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ABSTRACT

Experimental analysis on pH and salinity effects during biological regeneration of nitrate laden anion exchange resin

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ABSTRACT

Nitrate removal from wastewater is generally achieved using biological denitrification due to its cost-effectiveness. However, risks connected to the contact between water and bacteria are the reason why both American and European legislations allow biological denitrification to be applied to wastewater but not to drinking water. Therefore, a riskless and economical alternative is necessary to obtain the same results.
Anion exchange processes have been identified as one of the most promising treatment for nitrate removal from water. The ion exchange process produces spent resin that needs to be disposed of due to the high concentration of nitrate on it, hence becoming hazardous material. A more economical alternative to treat the spent resin is the regeneration, with the possibility to reuse the resins for other nitrate filtration treatments.
An efficient regeneration technique for the nitrate-laden anion-exchange resin is the elution with a regenerant brine. This process actually removes nitrate from the resin and provides regeneration for future filtration applications. This fast and effective method though, is affected by a problem hidden in its operating method: nitrate is basically just transferred from the wastewater to the regenerant brine that needs to be disposed of or treated somehow. It clearly appears that the regeneration by simple elution cannot be considered as a valid method to efficiently perform the regeneration process of the spent resin, since the nitrate pollution problem is not solved but just transferred to another water stream.

The direct biological regeneration is a method that provides regeneration of the spent resin using biomass. It is called ‘direct’ because the biomass and the resin find their place together in the same solution, so that the biomass is directly in contact with the resin, accomplishing resin regeneration and biological nitrate destruction concurrently.
The biological regeneration of the spent resin is a complicated mechanism that is composed of two intrinsically related processes:

- Nitrate release by desorption from the resin to the solution;
- Biological denitrification performed by the denitrifying biomass.

The nitrate release by desorption is a fast process that makes the nitrate available for the biomass immediately. The nitrate is released in the solution and the mechanism is governed by the desorption, which is modeled with the desorption isotherm.

At this time, the nitrate present in the solution is attacked by the denitrifying biomass that starts to decompose the nitrate into nitrogen N_2 gas and makes the bio-regeneration process begin.
The two processes are intrinsically related because, without the biomass, the nitrate release would reach an equilibrium between the nitrate in the solution and the nitrate loaded on the resin. The denitrifying bacteria modify the nitrate concentration in the solution by attacking the nitrate substrate and performing biological denitrification, so that to a nitrate release step corresponds a denitrification step.
The biological denitrification is therefore influenced by the desorption, since the whole nitrate loaded on the resin is released step by step and not all at once, so the nitrate concentration in the solution is different from the case in which all the nitrate would directly be in the solution.
This regeneration method could directly and biologically decompose into innocuous nitrogen gas N_2 the nitrate that was previously loaded on the resin, performing an economic, stable and efficient regeneration of the resin.

Previous research work (Wang et al., 2008) showed the feasibility of the biological regeneration applied to perchlorate laden resins and the results indicated that the method was effective in regeneration and the resin could be repeatedly regenerated with the method. The regenerated resin was effective, stable, and durable in the filtration treatment of perchlorate showing very good capacity of being regenerated with the biological process, indicated by the good performance in filtration treatments after regeneration, absolutely comparable with the performance of the virgin resin.
The biological regeneration was then applied to nitrate laden resin with the same good results as in the perchlorate case, so the process could be investigated to identify the best working condition for the improvement of the process.
The biological regeneration could be therefore used as a solution to the regeneration problem, since the nitrate loaded on the resin is not just simply transferred to another solution but directly decomposed into innocuous N_2 nitrogen gas.
The consequential problem of how to treat the high nitrate-concentrated solution resulting from the regeneration by elution of the resin and the further step in the regeneration process given by the elution is, in this way, avoided by treating directly the resin with the denitrifying biomass.

This valuable advantage makes the biological regeneration a promising treatment within the processes for nitrate removal from wastewater.

The direct biological regeneration is the combination of nitrate desorption from the resin and biological reduction of the desorbed nitrate. For this reason, it was necessary to investigate the parameters that could affect the process to obtain as a result the most suitable conditions for a fast, effective and stable development of the regeneration process.

The first purpose of the work was to have denitrifying biomass to be used for the regeneration process, by cultivation of biomass from anaerobic sludge from a municipal wastewater plant.

The spent resin for the regeneration part was provided by column filtration tests, having the double target to provide spent resin and to demonstrate the actual possibility to reuse the regenerated resin for several nitrate-removal filtration processes.

For this work, the chosen parameters affecting the regeneration were the pH and the salinity (proportional to conductivity) that affect the denitrification process as well.

For this reason, regeneration and pure denitrification were investigated to compare the behavior of the bacteria with and without the resin. Four pH values were chosen since the literature indicates that the best suitable pH range for denitrification is 8 – 9, therefore the chosen pH values for this experimental work were 7, 8, 9, 10. The results will be compared and the best condition identified.

The salinity part involved regeneration experiments at different salinity value since this parameter can affect both the nitrate release and the denitrification.

Desorption was also investigated because of the relation between denitrification and desorption. The purpose of the desorption investigation was to obtain the desorption isotherm, a very useful data for future applications and studies involving a modeling of the whole bio-regeneration process.

In the last part of the experimental work it was attempted to obtain a model for the biomass growth by performing a complete denitrification reaction with a simultaneous conduction of MLVSS concentration test.

Main results are showed in figures 1, 2 and 3, where nitrate concentration is plotted vs. time.

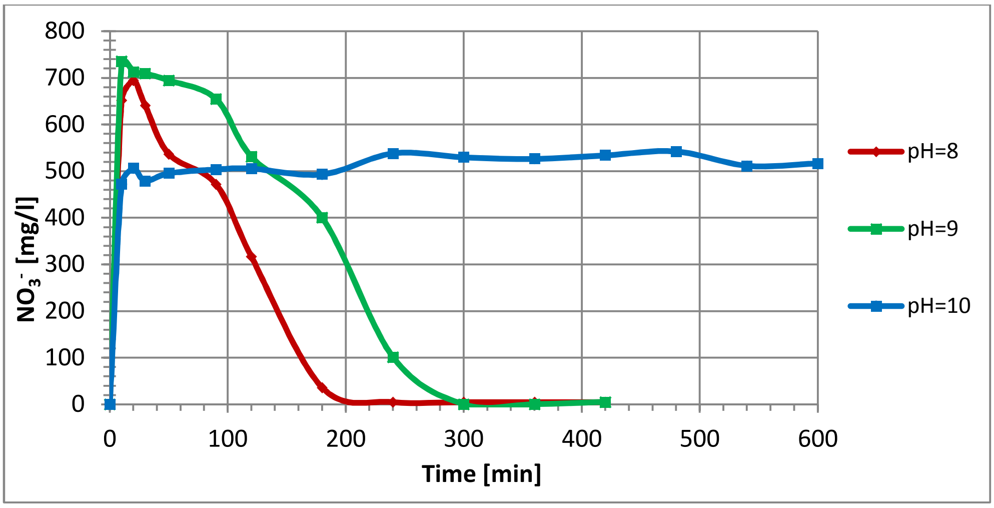

Figure 1 – Regeneration curves – pH effects.

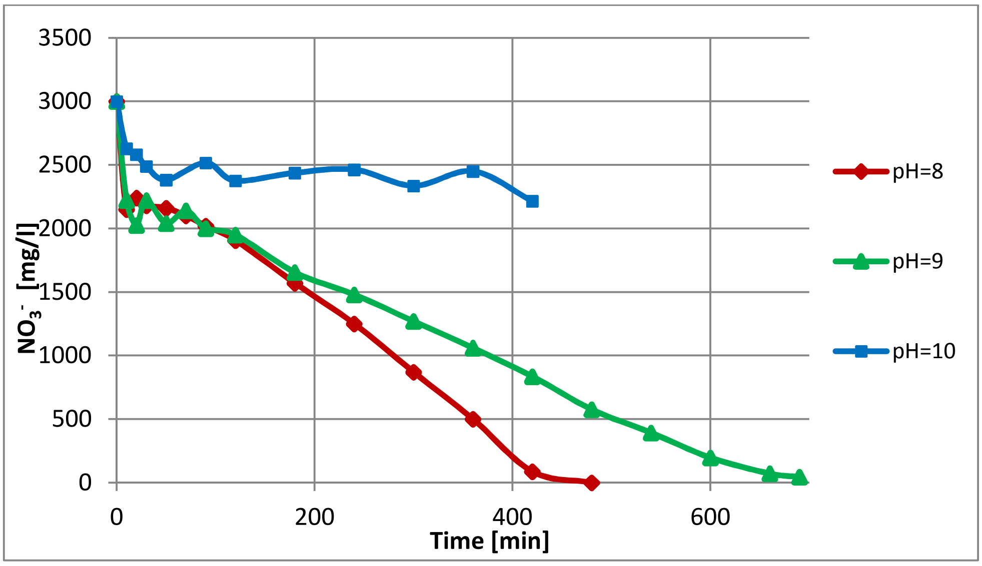

Figure 2 – Denitrification curves – pH effects.

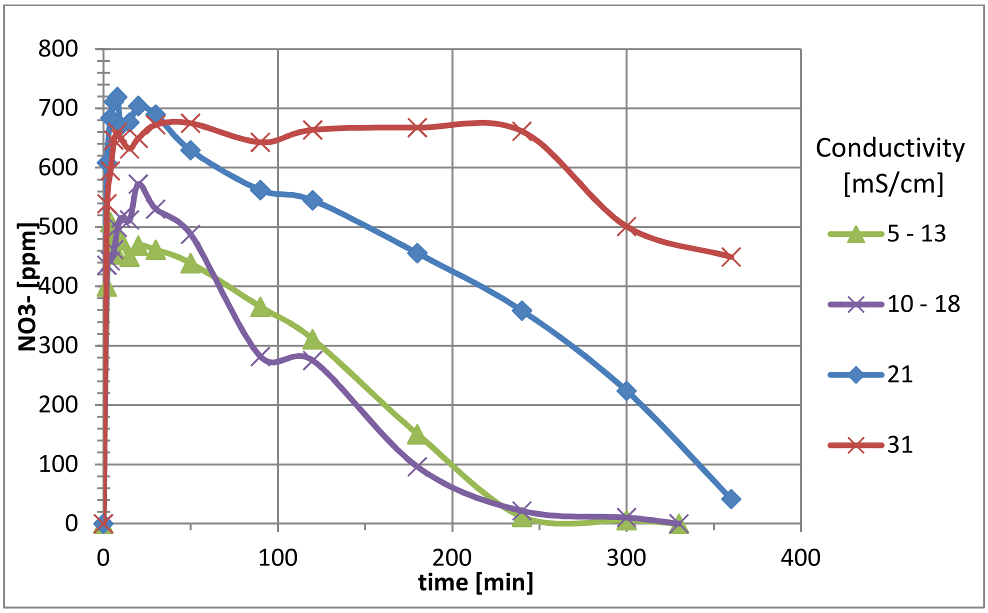

Figure 3 – Regeneration curves – Salinity effects.