Treatment of hydroponic drainage in a electrochemical reactor

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Introduction

Electrocoagulation (EC) enables removing various types of pollutants and is claimed to be more effective that conventional chemical coagulation as it generates lesser amounts of sludge. In addition, it does not require additional chemical agents and is characterized by low electric energy consumption. The iron anode of the reactor enables also electrochemical reduction of nitrate, whereas phosphorus compounds are removed in simultaneous process of electrocoagulation. As a result of the electrolytic dissolution of the iron anode, the released ions form hydroxides which are then precipitated. Afterwards, they adsorb phosphorus compounds and are accumulated in sludge which is removed from the reactor together with the sludge.

Horticultural wastewater (drainage) is generated during soilless plant cultivation in an open system, wherein - after the flow through the cultivation system - the nutrient medium is usually discharged to surface waters or to greenhouse ground. Significant loads of phosphorus (50-100mgP/L) and nitrogen (200-600 mgN/L) compounds introduced to the environment with horticultural wastewater contaminate ground and surface waters. Considering its properties (a low ratio of organic compounds to total nitrogen), hydroponic wastewater requires specific treatment methods. Electrocoagulation has for years been extensively investigated to identify its viability in removing phosphorus compounds from wastewater and surface waters; hence, the aim of this study was to determine the effect of three intensities of direct electric current on the effectiveness of hydroponic drainage treatment in a fed-batch electrochemical reactor

Materials and methods

Drainage used in the study derived from soilless tomato cultivation in an open system. The study examined 3 intensities of electric current, i.e. R1-0.045 A, R2-0.136 A, and R3-0.283, at drainage hydraulic retention time of 24 h. An anode made of iron sheet was mounted inside the reactor, while rotating reactor discs with a total surface area 0.113 m2 served as a cathode. The electric current was sourced from a laboratory power supply (HMP4040, Rohde & Schwarz, Germany).

Physicochemical analyses were carried out for filtered samples and included determinations of:

- the content of total phosphorus ,
- the content of total nitrogen ,
- the content of nitrates, using ,
- the content of ammonia nitrogen and nitrites ,
- pH, electrolytic conductivity, and temperature .

Figure. 1 The laboratory installation for drainage treatment operating based on biomass attached to the filling (biofilm)

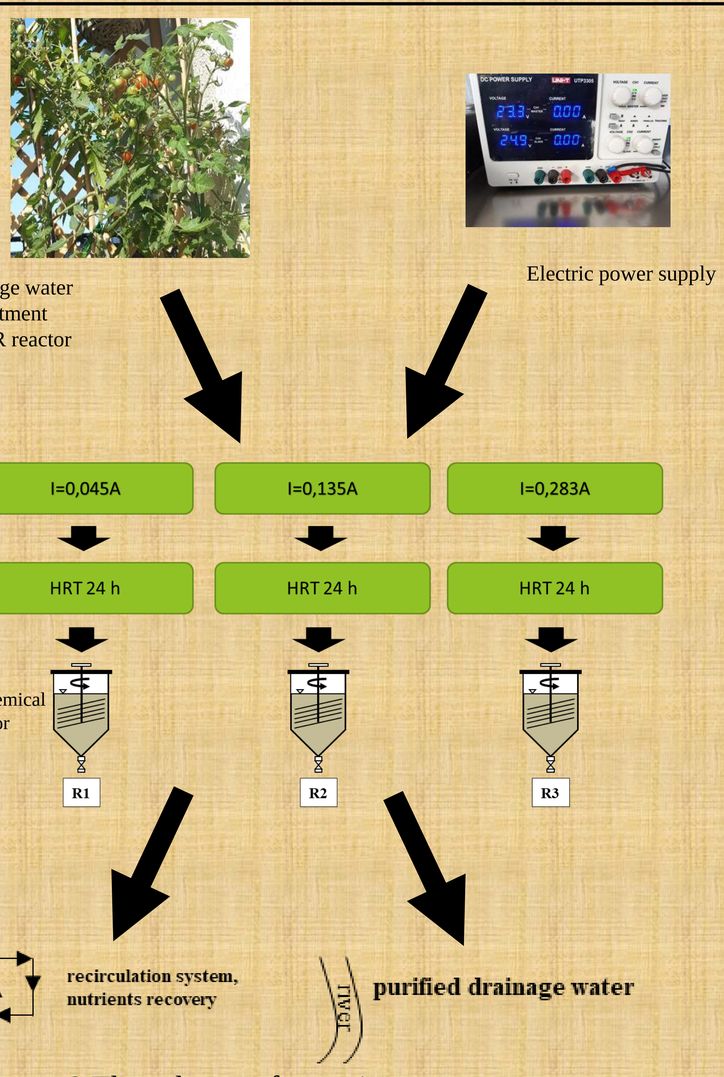

Figure 2 The scheme of experiment

Results

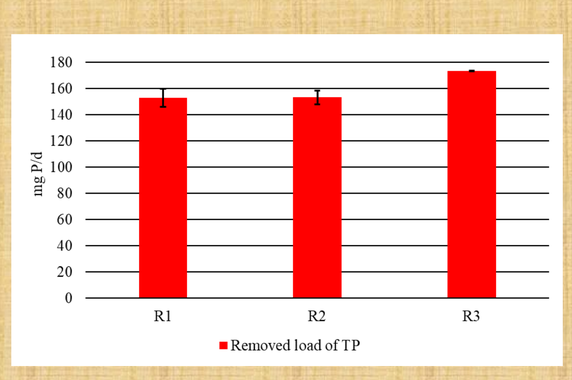

Fig 2 Load removed of TP obtained in research

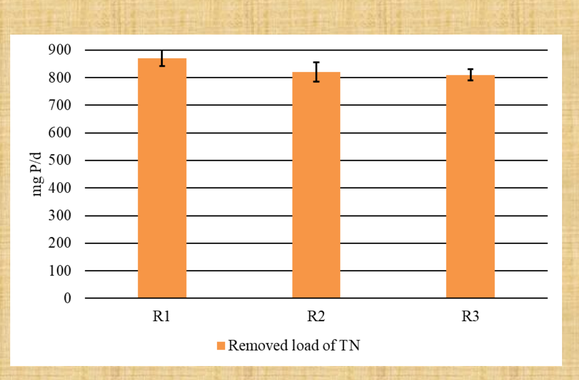

Fig 3. Load removed of TN obtained in research

A similar effectiveness of phosphorus removal (88%) was achieved at current intensities of 0.045 A and 0.136 A. Increasing current intensity to 0.283 A enabled removing 99.99% of phosphorus from the drainage, which corresponded to its recovery rate of 86.82 mg P/L*d. Nitrogen removal efficiency in electrochemical treatment processes was significantly lower and reached 3.20%. The use of electric current resulted in increased concentrations of ammonia nitrogen (from 0.460±0.394 mg N/L-R1 to 4.626±2.235 mg N/L-R3) and nitrite nitrogen (from 0.448±0.325 mg N/L-R1 to 1.313±0.196 mg N/L-R3) in the treated drainage. In addition, it decreased drainage pH to the value below 3 in each of the reactors (drainage pH at the inlet was pH=6.06.).

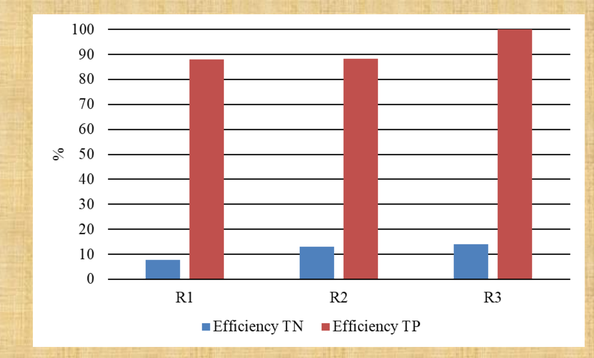

Fig.4 The effectiveness of TP and TN removal in EBR

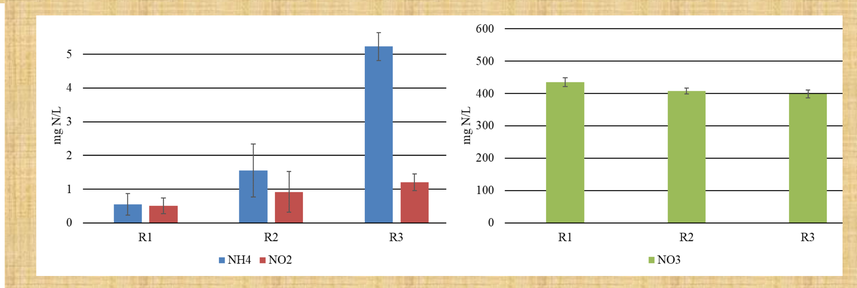

Fig 5. The content of nitrate, nitrite and ammonium nitrogen in wastewater from the reactors

Conclusions

The use of electrochemical processes in horticultural wastewater treatment enables almost complete recovery of total phosphorus and only a slight reduction of nitrogen compounds. Thus, electrochemical processes may prove viable in aiding other processes deployed for drainage treatment, especially in the case of phosphorus compounds.

Funding

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