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Primary treatment optimization of a fish canning wastewater from a Portuguese plant

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ABSTRACT

A sequence with three stages was optimized as a primary treatment for wastewaters from a fish canning industry of northern Portugal. Sedimentation tests were assessed at different times. The removal of a high fraction (75%) of oil and grease (O&G) and of some (48%) total suspended solids (TSS) occurred after a settling time of 1.5 h. Coagulant dosage and pH value were optimized in the coagulation/flocculation treatment using several organic and inorganic coagulants. Best removal efficiencies (99.2% O&G, 85.8% TSS and 25.2% dissolved organic carbon (DOC)) were reached using 400 mg/L of $FeCl_3$ at raw pH wastewater. DAF was also tested, optimizing chamber pressure and recycle ratio. Removals of 94% for O&G and 43% for TSS were achieved. The coupling of the latter two processes was also investigated, but no improvement of the previous results was observed. The best approach proved to be a decantation process followed by coagulation/flocculation treatment.

1. Introduction

Portugal is the largest fish consumer per capita in the European Union (EU) and third worldwide. Fish consumption in Portugal (55.6 kg/per capita/year) is more than twice the average consumption in

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the EU-2 [1]. The increase in consumption is mainly due to the consumer's perception that fish is a healthy alternative to other protein sources [2]. To meet this demand, the total fish processing has also increased. For example, in 2010, according to data from the National Statistics Institute, 42,000 tons of prepared and canned fish were processed in Portugal.

Similar to most processing industries, fish processing produces large volumes of wastewater, which contains especially organic contaminants, salts and oils dispersed therein [3]. The fish canning factories use a high variety of raw materials and depending on the particular operation, the degree of contamination may be small (e.g. washing operations), mild (e.g. fish filleting) or heavy (blood water or brine waters) [4]. Additionally, most fish canning industries located at northern Portugal only have pre-treatment of their wastewaters before discharge. All these factors together make difficult, for this type of industries, to meet the emission limit values (ELVs) for industrial wastewaters (Decree-Law no. 236/98). Due to this reason and to the implementation of strict discharge limits, it is necessary to study the application of a sustainable treatment sequence to this type of wastewaters that allows obtaining water with quality requirements for its discharge or reuse in the industrial process.

Primary wastewater treatment involves the removal of suspended solids by physical or physicochemical processes. Natural sedimentation may be assisted by the addition of coagulants and/or flocculants or carried out by centrifugation. This step also includes neutralization, stripping and removal of oil and grease by flotation.

Different processes have been described in the literature for the treatment of wastewaters with high oil and grease content, but the most commonly used are: chemical destabilization [5], membrane processes [6] and electrochemical methods [7]. The process of flotation for treating oily wastewaters was also already examined [8].

The principle of chemical destabilization of stable oil emulsions consists on canceling the energy barrier that exists between the oil droplets. This is attained by the addition of chemical compounds that neutralize the electric charge responsible by the repulsion of the droplets. The destabilized droplets are then agglomerated by coalescence or flocculation and, after that, separated by decantation, dissolved air flotation (DAF), centrifugation or filtration. The three neutralizing agents commonly used are metal salt [9], acids [10] and synthetic polyelectrolytes [11,12]. The best choice for a particular application depends on the system.

However, despite these techniques generally lead to interesting results, sometimes the characteristics of the treated effluent do not comply with the legal standards for discharge. To overcome these difficulties, dissolved air flotation (DAF) is sometimes a good solution. With DAF low density particles in suspension are brought to the surface of the liquid and removed, obtaining a clarified liquid. The suspended particles are carried to the surface by several microbubbles formed by the release of recycled water with dissolved air at high pressure into a flotation cell, at atmospheric pressure, that contains the wastewater to be treated [13]. The application of flotation to oil/water emulsions treatment was examined by Moosai and Dawe [14] and Qi et al. [15].

This work aims to optimize the primary treatment of a fish canning industry wastewater by sedimentation, coagulation–flocculation and flotation treatment processes. The treatment efficiencies were assessed in terms of total suspended solids (TSS), dissolved organic carbon (DOC) and oil and grease (O&G) removals.

2. Materials and methods

2.1. Chemicals

Two organic coagulants were provided by Rivaz Química, S.A.: RIPOL 070, a diester sulfosuccinate in propane – 1,2 diol solution, with 50–100% of sodium dioctil sulfosuccinate and 10–25% of 1,2-propanediol and RIFLOC 1815, a polyamine aqueous solution, with 25–50% of 1,2-ethanediamine polymer with (chloromethyl) oxirane and N-methylmethanamine and 18% approx. of aluminum polychloride. Solutions of five inorganic coagulants were supplied by Quimitécnica S.A. and were used without further purification: aluminum sulfate ($Al_2(SO_4)_3 \cdot 16H_2O$, 17% Al_2O_3, density = 2.7 g cm^{-3}), ferric sulfate ($Fe_2(SO_4)_3$, 44 ± 1%, density = 1.56 g cm^{-3}), ferric chloride ($FeCl_3$, 40%, density = 1.44 g cm^{-3}),