EFFECTIVENESS OF TREATMENT OF DRAINAGE FROM SOILLESS CULTIVATION IN A SEQUENCING BATCH BIOFILM REACTOR (SBBR) WITH DIRECT ELECTRIC CURRENT

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Keywords: soilless plant cultivation wastewater treatment, sequential reactor with biofilm, nitrogen and phosphorus compounds, external carbon source, method of substrate dosing, method of supplying reactors with direct electric current

Summary

Greenhouse wastewater is generated during soilless plant cultivation in an open system or when there is a need for exchanging nutrient medium in a closed system. Herein, nutrient excess – referred to as overflow or drainage – is discharged untreated to the natural environment. Horticultural wastewater outflowing from soilless cultivation systems have high concentrations of nitrogen and phosphorus, with total nitrogen concentration ranging from 150 to 600 mg N·L-1, and that of total phosphorus from 30 to 400 mg P·L-1. Discharge of untreated drainage to the natural environment causes the contamination of groundwaters, surface waters as well as the ground adjacent to the greenhouse. The unsolved problem of greenhouse drainage treatment, posing severe threat worldwide, has urged the search for novel solutions enabling effective removal of nitrogen and phosphorus compounds.

The present study aimed to determine, the type, dose, and feeding method of an external source of organic carbon and direct electric current on the effectiveness of biological and electrochemical processes ongoing during the treatment of wastewater from soilless tomato cultivation in a sequencing batch biofilm reactor (SBBR). Experiments were conducted with real horticultural drainage from a greenhouse (surface area of approximately 200,000 m2), wherein tomatoes are grown on the substratum from mineral wool. The SBBR had an anode made of iron and a cathode made of stainless-steel disks mounted on a rotating vertical shaft. The reactor's construction enabled running simultaneous processes of hydrogenotrophic and heterotrophic denitrification, electrochemical nitrate(V) reduction, and electrocoagulation of phosphorus compounds. The electrodes were connected to a direct current power supply. The study was divided into three stages: stage I enabled determining the effect of type and dose of an external organic carbon source and direct electric current on the quality parameters of drainage; stage IIa allowed determining the effect of organic substrate feeding method on effluent quality; stage IIb aimed to determine the effect of direct electric current on greenhouse

drainage treatment effectiveness; whereas stage III was expected to determine the effect of the order biological and electrochemical processes applied on the effectiveness of nitrogen and phosphorus removal and also organic substrate consumption.

The results obtained allowed presenting the concept of using a batch reactor with a biofilm to treat greenhouse wastewater and formulating several conclusions, the most important of which include:

- The concentration of organic compounds, both acetic acid and sodium acetate, expressed as the C/N=1.5, was adequate to achieve high efficiency of total nitrogen removal, while at the same time it did not result in a significant amount of organic compounds in the treated wastewater. At C/N=1, the in total nitrogen removal efficiency decreased, while C/N=2 resulted in a significant increase in the concentration of unused organic compounds.
- Even dosing of organic substrate and feeding it in two doses (50% at the beginning of the cycle and 50% after 12 h of reactor operation) caused a decrease in the removal rate of total nitrogen in the bioreactor. Total nitrogen was then removed according to the zero-order equation. Removal of total nitrogen in the bioreactor fed with the entire dose of the substrate at the beginning of the cycle followed the pseudo-first-order equation, and the recorded reaction rate was the highest.
- Regardless of the treatment system used in the two reactors (electrochemical and biological), the use of acetic acid ensured a higher organic substrate consumption efficiency than in the bio-electrochemical reactors -under any DC power option.
- Using sodium acetate in a two-reactor system, in which first biological and then electrochemical processes were carried out, the efficiency of nitrogen removal was higher only compared to that obtained in the bio-electrochemical reactor, in which a constant electric current was supplied for 24 hours.
- Increasing the electric current density above 1.2 $A \cdot m^{-2}$ did not significantly increase the efficiency of total phosphorus removal in the electrochemical reactor.
- In reactors using acetic acid, regardless of their type, higher consumption of the organic substrate was recorded compared to sodium acetate.
- The efficiency of total nitrogen removal in the electrochemical and then biological reactor system was higher than in the bio-electrochemical reactors regardless of the method of electric power supply.
- The type of carbon source used in the bioreactor had a significant impact on the amount of total nitrogen removed per milligram of organic carbon source supplied.

- The concentration of phosphorus compounds in wastewater treated in biological and electrochemical reactor systems (regardless of configuration), both using sodium acetate and acetic acid, was lower than in the effluent from biological, electrochemical and bio- electrochemical reactors.
- The percentage of nitrogen and phosphorus in the sludge was the highest in the reactors supplied with electric current only.