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Treatment of three agro-industrial wastewaters by dried bio-absorbent orange peels and brewery spent grains

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Abstract: This study aims to determine the efficiency of reducing the phenol content (hence BOD/COD) of three agro-industrial wastes: olive mill effluent- olive mill wastewaters- OMW, brewery sludge – BS, and white wine lees – WWL by orange peel (OP) and dried brewer' spent grains (BSG). Orange peels and dried brewer's spent grains are found to have absorbing properties to phenolic compounds. They can be characterized as absorption materials that use the mechanism of absorption (same as activated carbon- sorbent material/precursor mechanism) (Gayatri, 2010).

Keywords: Olive mill wastewaters, brewing sludge, white wine lees, orange peels, brewery spent grains

1. Introduction

Agro-industrial-based industries produce every year a vast number of residues (700 million tons annually in E.E.) that are released into the environment without appropriate disposal (Papanikolaou, 2008). This contributes to environmental pollution and harmful effects on both human and animal health mostly due to their organic content. Treating wastewater can occur by biological, chemical, or physicochemical means (Sarris, 2013), and among them, absorbent materials can be used as one of the most efficient and easily implemented means to treat them.

1.1Absorption materials

Absorption is defined as a physical or chemical phenomenon or process in which atoms, molecules, or ions penetrate through the volume, not the surface, into a liquid or solid material in a bulk phase. It is based on the phenomenon of ion exchange between an absorbate and an absorbent material, thereby dispersing the absorbed material throughout (McMurry, 2003).

1.1.1 Orange peels (OP)

Orange peel is the thick, pitted rind of an orange known as the skin. They are mainly produced by the juice which results about 55 million tons of production annually (Mahato, 2019). They are considered waste, although they contain phenolic compounds which are phytochemicals such as flavonoids (e.g., polymethyl flavones and hesperidin) that are very beneficial to health. It also contains a high amount of sugar mainly in fructose equivalents.

1.1.2 Dried BSG

BSG, also known as draff, is food waste that is a by-product of the brewing industry. It usually occurs as a solid residue after the wort production process during brewing. The product is wet in its production state and has a short shelf life but can be dried and processed in many ways to preserve it, e.g., by drying. It is mostly available at a low cost and 36.4 million tons of BSG are produced annually. (Santos et al., 2003)

1.2 Absorbate media

1.2.1 Olive mill wastewaters (OMW)

OMW is the main waste stream resulting from the mechanical processing of olive fruit for olive oil production. Due to their high content of polyphenols, they are characterized by a high level of toxicity. Annually, 8.0 million tons of OMW are generated, which are highly aesthetically compromised due to their strong odor, dark color, and high content of organic matter that directly affect the environment. (Sarris et al., 2011)

1.2.2 Brewing sludge (BS)

BS is the solid residue that sinks to the bottom of the tanks during and after beer fermentation and consists of dead dry cells. They are characterized by a high organic load, high total nitrogen/total phosphorus content, optimal pH, and salinity including secondary plant nutrient values (Ca_2^+, Mg_2^+, Na^+, and K^+). Due to its high organic load, it causes harmful effects on the exposed soil (Chen et al. 2016). Humans can be affected by transmission up the food chain (Arthurson 2008) when BS is used for agricultural purposes. Annually, 1.5 million tons of BS are produced

1.2.3 White wine lees (WWL)

White wine lees are the sediment left in the tank or cask after the end of the fermentation of white wine or during the rest of the processes. They are characterized by a high phenol content and consist mainly of dead yeast cells. 1.8 million tons of white wine lees are produced worldwide every year. (Sancho-Galn, p. 2020)

1. Material and methods

2.1 State of the Art

Now, this study only aims to investigate the ability of absorbent materials (OP and dried BSG) to absorb phenolic compounds from the three mentioned agro-industrial wastes and propose a possible waste treatment model (Figure 1).

2.1. Pre-treatment

Lees and BS were hydrolyzed in a ratio 2:1 (water-waste) under constant stirring for 4 hours at 40°C to obtain PC-rich hydrolysates and then centrifuged at 9000 rpm for 10 min. at 4oC to remove any remaining solids. OP and BSG were dried at 85°C for 72 hours and then processed into a 0.2mm powder. Hydrolysis was performed at a weight/volume ratio: 150 g/L at fixed pH=2 (by using 5 M HC), at 40 °C under continuous stirring for 4 hours to remove phenols (Tsouko, 2020). Then, OP was filtered, dried again at 85 °C for 72 hours and processed to a 0.2 mm powder while the hydrolysates were collected and frozen for further analysis.

2.2 Screening

A screening was performed to identify the ratio at which the bio-absorbent materials had the ability to absorb more PCs. The treated powder was infused at various concentrations (1, 3, 5, 7, 9, 12, 15, and 20%) into 25 ml of treated waste for 4 hours. Samples were centrifuged at 9000 rpm at 4 °C to receive the liquid treated phase (Tsouko, 2020). The phenol reduction in the samples was determined using the Folin-Ciocalteu method. The procedure was performed in duplicate, also the PC's determination.

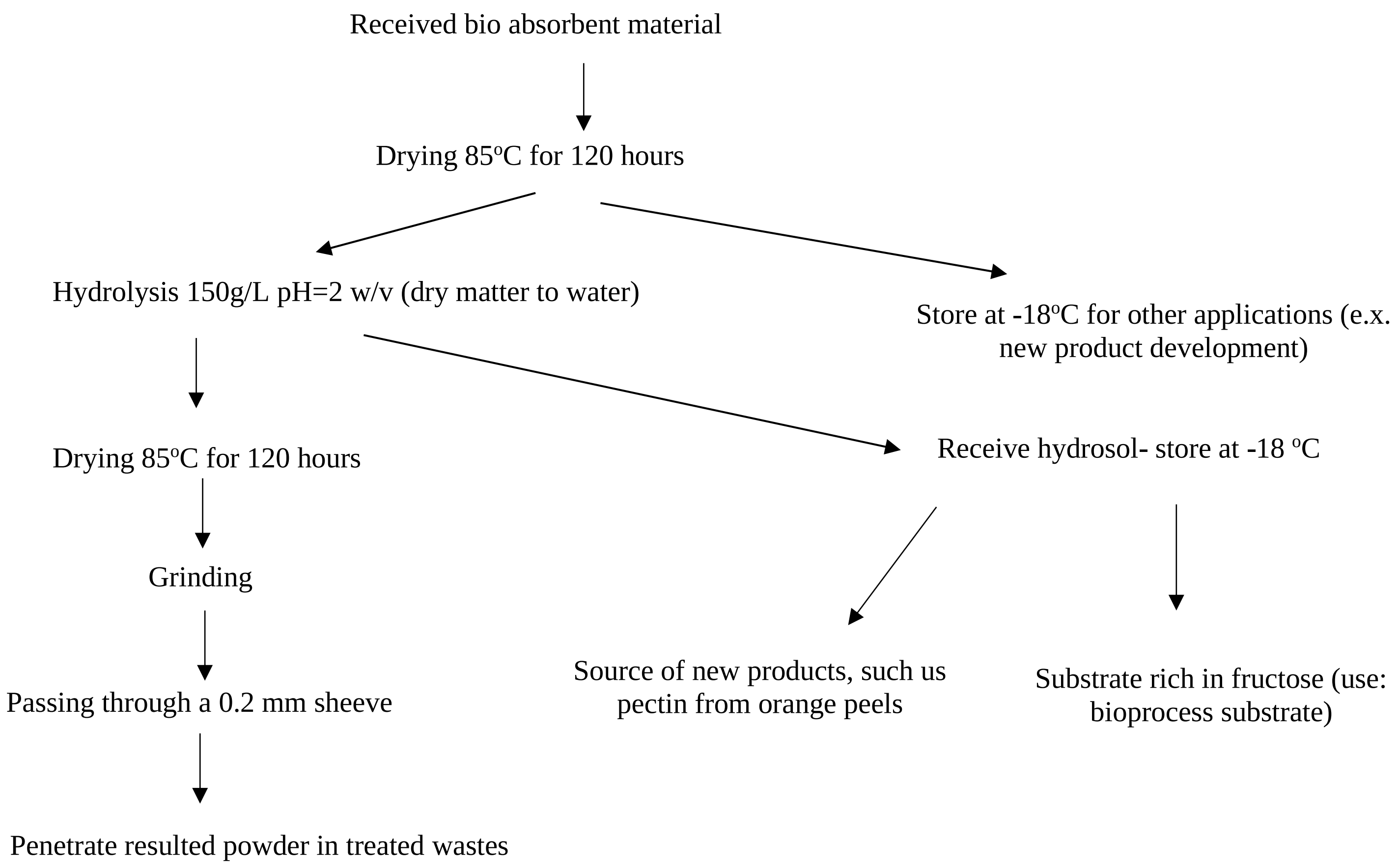

Figure 1: Flow chart of the method followed.

The initial phenol content of the absorbate media (OMW, WWL and BS) was determined by the Folin-Ciocalteu method and was: OMW 2.19 g/l, BS 4.12 g/l and WWL 1.82 g/l.

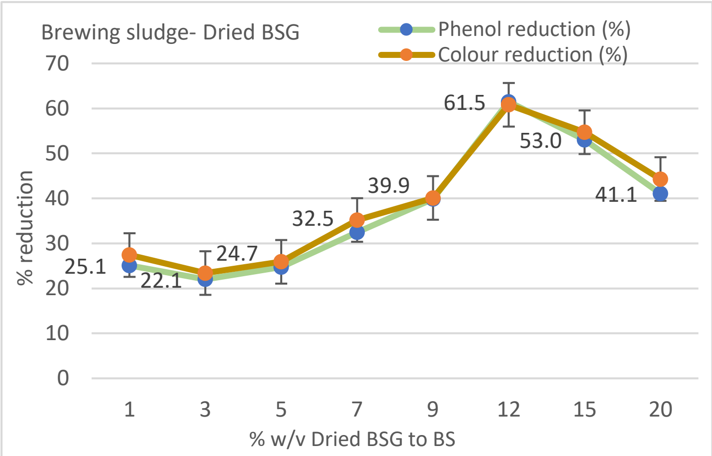

Figure 1: Phenol reduction/color reduction in BS from dry BSG

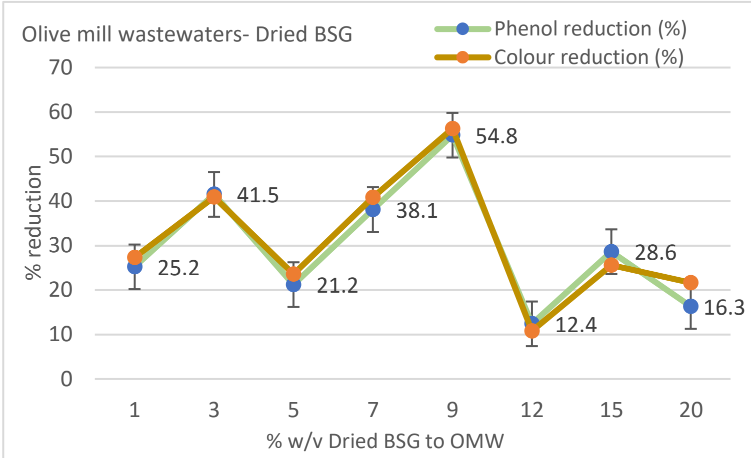

Figure 2: Phenol reduction/color reduction in OMW from dry BSG

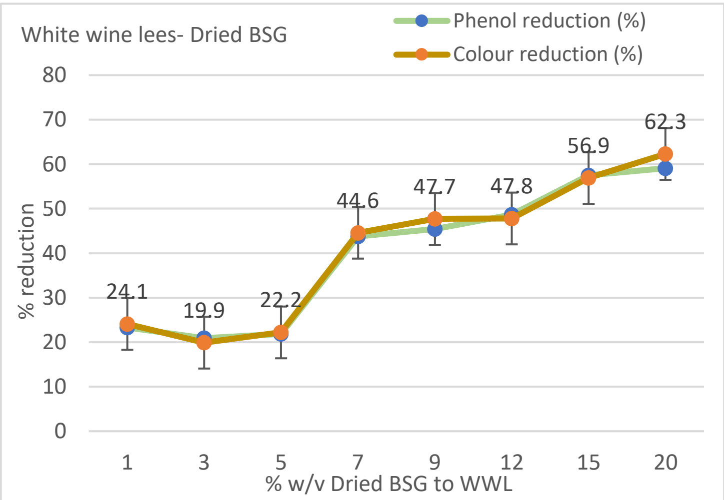

Figure 3: Phenol reduction/color reduction in WWL from dry BSG

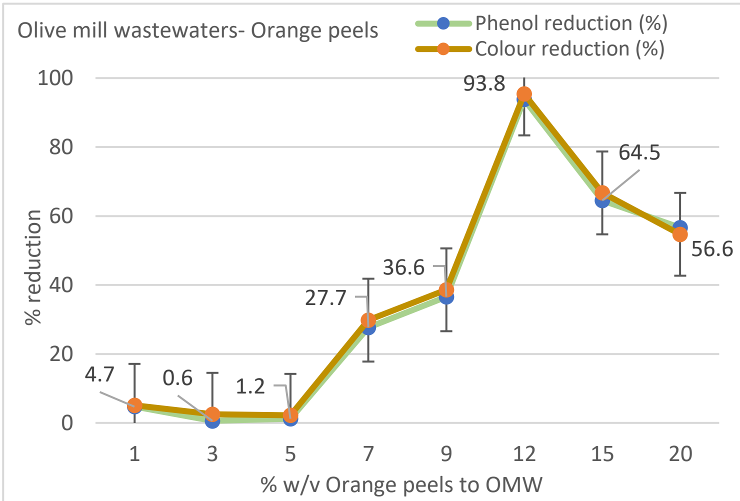

Figure 4: Phenol reduction/color reduction in OMW from OP

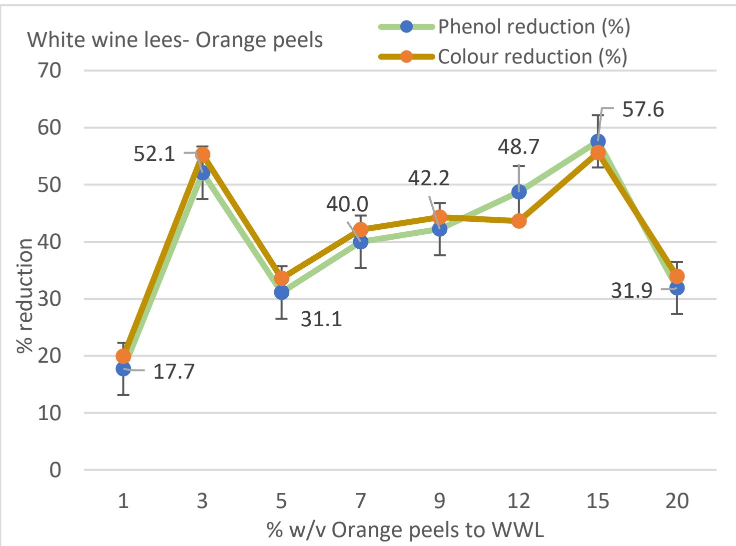

Figure 5: Phenol reduction/color reduction in WWL from OP

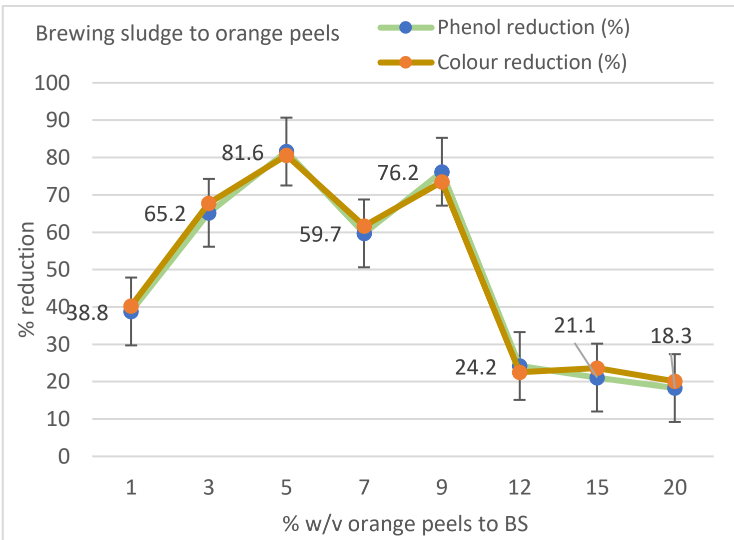

Figure 6: Phenol reduction/color reduction in BS from OP

2.3 Results

Table 1: Results from the phenol absorption/ color reduction to the media by two absorption materials

Absorption material	Substrate	Maximum phenol reduction %	Maximum color reduction %	% w/v absorption material/substrate	pH/ Time/Temperature
Dried BSG	Brewing sludge	61.5	60.8	12	2 /4 hours/ room temperature
	Olive mill wastewaters	54.8	56.3	9	
	White wine lees	59.1	62.3	20	
Orange peels	Brewing sludge	81.6	80.6	5	
	Olive mill wastewaters	93.8	95.4	12	
	White wine lees	57.6	55.6	15	

The results showed that the maximum phenol absorption by dried BSG in the brewing sludge was 61.5%, while the maximum color reduction was 62.3% in the white wine lees. The maximum phenol absorption by orange peel was 93.8% in OMW and the maximum color reduction was 95.4% in OMW also.

3.0 Conclusion

This study concludes with the following:

- The absorbent materials demonstrated a high ability to remove phenolic content from the absorbent media.
- Orange peels showed a higher ability to remove phenolic content from the treated waste and color reduction, compared to BSG but also BSG showed quite high values of reduction.
- Based on the results of this study, it can be concluded that technologies for treating agroindustrial steams with high phenolic content could potentially be developed using those results.

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