OLIVE MILL WASTEWATER STORED IN EVAPORATION PONDS: INTEGRAL ASSESMENT OF IN SITU BIOREMEDIATION STRATEGIES (COMPOSTING vs VERMICOMPOSTING)

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Introduction

In the olive oil production process, the disposal of olive wastewaters (OMWW) is one of the major environmental concern (Gaillou *et al*., 2018). The most cost-effective method is direct application of OMWW on soil, but this causes strong phytotoxic and antrimicrobial effects, increasing the soil hydrophobicity (Sierra *et al*., 2007).To solve this concern, the most common method for its management has been the storage in evaporation ponds. The large amounts of OMWW produced in Mediterranean countries, the difficulty in handing and its characteristics, underline the need to found adequate treatment methods to ensure a correct disposal of these wastes. This study aims to assess *in situ* bioremediation strategies for the treatment of OMWW based on composting and compo-vermicomposting.

Material and methods

The area of study was located in Mora (Toledo, Spain) (39° 40’ 07.4” N 3° 49’ 40.2 W m.s.n.), the climate in this area has been classified as sub-humid. In this location there are eight evaporation ponds in 5 ha, which were used to OMWW storage. The bioremediation treatment based on *in situ* composting and compo-vermicomposting consist on four trapezoidal piles with 7.5 m x 3.5 m x 1.5 m with 27 m^3 of mixture in each pile. To carry out the treatments were prepared 183 m^3 of mixture with OMWW and different organic materials available near to ponds, with the following proportions and characteristics (Table 1.).

Table 1. Characteristics of the OMWW and raw materials tested in bioremediation strategies.

Material	Volume m^3 (% f.w.)	Moisture (%)	MOT (%)	C (%)	N (%)	Apparent density ($t\ m^{-3}$)	Polyphenols ($mg\ kg^{-1}$)
OMWW	60 (33)	39	45.8	30	1.6	0.80	19996
Rabbit manure (RM)	80 (44)	63	73.7	48	1.2	0.40	4809
Spent mushroom (SM)	34 (19)	75	78.3	46	0.6	0.35	2008
Chicken Manure (CM)	8 (4)	13	29.7	46	2.3	0.50	3356
Initial Mixture	183 (100)	50	37.3	C/N= 25		0.60	6086

The OMWW and composting samples were air-dried to 45°C in order to avoid the phenolic compounds degradation and then ground to obtain a dust particle size with agate ball mill (Frischt Analysette 3 SPARTAN). Humic fractions were extracted and analyzed as described by Estrella-González *et al*. (2019). The germination index was assessed using of *Lepidium Sativum* seeds. Ecotoxicity was measured by determining the bioluminescence inhibition of *Aliivibrio fischeri* according to Jarque *et al*. (2016). During the maturity phase in the two vermicomposting piles were introduced the earthworms. Healthy earthworms, a mixture of *Eisenia foetida* and *Eisenia andrei* with a 90/10 earthworms ratio, respectively, was applied to vermicomposting breeding of 7m x 1,3m x 0,4 m (2.5m^3) constructed near to pile with an initial density of 2500 earthworms/m^3. The EXI^2 index that allows to evaluate the thermophilic behavior during the bio-oxidative phase was calculated according Pelegrin *et al*. (2017).

Results and discussion

During the first 20 days of composting, the temperature remained below to 40°C in the four piles. After the first turning at 20 days, the temperature quickly raised the thermophilic range (>40°C), which was maintained at least during 45 days. This slow rise of the temperature in the mixtures could be due to; 1) the excess of moisture in OMWW; 2) the presence of the recalcitrant components like phenolic compounds (Table 1), which difficult the bio-activation in the mixture, 3) and the scarce porosity of the matrix, due to the hydrophobicity character of OMWW. The EXI^2 Index also showed the same slow increase in all the piles if compared with other composting studies (Pelegrin *et al*., 2017) about sewage sludge and agri-food sludge. The stability in EXI^2 values reached about 150 days could be indicating a decrease in the microbial degradation of the more-labile OM content.

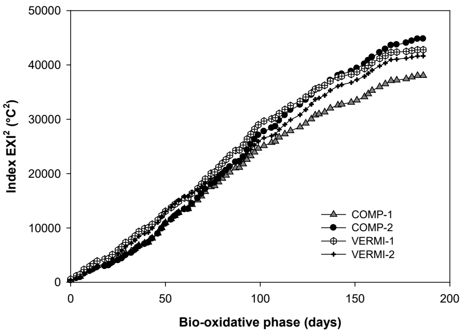

Fig 1. Evolution of the cumulative values of EXI^2 during the bio-oxidative phase.

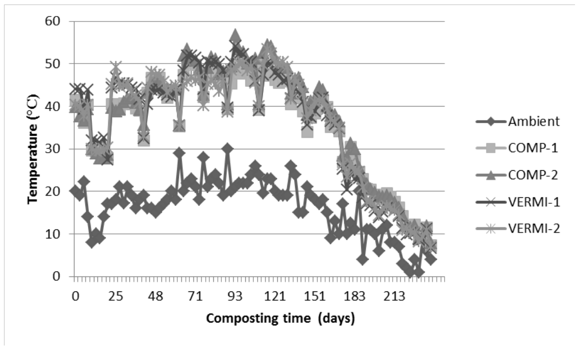

Fig 2. Temperature evolution during composting process

As it would be expected, in the phenolic compounds of OMWW was detected a dilution effect when mixed with different organic materials, but the initial mixture present toxicity unit (TU) values above 5, which could be considered as an acute toxicity level. As it can show in Fig. 2, the levels of TU progressively decreased from the beginning of composting, reaching lowest values in vermicomposting piles at the end of the process. The humic content increased during composting, especially during maturation phase. The GI reached values were of 112 and 129% in the composting piles and 99.7 and 100 % in vermicomposting piles, obtaining a non-toxic and humified product.

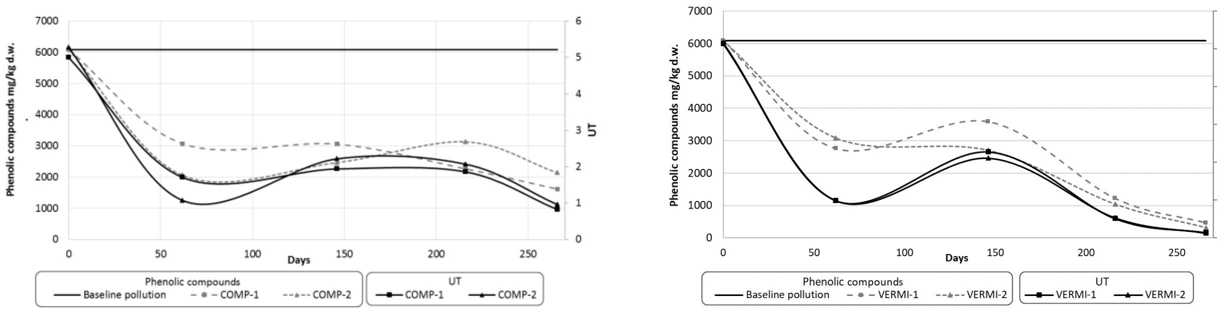

Fig.2. Evolution of the phenolic compounds and toxicity units (TU) in the four piles tested during the composting process.

Conclusions

The bioremediation strategies tested were showed as feasible methods to treat OMWW. During the composting and especially vermicomposting an important degradation of the polyphenol compounds were observed, which consequently allowed to reduce the toxic and phytotoxic effect of OMWW. Due to its characteristics, a correct management of the composting process is needed in order to disposal the maximum amount of OMWW.

References

Estrella-González, M.J., Jurado, M.M., Suarez-Estrella, F., López, M.J., López-González, J.A., Siles-Castellano, A., Moreno, J. 2019. Enzymatic profiles associated with the evolution of lignocellulosic fraction during industrial-scale composting of anthropogenic waste: Comparative analysis. Journal of Environmental Management 248, 109312.

Galliou, F., Markakis, N., Fountoulakis, M.S.m Nikolaidis, N., Manios, T. 2018. Production of organic fertilizers from olive mill wastewater by combining solar greenhouse drying and composting. Waste Manag. 75, 305-311.

Jarque, S., Masner, P., Klánová, J., Prokes, R., Bláha, L. 2016. Bioluminiscent *Vibrio fischeri* assays in assesment of seasonal and spatial patterns in toxicity of contaminated river sediments. Front. Microbiol. 7, 1738.

Pelegrín M., Sáez J.A., Andreu-Rodríguez, J., Pérez-Murcia M.D., Martínez-Sabater E., Marhuenda-Egea F.C., Pérez-Espinosa A., Bustamante M.A., Agulló E., Vico A., Paredes C., Moral R. 2018. Composting of invasive species *Arundo donax* with sewage and agri-food sludge: Agronomic, economic and environmental aspect. Waste management 78, 730-740.

Sierra, J., Marti, E., Garau, A.M., Cruañas, R. 2007. Effects of the agronomic use of olive oil mil wastewater: field experiment. Sci. Total Environ. 378, 90-94