



M. NIAOUNAKIS & C. P. HALVADAKIS

OLIVE-MILL WASTE MANAGEMENT

Literature Review and Patent Survey

TYPOTHITO - GEORGE DARDANOS



M. NIAOUNAKIS and C. P. HALVADAKIS

Olive-Mill Waste Management: Literature Review and Patent Survey

430 pp. (17×24 cm.)

Publication Number 297

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First published: February 2004

Executive Editor: Christos STAVROPOULOS

Compositor - Pagemaker, Films: Maria-Nelli KARELOU

Montage: Rania AMOLOCHITOU

Cover Designer: Kyriakos ATHANASIADES

Corrector: Efthimia EXARCHOU

TYPOTHITO - GEORGE DARDANOS Publications

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Statement

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Printed in Greece

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ISBN 960-402-123-0

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Foreword

Olive milling like every human activity and industrial process results in a low-entropy desired product and a high-entropy unwanted by-product or waste termed olive mill waste. The production of olive oil, viewed in a holistic perspective, begins with the picking of olives and ends after their processing in olive mills. Olive mill technology at present generates a variety of waste in both energy and mass forms. In addition to solid waste generated in the olive groves by annual pruning of olive trees, a considerable amount of solid waste is generated during milling in the form of leaves and small twigs brought to the mill with the olives and in the form of crushed olive stones and sizable remnants of olive pulp (flesh) following olive oil extraction. Leaves and twigs can be used as animal feed (mainly for goats) or in the production of compost after mixing with other appropriate materials. Liquid waste is known as olive mill wastewater (OMWW) since during olive milling and olive oil extraction substantial amounts of added water as well as olive juice (or olive vegetation water) combine with small amounts of unrecoverable oil and fine olive pulp particles to constitute this type of waste. Gaseous waste consists of fumes produced during malaxation of crushed olives and exhaust gases from burners providing thermal energy to the mill. Finally, energy waste consists of thermal energy losses and acoustic energy (noise) of utilized machinery.

From an environmental point of view OMWW is the most critical waste emitted by olive mills in terms of both quantity and quality. There is archeological evidence that this effluent has been damaging delicate shoreline environments for thousands of years around the Mediterranean. Pollution from olive oil production is often a problem in poor communities in southern Eu- xi

rope and North Africa where sophisticated solutions to the problem are too expensive. The problems created in managing this waste have been extensively investigated during the last 50 years without finding a solution, which is technically feasible, economically viable and socially acceptable. The prevalent waste management strategy up to date has been traditional wastewater treatment processes aimed at reducing pollution loads to legally accepted levels for disposal into environmental media (mainly land and water bodies). Recently, Spain has adapted a manufacturing process for olive oil production, which minimizes the utilization of water and, therefore, of generated wastewater, the so-called two-phase olive mill extraction technique. The pollution load is, however, the same since it originates from the olives and not from the water utilized during olive processing. In view of the above, it is apparent that a new strategy for olive waste management must be adopted. Up to now the emphasis has been on detoxifying OMWW prior to disposal. However, the present trend is towards further utilization of OMWW by recovering useful by-products.

OMWW contains most of the water-soluble chemical species of the olive fruit. Critical chemical species like water-soluble phenols and polyphenols appear to be an obstacle during treatment -being recalcitrant- but can be industrially beneficial if isolated. If one considers that the pollution load is merely the remnants of olives (a natural product), it is preferable to adopt a waste utilization management strategy. It is not surprising that during recent years a number of patents have appeared following such strategy. OMWW management is presently approached by both in-house process modification combined with waste minimization and end-of-pipe waste utilization.

The focus of the present study is to evaluate the existing technologies and to develop environmental criteria for disposing and/or reusing olive mill wastes in general, and wastewater in particular. The prior art is critically reviewed by both discussing the extensive literature coverage -more than 1000 references are cited and commented upon, including journals, patents, conference proceedings, dissertations, theses, technical notes, reports of projects- and by recording the traditional techniques still being used by smaller olive mills, which have been passed down from generation to generation. It is a fact that most of the literature or know-how comes from countries around the Mediterranean. A substantial part of the literature collection consists of patents. Despite their technological importance, up until now patents appear to have been cited rarely in scientific journals or books.

More emphasis has been given to OMWW and to the new by-product, known as "alpeorujo" in Spain, generated by the two-phase extraction pro-

cess (2POMW). OMWW represents the still unsolved problem of the olive mill industry, both for its extent and significance. 2POMW represents a new type of problem due to its consistency (thick sludge that contains pieces of stone and pulp of the olive fruit as well as vegetation water) and its steadily increasing production, especially in Spain. The rest of the olive wastes, such as olive cake, leaves and twigs, do not represent a serious environmental problem and have only been commented upon briefly. The various olive oil extraction systems have been described shortly together with the effects each one of them has on the environment.

The wastewater (brines) arising from the table olive industry has also not been reviewed. It was considered that brines constitute a different type of wastewater.

It is not the intention of the present study to propose any solution. Instead, it defines the problems faced by the olive mill industry, makes proposals for discharge/reuse of olive mill wastes on the basis of each treatment technique and shows the current trends in the olive waste management.

Some of the conclusions of the present study are:

- Most of the technologies reviewed in this study have been tested on a small scale only. In depth assessment of these results and subsequent full-scale applications has yet to be carried out.
- The olive mill waste management can be viewed as: i) extracting valuable materials (e.g. irrigation water, compost, fodder, fuel, antioxidants etc.); and ii) in lowering pollution load for final disposal to natural receiving bodies (surface water, land and sea). The double nature of olive mill waste (as a pollutant of streams or a resource to be recycled) causes antagonism between agriculture and environmental groups, because of their different point of view on this topic.
- Most of the treatment processes are focused on both bioremediation, as a means of reducing the polluting effect of OMWW and transformation into valuable products, together with modification of the technology used in oil extraction. The presence of large amounts of phenolic compounds constitutes one of the major obstacles in the detoxification of OMWW. These recalcitrant compounds decelerate the process, hinder removal of part of COD and detract from its economic viability. Nowadays, the trend is towards turning this problem to a benefit by extracting these compounds. Recent studies have shown that the abundant phenolic antioxidant fractions of olive oil have a potent inhibitory ability on reactive oxygen species. There is an increasing body of evidence indicating the involvement of oxygen-derived free radicals in several pathologic processes, such as cancer

and atherosclerosis. OMWW has a powerful antioxidant activity, and thus might be a cheap source of natural antioxidants. Up to now the antioxidant compounds of OMWW have not been effectively exploited, due to the impracticality of extracting usable amounts of antioxidant compounds using conventional technology.

- The problem of olive mill waste is further aggravated by the lack of a common policy among the olive oil producing countries. Every country has its own legislation/regulations that often vary greatly among them with a consequent non-uniform application of generally accepted guidelines. For this reason there is a need for a unified strategy behavior among the EU member states.

To the best of our knowledge this is the first extensive and all-encompassing review to appear on the subject of olive mill wastewater. A few earlier reviews can be found in the literature, but these are mostly partial in scope and outdated. This is quite surprising given the environmental impact of this waste. It is hoped that this review will increase public awareness and will further provide a valuable information resource for olive oil producers, researchers and policy makers dealing with the problem of olive mill wastes.

The present publication has been financed by EU Regional Directorate-General (ERDF Innovative Actions 2000-2006, Programme 2001 GR 16 0 PP 209. The project title was "North Aegean Innovative Actions and Support (NALAS)", while this work was a deliverable of Action 7.6 "Innovative Olive Mill Waste Management Systems".

The authors would like to acknowledge the help of various individuals who contributed in certain aspects of the present work. Specifically, thanks are due to D. Schaelicke and M. Karatzas for aiding in management issues and compiling supplement information; C. Tzoutzoumitros and M. Hadjimanolakis for perfecting certain figures and chemical formulae; W. Bolger for helpful comments regarding the text; and to the editorial board of Dardanos Publications for their efforts into materializing the book form of this work.

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Mytilene, January 2004