WATERPRO

Using batch adsorption experiments for selecting most effective adsorbent

Introduction

Nutrient removal efficiency depends on properties of adsorbent and applied process conditions. It is important to select proper material or combination of materials for each individual wastewater treatment case. Commonly used adsorbents are zeolite, vermiculite, charcoal and biochar. The utilization of local industrial by-products such as slag, flyash and waste rock as adsorptive materials can be cost-effective way to reduce nutrient content in wastewaters.

Batch adsorption technique is reliable and widely used for selection the suitable material and determination its optimal dose for removal specific contaminants from wastewater. Based on batch adsorption tests performed in the laboratory scale, it is possible to evaluate the effect of process conditions, including contact time, pH and temperature, on performance of particular adsorptive material.

Thorough characterization of wastewater composition is an important step prior to making a decision on selection a material for preliminary adsorption tests. The mineralogical and geochemical evaluation of the mineral adsorbent material is essential, if the properties are not well known previously.

Methods

Nitrogen-rich wastewater was collected from a fertilizer plant and stored in plastic containers in a cool room at 8 °C. The concentrations of ammonium and nitrate were determined by spectrofotometer (Hach-Lange DR 2800) using cuvettes tests LCK 303 (measuring range 2-47 mg/l). Samples were diluted with ion exchanged water in a ratio of 1:50. Dilution was necessary because of the high nitrogen and sulfate concentration in the wastewater.

Zeolite was applied as an adsorbent and its mineralogy was analyzed in GTK`s mineralogy laboratory using a scanning electron microscope (LV-SEM, JEOL JSM5900-LV) combined with an energy dispersive spectrometer (EDS, Oxford Instruments). The mineralogical characterization of the samples of fresh materials and after wastewater treatment entailed the identification and quantification of mineral phases.

To analyse the effect of contact time, adsorbent dose, pH and temperature on ammonium removal, a series of batch adsorption experiments were performed using a jar-tester Flocculator 2000 (Kemira). In general, jars were filled with the wastewater sample and desired amount of adsorbent material (fig. 1). The mixture was vigorously stirring and samples were periodically collected for analysis. Different process conditions were applied during the adsorption experiments to determine the optimal process conditions.

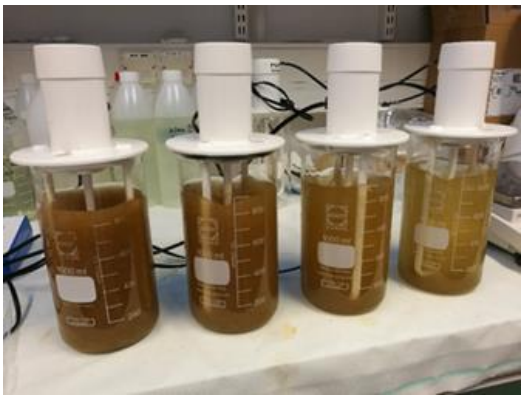

Fig. 1. Batch adsorption test with zeolite and ammonium-rich wastewater sample

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Results

Mineralogical results showed that zeolite samples consist mainly of zeolite minerals clinoptilolite and modernite, but quartz, K-feldspar and plagioclase were also identified.
The initial concentration of ammonium in treated wastewater was of 427 mg/l. The better treatment results were obtained for longer contact time and higher adsorbent dose. The performance of zeolite in the reduction of ammonium concentration was also temperature dependent. Lower temperature (8-9 °C) enhanced ammonium removal by zeolite, what was especially visible for smaller amount of material (4-8 g) used for wastewater treatment (fig. 2).
However, under various pH conditions (pH 4-9), there were no major changes in the adsorption efficiency of ammonium onto zeolite.

Tips for batch adsorption tests:

- Basic information about wastewater composition, and content of nitrogen is important for selecting cuvette tests with suitable measuring range concentrations for spectrophotometric analysis. If the concentration is expected to be below detection limit of available cuvettes tests then different analytical method should be considered to get actual removal rate.
- Batch adsorption test results are not scalable directly to industrial level, so prior to any decision making process the pilot tests should be conducted for the most promising absorbents. For successful test results it is vital to know seasonal variation of treated wastewater.

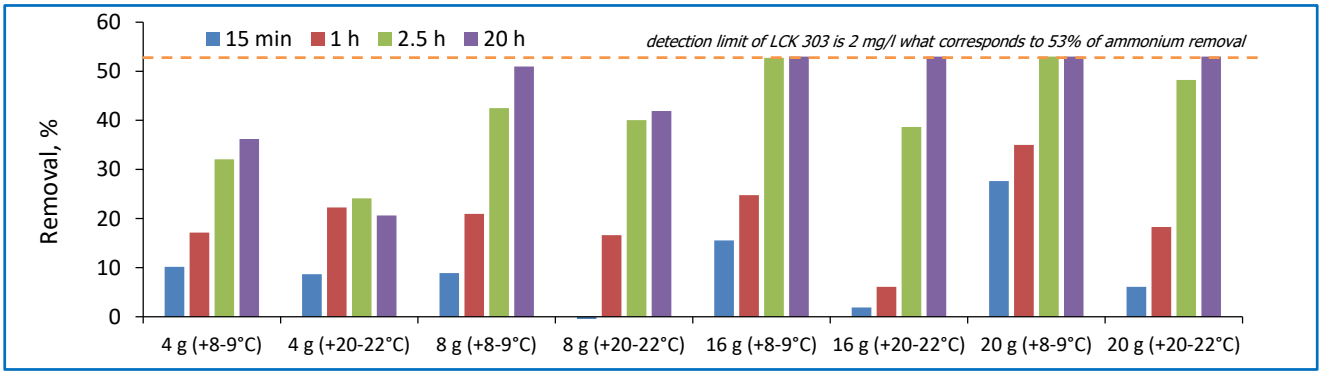

Figure 2. Ammonium reduction results with different dosage of zeolite and varying temperature conditions

The actual removal percentage of ammonium was higher than 53% (as shown in fig. 2), since concentrations below 2 mg/l could not be detected reliably due to the detection limit of the cuvette tests used for ammonium analyses .

Conclusions

A successful performance of batch adsorption tests requires careful planning and pre-research work. The proper experimental approach allows to select the most suitable adsorptive material and its dosage for treatment specific wastewater. A controlled laboratory environment makes possible to test adsorption with various scenarios in a reliable way. Batch adsorption tests can be performed in different temperature and pH conditions to confirm adsorbents feasibility for application in the field conditions.

More information:

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