Optimizing the use of electric current to support the biological treatment of drainage water from soilless tomato cultivation in an acidic environment

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Introduction

Soilless cultivation in greenhouses results in the generation of an overflow, called drainage. This type of wastewater is difficult to manage due to high concentrations of biogenes (nitrogen, phosphorus) and low contents of organic compounds. Drainage cannot be directly re-circulated or discharged to the natural environment; therefore solutions are sought to ensure its effective pre-treatment or treatment. At the same time, novel methods for the recovery of valuable elements, phosphorus in particular, are in a great need. Our earlier study has indicated the feasibility of drainage water treatment by deploying electrical current and an external carbon source.

The conducted research was aimed at optimizing the use of electric current to support biological treatment of drainage waters. Effective bio-treatment requires appropriate loads of organic compounds. Simultaneously, pH in the reactor significantly affects the solubility and, consequently, the availability of phosphorus compounds. At alkaline pH, they appear in the form of insoluble sludge and are unavailable to microorganisms, significantly impairing their activity and development. On the other hand, electric current supports autotrophic denitrification and electrocoagulation of pollutants, including the precipitation of phosphorus with iron ions.

Experimental

The experiment was conducted in reactors included in the laboratory installation for drainage treatment operating based on biomass attached to the filling (biofilm). The direct current intensity was 0.2A and the hydraulic retention time was 24h. A steel plate (anode) was installed inside the reactor, while the stainless steel bed discs served as the cathode. Two methods of electrical current supply were tested:

- R1- HRT 24h, including 1-12h with electrical current flow followed by 13-24 h without the current flow;
- R2- HRT 24h, including 1-12h without electrical current flow followed by 13-24 h with the current flow.

Acetic acid was used as an external carbon source at C/N=1.5. Initial pH was 3.2.

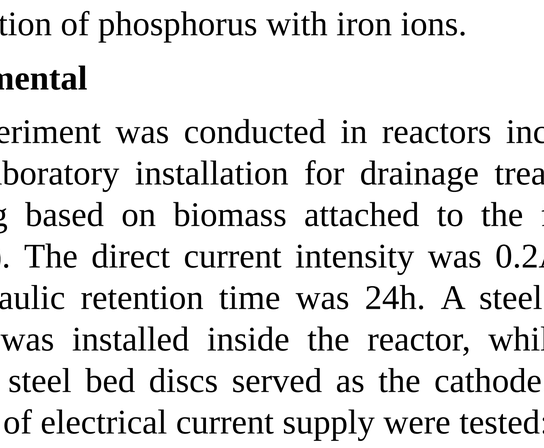

Figure 1 Full-technical scale soilless tomato cultivation in North-Eastern Poland (Europe) https://www.google.pl/maps

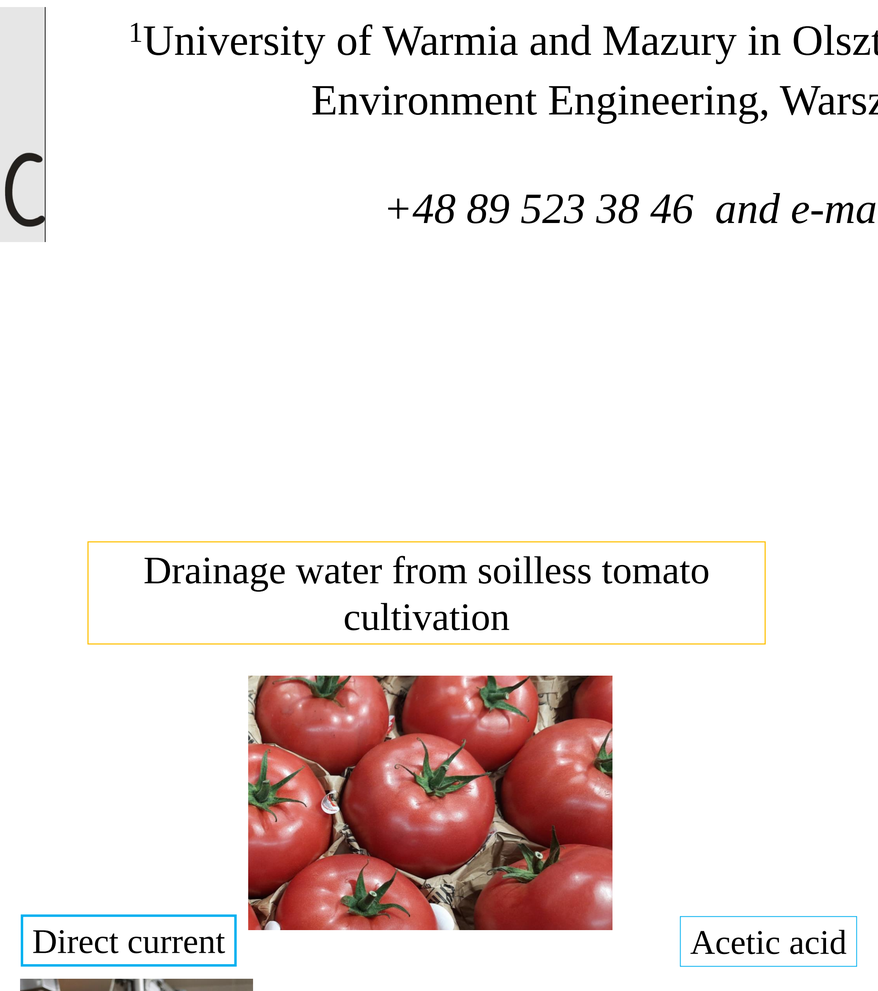

Figure 2 The scheme of experiment

Results and discussion

The method of supply electric current to the reactors significantly influenced the efficiency of drainage water treatment. The final application of the electric current (R2) increased the efficiency of using the organic substrate by 18.0% and nitrogen removal by 5.4%. At the same time, the efficiency of phosphorus recovery decreased only by 1.0%. Despite the higher efficiency of denitrification in R2, a higher percentage of nitrites was recorded, which was 13.4% (R2) with 7.1% in R1. The electrolytic conductivity of drainage waters decreased from 6.20±0.21mS/cm to 4.98 ± 0.55 mS/cm (R1) and 4.40 ± 0.44 mS/cm (R2).

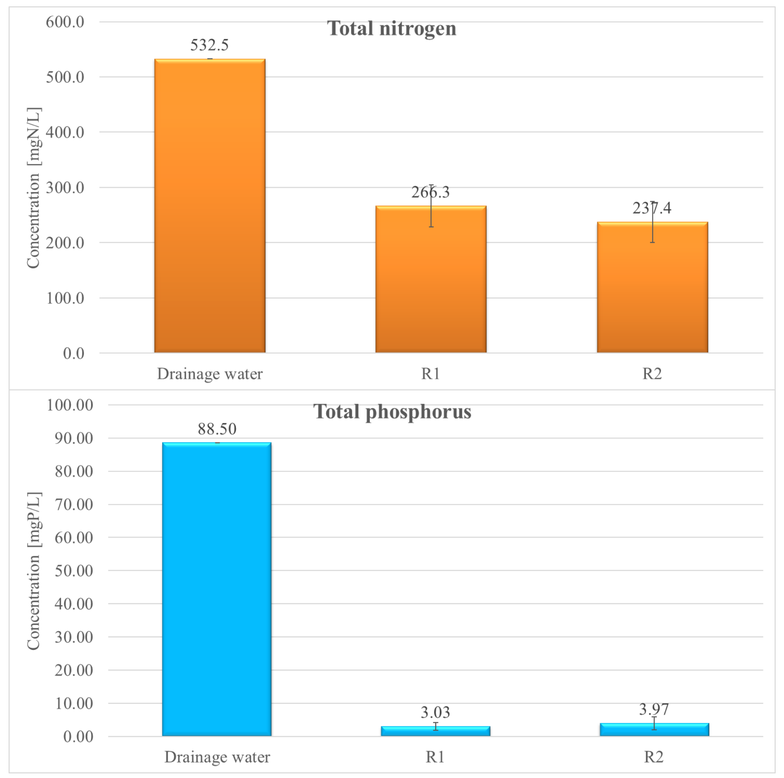

Figure 3 Changes in the concentration of total nitrogen and total phosphorus

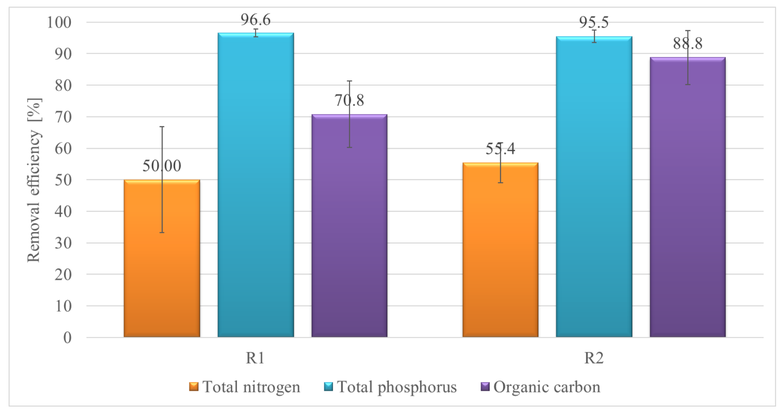

Figure 4 The effectiveness of total nitrogen, total phosphorus and organic carbon removal in EBR

Conclusions

Due to its specific composition, drainage waters pose a challenge in terms of treatment technology. One of the solution is to use electrobiological processes. The conducted research has shown that by consuming the same amount of energy in R2 as in R1, we can significantly increase the efficiency of the treatment.

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