Biological treatment of industrial wastewaters: a fungal approach

most of the researches have used synthetic effluents in controlled conditions. Of course, the obtained results could give little information on how a fungus could behave in a wastewater treatment plant, competing with bacterial contamination (Gao et al., 2010). To date, very few experiments have faced the industrial problematic, so that nowadays the application of fungi in a plant is still a technical challenge.

From an applicative point of view, a fungal free-cell treatment shows some drawbacks, since the mycelium could be too exposed to the environmental stresses. A good alternative could be the immobilization of the biomass on supports, with the aim to protect the biomass and improve the fungal activity (Rodriguez-Couto et al., 2009). Confirming this, it has been observed that in some cases a supported biomass showed a higher enzymatic production compared with a free one (Gao et al., 2010). Moreover, the immobilisation of the fungus could allow the use of the system repeatedly, with obvious advantages from a further application point of view.

The aim of this study was to assess if the selected strain, Bjerkandera adusta MUT 2295, would confirm its potential to degrade aromatic molecules, including dyes, also in a not controlled environment, as real effluents, outcoming from wastewater treatment plants. Different inert supports have been tested to select the more adapt one to host the fungal biomass. The bioremediation efficiency towards coloured wastewaters of a free-cell system and an immobilized one was compared.

2. Methods

2.1 Effluents

The wastewaters were kindly provided by Fidia Engineering S.r.l. (BG, Italy), owner of several wastewater treatment plants in Italy. The effluents were sampled from the homogenization tank before the activated sludge treatment of textile (T) and pharmaceutical (P) industries. The textile effluents (T1 and T2) were highly coloured, strongly alkaline (pH ranged between 10.4 and 11.9) and with a COD between 370 and 400 mg/L. The pharmaceutical effluent was poorly coloured, acidic (pH 4.8) and with an elevated COD (20,800 mg/L). When the pH overcame 8, it was adjusted to a standard neutral value (pH 7). When the COD was lower than 400 mg/L, a low amount of glucose (0.1 mg/L) was added to enhance fungal growth.

2.2 Organism

The strain, Bjerkandera adusta MUT 2295, is preserved at the Mycotheca Universitatis Taurinensis (University of Turin, Department of Plant Biology). The strain was selected in a previous study because of its efficient decolourisation activity towards different dye classes and effluents (Anastasi et al., 2010).

2.3 Wastewater (T1 and P1) treatment

The fungus was inoculated as twenty agar plugs (5 mm of diameter), taken from the margins of an actively growing colony on MEA, in 500 mL flasks containing 200 mL of an high nitrogen content medium as previously described (Anastasi et al. 2010). After 7 days, the culture broths were replaced with 100 mL of T1 or P1 and the cultures were followed for 5 days. In order to compare the effectiveness of the fungal treatment with the secondary treatment used in the plants, flasks containing the effluent (100 mL) and 20 mL of activated sludge, sampled in the two plants, were set up according to the procedures suggested by Fidia Engineering S.r.l. Abiotic control (without fungal inoculum) was set up and each culture condition was assayed in 3 biological replicates. The flasks were incubated at 25 °C and 120 rpm in an orbital shaker (Infors) for 5 days.

2.4 Biomass immobilization on inert supports

The experiment was carried out using 4 inert supports (Figure 1): A, circle industrial support; B net industrial support; C, polyurethane foam PUF (2 cm^3); D, stainless steel scourers (1 cm^3). Supports A and B are normally employed for activated sludge immobilization and they were kindly provided by Fidia Engineering S.r.l., while support C was kindly provided by the Department of Civil and Environmental Engineering of the University of Florence.

The fungus was pre-grown as above described (2.3). After 7 days, the biomass was harvested, homogenized and inoculated (5 mL) in flasks containing 200 mL of high nitrogen content medium and the different supports (60% of the volume). The carriers colonization was carried out both under

were recorded between the 2 culture conditions. In fact, the immobilized biomass was able to completely maintain the degradation yields of the free one and even slightly improve them.
Confirming what previously seen for a textile wastewater (T1), fungal treatment was more effective than activated sludge on colour reduction but not in COD reduction. In fact, the fungus removed more than the double of the effluent colour, even though concerning COD reduction, almost the opposite behaviour could be seen. Again, looking at a complete bioremediation process of textile effluents, the 2 biological approaches (fungus and activated sludge) had a complementary and not overlapping action, which could be fundamental for a further industrial application.

Table 3: Decolourisation percentage (DP), COD reduction, enzymatic production (MnP activity) and pH of T1 and P1 after the fungal and the activated sludge treatments.

	DP	**COD** *% reduction*	**Perox** *(U/l)*	**pH**
B. adusta				
free	*62.0*	*47.6*	*1.4*	*8.2*
immobilized	*63.8*	*48.3*	*15.3*	*8.1*
activated sludge	*30.2*	*80.5*	*/*	*8.6*

4. Conclusions

In conclusion, a very interesting fungal strain, Bjerkandera adusta MUT 2295, was selected for its capability to be active in bioremediation processes, acting towards several parameters, as colour and COD. A complementary approach with active sludge could be hypothesized.
From a practical point of view, in the future, it should be considered to evaluate the fungal potential also during longer treatment, carried out on several cycles, in order to mimic the industrial conditions the fungus would work in. Furthermore, the process should be scaled-up to larger volume, in order to confirm the robustness and the applicability of the system.

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