Drying of olive waste mill wastewater for material recovery

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Introduction

Olive oil industry generate large quantities of olive by-products especially in Mediterranean countries. Different kinds of extraction processes are commonly used. The 3-phase system, mainly used in Tunisia, Greece and Italy, generates a solid residue (named olive mill solid waste SW) and a liquid effluent (olive mill wastewater OMWW). Approximately 30 million tonnes of OMWW are generated each year in the Mediterranean region (Roig et al. 2006). The OMWW contains water (around 80%), soluble organic compounds and salts and it is slightly acidic. These wastes are in most cases land spread, composted or treated by chemical or electrochemical oxidation. For logistical and economical reasons, OMWW are often discharged and stored in natural open-air basins, that causes soil and sub-soil contamination. Indeed, the waste surface rapidly dries (as a result of the heat supplied by air flow and sun heating), and a crust rapidly covers the surface, thus inhibiting the mass and heat transfers with the close environment.

Figure 1: OMWW after 2h of air drying (oven 80°C)

Figure 1 shows the formation of a black layer with a plastic-like consistency covering the liquid waste. This crust prevents the evaporation of water, enhancing the percolation of wastewater into the ground. Moreover, this waterproof layer restrains the soil aeration and drainage thus sterilising the soil.

However, due to its high energy content the use of such wastewater remains attractive . Indeed, recent studies have focused on combined strategies for the treatment and the energy recovery by impregnating the wastewater on low-cost biomass for green solid fuel production. The combustion of these green fuels in domestic boilers has shown good efficiencies. But the solid fuel production and the process optimization require the previous drying of the impregnated samples. This is a necessary but expensive step (in terms of storage volume, amount of electrical energy used and investments). Convective drying is generally the most applied technique because it is the best possible compromise between a good drying efficiency and a relative low application cost.

Material and methods

In this study, drying of OMWW samples was performed in a forced convective dryer. The set-up included a balance to monitor the sample mass. The different operating parameters (sample temperature, air humidity, velocity, ...) were also continuously acquired . Three samples were studied; the OMWW and the waste water impregnated on sawdust (IS-25g for 100 g of OMWW) or on exhausted olive mill solid waste (ISW- 35 $\%_w$). The sample drying procedures were performed for temperature ranging from 40 to 60°C and for air velocity in the 0.7 - 1.3 m/s range. The moisture content (X) of the studied samples was estimated from mass measurements (eq. 1);

$$X = \frac{m(t) - m_s}{m(t)} \qquad \text{Eq. 1}$$

and the drying kinetic investigated via the Henderson and Pabis model (Meisami-Asl et al. 2009); eq. 2.for different operating conditions as follow:

$$X = a \exp(-kt) \qquad \text{Eq. 2}$$

This model is commonly used to describe the drying of diffusive transfer inside thick materials (agrifood products, wood chips, ...).

Results

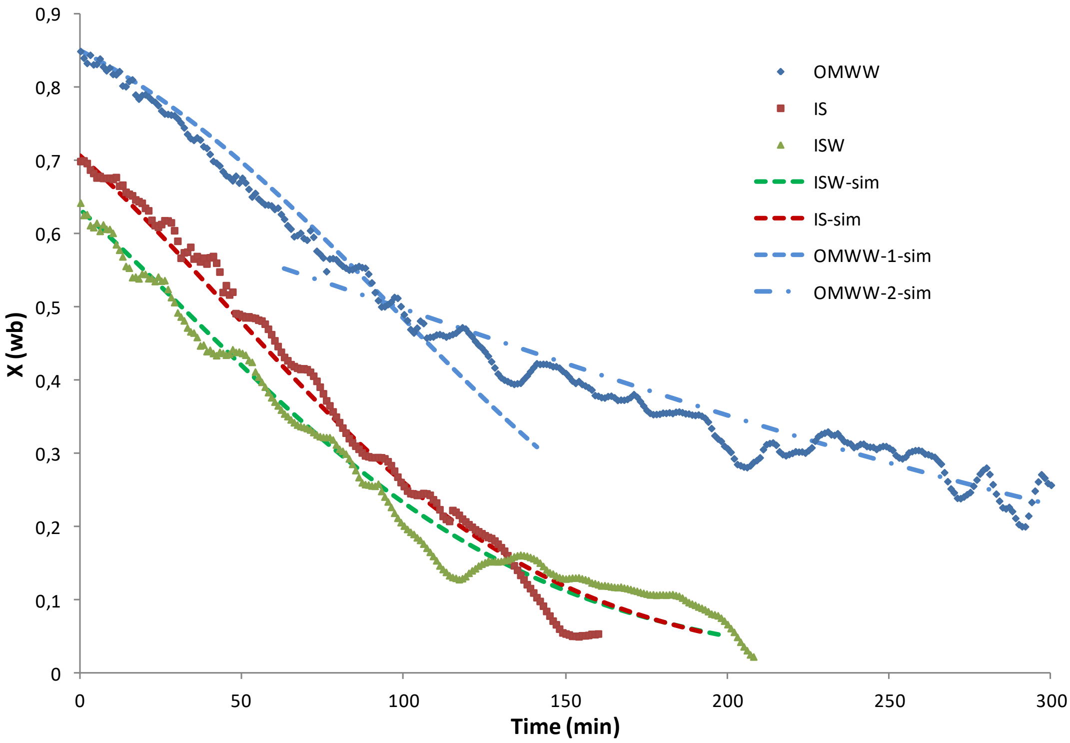

Figure 2: drying kinetics (experimental and calculated) of the studied samples (OMWW, IS and ISW); operating conditions: V = 1 m/s, T = 50°C

Figure 2 shows the experimental and simulated drying kinetics of the three samples performed at 40°C and 1 m/s. First, the experimental results show that the drying is faster for the impregnated materials than for the OMWW. Similarly, the wastewater impregnated with sawdust (IS) dry faster than the liquid after impregnation on exhausted olive mill solid waste (ISW). The numerical investigations are performed for each test by minimizing a quadratic criterion between the experimental and the calculated values. As it can be observed in Figure 2, the model of Henderson and Pabis well approximated the drying kinetics of the impregnated samples, but not at all the OMWW drying. Actually, the model is able to approximate the beginning or the final part of the curve, but not both sections at the same time. This transition section corresponds to formation of the crust. In the first section of the curve, the drying is fast because the water is at the surface of OMWW, then the water is isolated from the convective air by the crust, thus constraining the mass transfer from the solution to the exchange surface.

Conclusion

The study shows that the impregnated samples dry faster than the wastewater alone, and that it becomes easily to recover for heat supplying applications. Moreover, after impregnation, the material dries uniformly, limiting the wastewater percolation, and reducing the time of storage.

References

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