Strategies for the Minimization of Highly Polluted Effluents and Secondary Raw Material procurement to achieve a Circular Economy in fish canning industry

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Introduction

Tuna canning is one of the most important food sectors on the coast of the Cantabrian Sea. Specifically, companies in the Basque Country are known for maintaining a traditional procedure from fishing to processing, as small companies whose main objective is to obtain a high quality in the final product. However, the rise in raw material prices, environmental regulations, increasingly restrictive and sustainability standards demanded by society, are some of the main challenges is facing the sector.

Specifically, in the case of the aspects related to the use of water, this industrial sector produces an important environmental impact caused mainly by the high-water consumption, the generation of wastewater, and the production of waste. The artisanal fish canning sector produces effluents with high organic load, oils and fats, nitrogen (N), phosphorus (P), solids, and salt content (10–50 times higher than urban wastewater).

The Water Framework Directive (WFD) (European Commission, 2000) and other directives related to water have helped to strengthen the protection of the waters of the European Union (EU). Therefore, the canneries must take measures to treat the water until its total purification for discharge into the receiving waters, which requires costly and complicated treatment systems. In some cases, the water management entities of the area allow the discharge to the sanitation network although they are required to comply with the emission limit values (ELVs) (Cristóvão, 2012) because these loads can cause problems of inhibition in the biological treatment at the wastewater treatment plant (WWTP) (Osuna-Ramirez, 2017).

Hence, it is necessary to detect, quantify, and establish corrective actions, particularly, considering the spatial concentration of this type of company and their seasonal nature. It may happen that, although each company located in the area is able to comply individually with the discharge regulations, if all of them were to discharge their wastewater simultaneously to the sanitation system, urban WWTP would not be able to manage with that high point load.

In this context, the LIFE VERTALIM project has developed and validated the strategy called "three barriers" to reduce discharges at source through the improvement of the efficiency of the production processes of 4 fish canning companies. With the implementation of these eco-efficient plans, opportunities have been identified for improving water consumption, optimizing the use of raw materials and minimizing the generation of waste, as well as the valorization of secondary raw materials. The implementation of these improvings measures has helped to minimize and improve the quality of the canning of the canneries for subsequent safe integration into the urban sanitation network (Gutierrez, 2019).

Material and methods

Under this framework, the European project LIFE VERTALIM (http://www.azti.es/vertalim) was born, with the main objective of developing a holistic solution (technical, legislative, social, and environmental) for the controlled integration of the discharges of four small food companies into the urban sanitation system. In order to comply with the stated objective, the project is based on four action blocks: (1) the minimization of discharges at source in the canning companies; (2) the implementation of a tele-control system via GRPS (General Packet Radio Service) based on a global system for mobile communications technology in the network of sanitation and industrial discharges for the submission of data to the SCADA (Supervisory Control AND Data Acquisition); (3) the simulation, modelling for the control of discharges, and design of a management tool for the sewer system; and (4) the demonstration of the integral management system of discharges in the sanitation network (Gutierrez, 2018). The tool designed in LIFE VERTALIM aims to guarantee the success of this integration, allowing us to minimize the stressful factors of risk that may affect the quality of the final discharge of the WWTP.

The demonstration test of the project is being carried out in the area of the River Artibai, its estuary, and the adjacent coastal waters (Basque country, Northern Spain). In this area, there is a strong presence of industry in the canning sector, whose discharges have an important impact on the urban sanitary network. This urban WWTP treats the wastewaters from the surrounding municipalities, mainly the coastal village of Ondarroa and the inland town of Berriatua. In this area, the treatment of tuna canning wastewater is particularly difficult, due to the presence of the large number of small companies that are widely dispersed and have a high seasonal activity (Zufia, 2002).

The implementation of low-cost innovative solutions, through the performance of "3 Barriers system" based on clean and eco-efficient production and wastewater pre-treatment for fish canneries has been achieved in the project. Figure 1 indicates the objective of each barrier to reduce water consumption and minimize pollution of effluents.

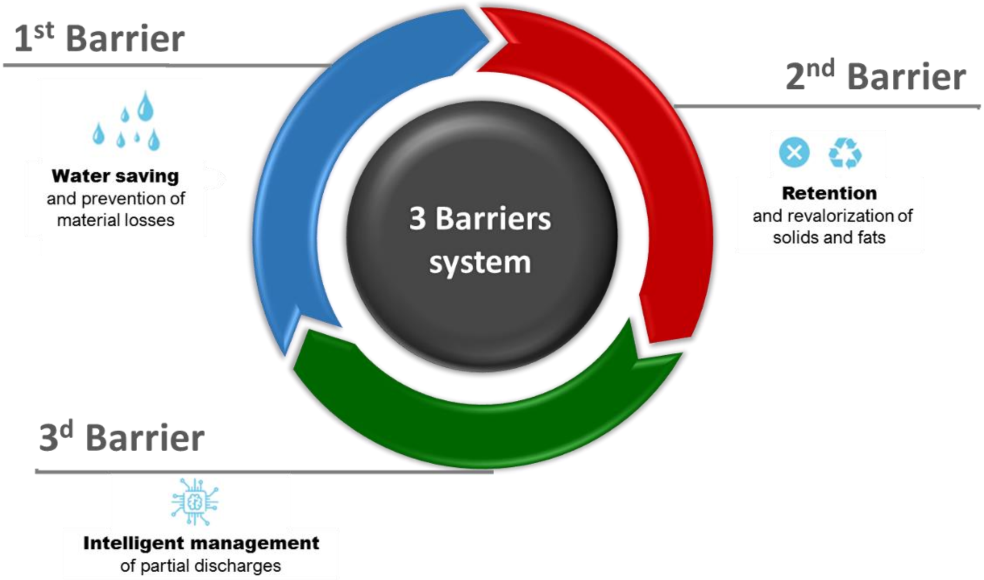

Figure 1: 3 barrier system methodology based on eco-efficient production

The analytical characterization of wastewater was made according to the standard methods for the examination of water and wastewaters (APHA; AWWA; WEF, 2012).

Results and discussion

The first step was the production diagnosis for identification of the main processes for water consumption and wastewater generation in the four companies of the project. For this purpose, several visits were made for the on-site observation of each process to quantify the water consumption and detect sources and causes of pollution generation by collecting wastewaters samples to analyse their contamination. Figure 1 shows the processes that generate large volume of effluents and the moment of the production in the working day in one of the canneries of the LIFE VERTALIM project. The effluents were produced discontinuously with wastewater generation peaks along a production day.

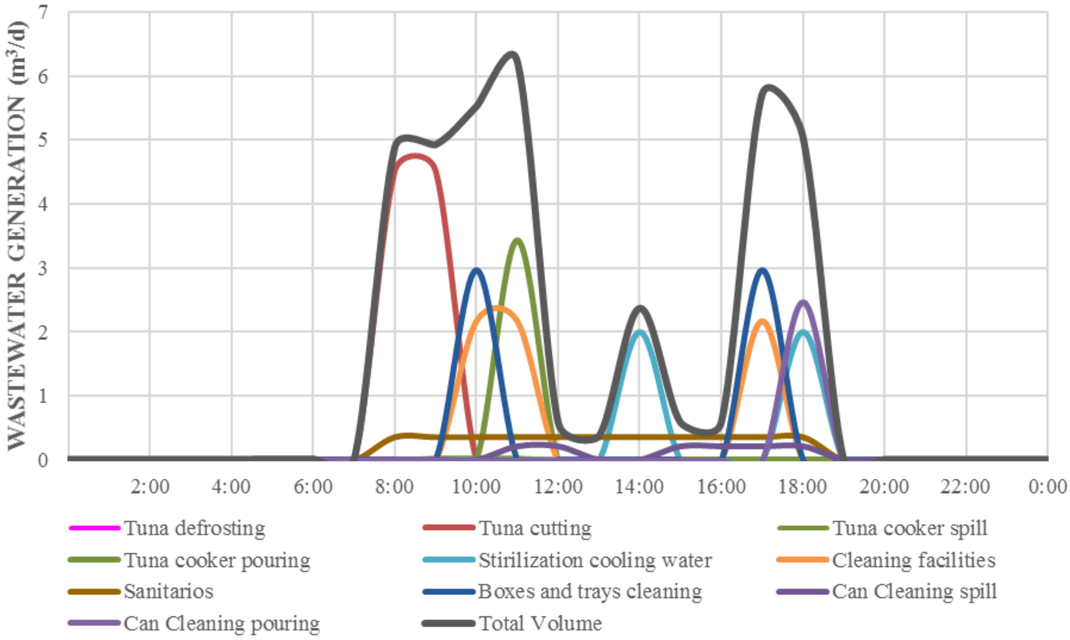

Figure 2: Example of wastewater generation along a working day by process.

Moreover, Figure 3 shows the processes with more water consumption were the tuna cutting, and the cleaning of machinery, trays and installation. Thus, the first barrier was needed to propose a collection of improving measures that helped to reduce water consumption and avoided solids in effluents for these processes.

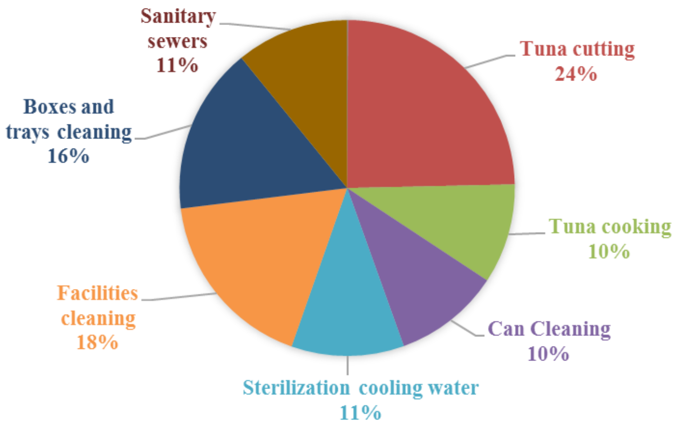

Figure 3: Water consumption ratio by process

The second feature of these types of effluents is the main contaminants and their source. In the case of fish canneries, the main pollution in wastewater comes from grease, conductivity and, in some cases, their temperature. Figure 4 shows the main processes that cause the worst pollution.

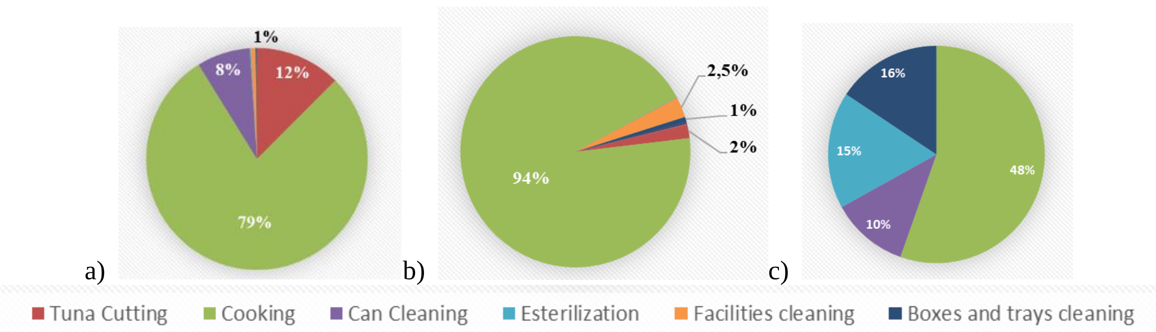

Figure 4: Main contaminants of the effluents a) fats, oils and grease, b) conductivity and c) high temperature, and the main processes that originate it

The most polluting process is the cooking of tuna in brine. Thus, the 2nd barrier proposed a pool of improving measures to prevent the wastewater pollution by acting in the tuna cooking process mainly, but also in tuna cutting and tuna canning. The application of these improving measures led to the recovery of fats and fish fragments that had previously ended up in the effluents or waste and that have been recovered for its valorization, generating circular economy.

On the other hand, some currents at high temperatures and low pollution have been recovered and reused by means of measures included in the third barrier.

These actions have led, on average, to a reduction of 30% of the wastewater discharges to the environment and a reduction of food losses of up to 0.1%. Moreover, there has been a reduction, on average, between 40% and 90% related to high organic load, mainly because of the recovery of secondary raw material such as fish protein from tuna pieces and fats with high Omega-3 content that previously ended up in the effluents.

Figure 5: Average improvement in different aspects of the production after the 3-barrier system implementation in four canneries of LIFE VERTALIM project.

Conclusions

In conclusion, the application of the "3-barriers system", developed in the LIFE VERTALIM project, contributes to comply with the emission limit values (ELVs) for the integration of canneries effluents into the urban sanitation systems, increasing the revalorization of secondary raw material, enhancing the circular economy of the area and reducing the sanitation costs for the canneries.

The results allowed the four canneries to dispose their pre-treated effluents to the urban sanitation system, avoiding the high costs of an industrial wastewater treatment plant (WWTP). The implementation of the 3-barrier system allowed the tuna canneries not only to reduce the industrial effluents treatment, and waste management but also to improving their productivity almost 1 % and the recovery of omega-3 rich oil and fish solids for new products as tuna crumbs and protein valorisation for fish meal.

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