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Olive oil waste treatment: A review

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Abstract

The most intriguing results were obtained on UASB reactors, both at laboratory and pilot scale, fed on diluted waste, and the most promising results were obtained on UASB reactors, both at laboratory and pilot scale, fed on diluted waste. With these digesters, volumetric loading rates were observed and 70 percent removal efficiency was achieved. The start-up of UASB reactors fed with waste from olive oil mills is a complicated process that must be carefully monitored and optimized. Starting with very diluted trash yielded the greatest results. Granulation of the sludge, as seen in UASB digesters fed on sugar beet wastewaters, was not attained; however, the sludge's settleability was observed to be excellent. Since the olive oil industry has been blamed for a lot of pollution, there has been a lot of pressure to improve olive oil waste treatment facilities. Bioremediation (ex-situ, in-situ), thermal processes (incineration, pyrolysis, gasification), evaporation, membrane processes, electrolysis, ozonation, digestion, Coagulation/flocculation/precipitation, and distillation are among the many methods currently in use. Per the waste treatment approach, both advantages and downsides were described, along with the methodology and explicit flow diagrams. Furthermore, the most recent studies were provided, with around twenty–five figures primarily illustrating the efficacy of current waste treatment procedures versus time or temperature. The comparison of the various olive oil waste treatment approaches revealed that, while bioremediation is the most environmentally beneficial option, it is not the only one.

Keywords: Sugar beet wastewaters; Bioremediation; UASB digesters; Pyrolysis; Membrane processes

1. Introduction

Olive oil is considered one of the healthiest of vegetable oils and highly favored by US consumers (1). In November 2015, global production of olive oil was 2.9 million tonnes (3.2 million US tons), according to the International Olive Council (IOC). Mediterranean countries are responsible for producing of 96% of the total olive oil, with Spain, Italy, Turkey and Tunisia leading production. The United States produces approximately 0.5% of the global total, with California, Texas and Arizona responsible for most of that production. (2). Olive oil production is well characterized and the industry is considered quite mature. Olive mill wastewater (OMW) treatment and disposal is one of the main problems facing the olive oil industry (3).

The environmental impact of olive oil production is critical in all olive oil producing countries in the Mediterranean. The oil extraction processes need a significant amount of water and produces huge amounts of olive mill wastes (OMWs) in short period of time (October-January) of olive harvesting season (4). Management of (OMWs) is considered a major environmental challenge in Mediterranean region. Olive oil extraction generate two types of waste streams: a liquid stream called (OMWW) or locally named “Zibar” and a solid residue known as pomace, locally referred to as “Jift.” Olive mills dispose their OMWW in settling ponds that are normally under-sized and sometimes get overloaded causing spillage to nearby valleys (5). There are no proper facilities for treatment of OMWW in individual mills, so their

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minimization, prevention and treatment, have long been investigated to reduce their environmental impacts caused by their uncontrolled disposal (6).

2. Olive mill industry waste water

The two common separation methods used to extract olive oil are the traditional extraction method, as described above and extraction by decanter process. Two-phase and three-phase decanter processes are the two main types of decanters used in the extraction of olive oil (7). Two-phase decanter produces two products, the olive oil mixed with OMW, which later requires the use of a separator to separate the olive oil from the OMW by their densities. This results in a very wet pomace with water content ranging between 65% and 70% by weight (8). Olive oil extracted by two phase decanter usually contain higher content of total phenols and receives higher sensory evaluation score (9). On the other hand, three-phase decanter produce three products: approximately 20% olive oil, 30% wet solid waste 20 called crude olive cake or olive husk, and 50% liquid waste also called olive mill wastewater (OMW) (10). The solid waste is a mixture of pressed olive pulp and olive stones that can be processed to extract remaining olive oil, but can also be used for solid fuels or animal feed (9). OMW is a mixture of vegetative water, soft tissues of olive fruits, and the water used in different stages of the extraction process including water added during the washing step, water from rinsing filtering discs, and water used during centrifugation (5). OMW is characterized by a strong unpleasant smell, high levels of organic pollutants (COD levels up to 220 g/L), a pH range from 3-5.9, high total phenol content (up to 24 g/L), long chain fatty acids, and high solid content (20 g/L). OMW in the past was disposed in primitive ways such as in a landfill; discharge into nearby rivers, lakes or seas and evaporation in lagoons (6). These disposal techniques led to local environmental problems including soil contamination, water body pollution, odor and underground seepage (11). Untreated OMW was used on soils and crops as a fertilizer that partially solved the problem of OMW disposal, but was not necessarily a sound long-term solution. The OMW was rich in organic materials and nutrients, so some soils benefited from OMW applications (12). OMW used on cereal crops and olive trees had some nutritional benefit. On the other hand, OMW inhibited seed germination and slowed plant growth (6). All these applications had major side effects on the environment, which motivated scientists and researchers to find techniques to improve OMW treatment and remove its toxicity (13).

3. Olive oil waste water characteristics

Eight analytical methods were used in this study to measure the effect of high power ultrasound (HPU) and EF processes on contaminants present in OMW, and to provide a comparison between the efficiency of each treatment process. Several analyses are commonly used in the waste-treatment industry, while others were used to specifically characterize OMW waste (14).

3.1. Chemical Oxygen Demand

Chemical oxygen demand (COD) is the amount of dissolved oxygen that must be present in water to oxidize chemical organic materials, like petroleum. COD is used to gauge the short-term impact wastewater effluents will have on the oxygen levels of receiving waters (9).

Chemical oxygen demand (COD) is the amount of organic compounds in wastewater and is one of the main parameters used to measure water quality. COD levels in wastewater are expressed in milligrams per liter (mg/L). The COD level in OMW ranges between 100-220 g/L (7) and the targeted COD level after treatment to enable potential reuse in agriculture must be 10-30 mg/L (1). One of the first procedures to measure COD level in wastewater was using potassium permanganate ($KMnO4$) as an oxidizing agent, however, the efficiency and consistency of potassium permanganate in oxidizing the organic compounds present in wastewater varied widely and that showed the poor oxidizing ability of potassium permanganate (4).

3.2. Biochemical Oxygen Demand

BOD is a procedure used as an indicator of the effectiveness of wastewater treatment processes. BOD is the amount of oxygen required by aerobic microorganisms to breakdown organic compounds present in the wastewater at a specific temperature and time. BOD level is expressed in milligrams of oxygen ingested per liter of wastewater throughout 5 days of incubation at 20°C (14).

4. Physicochemical treatment of olive mill wastewater

Solids of the size that are visible to the naked eye can be separated either by settling under the influence of gravity or by flotation, depending on the relative densities of solids and water (12). They may also be easily separated by filtration. However, very fine particles of a colloidal nature (called colloids, size < 1 µm) which have high stability are significant pollutants (8). The reason for this stability is that these particles have electrostatic surface charges of the same sign (usually negative) (15).

4.1. High Power Ultrasound

The utilization of ultrasound in food processing began after the Second World War. Application of ultrasound was mainly aimed at quality assessment, for example in detecting foreign bodies in food (16).

4.2. Physical Processes

Physical processes such as evaporation, dilution, sedimentation, filtration and centrifugation are commonly used to treat OMW, but each process alone could not decrease the organic content and toxicity of OMW to an acceptable level (6).

5. Biological treatment of olive mill wastes

Biological treatment methods are commonly used worldwide, as they are considered environmentally friendly, cost effective and reliable (7). Selection of microorganisms to be used in the treatment of OMW is very critical as OMW contain phenolic substances that could inhibit or kill the microorganism used (17).

5.1. Anaerobic Digestion

Anaerobic digestion, as the name implies, is a process performed in the absence of oxygen by anaerobic microorganisms (10). This type of digestion includes a group of processes by which anaerobic microorganisms break down biodegradable material in the absence of oxygen and produces a gas mainly composed of carbon dioxide ($CO2$) and methane ($CH4$) that can be used for energy production (9).

5.2. Aerobic Treatment

Aerobic treatment in the presence of natural occurring microorganisms (such as fungi, protozoa, bacteria and other microbes) is an effective method for treatment of OMWW to reduce its pollution (12). In aerobic processes, oxygen is provided either by agitating the reactor or by supplying air by compressor. It is based on targeting the degradation of phenolic compounds, the major contributor to phytotoxicity (10). These options are scientifically appealing; however, they are not widely used commercially possibly because of cost considerations (12). The aerobic method cannot detoxify OMWW inhibitory compounds such as polyphenols and lipids (18). The capital investments in aerobic methods are lower than anaerobic methods but the running costs are significantly higher due to the need of continuous air supply (19).

5.3. Combined Biological Processes

Previous studies showed that anaerobic and aerobic treatments alone are incapable of achieving optimum requirements (3). To that effect, combinations of aerobic and anaerobic treatments together or two treatments from the same category were studied (11).

5.4. Composting

Composting is a decomposition process by aerobic microorganisms to breakdown organic matter within a few weeks into a paste or sludge like product that can be used as a soil conditioner or fertilizer (6). Compost produced from OMW is considered high quality compost and is used as a fertilizer for crops (7).

6. Olive mill waste management practices

There are no exclusive solutions exist yet, but several options have been recommended for valorization of olive mill waste streams. Several factors are to be considered when selecting the best management practice (12). These include the quantity of waste to process, required investment in infrastructure, available land for application, agronomic benefits that follow and the local regulations (16.

7. Conclusion

In this paper, the current management's methods for olive mill wastes and treatment methods and techniques applied for the management of olive mill wastewater and solid waste in major oil producing countries were investigated (4). Due to favoring warm weather conditions and large open areas in the MENA region, liquid waste disposed in evaporations lagoons equipped with suitable mitigation measures such as rubber lining to prevent any leakage to ground water and alleviate any environmental impacts is recommended for OMMW pretreatment followed by constructed wetland treatment which are financially affordable by mill owners (20).

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Galanakis, C.M. Olive Mill Waste Recent Advances for Sustainable Management; Academic Press: London, UK, 2017; pp. 1–3.

[2] FAOSTAT. Food and Agriculture Organisation Database. 2015. Available online: http://www.fao.org/home/search/en/?q=Olive%20mill%20wastes%20production (accessed on 4 April 2020).

[3] Khdair, I.A.; Abu-Rumman, G. Pollution Estimation from olive wastewater in Jordan. Heliyon 2019, 5, e02386.(CrossRef) (PubMed)

[4] Roig, A.; Cayuela, M.L.; Sanchez-Monedero, M.A. An overview on olive mill wastes and their valorization methods. Waste Manag. 2006, 26, 960–969. (CrossRef)

[5] Khdair, I.A.; Abu-Rumman, G. Evaluation of the environmental pollution from olive mills wastewater. Fresen. Environ. Bull. 2017, 26, 2537–2540.

[6] Galanakis, C.M. Recovery of high added-value components from food wastes: Conventional, emerging technologies and commercialized applications. Trends Food Sci. Technol. 2012, 26, 68–87. (CrossRef)

[7] Barbera, A.C.; Maucieri, C.; Cavallaro, V.; Ioppolo, A.; Spagna, G. Effects of spreading olive mill wastewater on soil properties and crops, a review. Agric. Water Manag. 2013, 119, 43–53. (CrossRef)

[8] Boubaker, F.; Ridha, B.C. Anaerobic co-digestion of olive mill wastewater with olive mill solid waste in a tubular digester at mesophilic temperature. Bioresour. Technol. 2007, 98, 769–774. (CrossRef)

[9] Ouzounidou, G.; Zervakis, G.I.; Gaitis, F. Raw and microbiologically detoxified olive mill waste and their impact on plant growth. Terr. Aquat. Environ. Toxicol. 2010, 4, 21–38.

[10] Morillo, J.A.; Antizar-Ladislao, B.; Monteoliva-Sanchez, M.; Ramos-Cormenzana, A.; Russell, N.J. Bioremediation and biovalorisation of olive-mill wastes. Appl. Microbiol. Biotechnol. 2009, 82, 25–39. (CrossRef) (PubMed)

[11] Alburquerque, J.A.; Gonzalvez, J.; Garcia, D.; Cegarra, J. Effects of a compost made from the solid byproduct (alperujo) of the two-phase centrifugation system for olive oil extraction and cotton gin waste on growth and nutrient content of ryegrass (Lolium perenne L.). Bioresour. Technol. 2007, 98, 940–945. (CrossRef)

[12] Paraskeva, P.; Diamadopoulos, E. Technologies for olive mill wastewater (OMW) treatment: A review. J. Chem. Technol. Biotechnol. 2006, 81, 1475–1485. (CrossRef)

[13] Suzzi, G.; Tofalo, R. Trattamento dei reflui. In Collana Coltura & Cultura-L'ulivo e l'olio; Pisante, M., Inglese, P., Lercker, G., Eds.; Bayer Crop Science: Bologna, Italy, 2009; pp. 690–695.

[14] Alburquerque, J.A.; Gonzalvez, J.; Garcia, D.; Cegarra, J. Agrochemical characterization of "alperujo", a solid by-product of the two phase centrifugation. Bioresour. Technol. 2004, 91, 195–200. (CrossRef)

[15] Wahsha, M.; Bini, C.; Nadimi-Goki, M. The impact of olive mill wastewater on the physicochemical and biological properties of soils in northwest Jordan. Environ. Qual. 2014, 15, 25–31.

[16] Rigane, H.; Chtourou, M.; Mahmoud, I.B.; Medhioub, K.; Ammar, E. Polyphenolic compounds progress during olive mill wastewater sludge and poultry manure co-composting, and humic substances building (Southeastern Tunisia). Waste Manag. Res. 2015, 33, 73–80. (CrossRef)

[17] Belaqziz, M.; El-Abbassi, A.; Lakhal, E.K.; Agrafioti, E.; Galanakis, C.M. Agronomic application of olive mill wastewater: Effects on maize production and soil properties. J. Environ. Manag. 2016, 171, 158–165. (CrossRef)

[18] Ayoub, S.; Al-Absi, K.; Al-Shdiefat, S.; Al-Majali, D.; Hijazean, D. Effect of olive mill wastewater land-spreading on soil properties, olive tree performance and oil quality. Sci. Hortic. 2014, 175, 160–166.(CrossRef)

[19] Niaounakis, M.; Halvadakis, C.P. Olive Mill Waste Management. Literature Review and Patent Survey, 2nd ed.; Elsevier: London, UK, 2006.

[20] Rusan, M.J.; Malkawi, H.I. Dilution of olive mill wastewater (OMW) eliminates its phytotoxicity and enhances plant growth and soil fertility. Desalin. Water Treat. 2016, 57, 27945–27953. (CrossRef)