Innovative biotreatment of oil mill wastes to produce a first class soil conditioner

Konstantinos Chassapis, Maria Roulia, Georgia Panagopoulou, Dimitrios Gkikas

Inorganic Chemistry Laboratory, Department of Chemistry, National and Kapodistrian University of Athens, Panepistimiopolis, Zografou, 15771, Athens, Greece
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Presenting author email: gpanago@chem.uoa.gr

Over 750 million olive trees (*Olea europaea L.*) are cultivated worldwide, 95% of which are in the Mediterranean region. Greece lies among the top three main olive oil producers worldwide, after Spain and Italy, all accounting for the 93% of the European olive oil production (Buckland and Gonzales, 2010)

During olive oil extraction a large amount of solid and aqueous residues known as olive oil mill wastes (OMW) arises as by-product. The most dangerous pollutant is the phenolic residue constituting 2-15% of the organic fraction.

OMW can be directly discharged neither into aquatic receivers nor onto land. Their insufficiently stable organic matter can cause negative effects on both soil properties and plant growth release of phytotoxic substances, and microbial immobilization of plant nutrients (La Cara *et al.*, 2012). In Greece, neutralization of OMW with lime is applied casually, prior to disposal in evaporation ponds/lagoons. In these cases, serious environmental problems may arise, such as overflow and contamination of neighbouring systems with polyphenols, other toxic organic compounds, high COD, low dissolved oxygenas well as induction of anaerobic conditions and odour nuisance. However, the high content of organic matter and mineral salts offers a promising basis that OMW can be exploited as a raw material to produce eco-friendly soil conditioners, suitable to organic cultivations, useful from both economic and scientific point of view. The utilization of the anaerobic digestion was reported as one of the most promising technologies for the disposal of OMW.

Bioremediation of OMW via composting is an integrated olive oil waste management. The main advantages are the reduction of organic pollutants and the production of a neutralized compost material. On the other hand, traditional OMW composting is a time consuming process that takes place for 8-12 months, needs large land areas and sometimes the end product is not the expected one because the whole process depends on many parameters. Generally, the compost is a good organic matter source that increases soil's fertility, water retention and cation exchange capacity. It also favours soil's microbial populations that lead to pesticides and other organic substances breakdown. Moreover compost can impair the development of soil-borne pathogens and reduce heavy metals bioavailability.

In the present work, a new green method for the biotechnological treatment of oil mill wastewaters is discussed. The innovation introduced, compared with the traditional composting of OMW, involves the addition of a biocatalyst (Chassapis, 2004), extremely rich in microorganisms, which accelerates the biodegradation of phenols, thus, affecting decisively the composting process.

The materials used in composting are described below:

1. Olive mill waste waters from 3-phase mill. They may be replaced by 2-phase mill wastes.
2. All plant materials that remain in olive mills before olive oil extraction. They may be replaced by other green residues.
3. Biocatalyst

   Innovative solid substrate based on a special organic rock of mineral origin, inoculated with laboratory cultivated soil microorganisms.

   Typical analysis of the biocatalyst:

   Microorganism population (Bacteria, mycetes, actinomycetes,) 2×10^9 c.f.u./g

   Humic substances 30% (dry basis)

   Mineral content 38% (dry basis)

   The composting procedure involves the following stages:

- Mixture of OMW and crushed plant residues 50:50
- Addition of biocatalyst and nutrients
- Stacking of the composting mixture to piles

- Monitoring of physicochemical parameters
- Aeration of the mixture
- Wetting whenever moisture falls below 50%
- Biostabilization for two months

This process is based on the biocatalytic treatment of OMW and is advantageous as being faster and cheaper than any similar composting method. The aim is to utilize degraded and toxic remains to produce eco-friendly compost with higher added value compared with those obtained from the conventional methods of waste management. The biocatalyst accelerates five times the biochemical reactions in the compost, enhances the bio-oxidative phase of composting and provides all the necessary microorganisms for the decomposition of polyphenols, carbohydrates, lipids and other organic substances. Additionally, the biocatalyst operates at a wide pH range.

The evolution of polyphenolic compounds was studied using Folin-Ciocalteu quantitative analysis parallel to other compost maturation indices (Kazamias *et al.,* 2017) as shown in Table 1.

Table 1. Basic physicochemical parameters of OMW material before and after composting

Parameter	OMW	Initial mixture	After 60-d treatment (Soil conditioner)
Moisture (%)	90.3	68.1	48.9
Electrical conductivity (mS/cm)	41	1.92	1.8
pH	5.48	5.7	7.3
Bulk density (g/ml)	0.98	0.33	0.4
Ash (% w/w)	7.3	14.0	21.9
Organic matter (% w/w)	92.7	86.0	78.1
Total organic carbon (% w/w)	53.8	49.9	45.3
Total Kjeldahl nitrogen (% w/w)	1.7	1.3	1.3
Humic acids (% w/w)	nd	5.8	8.0
Total phenols (mg/kg)	374.3	80.3	32.3

The results presented in Table 1 reveal a significant reduction of the polyphenols content (91.4%) between OMW and the produced compost as a result of the biocatalytic treatment.

The product obtained was further evaluated regarding its soil-conditioning and biofertilizing properties. The process described above was applied to the OMW of an olive oil cooperative in Rovies Euboea. The product was applied to their olive trees with spectacular results.

In summary, an innovative simple and quick green method for the biotechnological treatment of OMW is presented, which can be easily upgraded on the large scale, to handle effectively wastes from olive oil production and produce a first class soil conditioner. The proposed method is a low cost process in both investment and operation and converts a toxic waste into a product with first class soil conditioning properties. It offers a significantly reduced production time of 2 months compared to 12 and 18 months needed by the common procedures. The soil conditioner produced shows positive effect on plant growth and can replace the more expensive and non-renewable black-humus peat. The whole process meets the requirements of ECOLABEL and the product can be used in Organic farming.

References

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