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Effect of surface loading fluctuations on ammonium removal during rapid sand filtration

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Introduction

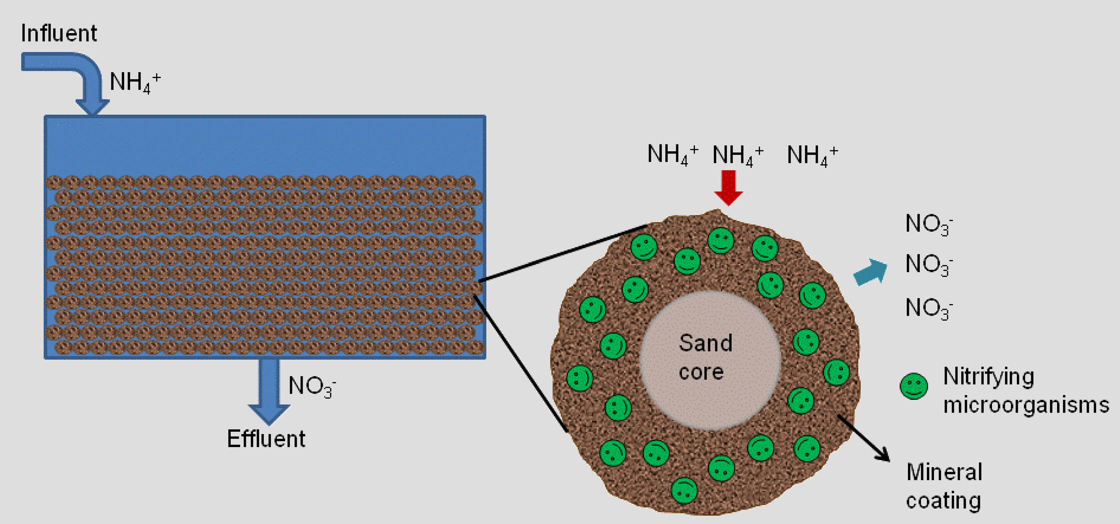
- Rapid sand filtration is used in drinking water treatment to remove particles and inorganic compounds such as NH_4^+, Fe^{+2} & Mn^{+2}
- NH_4^+ is removed biologically by microorganisms attached on the sand
- About 25% of waterworks in Denmark exceed the effluent NH_4^+ guideline of 0.05 mg/L.
- Loading can often change due to switching between abstraction wells with different water quality
- Loading that exceeds a filter's removal capacity may cause transient ammonium breakthrough

Research question:

In which operating region have NH_4^+ loading changes no effect a filter's performance?

Objectives

- Investigate the relationship between NH_4^+ loading and effluent NH_4^+ concentration in a filter
- Identify the loading region where loading changes do not affect effluent concentration



Surface loading :
Ammonium load per unit of external surface area

Figure 1: Sketch of nitrification in a rapid sand filter. Ammonium is degraded by a nitrifying biofilm attched on the sand grain surface

Conclusions

- NH_4^+ loading variations below the critical loading had no effect on effluent NH_4^+ concentration
- Once the critical loading was exceeded, effluent NH_4^+ concentration was strongly affected by loading increases
- For the investigated filter, the critical load was 5 times larger than the operating load. Performance of this filter is expected to be robust against load variations

Method

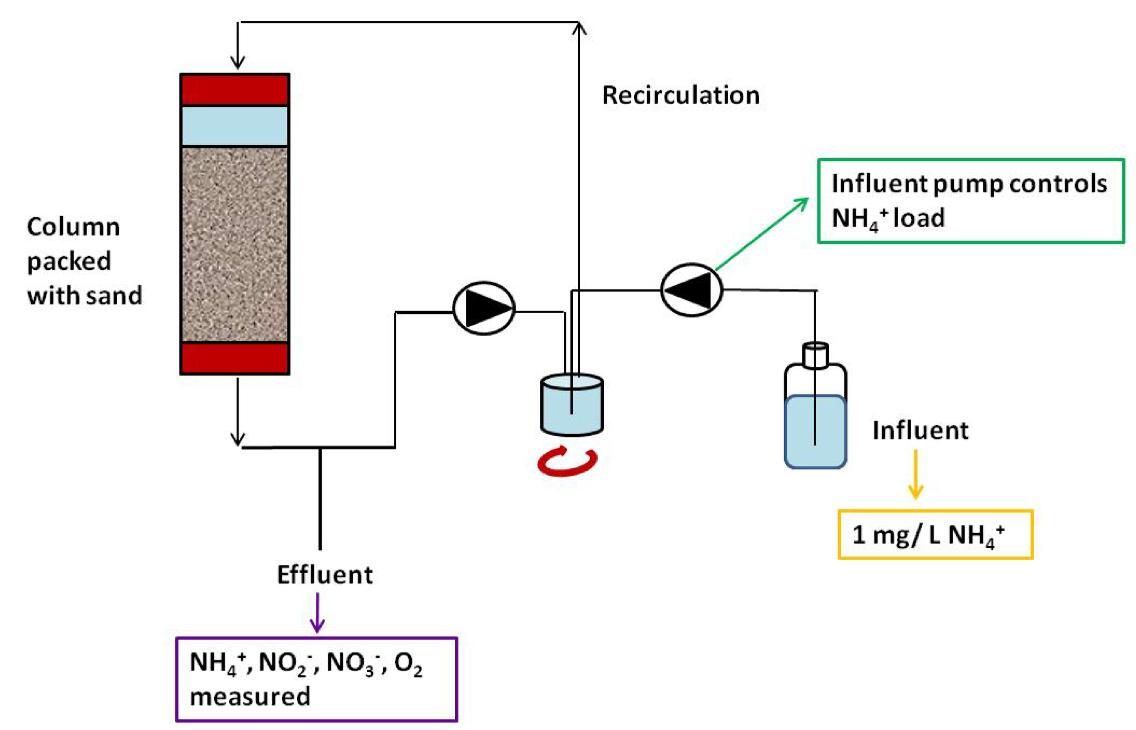


Figure 4: Schematic drawing of experimental set-up. Column dimensions: 5 cm x 2.6 cm ø. Loading was controlled by adjusting influent flow rate, influent concentration was 1 mg/L.

Table 1: Different experimental loads applied. Steady state loading = surface loading of the full scale filter. Duration of experiments was short to avoid growth of nitrifying biomass

Loading (mg NH_4^+-N/ m^2 sand surface area / h)	Duration of experiment (h)
0.4	steady state
1	5
2	4
4	3

Results

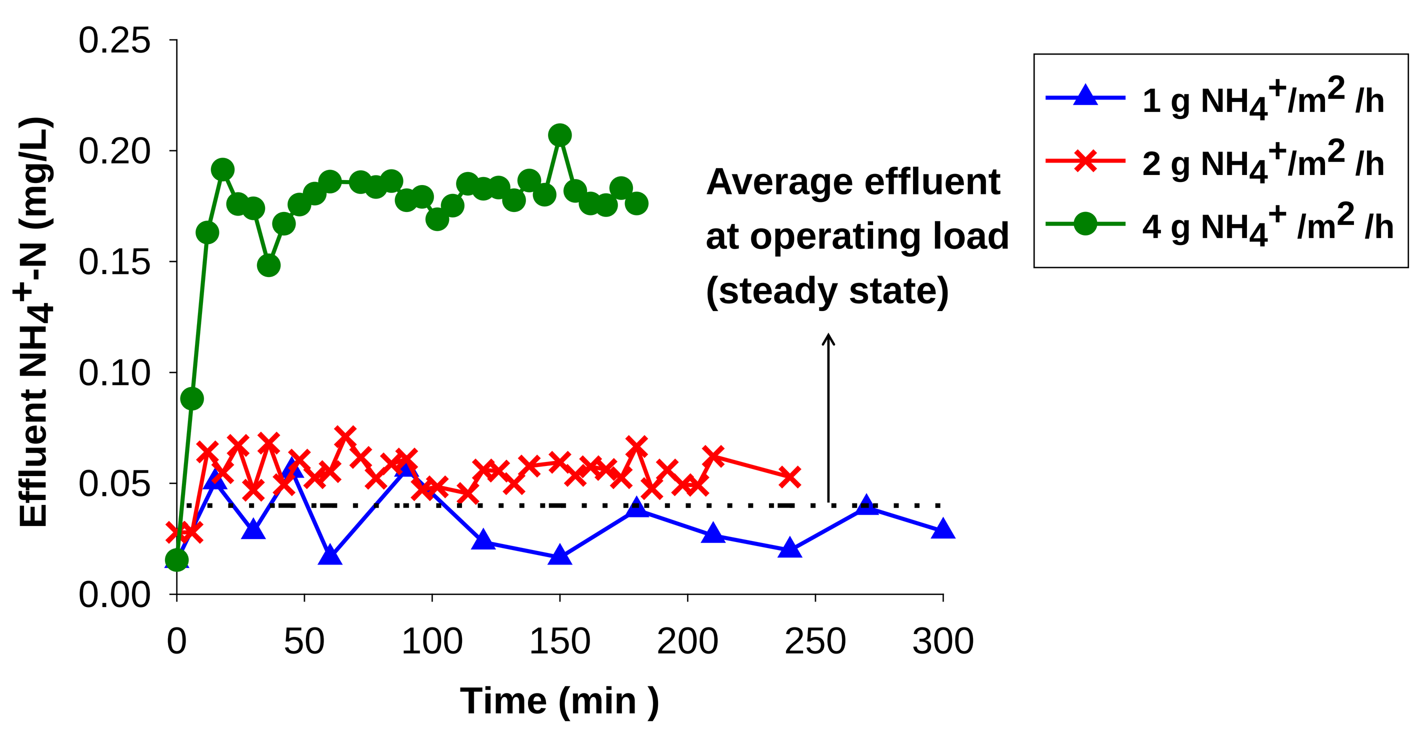


Figure 2: NH_4^+ effluent concentration profile during loading increase experiments. During each loading change ammonium effluent concentration stabilizes to a new value (temporary steady state)

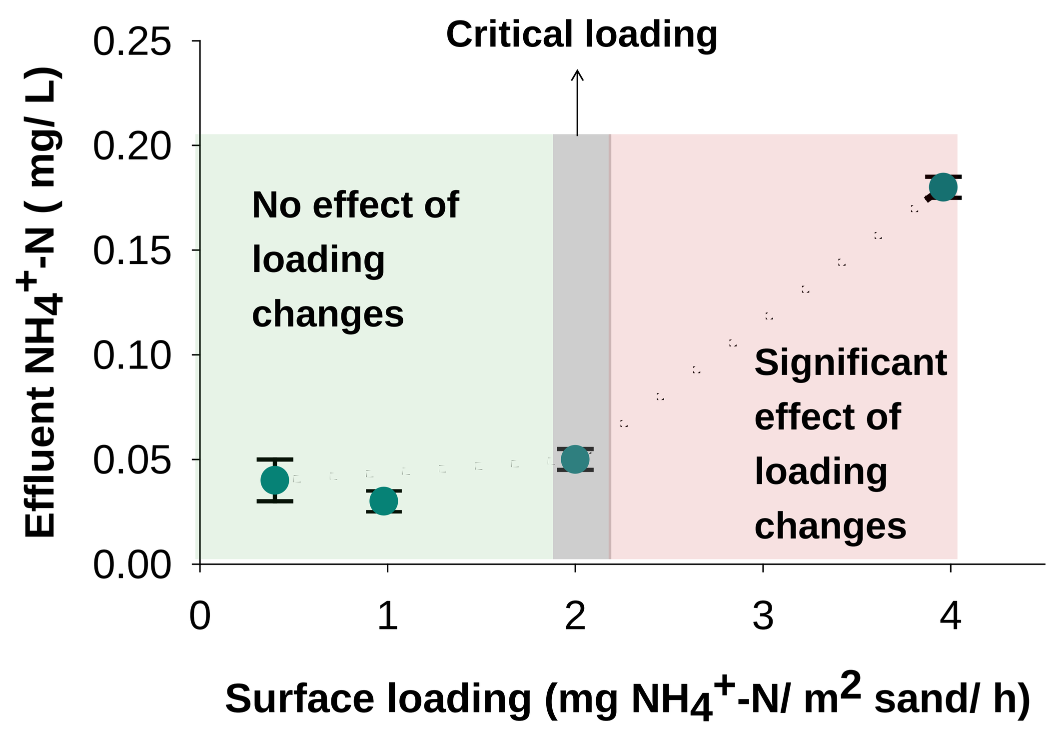


Figure 3: Relationship between NH_4^+ effluent concentration (temporary steady state concentration) and surface loading

- Loadings up to 2 mg NH_4^+- N/ m^2 / h have no effect on ammonium effluent concentration

  (t-test, $\alpha = 0.05$)
- Loadings higher than 2 NH_4^+- N/ m^2 / h result in higher effluent NH_4^+ concentration
- **Critical loading = 2 mg NH_4^+- N/ m^2 / h**

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DWBIOFILTERS
Sustainable Drinking Water Treatment – Biological filters