Solar-powered algal production on tomato processing industry wastewater

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Life Algaecan Technology

The LIFE ALGAECAN project proposed a sustainable treatment model of effluents with high organic load that combined cost-effective heterotrophic microalgae cultivation with spray drying of the collected microalgae to obtain a product of commercial interest as raw material to produce biofertilisers, animal feed, bioplastics, etc. The technology applied in the project is an innovative concept for wastewater treatment, its reuse and resource recovery to obtain a high-quality water stream. The prototype (Figure 1) was powered by renewable energy (solar energy supported by biomass), which minimized the carbon footprint and operating costs of the process. The final effluent quality was very high, allowing reuse for equipment cleaning or irrigation purposes. In the context of promoting circular economy and innovative technologies, this study aims to replicate the demonstrated prototype and treatment schemes in a tomato processing industry.

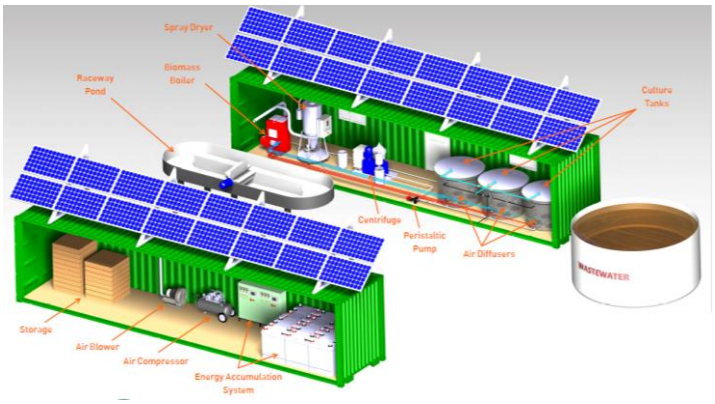

Figure 1. Life Algaecan demo plant.

Tomato processing industry - Case Study

The tomato processing industry that stands as the case study in the present work includes 3 different production lines: the production process of tomato pulp, the production process of diced tomatoes and the production of diced peeled tomato in aseptic packaging. The factory usually operates seasonally from the end of July to the end of September and has a processing capacity of 3500tn of fresh tomatoes per day. For the needs of production, 4m^3 of fresh water per tn of fresh tomatoes are required. Additionally, around 50tn/y citric acid and 10tn/y calcium chloride are used. From the tomatoes processing, solid and liquid waste are produced. The wastewater ends up in the wastewater treatment plant of the factory with an hourly flow rate of 300m^3. The quality characteristics of wastewater are as follows: 500mg/L COD, 300mg/L BOD_5, 100 mg/L suspended solids (SS) and 20mg/L total nitrogen (TN). The solid waste mainly includes tomato peels and spores and constitutes 3% of the incoming raw material; around 105tn/d. Currently, this waste stream is further used as animal feed in nearby farms. Defect tomatoes and plant residues are led to a privately owned landfill. The wastewater is treated in a plant that applies activated sludge technology and operates seasonally according to the operation of the factory. The treated effluent is disposed into the central drainage ditch of Xynias lake presenting the following characteristics: pH 6-9, Dissolved oxygen > 3 mg/L, Temperature < 28 ºC, TSS < 50 mg/L, BOD_5 < 25 mg/L, COD < 125 mg/L, electrical conductivity < 750 kS/cm, chloride ions< 120 mg/L, degree of alkalization 60%, boron <3 mg /L, total nitrogen < 10 mg/L and total phosphorus 0.4 – 5 mg/L.

Sustainable tomato processing wastewater valorisation scheme

The design of the full-scale replication in tomato processing facilities was made considering a wastewater flow rate of 300m^3/h. As far as wastewater characteristics are concerned, the following characteristics will be taken into consideration: COD: 500mg/L, BOD_5: 300mg/L, SS: 100 mg/L and TN: 20mg/L.

Figure 2 presents a simplified flow diagram of the full-scale replication of ALGAECAN system in a tomato processing industry. The flow rates, the characteristics of the influent and effluent along with the daily production of the microalgae are presented. The dimensioning of the equipment is also evident.

The final products of the full-scale replication of the ALGAECAN system in the tomato processing industry are: 6480m^3/d water effluent from the ultrafiltration unit, 644m^3/d treated effluent with 1365mg/L COD, 649mg/L

SS and 63mg/L TN and 1,14tn/d microalgae powder that could be promoted in the market either in bulk or packed in 5-20kg bags.

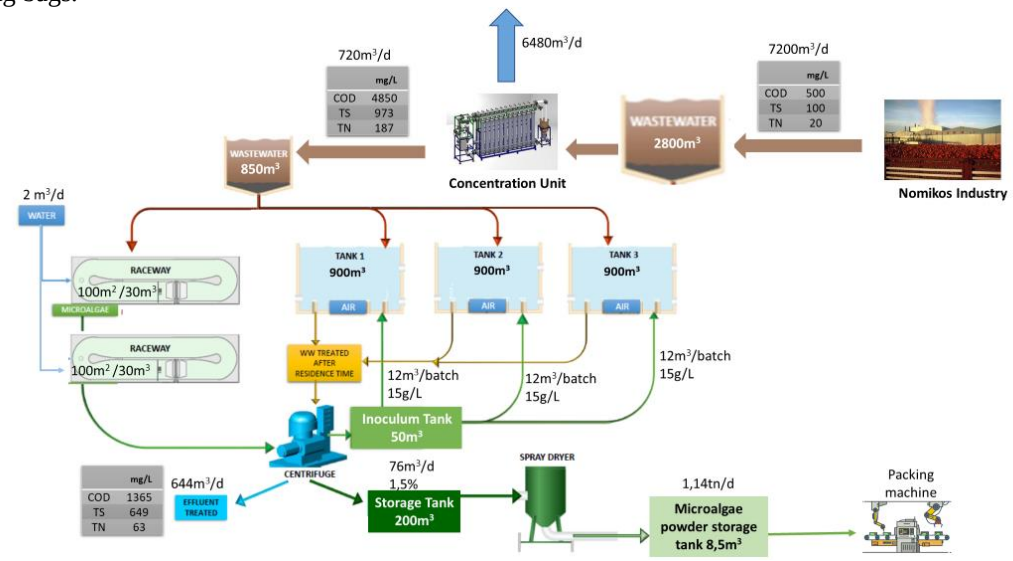

Figure 2. Flow diagram of full-scale replication of ALGAECAN system in tomato processing industry.

The potential uses of these end-products could be as described below. The water effluent from the ultrafiltration unit is of high hydraulic load (6480m^3/d). Given that the ultrafiltration unit is not included in the ALGAECAN system, but it was added in order to concentrate the wastewater nutrients' content and favour the microalgae cultivation, there are no operational and performance data regarding its performance. According to literature data, its pollution load could be considered very low and free of suspended solids. In this context, this stream could be reused within the industry.

As far as the treated effluent is concerned, the concentration of the suspended solids exceeds by fold the limit concentrations of the European legislation related to the possible reuse of effluents in irrigation. For this reason, an additional post-treatment step should be incorporated in the valorisation scheme in order to achieve the standards for water reuse. Technological alternatives that could be adopted include filtration, membrane-based techniques such as reverse osmosis, air flotation units such as DAF, sedimentation after coagulation etc. Yet, in the case of the tomato processing industry, the ultrafiltration unit that has already been incorporated in the full-scale system may be used for the post-treatment of this effluent. Regarding the possible reuse within the industry of this effluent, there are no sufficient data (e.g. concentrations of nitrates, nitrites, pH etc.) to examine this possibility.

The microalgae produced are expected to have a similar composition to the respective that derived from the demo plant. Thus, the potential uses of this product are as a fertiliser or as animal feed. Through the ultimate analysis of the produced algae of the demo system, it was evident that the produced algae could be commercialized as a solid NPK organic fertilizer being in line with the respective EU legislation framework. As far as the animal feed perspective is concerned, the algal end-product could be efficiently incorporated into the feed for a variety of animals, substituting a significant part of the animal feed required.

Conclusively, the proposed system could promote sustainability in tomato processing industries.

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