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Short communication

Energy utilization and recirculation of currant-finishing wastewater

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Abstract

In this study, a new method for the treatment of currant-finishing wastewater was proposed in the context of the "clean technology" concept. This method consisted of two stages. In the first stage, the currant-finishing wastewater was recirculated in the currant-wash process and in the second stage this wastewater was utilized for the production of energy through anaerobic digestion. Recycling ratios from 0 to 95% were examined. By increasing the recycling ratio, effluent's COD increased from 3808 to 43,722 mg/l, effluent's BOD from 681 to 5378 mg/l, total sugars from 2.57 to 42.13 g/l, total phosphorous from 0.79 to 5.14 mg/l and total Kjeldahl nitrogen from 7.36 to 51.9 mg/l while fresh water addition decreased from 6 to 0.3 kg per kg of currants processed. The optimum recycling ratio range for the wastewater energy utilization proved to be 30–40%. In this range, the mass of COD and sugars digested was maximized resulting in the highest biogas production. Thus, the proposed system could be promising since water consumption is minimized and wastewater energy utilization is achieved rendering the process almost energetically self-sufficient.

Keywords: Currant; Currant-finishing wastewater; Wastewater reuse; Anaerobic digestion; Energy recovery

1. Introduction

The volume of currant-finishing wastewater (CFW) produced in Greece is estimated to be 4–6 m^3 per tonne of currants processed. The annual production of currants in Greece is about 80,000 tonnes for Sultana type currants and 87,000 tonnes for Corinthian type currants. Thus the corresponding CFW are of the order of 400,000 and 500,000 m^3, respectively, per year. These are disposed in the sea causing environmental pollution equivalent to a total population of 130,000 people [1].

The CFW are produced during currant washing. This is usually done by spraying fresh and recycled water in a primary washing unit followed by a SO_2 treatment unit for sterilization and decolourisation of currants. After this, there is a second washing unit where the currants are finally washed using just fresh water. The spent water goes through a fine rotating screen for suspended solids removal. Some of this screening wastewater is reused for washing while the remainder is rejected as CFW. The recycled wastewater is usually about 20–30% of the fresh water flow. At any time, the ratio of washing water to raw currants input in the primary washing unit is about 10/1 to 15/1 (weight per weight) [2].

CFW contains mainly sugars, tannins and colloidal suspended solids [3]. The concentration of sugars, mainly glucose and fructose, ranges between 10 and 30 g/l, while average COD values have been reported as 20,000–30,000 mg/l with a COD/BOD_5 ratio of around 10 [3]. A high COD/BOD_5 ratio indicates high toxicity of CFW, probably due to the presence of tannins extracted from the grape skin and from the use of SO_2 during processing.

A small amount of lipids is present in CFW. The level of total Kjeldahl nitrogen (TKN) varies from 50 to 100 mg/l and tends to follow the trend of COD. The pH of CFW is slightly acidic (∼6.3).

Among the common types of CFW treatment, aerobic biological oxidation (biofiltration/activated sludge) is considered to be an expensive option in terms of both capital and operational cost [4]. Alternatively, anaerobic digestion of CFW seems to be more advantageous than aerobic treatment due to the fact that it requires lower energy [3,5].

This paper reports on the possibility of recirculation of CFW in an effort to remove suspended and colloidal particles, minimizing water volume and energy under the philosophy of "clean

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technologies concept", while achieving the energy utilization of the wastewater through anaerobic digestion.

2. Materials and methods

2.1. Methodology

Fig. 1 is a block diagram illustrating the steps of the currant-wash process that were followed in the laboratory scale plant. The 0.5 kg of currants were washed using 3 kg of water for 10 min in the primary washing unit. The mixture was drained on a sieve and the drains were collected and filtered for the removal of solid wastes. The currants were led to a SO_2 treatment unit for sterilization and decolourisation. Then the currants were rewashed in the final washing unit with a mixture of fresh and recycled water. The drains of this unit were led to the primary washing unit.

The drains collected from the primary washing unit, after the solid wastes' removal, were treated with aluminium (1% w Al/w suspended solids) followed by lime for pH adjustment at 8.5 and by Praestol-2540 (0.05%, w/w). Praestol-2540 is a mildly anionic polyelectrolyte of the polyacrylamide type. The chemically treated effluent was transferred to a settling tank for sedimentation. After one hour, the separated sludge was removed by pumping it from the bottom of the settling tank and the supernatant liquid was divided into two portions: one portion was removed (in order to adjust the recycling ratio and to make the necessary chemical determinations) and the other was recycled.

The 0.5 kg of new currants were added to the primary washing unit and the process described above was repeated. Every sequence of trials was continued until there was no change of the effluent soluble characteristics; that is until steady state conditions were achieved.

The recycling ratio of the effluent was defined as follows:

$$r = \frac{Q_r}{Q_r + Q_{in}} \times 100\%$$

where r is the recycling ratio, Q_r the volume of effluent recycled per each trial, and Q_{in} is the volume of fresh water added per each trial.

The aim of each experiment was to determine the influence of the applied effluent recycling ratio on the characteristics of the discharged effluent.

Experiments were run under recycling ratios of 0–95% with a step of 5%. For each trial the following parameters of the discharged effluent were measured: BOD_5, COD, total phosphorous (TP), total Kjeldahl nitrogen (TKN) and total sugars (TS).

The discharged effluent was collected and was led to a UASB reactor (Fig. 2) with a volume of 20 l and operating temperature of 35 °C. The organic loading rate (OLR) was kept constant for all recycling ratios and equal to 5 g COD l^{-1} day^{-1}. In order to achieve this, the hydraulic retention time (HRT) varied from

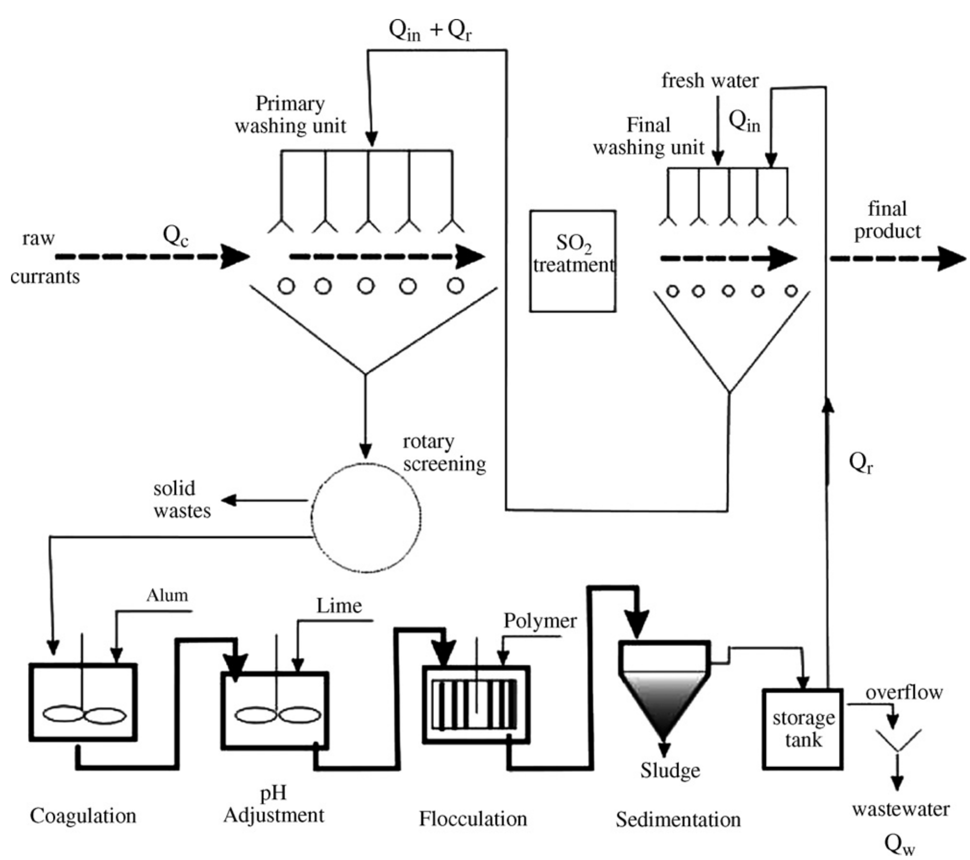

Fig. 1. Block diagram of laboratory pilot plant (currant-wash process–wastewater treatment).