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AN INTERNATIONAL NETWORK FOR DEVELOPING RESEARCH, TECHNOLOGICAL TRANSFER AND DISSEMINATION ON TREATMENT AND UPGRADING OF MEDITERRANEAN AGRO-INDUSTRIAL WASTES AND EFFLUENTS

Extended abstract

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Background

During the last years one of the most used keyword in environmental context has been "biorefinery" that is analogous to today's petroleum refinery but, differently, means use of renewable sources for production of bio-molecules and fuels (Petruccioli et al., 2011). Also the new UE FP8, the so called "Horizon 2020", considers the biorefineries' development as a strategic objective. Hence, all by-products, residues, wastes and wastewaters coming from agro-industrial activities should be increasingly regarded as potential resources that must be reused and valorized, thus minimizing the simple disposal. This approach allows to think positively to bioeconomy based on conversion of biomasses to chemicals and biofuels, thus avoiding or, at least, reducing drastically the competition on land use for food.

International Association of Mediterranean Agro-industrial Wastes (IAMAW)

In this scenario, a new scientific association dealing with the recycling and management amelioration of Mediterranean organic wastes was born in 2009. The term Mediterranean refers to climatic region and not to geographic location, so that waste problems of other areas in the world, characterized by Mediterranean climate, such as parts of Australia, South Africa North and South America, will also be addressed.

Some of the aims of the associations are: i) fostering environmental solutions for agro-food and forestry by-products, residues, wastes and effluents typical to the Mediterranean region through reduction, treatment, reuse and amelioration; ii) promoting knowledge dissemination and transfer of know-how among members, end-users, stakeholders and the scientific community; iii) improving and demonstrating techno-economical feasibility of the proposed solutions; iv) creating working links with relevant international bodies, scientific organizations and industrial partners; v) assisting policy-makers in defining more rational and uniform laws and regulations in the field of Mediterranean waste management; vi) assisting in the identification of Best Available Technologies (BAT). The members of the association are engaged in various scientific disciplines and their expertise in wastes and wastewaters valorization and treatment imply the use of various technologies (*e.g.*, composting; aerobic and anaerobic processes; bioremediation; biotechnology and physical/chemical processes for production of biofuels, fine chemicals and biomaterials).

Selected biorefinery case studies and deliverables

A selection of the main research activities and deliverables obtained by some selected IAMAW members is reported in Table 1: each row summarizes significant results on efficient wastes treatments and, mainly, on the production of biofuels, high-quality composts, feeds and biomolecules of industrial interest in food, nutrition,

cosmetics and pharmaceutics. These research activities are grouped in five different topics that represent the IAMAW working groups. Various wastes and wastewaters have been characterized (Aviani et al., 2012; Diaz et al., 2011) and their valorization strategies investigated: orange peel wastes, sunflower oil cake, wheat straw and sweet sorghum biomass, winery and greenhouse wastes, dairy manure, distillery wastewater and whey are only some examples (Table 1). Several research groups have focus their attention on treatment, valorization and reuse of the residues of olive oil extraction process, namely olive mill wastes, that besides to be a serious environmental problem in relation to the incorrect disposal, can be regarded also as a possible resource containing simple and complex sugars, residual oil, proteins, minerals and phenols that could be either directly recovered by chemical extraction and purification or utilized for microbial processes (Petruccioli et al., 2011). Various case studies have dealt with upgrading of olive mill wastewater (OMWW), olive pomace or two-phase olive mill solid residue (TPOMW). The possibility to obtain high quality composts using various agro-industrial wastes and OMWs has been deeply investigated (Altieri et al., 2010) and the beneficial uses of these products have been widely tested (Raviv et al., 2011; Yogev et al., 2010). Some of the proposed treatment processes have been developed, optimized and, finally, patented (Altieri et al., 2011; Santori and Cicalini 2002).

Table 1. Main topics and selected aims of researches carried out by some IAMAW members

Topic	*Specific aims of research*	*Relevant results*	*Main Ref.*
Bioenergy from wastes	Anaerobic digestion processes of wastewaters and solid wastes from agro-industries (sunflower oil cake, OMWW, TPOMW, distillery wastewater, whey, etc.)	Optimization of anaerobic digestion and/or co-digestion processes (high-rate bioreactors, one and two-stage processes) at mesophilic and thermophilic ranges of temperature. Optimization of wastes pretreatments of: thermal, and/or chemical, mechanical, ultrasounds, microway, etc. Identification of microbiota in digestion processes through molecular biology techniques (DGGE, etc.)	Rincon et al., 2013; Siles et al., 2007; Fernández-Cegrí et al., 2012; Bertin et al., 2013
	Biohydrogen production from pretreated or mixed wastewaters	Biohydrogen and volatile fatty acids production was obtained on dephenolized OMWW. Hyperthermophilic *Thermotoga* strains were use to produce biohydrogen from molasses and cheese whey.	Scoma et al., 2013; Cappelletti et al., 2012
	Ethanol production from olive tree pruning	Optimization of steam-explosion pretreatment and consequent bioethanol production	Cara et al., 2008
	Biovalorization of biomasses (e.g., wheat straw) for energy and added-value products.	Set up of biomass pretreatments (autohydrolysis, enzymatic or acid hydrolysis) and fermentation technologies with submerged membranes for bioethanol production	Duarte et al., 2009
Waste treatment and recycling	Phyto-depuration process of OMWW	Patented process combining metabolic activity of soil microorganisms and various perennial tree species	Santori and Cicalini, 2002
	Degradation and detoxification of olive wastes and spreading on soils	Immobilized white-rot fungi inocula accelerate TPOMW detoxification and bioconversion	Sampedro et al., 2009
		Detoxification process and assessment of spreading on plants and microbial ecology in agricultural soils.	Ntougias et al., 2012
	Effect of solid olive-mill waste amendment on soil fertility and microbiota	This waste can be used as a soil amendment in olive orchards increasing the vegetative and productive activities of the trees, without long-term negative consequences on soil biochemistry and microbiota	Nasini et al., 2013
	Definition of OMWW biological process	A treatment in a Jet-Loop Reactor followed by an extensive treatment (stabilization ponds) was effective	Jail et al., 2010
	Physico-chemical treatment of OMWW	Application of lime and calcium hypochlorite led to significant dephenolisation and discolouration	Boukhoubza et al., 2009
	Optimization of dairy wastewater treatment in an industrial three-cascade-reactor plant	Assessment of the effects of aeration regimes and polluting loads on performances and on activated sludge population allowed to optimize the treatment parameters and robustness of the three-reactors plant	Tocchi et al., 2013
Ligno-cellulosic biomass	Feeds from olive pomace treated with fungi	Fungal treatment increases of protein content and digestibility and decrease of anti-nutritional compounds	Brozzoli et al., 2010
	Production of fermentable sugars and biomass fractionation	Optimization of dilute acid, hydrothermal or organosolv pretreatment of rapeseed straw, sunflower stalks and sugarcane bagasse, respectively	Diaz et al., 2011; Castro et al., 2011
		Novel direct steam-injection apparatus for sugars production by *Tamarix* biomasses grown in desert area.	Santi et al., 2012
	Activated carbons from agro-wastes	Activated carbon from olive-waste cakes was used efficiently for removal of pharmaceutical compounds	Baccar et al., 2012
Natural products from wastes	Production of enzymes from wastes and wastewaters	High production of lipases of possible industrial interest from *Candida cylindracea* grown on OMWW	Brozzoli et al., 2010
		Halotolerant fungi isolated from olive brine effluent, and grown therein, produced phenoloxidase enzymes	Crognale et al., 2012
	Fungal polysaccharides and enzymes	Production of glucans, chitin and chitosan for food and pharmaceutical industries using olive mill wastes	Di Mario et al., 2008
	Selective recovery of the polyphenolic fraction occurring on OMWW.	Antioxidants (e.g. hydroxytyrosol and tyrosol) were recovered by means of liquid-liquid solvent extraction	Kalogerakis et al., 2013
		Optimization of recovery of polyphenols, particularly hydroxytyrosol; Amberlite XAD16 allowed the higher recovery (about 60%).	Bertin et al., 2013
		Scale transfer feasibility of solid phase extraction procedure for the recovery of natural antioxidants	Scoma et al., 2013
	Biotechnological production	Anaerobic and anaerobic-aerobic integrated processes for	Beccari et al.,

	of biopolymers	polyhydroxyalkanoates production from OMWW	2009
Composting	Evaluation of thermal and static composting methods for bioconversion of olive mill waste as major ingredient and other wastes	Production of "mature" and "stable" compost rich in humus-like substances (patent MATReFO) Assessment of compost quality and its use for strawberry soilless cultivation	Altieri et al., 2011; Federici et al., 2011
		Enhancing soil nutrient status in olive orchards and short-term crops	Yogev et al., 2010
		Use of compost from olive mill residues in commercial cultivation of *Agaricus bisporus*	Parati et al., 2011
		Minimization of risks of bacterial canker spread through plant residue composting	Raviv et al., 2011
		Effective use of licorice waste compost in horticulture	Medina et al., 2011
	Vermicompsting for bioconversion of olive mill, winery and greenhouse wastes.	Development of vermicomposting processes using non-continuous and continuous feeding systems Vermicomposts as organic amendments for soil protection, soil remediation and fertility improvement	Fernandez-Bayo et al., 2009; Fernandez-Gomez et al., 2011
	Development of pilot and commercial scale composting technologies for by-products	Evaluation of resulting composts as soil conditioners, fertilizers and suppressants of soil-borne plant pathogens	Kavroulakis et al., 2010
	Compost quality amelioration by reducing polyphenols content and related toxicity	Isolation of autochthonous tannins-degrading bacterial strains from compost and their characterization for possible biotechnological applications and role in quality improvement of compost from OMWW	Pepi et al., 2013

IAMAW members have been actively involved in EU projects such as in the case of a recently ended EU project titled "Suitable Innovations and Treatment in Industrial Waste Waters Clusters (STInno)", in which IAMAW has been a partner together with Greeks, Finnish and Swedish. The overall goal reached by the STInno project has been to map the technologies for industrial wastewater treatment, to transfer sustainable technologies to olive mill wastewater treatment. The project has led to exchange of experience and knowledge between research and business. In the context this project and parallel ones a list of 110 feasible technologies has been prepared and various criteria of searching have been identified, like patented technologies, treatment processes, etc (www.lifeoleicoplus.it).

Concluding remarks

The valorization of food processing by-products, waste and effluents is a challenging opportunity for the sustainable and competitive development of several relevant industrial sectors. However, there are several key points of technical and scientific difficulty (*i.e.* seasonality, the microbial instability and high heterogeneity of wastes and effluents) that have to be addressed and dealt with for a more effective and rational upgrading of agro-industrial wastes (Petruccioli et al., 2011). In this context, the establishment of the IAMAW is expected to play a significant role in the years.

Keywords: added-values by-products, bioconversion processes, biorefineries, IAMAW, wastes valorization.

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