Application of iron sludge pellets for the removal of arsenic or phosphate from water

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Introduction

In drinking water production precipitates with a high iron content are formed. Although for drinking water utilities this iron sludge is considered a waste material, the iron(hydr)oxides can be effective adsorbents for e.g. phosphate and arsenic (Arai and Sparks, 2001; Banerjee *et al*., 2008; Mao *et al.,* 2012) . High phosphate concentrations can be a problem in surface or wastewater, and the presence of arsenic in drinking water is unwanted. Although at the moment the official standard for arsenic in drinking water is 10 µg/L, it now is recommended to lower this standard. In this research pellets were produced on laboratory scale, which show sufficient stability for handling, and adsorption isotherms were determined for both phosphate and arsenic.

Methods and materials

Due to different composition of the water matrix, the composition of iron sludge from different water utilities may vary. For application as a commercial adsorbent it is important that a constant quality of iron(hydr)oxide pellets can be produced, but the production of iron sludge of individual utilities is limited. Therefore, different sludges were studied, and it a mixture of 11 sludges was prepared, showing good adsorption capacity, and a sufficiently high production capacity. The iron content of the sludges varied from 31 to 53%, the mixture having an iron content of 38%.

Wet sludges were mixed with an aqueous solution of carboxymethyl cellulose (CMC, Gabrose P300D) (2wt% based on dry solids content of the sludge) as a binder material (Ogblonlowo, 1989; Qiu *et al*., 2003), dried at 105 ºC, milled and sieved to a pellet size of 0.5-2 mm. A commercial Fe_2O_3 adsorbent was used as a reference material.

Jar tests were carried out in order to determine adsorption isotherms for arsenic and phosphate.

Results and Discussion

Experiments were carried out with pellets prepared from different sludges (fresh iron sludge from Spannenburg and Huijbergen, the mixture and the reference adsorbent). It is known from literature that iron(hydr)oxides may crystallize into goethite upon aging, and therefore also aged material from Spannenburg was tested. Characteristics for these samples are shown in table 1.

Table 1: characteristics of the pellets studied

Sample (from Dutch production site)	S_{BET} (m^2/g)	V_{pore} (cm^3/g)	V_{micro} (cm^3/g)	S_{meso} (m^2/g)	Microporosity (%)
Spannenburg aged	154	0,241	0,045	63	19
Spannenburg fresh	187	0,318	0,057	71	18
Huijbergen	234	0.271	0.082	75	31
Mixture	182	0,238	0,05	82	21
Reference material	216	0,597	0,017	177	3

It was shown that the micro pore volume and iron content strongly affect the adsorption capacity, as is shown in figure 1. Furthermore, it is shown that indeed the adsorption capacity decreases upon aging of the sludge.

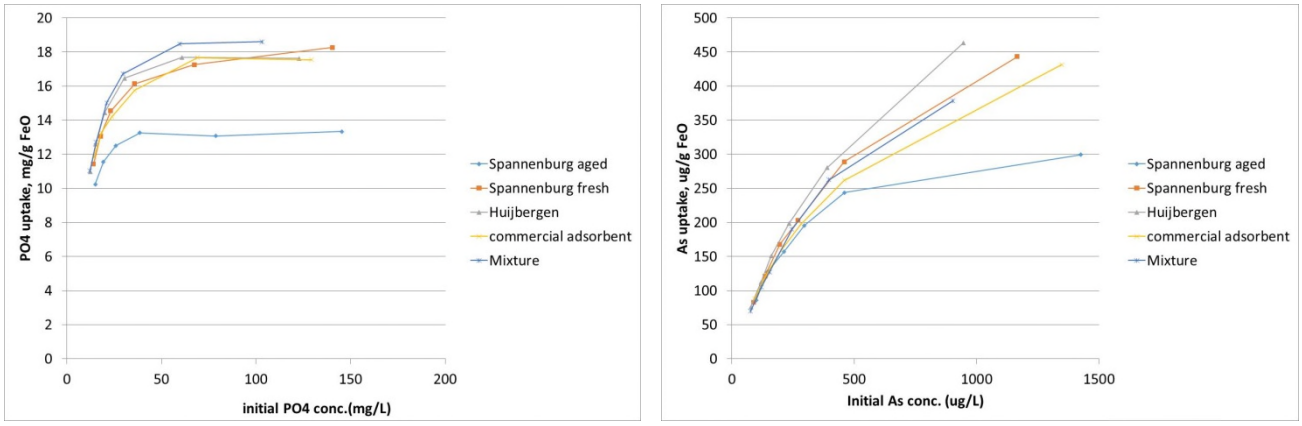

Figure 1: Adsorption of phosphate (right) and arsenic (left) on different iron sludge pellets.

From these data it can also be concluded that the adsorbents prepared from fresh sludge have a very good adsorption capacity for both phosphate and arsenic. Also Langmuir and Freundlich adsorption isotherms were determined. It was shown that at first adsorption at the surface takes place fast, followed by a slower adsorption, possibly in the pores. Two adsorption constants can be determined.

Conclusions

1. It was found that fresh iron sludge, depending on its iron content and pore volume, can have a relatively high adsorption capacity for either arsenic or phosphate. This adsorption capacity decreases upon aging of the material.
2. It is possible to prepare a mixed pellet with a high adsorption capacity.
3. Two adsorption constants can be determined, as the adsorption takes place in two stages.
4. Waste iron sludge from drinking water utilities can be applied as an effective adsorbent for removal of phosphate from surface water or arsenic from drinking water.

References

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