Nitrate removal using an adsorption bed with functionalized silica from rice straw ash

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Efficient resource use plays a key role in activating economic agents, ensuring a social welfare state and life quality. As far as water is concerned, a Water Framework Directive [1] has been approved to establish clear criteria for evaluating the chemical status of water and for identifying and reversing trends in the deterioration of its quality. In Europe, 87% of groundwater contains excess nitrates (European Environment Agency). In intensive farming and cattle-rearing areas, nitrate concentration in groundwater can reach up to seven times the legal limit. In addition to water pollution, agricultural activities are also responsible for a large quantity of waste that needs to be dealt with. Rice straw, for example, is usually eliminated by uncontrolled burning with harmful consequences related to air, flora and fauna pollution in wetlands.

In this framework, the present work describes the use of active silica-based adsorbents obtained from the controlled combustion of rice straw in preliminary lab scale tests for nitrate removal from contaminated waters, under the framework of the EU-funded LIFE LIBERNITRATE project [2]. A testing column was loaded with 1 L of gravel and 200 g of silica (previously activated by immersion - stirring for 18 hours - in 0.5 M HCl solution). Water containing 70 mg/L of nitrates was tested at different flow rates (78 L/d and 130 L/d). Once the indicated flow rate was set, the column was completely filled and then the eluate began to be sampled, with a sampling frequency of 1 h, for the analysis of the anions on the ion exchange chromatograph.

The pH values and the concentration of chlorides showed that the bed gradually released the hydrochloric acid used to complete the activation of the silica, while it adsorbed the nitrates and sulphates present in the supplied well water for both tested flows. The concentration of nitrates achieved values around 2 mg/L after 3 hours of test showing the high adsorbent potential of the active silica. The test conducted with greater flow showed an exhaustion time of about 4 hours, while for the slowest test the same condition was achieved in about 6.5 hours.

The implementation of this methodology aims to be a synergic application of efficient rice waste management, at a local level, to treat nitrate problems in overcropping areas. This way, initially considered (hazardous) waste is turned into new resources, completing a re-use cycle and promoting zero-waste scenario policies. This method could be an initial pretreatment in current water technologies that would decrease the energy requirements of the process or become a sustainable alternative for small villages where the construction of osmosis plants is not feasible.

[1] European Parliament, Council of the European Union. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Off. J. Eur. Parliam. 2000, L327, 1–82.

[2] https://www.lifelibernitrate.com/