PREPARATION OF MAGNETIZED BIOPOLYMER-CLAY ADSORBENTS

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Introduction

- Many water pollutants, that are either not biodegradable or that biodegrade very slowly, are causing numerous environmental problems and also tend to accumulate in aquatic organisms causing a range of diseases.
- The pollutants can be removed from contaminated waters by adsorption, electrodialysis, flocculation, ion exchange, precipitation, reverse osmosis, and other techniques.
- Adsorption is frequently the simplest to apply but is not always the most economic technique because of the price of synthetic adsorbents.
- Clays are inexpensive and relatively efficient adsorbents but are, due to their colloidal nature, rather hard to separate from water (1).
- However, magnetized clay adsorbents can easily be removed from water with either permanent magnet or electromagnet.
- The objectives of this work were: to study the magnetization of clay:biomaterial aggregates at different:
  - [clay]/[biomaterial],
  - $[Fe^{3+}]/[Fe^{2+}]$ ratios, and
  - to develop a simple model for detection of optimal conditions for magnetization of aggregates.

Methods and Materials

- We prepared nano-size adsorbents from:
  - two clays (bentonite and kaolin), and
  - two biomaterials (humic acids and starch).
- Freshly prepared absorbents where then coated with magnetite (2).
- The absorbents were prepared at five clay/biomaterial weight ratios in the range 2.5 to 27.6 and then magnetized at five Fe^{3+}/Fe^{2+} molar ratios in the range 0.60 to 3.90.
- Magnetite coated absorbents were separated from suspension using a low intensity magnet (7.69+0.80 mT).
- Adsorbents were tested in simultaneous adsorption on nitrate (NO_3) and phosphate (PO_4).
- The Response Surface Methodology (RSM) was used to plan the experiments and analyze results.

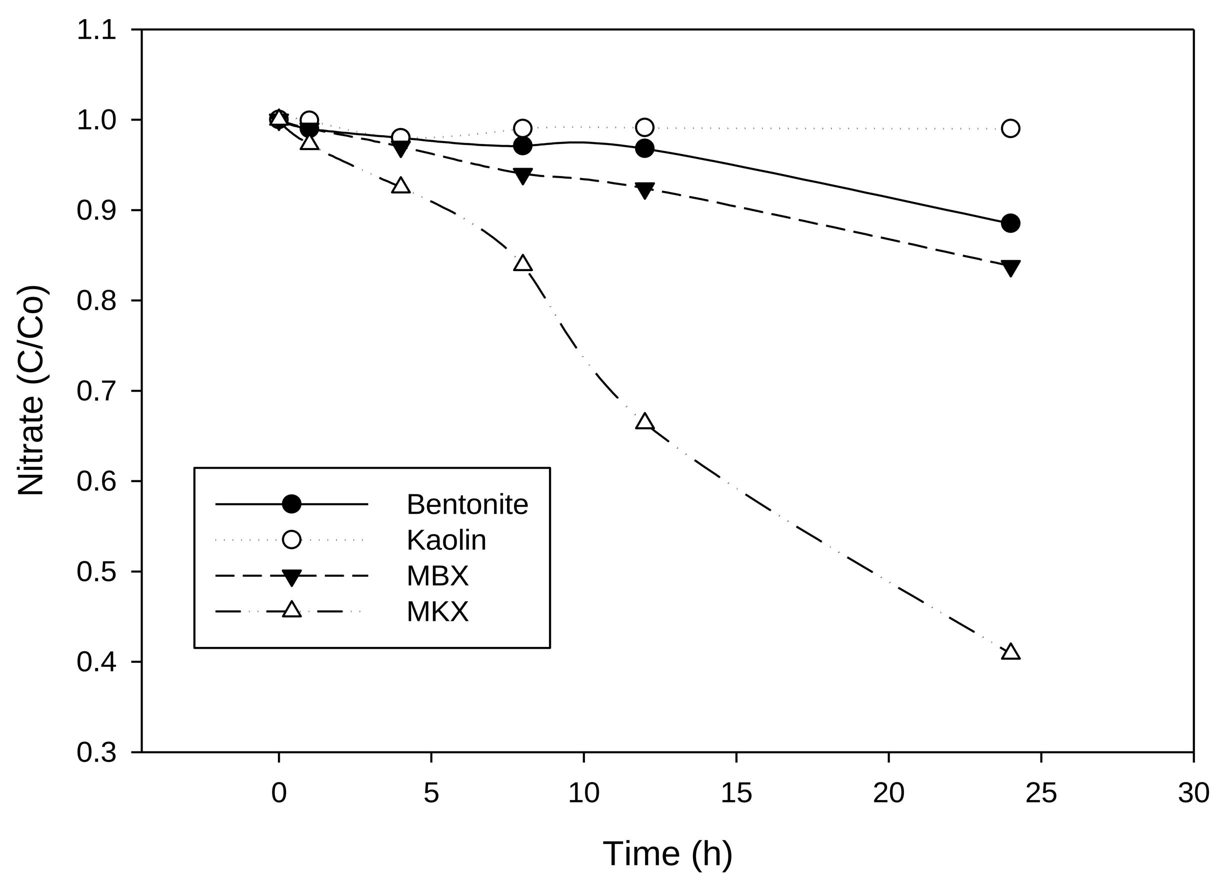

Figure 1. Nitrate Adsorption (MBX=magnetized Bentonite:Starch aggregates; MKX = magnetized kaolin:starch aggregates).

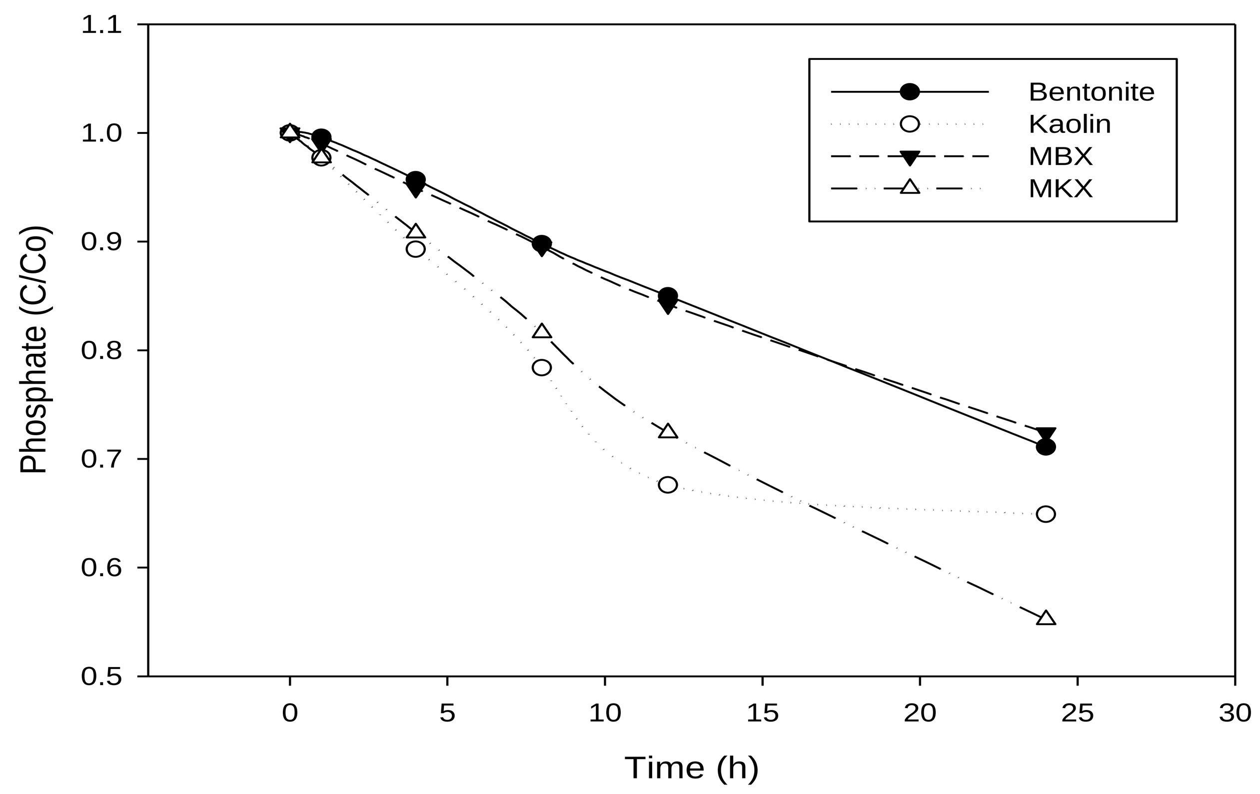

Figure 2. Phosphate Adsorption (MBX=magnetized Bentonite:Starch aggregates; MKX = magnetized kaolin:starch aggregates).

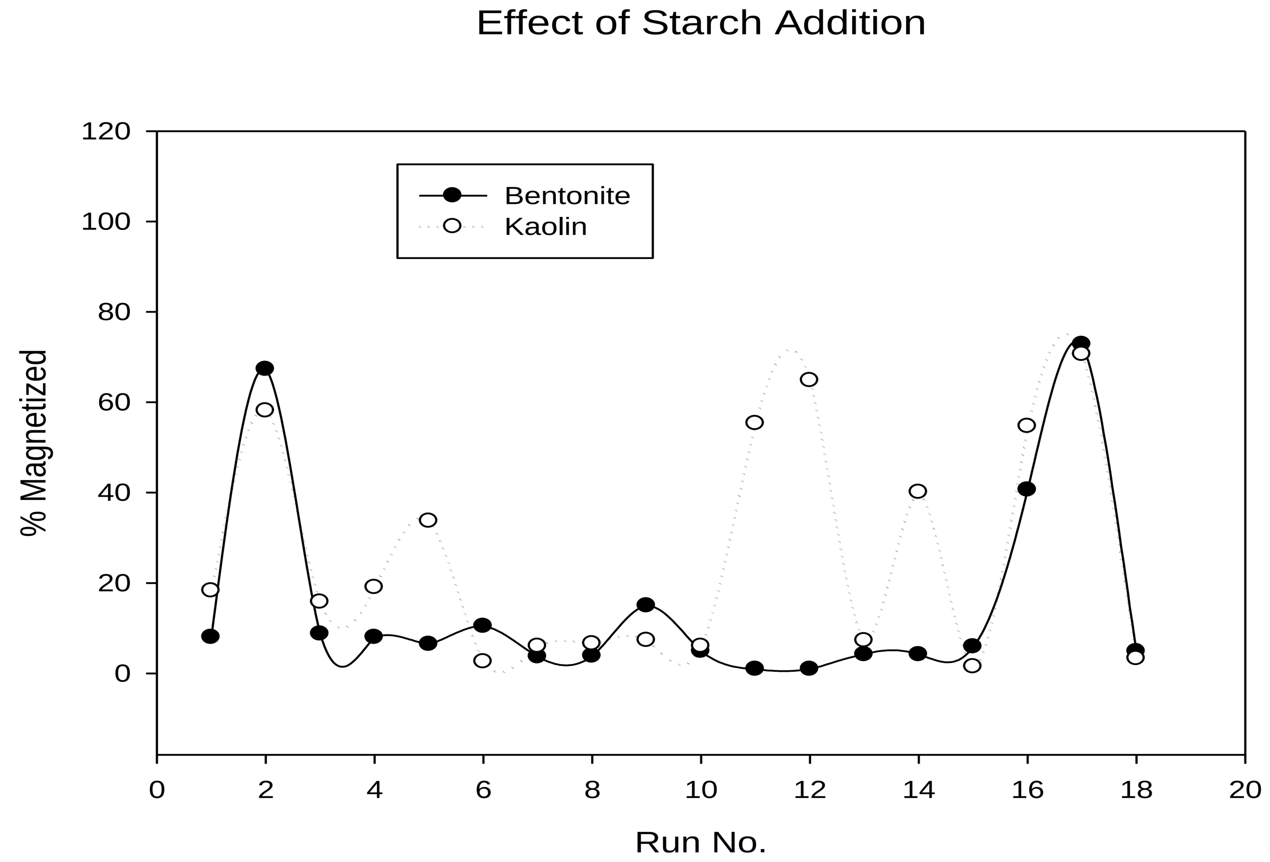

Figure 3. Magnetization of Bentonite:Starch (Bentonite) and Kaolin:Starch (Kaolin) Aggregates

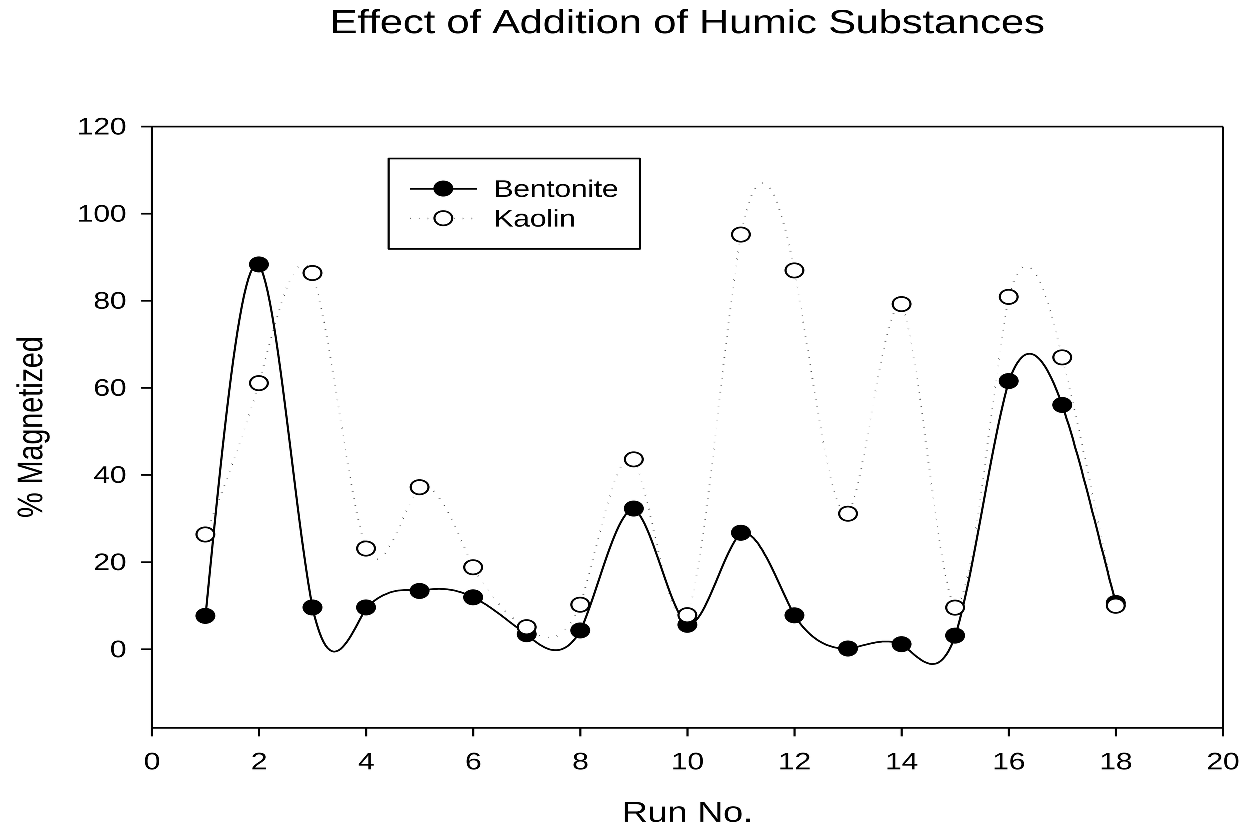

Figure 4. Magnetization of Bentonite:Humic Acid(Bentonite) and Kaolin:Humic Acid (Kaolin) Aggregates

RATIO	AGGREGATES			
	BENTONITE STARCH	KAOLIN STARCH	BENTONITE HUMIC	KAOLIN HUMIC
[Clay] / [Biomaterial]	6.1	6.1, 15, 24	6.1	2.5, 6.1. 15, 24
$[Fe^{3+}]/[Fe^{2+}]$	0.6, 1.1	0.6, 1.1	0.6, 1.1	0.6, 1.1, 2.3, 3.9

Table 1. Optimal [Clay]/[Biomaterial] and $[Fe^{3+}]/[Fe^{2+}]$ Ratios for Preparation of Magnetized Aggregates

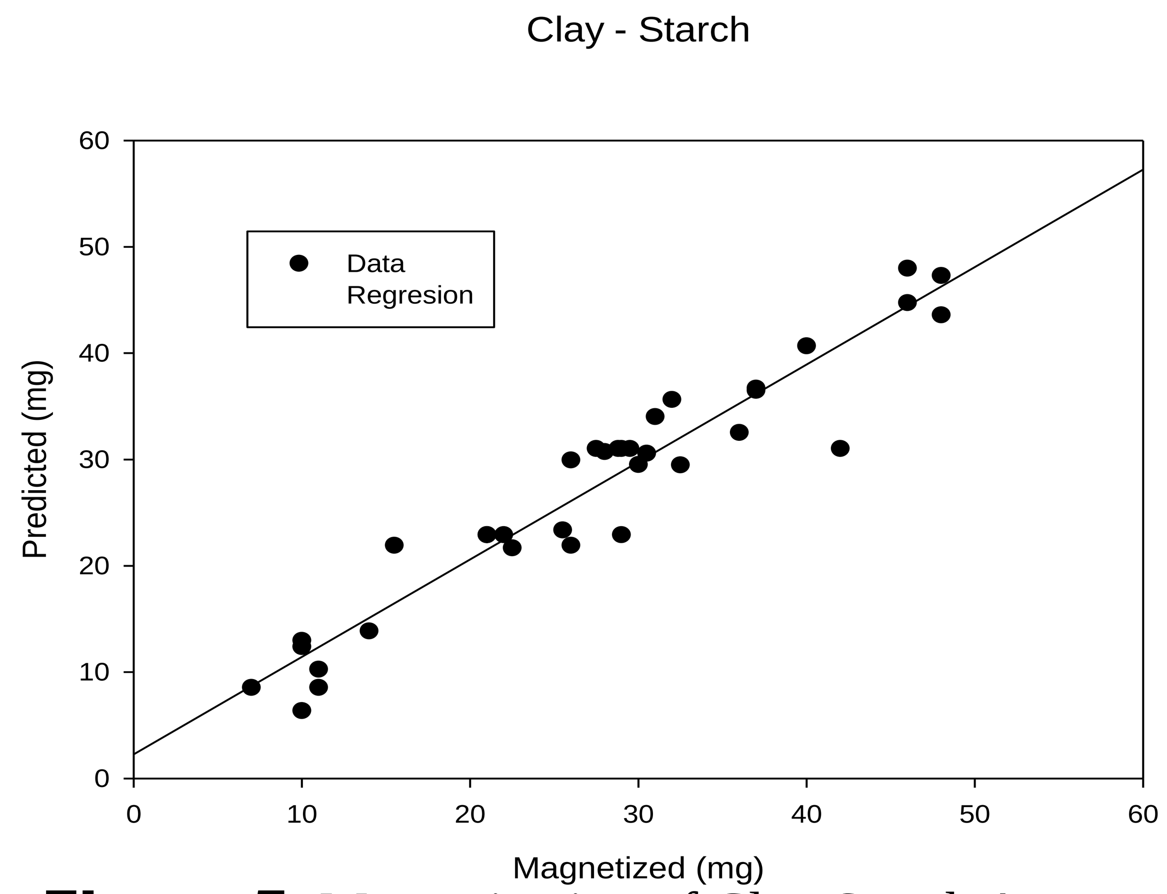

Figure 5. Magnetization of Clay:Starch Aggregates - Experimental and Modeling Results.

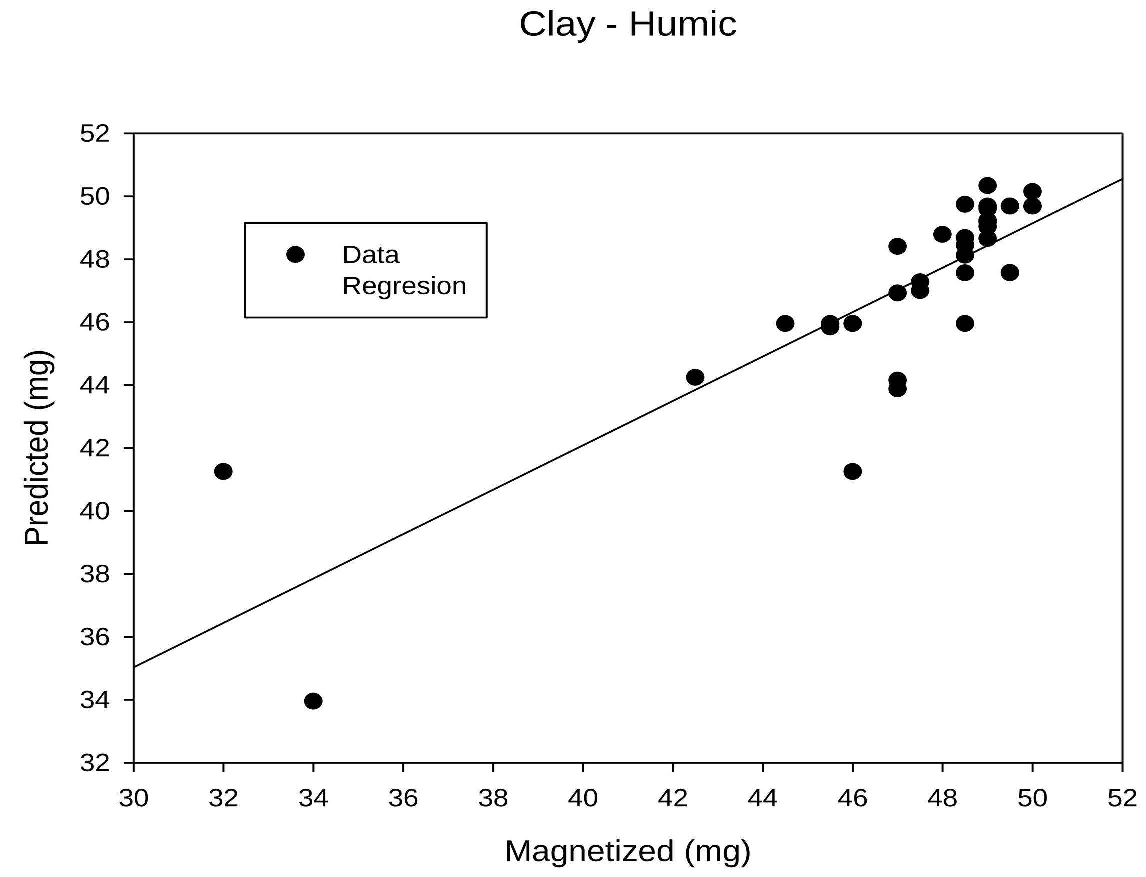

Figure 6. Magnetization of Clay:Humic Acids Aggregates -Experimental and Modeling Results.

CONCLUSIONS

Maximal concentration of magnetized absorbent in bentonite/starch and in kaolin/starch suspensions was detected at:
clay/starch weight ratio of 6.1 and
Fe^{3+}/Fe^{2+} molar ratio of 0.6 and 1.1.

Maximal concentration of magnetized absorbents in bentonite/humic acids and in kaolin/humic acids suspensions was also detected at:
a.clay/humic acid weight ratio of 6.1 and
Fe^{3+}/Fe^{2+} molar ratio of 0.6 and 1.1.

High concentration of magnetized adsorbent in both kaolin/starch and kaolin/humic acids suspensions was detected at:
kaolin/biomaterial ratios of 2.5, 15 and 25 and
Fe^{3+}/Fe^{2+} molar ratio of 0.6, 1.1, 2.3 and 3.9
but not in bentonite/starch and bentonite/humic acids suspensions.

The model predicted and experimental results are in good agreement over entire ranges of variables tested.

Literature

1) Bilanovic D.D., Kroeger T.J., and S.A. Spigarelli (2007) Behaviour of humic – bentonite aggregates in diluted suspensions. Water SA, 33, 1, 111 – 116.

2) Bilanovic D.D., Kroeger J.T. , Armon R., Rehm A.C., and N.A. Burnham (2008) Magnetite coating of colloidal clay-xanthan aggregates. Gordon Research Conference - Green Chemistry, August 3-7, Bates College, Lewiston, ME.