Removal of phosphate with iron oxide (rust) and steel wool

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Introduction

There is a limited amount of phosphate on earth and with the quantities we are using at the moment we will run out in 400 years taking it to the maximum. This is a big problem because without phosphate there is no life possible. Most of the phosphate we use eventually ends up in our wastewater, about 20 mg/L (Wetterskip Fryslân). We aim to recover a pure phosphate solution, so it can be re-used as for example fertilizer. Our research is focused on finding an efficient way to remove and recover phosphate from wastewater. The first step in our research was to remove phosphate from water using with rust (iron oxide).

Question

How can we remove and recover phosphate from (waste)water in an efficient and sustainable way?

Method

1) Batch Experiments:

We started with batch experiments using 1 gram rust and 4 different combinations of 5 mg/L phosphor, 50 mg/L calcium and 100 mg/L carbonate in duplicates. We took samples several weeks and analyzed phosphate and calcium with ion chromatography and carbonate with a Total Organic Carbon test.

2) Iron oxide:

After the batch experiment, we made a set-up (Figure 1) We started a 3 hour recirculation experiment, with 20 mg/L phosphate and 15 mg/L calcium using one liter of water. It had a contact time of 30 minutes per hour. Samples were analyzed for phosphate and calcium. A second recirculation experiment was done for 1 week with 100 mg/L phosphate and 15 mg/L calcium and 1 liter of total liquid.

3) Steel wool:

As a comparison with the iron oxide, we did a 3 hour recirculation experiment (20 mg/L phosphate and 15 mg/L calcium) again, using steel wool instead of iron oxide

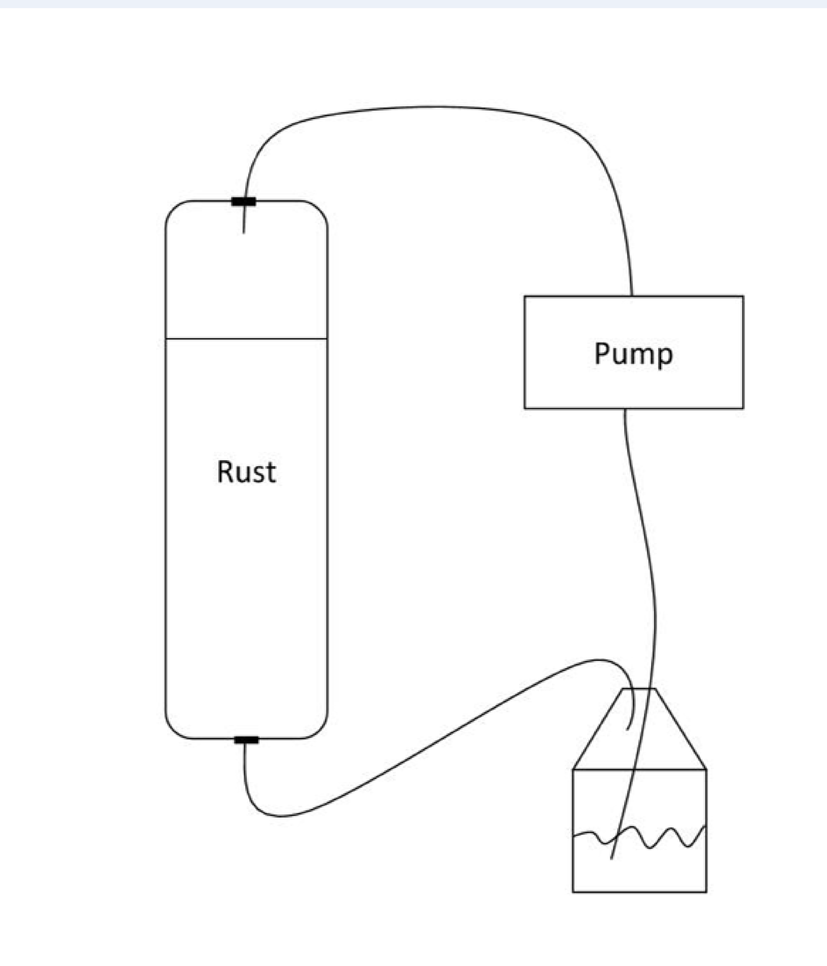
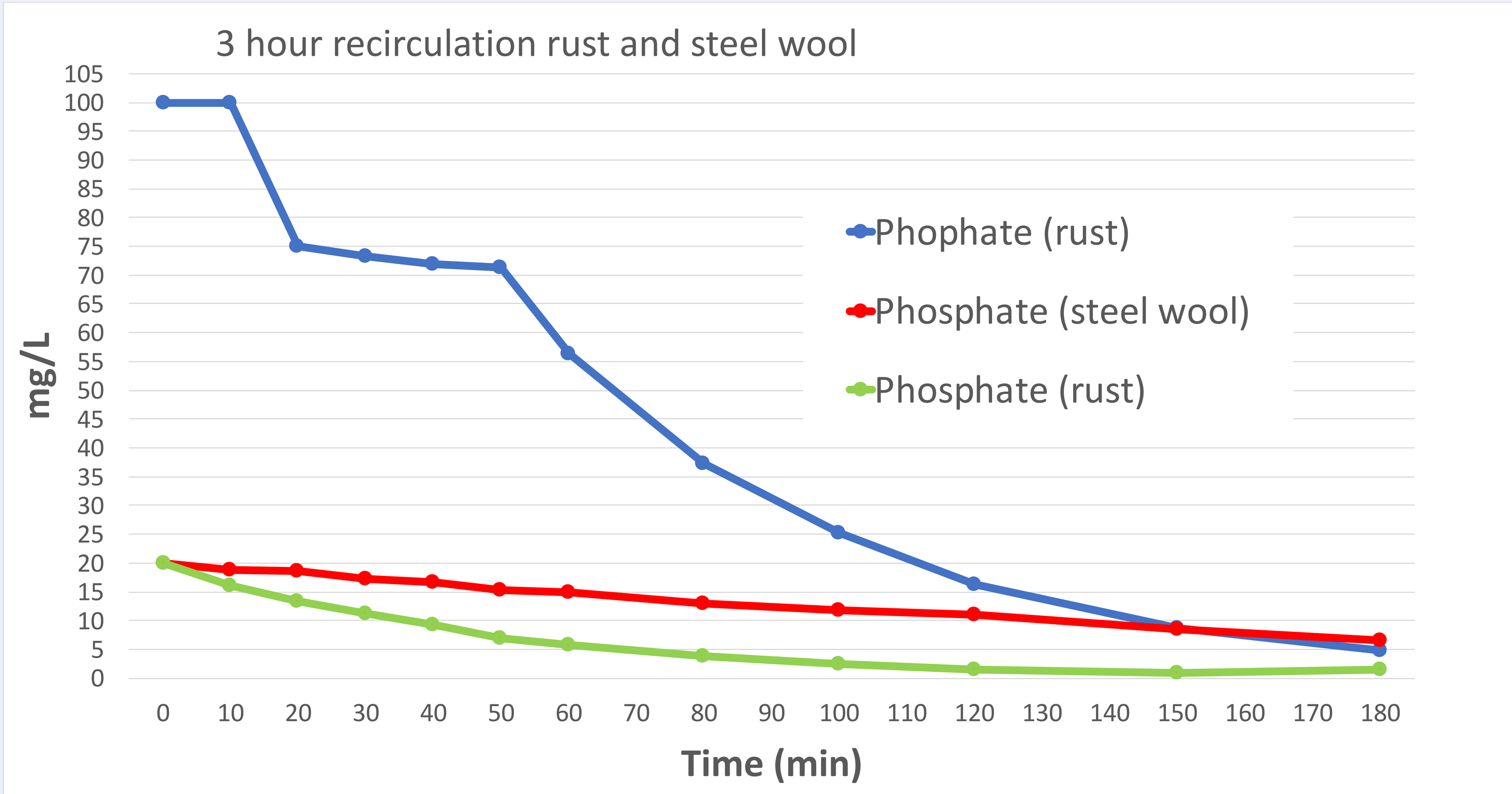


Figure 1: set-up

Results

The batch experiments showed us that phosphate was reduced when in contact with rust (iron oxide).



Graph 1 shows the experiment with the rust using 20 and 100 mg/L (blue and red line) and the experiment with the steel wool using 20 mg/L (orange line).
As shown in the graph, the phosphate was removed in all 3 experiments. Using steel wool seems less efficient as using rust.

Conclusion

- 20 mg/L phosphate was removed with almost 98% efficiency using rust.
- 100 mg/L phosphate was removed with more than 95% using rust,.
- 20 mg/L phosphate was removed with 67% using steel wool.

Future perspectives

In the future, we would like to do:

- Experiments with actual effluent from a wastewater treatment plant.
- More experiments with other types of rust. For example, rusty nails or the re-use of waste materials.
- Find a way to recover phosphate from rust and the phosphate and calcium from steel wool so we can use it again.

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