Heterotrophic microalgae cultivation to couple wastewater treatment with feed and fertilizer production

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When fruits and vegetables are cleaned and processed, their residues are transferred to water both in solid and dissolved form. These effluents contain high organic and nutrient loads, but can also carry a small proportion of cleaning products, disinfectants, fibres, soil, insects or pesticides. Currently, the aerobic digestion is the pre-treatment system used in the fruit and vegetable processing (FVP) industry effluents before they are discharged in a municipal treatment plant. However, this on-site treatment generates large amounts of sludge that must be managed as waste.

The new treatment system developed under the LIFE ALGAECAN project will demonstrate the feasibility of an innovative in-situ treatment process for FVP effluents, which addresses the environmental problems associated with its current management using heterotrophic microalgae as treatment technology. This way, a purified liquid effluent will be obtained which can be used as irrigation water or for cleaning equipment or facilities, and a semi-solid stream of microalgae, which, after concentration using spray drying technology, can serve as raw material for the production of biofertilisers and animal feed. In addition, the energy used in the process is 100% from renewable energy.

Methodology

The treatment system prototype (Figure 1) is composed of three main steps:

a) Microalgae growth zone, which consists of a raceway for inoculum growth and a closed, aerated and stirred reactor where the treatment of wastewater with microalgae is carried out.

b) Area of microalgae separation from the treated wastewater by centrifugation. In this stage, two streams are obtained, clean water that can be used for irrigation, washing equipment, etc., and a stream with a microalgae concentration of ~ 10% for introduction into the next stage of the process.

c) Spray drying zone, where the stream with microalgae is dried to obtain the microalgae powder to be used as raw material in animal feed and biofertilisers.

These sysems are placed in two containers equipped with solar panels and a biomass boiler that provide energy to the whole system.

Figure 1. Pilot plant for the treatment of wastewater with heterotrophic microalgae.

Preliminary Results

An initial physical-chemical characterisation of the wastewater has been carried out in each of the facilities where the demonstration plant is going to be installed (HUERCASA company in Spain and VIPI company in Slovenia) to assess if the microalgae could be used for the treatment of this kind of effluents.

Once the wastewater had been characterised, the project team has proceeded to select the appropriate heterotrophic microalgae strin for the treatment, firstly, searching for microalgae adapted to their cultivation in the dark in commercial culture collections and finally searching among those cited in scientific publications. Finally, tests were carried out with *Chlorella sp*. microalgae and a mixture of microalgae from algal pond installation for treating the biogas plant digestate used in the AlgaeBioGas project (AlgaeBioGas.eu).

The tests consisted of growing the microalgae in the dark for 6 days in a pure culture and, after this time, put them in contact with the FVP wastewater. As a result, a large contamination of the medium by bacteria was obtained. To solve this problem, it was decided to cultivate the inoculum under autotrophic conditions before bringing it into contact with wastewater under heterotrophic conditions. By proceeding this way, tests were made in stirred and aerated 10L reactor.

As it turned out, the microalgae mixture harvested nutrients more effectively than *Chlorella sp*. The nutrient uptake was also better if the algae were starved or at least grown in a nutrient poor medium before utilized for the wastewater treatment. Additionally, to overcome problems related with infections without adding antibiotics, chemicals or other costly approaches, wastewater was inoculated with concentrated algae (algal paste) obtained by centrifugation.

The retention time used for optimal microalgae growth in the laboratory was 3 days, and the temperature at which the tests were done was 25ºC. Under these operating conditions, 300 mgmicroalgae/Lculture/day of biomass was produced.

With the operating conditions obtained on a laboratory scale, pilot-scale tests (Figure 1) have been carried out at the HUERCASA company facilities, obtaining as products resulting from the wastewater treatment process a water stream that complies with the legal discharge parameters and a microalgae powder (1250 gmicroalgae / m^3 wastewater) that can be used as fertilizer or for animal feed.

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