Flocculation on the Treatment of Olive Oil Mill Wastewater: Pretreatment

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I. Introduction

THE intensive activities of industry is accompanied by many type of wastewaters which decrease of environmental quality. Although these activities involves implementation of environmentally accepted processes, enormous quantities of industrial wastewaters are discharged into natural water bodies. Industrial wastewaters are mostly loaded with high organic matter [1].

In spain, the main olive oil producer worldwide, there are more than 1700 olive oil factories, which gave rise to more than 1,54 million tons of virgin olive oil during the 2010 campaign [2]. Olives and olive oil production grows year by year, and so does olive oil mill wastewater (OMW).

An average sized olive oil factory produces 10–15 m^3/day of OMW. Low pH, extremely high concentration of suspended and dissolved solids as well as heavy organic load are the regular characteristics of OMW. Among the latter, the high concentration of phenols and tannins commonly present in this effluent confers OMW phytotoxic and antimicrobial properties and low biodegradability [3,4].

Coagulation/flocculation is a commonly used operation in water and wastewater treatment in which compounds such as alum ($Al_2(SO_4)_3 \cdot 16\ H_2O$), aluminum chloride ($AlCl_3$), ferric chloride ($FeCl_3 \cdot 6\ H_2O$) and/or polymer are added to wastewater in order to destabilize the colloidal materials and cause the small particles to agglomerate into larger settleable flocs [5,6].

Objective

- Design and propose the use of a flocculation-sedimentation operation as a pretreatment of industrial wastewater from olive oil extraction factories.
- Study the influence of different concentrations of flocculants in solid-liquid separation and flocs formation.
- The reduction of the organic load on the wastewaters and identify the best flocculant to use.
- Determine the quality of the final water obtained.

II. Materials and Methods

A. Characterization of olive oil mill wastewater (OMW)

The wastewater (from olive oil produced by two-phase process) was analyzed and characterized using the following parameters:

- PH
- Moisture and volatile matters
- Total solid
- Organic matter
- Ash
- Chemical oxygen demand (COD)
- Total carbon (TC)
- Total organic carbon (TOC)
- Inorganic carbon (IC)
- Total nitrogen
- NO_2+NO_3
- Electric conductivity
- Turbidity
- Total phenolic compounds
- Chloride
- Sulphate
- Total iron

B. Experimental conditions and procedure

The developed oxidation process [7] for the wastewater treatment consists of the following operations: chemical oxidation, neutralization, solid-liquid separation and filtration (Fig. 1).

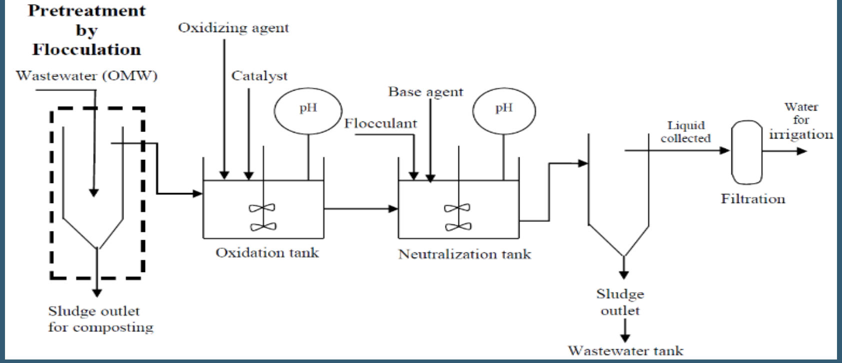

FIG. 1. Schematic diagram of the oxidation process used to produce irrigation water from olives and olive-oil-washing wastewaters.

C. FLOCCULANTS

Cationic polyelectrolytes: FLOCUDEX CS/45, CS49, and CS51.

Anionic polyelectrolytes: QG-2001 and Nalco-9913.

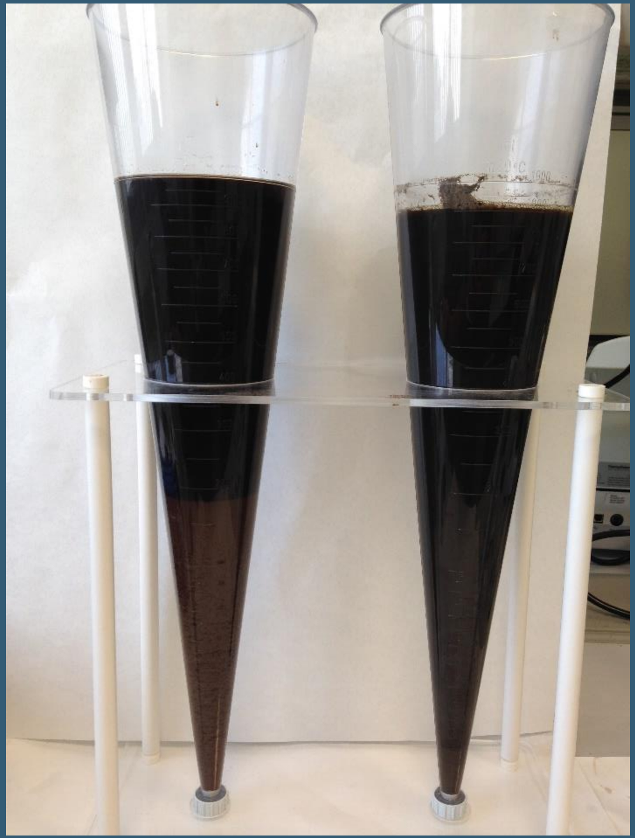

FIG. 2. Imhoff cone settling test.

III. RESULTS

TABLE I
Characterization of olive oil mill wastewaters.

Parameter	Sev-1	Sev-2	Sev-3
pH	8.5	8.6	8.8
Moisture and volatile matters, %	97.7	88.6	99.1
Total solids, %	2.32	11.4	0.95
Organic matter, %	0.32	1.8	
Ash, %	2.01	9.6	
COD, mg O_2/L	6187	18537	24302
Total carbon, mg/L	2636	14077	16077
Total organic carbon, mg/L	1891	11561	13371
Inorganic Carbon, mg/L	745	2516	2706
Total nitrogen, mg/L	113	390	376
NO_3+NO_3, mg/L	Trace	Trace	Trace
Conductivity, mS/cm	31.1	167	183
Turbidity, FTU	321.6	997	885
Total phenols, mg/L	37.8	190	179
Total Iron, mg/L	7.04	42.3	111
Cl, mg/L	10033	11544	12025
SO_4, mg/L	3922	1299	1299

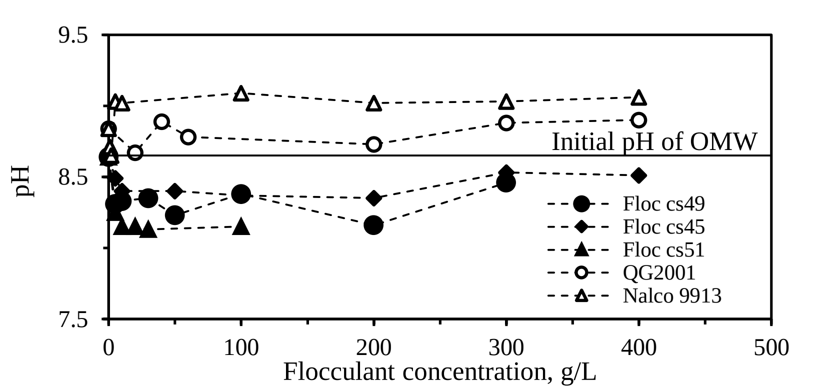

Fig. 3 pH variation on the OMW treated by flocculation.

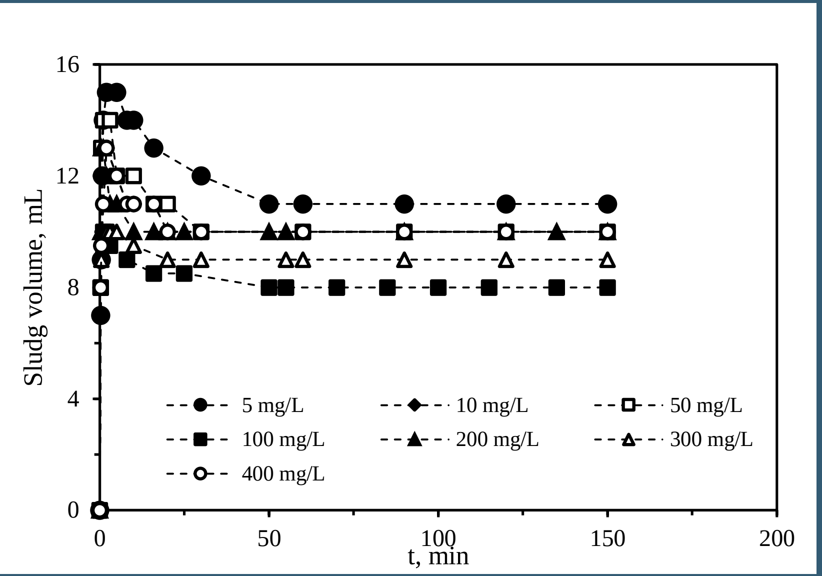

Fig. 4 Dynamic behaviour of sludge volume formed during flocculation with different concentration of Flocudex CS/45.

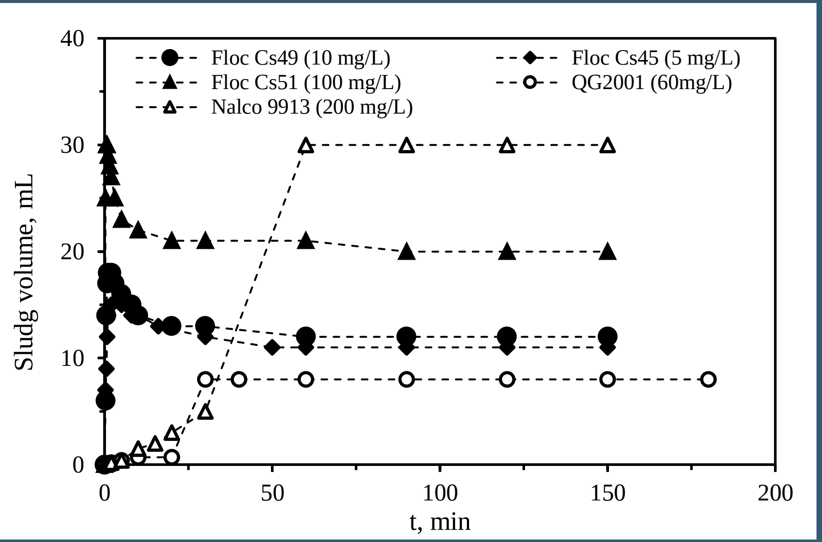

Fig. 5 Dynamic behaviour of sludge volume formed by all flocculants at the best flocculant doses.

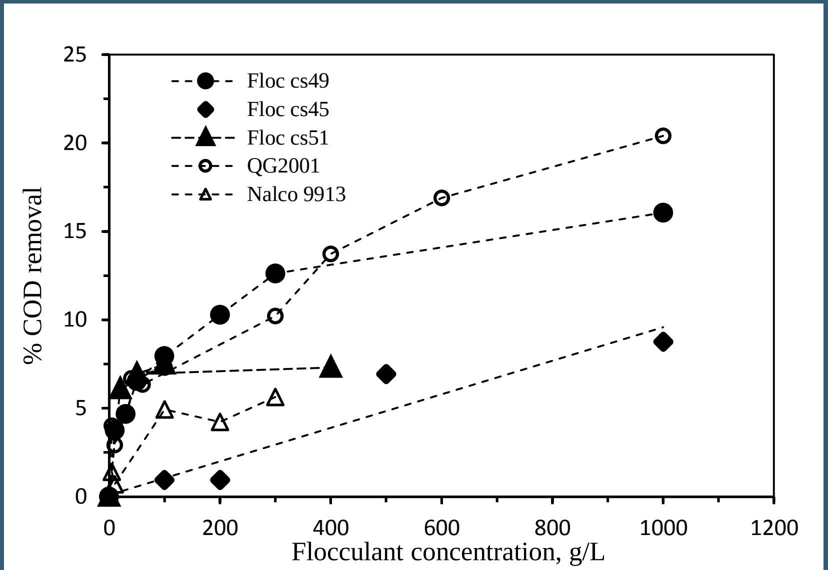

Fig. 6 COD removal by flocculants at different concentrations.

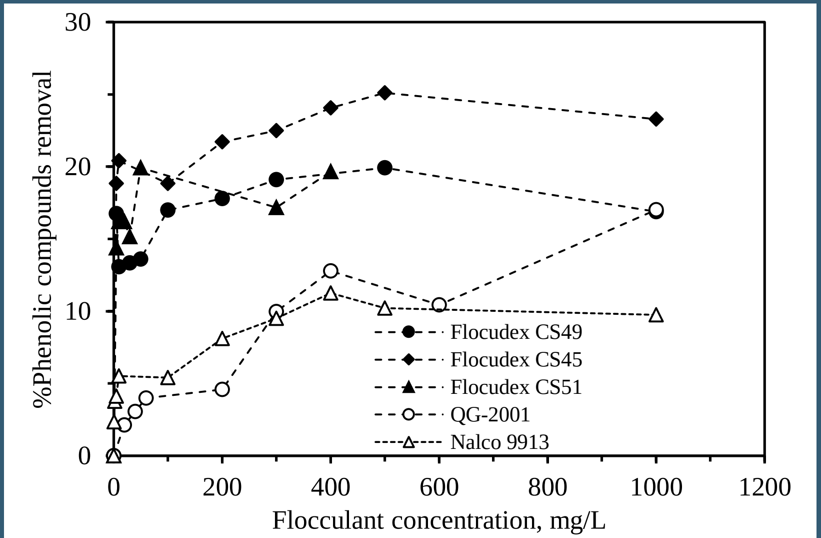

Fig. 7 Total phenolic compounds removal by each flocculant at different doses.

III. RESULTS

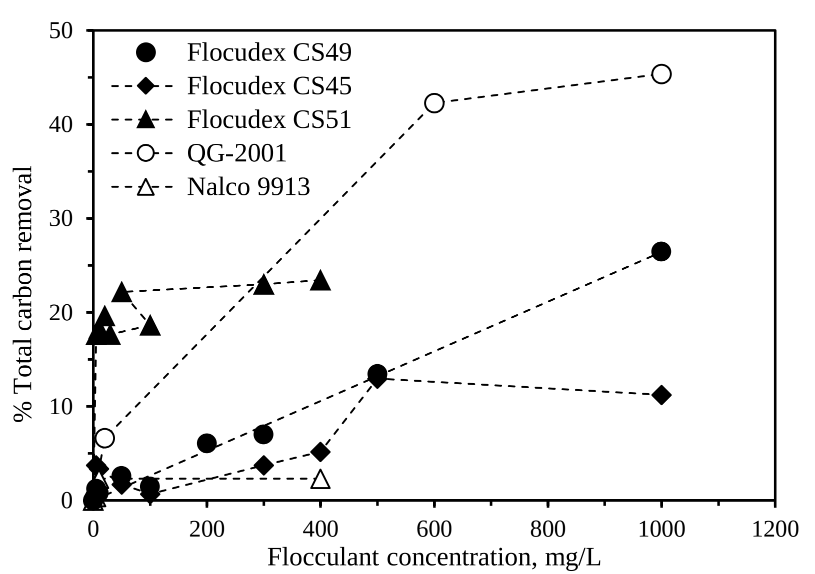

Fig. 8 Total carbon removal determined for each flocculant at different concentrations.

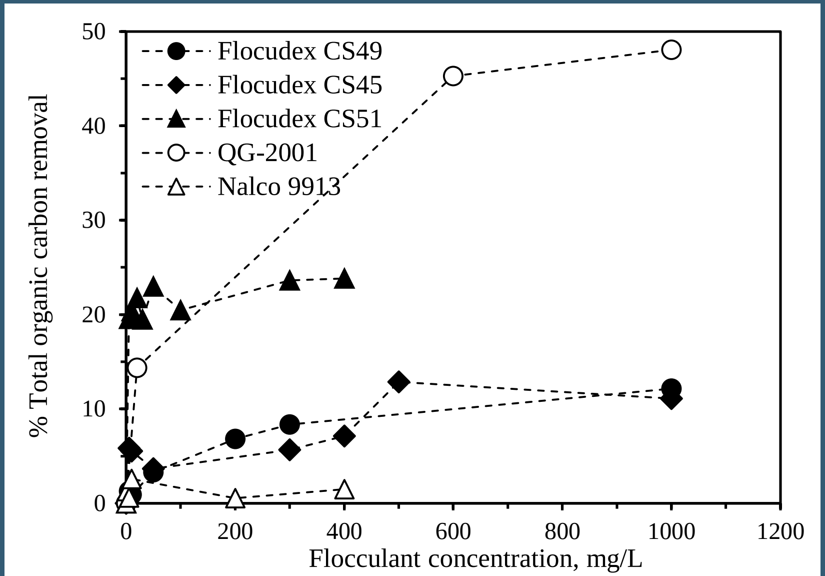

Fig. 9 Total organic carbon removal determined for each flocculant at different concentrations.

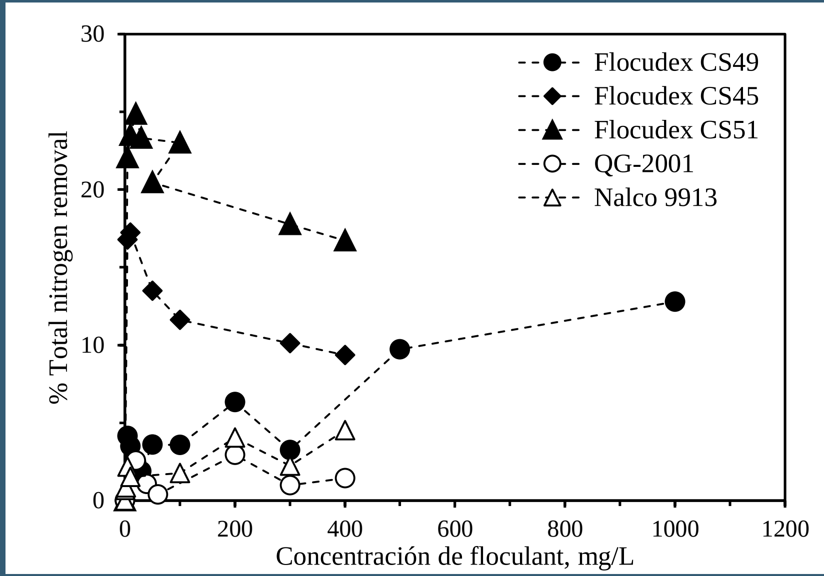

Fig. 10 Total nitrogen removal determined for each flocculant at different concentrations.

IV. Conclusions

Commercialization of advanced oxidation technologies is limited by the costs of treatment, mainly operating costs (costs of energy and chemical reagents). This fact implies that a pretreatment step by flocculation (COD removal = 5.6-20.4%) is a must application in the treatment processes based on the non-conventional methods.

Acknowledgment

The Junta of Andalusia and Ministry of Economy and Competitiveness (Spain) are acknowledged for financial support through Project Ref.: AGR-7092 "Application of advanced oxidation technologies for treating of washing wastewater of olive oil and olives".

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