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Impact of Corn Production on Agriculture and Ecological Uses of Olive Mill Sewage using Ultrafiltration and Microfiltration

Dr. Yuki Nakamura[1] and Dr. Marcus Lindholm[2]*

[1]Senior Researcher, Chemical Engineering and Environmental Sciences, University of Tokyo, Japan.*

[2]Professor, Chemical Engineering and Environmental Sciences, University of Tokyo, Japan.

Abstract--- The impact of olive mill sewage (OMS) is the most significant ecological issue in the Mediterranean area. This research is part of a comprehensive OMS administration plan focused on producing high-value goods from OMS with minimal discharge. OMS is an organic substance that can be repurposed into the soil following ultrafiltration (UF) and microfiltration (MF) treatment and utilized as an herbicide for agricultural production. This process promotes an ecologically conscious farming technique with reduced greenhouse gas emission (GGE), as sewage can either totally or partially replace chemical fertilizers, conserve clean water, and provide economic advantages to farmers. A comprehensive study was conducted on the Agricultural and Ecological Uses of OMS using UF and MF processes (AEU-OMS). This method produced two parts: UF retention and MF penetration, which were deficient in ions and phenolic molecules, were analyzed for their irrigation and nitrogen fertilization possibility, whilst UF-MF retention, which was abundant in these components, was examined for usage as a bio-herbicide. The plant toxicity of the UF-MF retention component on corn crops was assessed for seedling development and chlorophyll concentration.

Keywords--- Olive Mill Sewage, Herbicide, Agricultural Production, Ultrafiltration, Microfiltration, Ecology, Corn Production.

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I. Overview and Related Works

Groundwater is an important ecological resource for the sustenance of life. Freshwater is among the most endangered resources globally, owing to rising use, pollution from human actions, and global warming that modifies how rain falls. Industrial development, farming, and increasing urbanization exemplify activities that jeopardize freshwater supplies by discharging substantial quantities of poorly managed and untreated sewage. The emergence of contaminants from human activities in water bodies has become a significant problem due to its detrimental effects on the environment (Fedorov et al., 2022).

Consequently, more stringent regulations must be enacted to enhance water quality to achieve the United Nations Sustainable Development Goals (SDGs) by 2030. In this environment, it is essential to advance sewage treatment techniques for water restoration, guaranteeing access to high-quality water for the people of the future. The Mediterranean nations experience significant droughts, resulting in the implementation of water restrictions to satisfy people's demands. Furthermore, these regions exhibit significant agro-industrial activity that substantially influences regional economic development. Nonetheless, the resultant effluent from these operations significantly impacts the ecosystem owing to its substantial organic load, which includes refractory contaminants. Treating wastewater is essential for environmental protection and facilitating water reuse (Correddu et al., 2020).

In the last twenty years, global olive oil use has risen. The Mediterranean nations are the predominant producers of olive oil, constituting approximately 97% of global olive oil output. Nevertheless, this agroindustry is accountable for significant water utilization and the creation of liquid discharges and solid waste (Benaddi et al., 2023). OMS is the wastewater produced by the processing of olive oil that presents a considerable risk of environmental damage. Despite being generated seasonally and in lesser quantities than other sectors, the detrimental environmental impacts of OMS remain significant. The primary features of OMS include a composition abundant in organic materials, an acidic pH, elevated levels of phenolic substances, a substantial

amount of total solids, and a disagreeable odor, making this effluent an environmental issue. Consequently, the management of OMS before environmental discharge is a burgeoning concern (Jamrah et al., 2023).

Currently, no European Union (EU) regulation governs the appropriate management and reutilization of organic matter in soils for agriculture. Within the EU, every nation is accountable for its legislation for the secure elimination and reutilization of OMS. The predominant approach is the storage in evaporative ponds, which adversely affects surrounding communities because of the powerful scents. This method may adversely affect the soil, ground, and surface water.

Consequently, it is essential to advance technology for OMS administration to ensure effective and sustainable utilization in agriculture. Methods include membrane division, coagulation/flocculation, and biological processes used in treating OMS. Nonetheless, these approaches exhibit several drawbacks, including membrane fouling, increased maintenance, and elevated expenses. The substantial sludge generation during coagulation necessitated further treatment (Kirmaci et al., 2018). The limited efficacy of biological procedures for pigment removal, particularly the inability to meet legal discharge limitations, also hinders the use of these technologies. To mitigate the limitations, these approaches need sophisticated procedures for oxidation before or after treatment.

This study conducts a comprehensive analysis of the primary biological, physiological, and chemical approaches used for handling OMS, aimed at developing suitable methods for both sewage treatment and the generation or release of agricultural water in natural waterways. Given that OMS is a complicated effluent that cannot be effectively treated by a single purification method, particular emphasis will be placed on combined methods to offer a future strategy for managing these discharges (Liu et al., 2020). Olive oil has exceptional qualities due to its inherent polyphenols and nutrients, which are vital for human nutrition and health. This and the ongoing population expansion are resulting in heightened consumption and output (Figure 1).

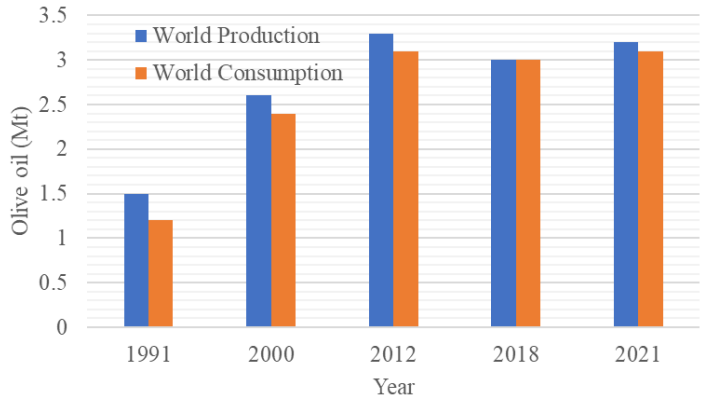


Figure 1: Consumption and Output of Olive Oil in Mt

The quantity of OP and OMS produced during olive oil extraction might vary considerably based on the extraction method used. The olive oil business is believed to generate around 48% OMS, 32% OP, and only 20% olive oil. Olive oil may be extracted by ongoing and/or intermittent procedures (Zahi et al., 2022). The intermittent process, called conventional pressing, has been supplanted by continuous operations owing to diminished productivity and elevated personnel expenses. The constantly operating system may function using a two or three-stage method (Gomes et al., 2023).

Several nations are now using two-stage procedures to minimize water use during operations. Consequently, the volume of wastewater produced is reduced. In two-stage operations, a solid waste with 60% moisture content is generated, which may later be treated by dryness or extraction to reclaim before unextracted olive, resulting in a novel by-product called sewage from the olive oil extracting industry (OOEI) (Domingues et al., 2021).

The OMS is regarded as a local ecological concern owing to its detrimental effects on aquatic organisms, stemming from toxicity, noxious aromas, and the obstruction of sunlight caused by an oily coating on the water's surface, which impedes oxygen transmission. The discharge of OMS in soil harms soil microorganisms and vegetation. OMS is a highly complicated effluent, exhibiting significant variability based on its origin, olive tree varieties, cultivation techniques, climatic circumstances, and manufacturing processes. This wastewater is distinguished by its dark coloration, acidic pH, elevated turbidity, substantial organic load, and distinctive

disagreeable odor (Al-Qodah et al., 2022). This sewage's volatility is notable since olive oil generation spans around four months.

II. Materials and Methods

Agricultural and Ecological Uses of OMS (AEU-OMS) using UF and MF processes are shown in Figure 2. The selected pre-processing included the acidic reaction of OMS to its isoelectric point, therefore destabilizing the components and facilitating their consolidation before removal by decantation. The equilibrium point was achieved at a pH of 2 with a concentration of 8.5 mL/L sulfur dioxide (96-99% purity).

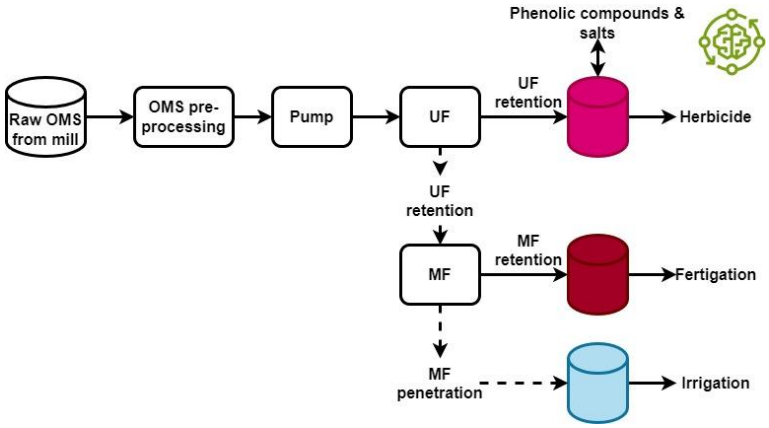


Figure 2: Agricultural and Ecological Uses of OMS using UF and MF Processes

After 3.5 hours of decantation, OMS was filtrated using a 6μm permeability filter. Prior research indicated that the already treated OMS pH significantly affected membrane system effectiveness, specificity, and fouling, with the optimal pH being about 6.5. Consequently, a 6M sodium hydroxide solution had been employed to increase the OMS pH. A chrome-plated pilot-scale ultrafiltration-microfiltration system with an input tank capacity of 75 liters has been employed. The OMS was subjected to filtration using a 165 kDa ultrafiltration ceramic substrate.

UF-MF

A comprehensive methodology was used, including an OMS pre-processing phase succeeded by a UF-MF procedure to facilitate effluent reuse in agricultural applications. As indicated in Table 1 earlier, substantial quantities of dissolved matter were extracted from the raw OMS from the mill during UF-MF. Following neutralization and pre-processing, the concentrations of phenolic compounds (PC) and salt (SC) levels in the input tank were 3.9 g/L and 38.1 g/L, respectively. The quantities had been decreased at the final result of the UF-MF system, with PC and SC concentrations measuring 0.98 and 3.8 g/L, respectively. The potassium and phosphorus concentrations in the input were 5.75 g/L and 0.55 g/L, respectively. At the system production, the concentrations were 1 g/L for potassium and 0.075 g/L for phosphorus. The SC and PC have been employed to forecast the optimization route for each component. This technique facilitated the recycling of MF penetration primarily for irrigation. At the same time, UF retention is an herbicide, and MF retention is used for fertigation due to its elevated SC and PC.

Phytotoxicity of MF Retention on Corn

The impacts of MF retention were first analyzed on corn to examine the advantages of the filtering method on the agricultural benefits of OMS.



Figure 3: The Usage of MF Retention in Three Concentrations (1/25, 1/20, and 1/15) for Crop

The study was conducted on crop seedlings using three concentrations of MF retention (1/25, 1/20, and 1/15). The data were presented as the corresponding PC in every dilute solution of MF retention (0.4, 0.5, and 0.6 g/L, respectively). None of the procedures examined substantially influenced the germination rates for the species; they were comparable to the control and ranged from 100% to 88%. The usage of MF retention dilutions significantly inhibited the expansion of corn species examined, particularly affecting root development (figure 3). The dose-effect correlation from the usage of MF retention concentrations 1/25, 1/20, and 1/15 on crop saplings showed a decrease of 15%, 45%, and 70% in height of shoots, respectively, relative to the control group. MF retention significantly suppressed root extension: the three concentrations of 1/25, 1/20, and 1/15 demonstrated 52%, 65%, and 77% reduction of root expansion relative to the control.

III. Results and Discussion

This study revealed that growth and development delays varied with various levels of UF-MF retention, contingent upon the species examined, with a decrease in chlorophyll concentration.

Table 1: Effect of NF Retention on Chlorophyll Concentration (mg/L) of PC for Varying Concentrations

PC (g/L in UF-MF Retention)	Chlorophyll (mg/L)
0	202.7 ± 45.4
conc.1/25	80.2 ± 32.1
conc.1/20	55.8 ± 23.3
conc.1/15	9.8 ± 4.1

Table 1 illustrates the effect of UF-MF retention on chlorophyll concentration at different levels of PC. At the starting concentration of 0 g/L in UF-MF retention, the chlorophyll concentration reaches a maximum of 202.7 ± 45.4 mg/L. As the concentration of PC rises due to dilution modifications, the chlorophyll concentration correspondingly decreases. At dilution ratios of concentration 1/25 and concentration 1/20, the chlorophyll levels decrease to 80.2 ± 32.1 mg/L and 55.8 ± 23.3 mg/L, respectively. The most significant decrease transpires at a concentration of 1/15 when the chlorophyll content abruptly diminishes to 9.8 ± 4.1 mg/L. This trend demonstrates an inverse correlation between PC concentration in UF-MF retention and chlorophyll content, indicating that elevated PC concentrations substantially reduce chlorophyll levels.

Table 2: Effect of UF-MF Retention on Corn Shoot and Root Lengths (cm) of PC for Varying Concentrations

PC (g/L, UF-MF Retention Dilution)	Corn Shoot Length (cm)	Corn Root Length (cm)
0	13.5 ± 0.5	14.0 ± 0.5
conc.1/25	12.0 ± 0.5	10.5 ± 0.5
conc.1/20	9.5 ± 0.5	8.0 ± 0.5
conc.1/15	7.5 ± 0.5	6.5 ± 0.5

Table 2 illustrates the impact of UF-MF retention on the shoot and root lengths in cm of corn at different concentrations of PC. At 0 g/L PC, the shoot and root lengths peak, reaching 13.5 ± 0.5 cm and 14.0 ± 0.5 cm, respectively. As PC concentration rises (due to NF retention dilution), a gradual reduction in both shoot and root lengths is seen. At a concentration of 1/25, the shoot length diminishes to 12.0 ± 0.5 cm, while the root length reduces to 10.5 ± 0.5 cm. Subsequent elevations in PC concentration lead to substantial decreases, with a concentration of 1/20 producing shoot and root lengths of 9.5 ± 0.5 cm and 8.0 ± 0.5 cm, respectively. At the maximum concentration of 1/15, the shoot and root lengths reach their minimum values of 7.5 ± 0.5 cm and 6.5 ± 0.5 cm, respectively. This pattern indicates a concentration-dependent inhibitory impact of PC on maize growth.

Table 3: Effect of UF-MF Retention on Corn Shoot and Root Weights (g) of PC for Varying Concentrations

PC (g/L, UF-MF Retention Dilution)	Corn Shoot weight (g)	Corn Root weight (g)
0	5.5 ± 0.5	3.7 ± 0.5
conc.1/25	2.7 ± 0.5	1.5 ± 0.5
conc.1/20	2.2 ± 0.5	1.0 ± 0.5
conc.1/15	1.0 ± 0.5	0.7 ± 0.5

Table 3, entitled "Effect of UF-MF Retention on Corn Shoot and Root Weights (g) of PC for Varying Concentrations," demonstrates the influence of UF-MF retention dilution on the weights of corn shoots and roots. At an initial concentration of 0 PC, the corn shoot and root weights are maximized, recorded at 5.5 ± 0.5 g and 3.7 ± 0.5 g, respectively. As the concentration of PC rises by dilution (1/25, 1/20, and 1/15), there is a

progressive and notable decrease in both shoot and root weights. At the maximum dilution (concentration 1/15), shoot weight diminishes to 1.0 ± 0.5 g, and root weight declines to 0.7 ± 0.5 g, signifying that heightened UF-MF retention dilution negatively impacts corn development regarding biomass accumulation. This pattern indicates a dose-dependent inhibitory impact of PC on the growth of maize shoots and roots.

IV. Conclusion

This study is integral to a complete OMS administration strategy aimed at generating high-value products from OMS with little waste disposal. OMS is an organic compound that may be reintroduced into the soil after undergoing ultrafiltration (UF) and microfiltration (MF) treatment, serving as a herbicide for agricultural purposes. This method fosters an environmentally sustainable agricultural practice with diminished greenhouse gas emissions since sewage may wholly or partly substitute chemical fertilizers, preserve potable water, and provide economic benefits for farmers. A thorough investigation of the Agricultural and Ecological Uses of OMS using UF and MF procedures (AEU-OMS) was performed. This approach yielded two components: UF retention and MF penetration, which were lacking in ions and phenolic compounds and were assessed for their potential in irrigation and nitrogen fertilization. In contrast, rich in these constituents, UF-MF retention was evaluated for its use as a bio-herbicide. The phytotoxicity of the UF-MF retention component on maize was evaluated for seedling growth and chlorophyll content.

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