemical | Sample |
|---|---|---|---|---|
| - | 105°C. 24-48 h | Analcime-metakaolin (3:1) | NaOH+ Na-silicate | GP1 |
| 2 M HCl washing. 10 g/200 mL. 24 h | 105°C. 24-48 h | Analcime | Na-Silicate | GP2 |
| 2 M HCl washing. 10 g/200 mL. 24 h | 105°C. 24-48 h | Analcime, calcined 400 ˚C 2 h | NaOH+ Na-silicate | GP3 |
| - | - | Analcime-metakaolin (3:1) | NaOH+ potassium silicate | GP4 |
| - | 105°C. 24-48 h | Analcime-metakaolin (5.7:1) | NaOH+ potassium silicate | GP5 |

Then analcime GP were applied as sorbents in the removal of $NH_4^+$. Before sorption experiments, the GP were crushed and sieved to a particle size <150 µm and washed with deionized water until pH was stable. Experiments were conducted in batch mode with synthetic wastewater. The effect of pH, sorbent dosage, and $NH_4^+$ concentration on the sorption capacity of analcime GP were studied.

## Results

### ❖ Effect of pH

The effect of pH was studied in pH values 2, 4, 6 and 8. Ammonium will form ammonia in alkaline conditions (Fig. 2). Therefore, pH was controlled to be under 9 during studies.

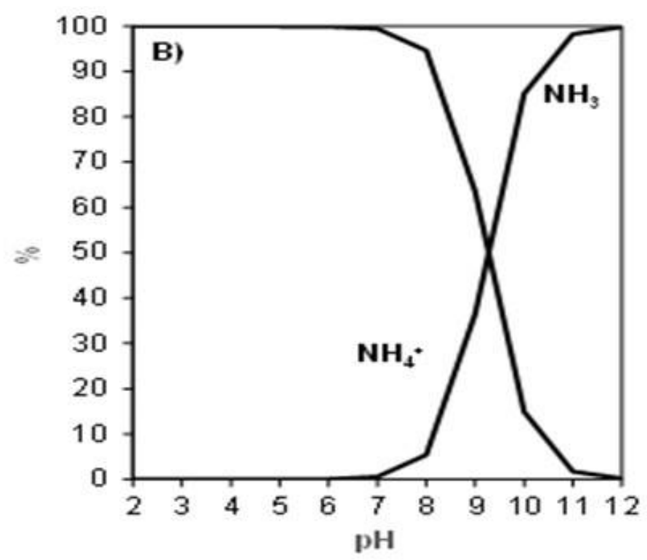


*Figure 2. Ammonium-ammonia speciation as a function of pH.*

### ❖ Effect of sorbent dosage

The sorbent doses 0.5, 1, 2, 5, 10 and 20 g/L were used in the experiments. Removal % of ammonium increased with increasing sorbent dose and at the same time pH increased strongly.

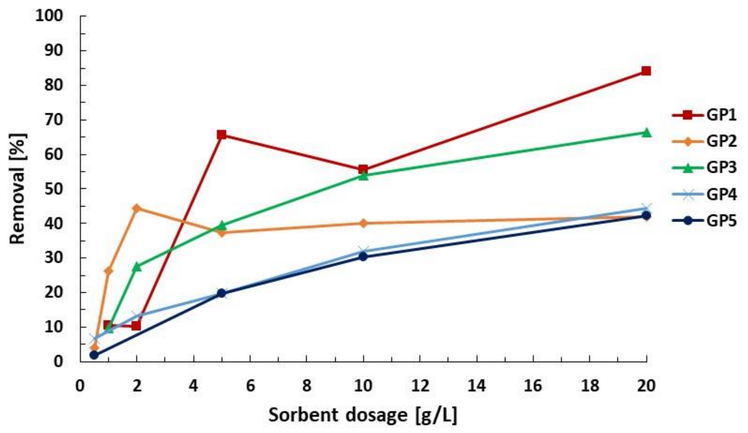


*Figure 3. Effect of sorbent dose on ammonium removal % with different analcime geopolymers. In all cases, $C_0(NH_3)$: ~50 mg/L, pH<9, contact time: 24 h, room temperature (~23 ˚C).*

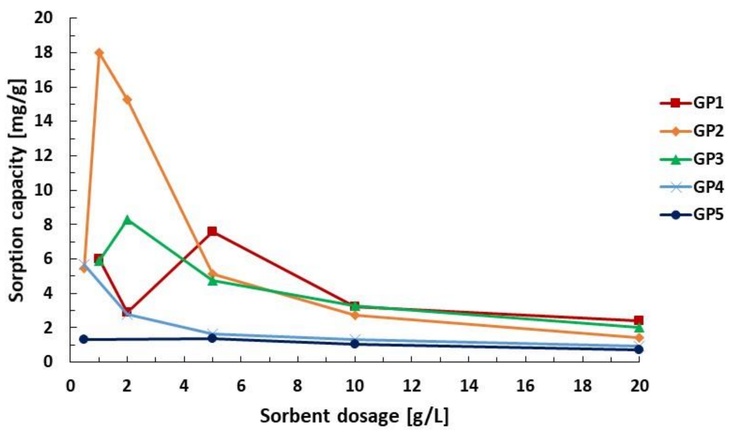


*Figure 4. Effect of sorbent dose on ammonium sorption capacity [mg/g] with different analcime geopolymers. In all cases, $C_0(NH_3)$: ~50 mg/L, pH<9, contact time: 24 h, room temperature (~23 ˚C).*

### ❖ Effect of initial $NH_4^+$ concentration

The initial ammonium concentration from 5 to 1000 mg/L were used. Concentrations were selected from practical reasons because sorbents should be suitable in a wide range of concentrations. Ammonium concentration in wastewaters from mining industry are typically quite low (below 50 mg/L) and from agricultural sources even 1000 mg/L.

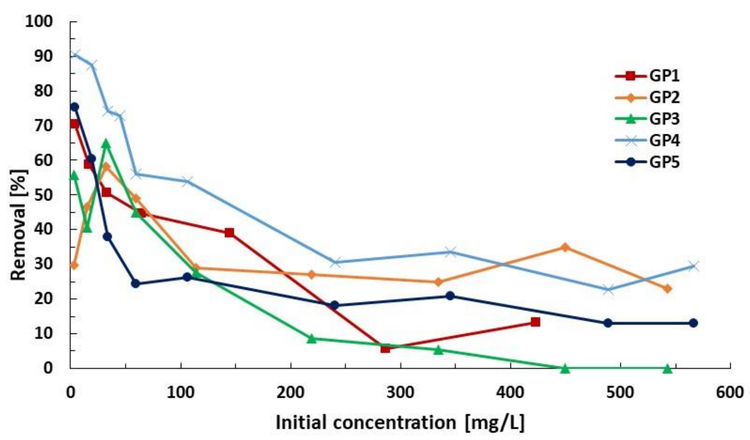


*Figure 5. Effect of initial concentration on ammonium removal % with different analcime geopolymers.. In all cases, m(sorbent): 5 g/L, pH<9, contact time: 24 h, room temperature (~23 ˚C).*

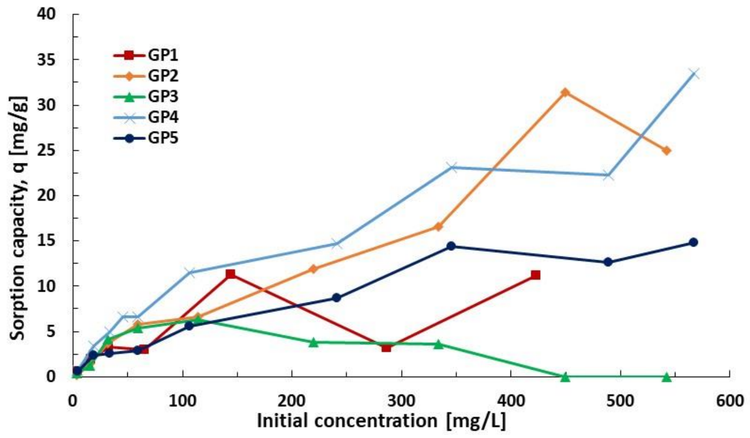


*Figure 6. Effect of initial concentration on ammonium sorption capacity [mg/g] with different analcime geopolymers. In all cases, m(sorbent): 5 g/L, pH<9, contact time: 24 h, room temperature (~23 ˚C).*

## Conclusions

- ➢Different types of analcime-based geopolymers were prepared and tested as a sorbent in ammonium removal
- ➢Ammonium removal efficiencies were clearly higher at higher sorbent dosage
- ➢The results indicate that analcime GP could be used as sorbents in water treatment
- ➢The use of the analcime GP in water treatment could lead to cost savings in water treatment as a low-cost by-product based GP are used instead of the commercial ion exchange resins

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**Further information**

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**Acknowledgements**

The authors would like to thank Keliber Oy for providing the material to this research. In addition, authors would like to thank Maa- ja vesitekniikan tuki ry. for the financial support.

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