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Fungal biosorption in wastewater treatment: decolourisation and detoxification of textile and tannery effluents

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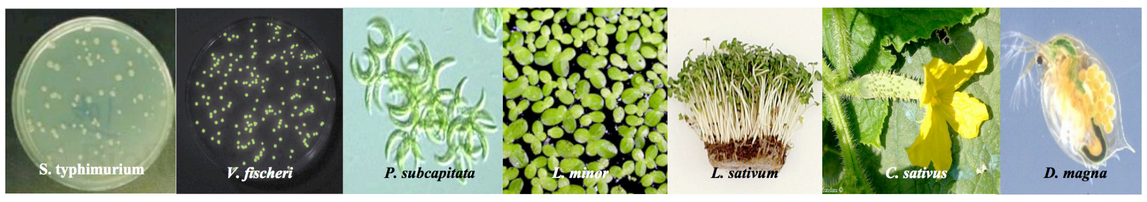
Background: textile and tannery effluents contribute enormously to water deterioration on account of the considerable amount of suspended solids, salts, heavy metals and of their high COD, due to the massive presence of weakly biodegradable and very toxic substances such as dyes and surfactants. Moreover, since these wastewaters exhibit large fluctuations in terms of quantities and pollution load, pH and temperature, they are not adequately treated in conventional wastewater treatment plants and, therefore, pollutants accumulate in the environment. All known physico-chemical techniques tested so far present some drawbacks, since they are not always applicable and/or effective. Biosorption, is a promising option for the removal of pollutants from aqueous streams because of its cost effectiveness and the possibility to treat large water volumes. Among the different biosorbents tested so far, fungal biomass has proved to be particularly suitable.

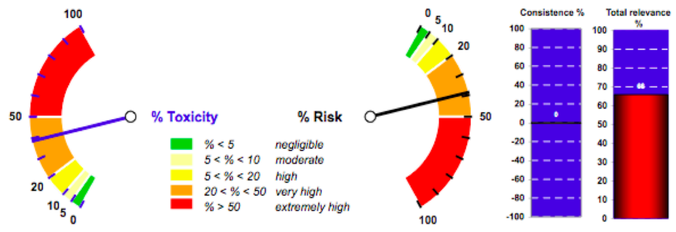
Aims of the research: in this Thesis the exploitation of 3 fungal strains in the biosorption treatment of textile and tannery wastewaters was evaluated.

1. Ecotoxicological characterisation of four wastewaters models

The toxicity of four mimed textile and tannery wastewaters was evaluated by means of a battery of 7 bioassays, using organisms belonging to different trophic levels. Moreover, a novel synthetic index for the environmental risk assessment developed by UNICHIM was applied to the outputs of the test battery.



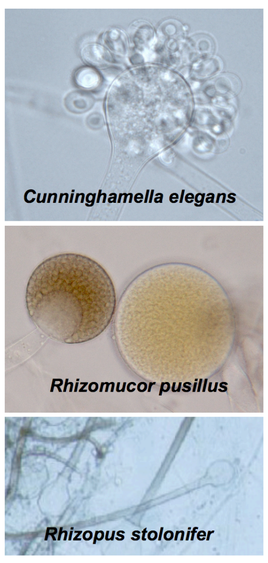
All four mimed wastewaters showed very toxic but no mutagenic effect.
The alga *Pseudokirchneriella subcapitata* was selected, as the most sensitive organism, for monitoring further remediation tests.

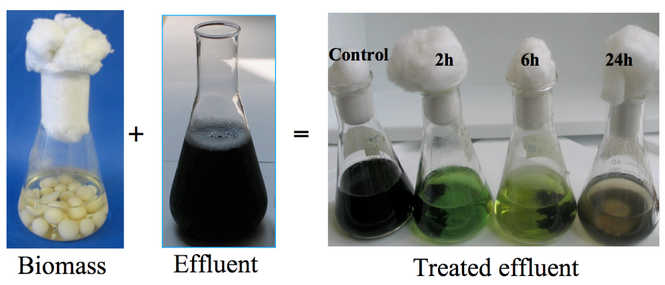


Besides, the contribution and the toxicity interaction between dyes and salts in wastewater was determined with two mathematical models, resulting in a high synergistic effect.

2. Selection of fungal strains

The biomasses of three fungal strains, *Rhizopus stolonifer*, *Rhizomucor pusillus* and *Cunningamella elegans*, were tested towards the wastewater models in biosorption experiments.





Biomass + Effluent = Treated effluent

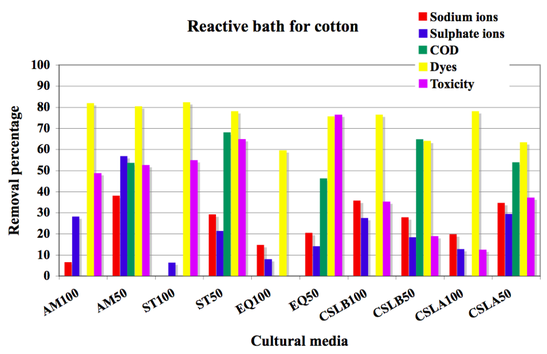
The 3 fungal strains was effective in the decolourisation (59-94%) of the four mimed wastewaters characterized by different classes of dyes, different dye concentrations, additives, salts and pH values.

Moreover, they reduced the COD (up to 59%) and the toxicity (up to 100%) of the wastewater models.

***C. elegans* was selected for the biomass optimisation study.**

3. Biomass optimisation: cultural medium and biomass pre-treatment

The biomass cultured on 10 media characterized by different C and N sources.



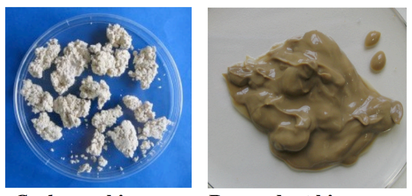
The biomass cultured in starch resulted the best in terms of costs, detoxification, COD and salt removal and decolourisation yields, thanks to many functional groups that bind molecules pointed out by FTIR analyses.

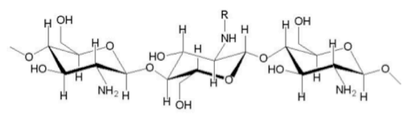
In order to confer robustness and stability to the biomass, *C. elegans* was subjected to chemical (acid or alkali) and physical (drying and lyophilisation) pre-treatments.

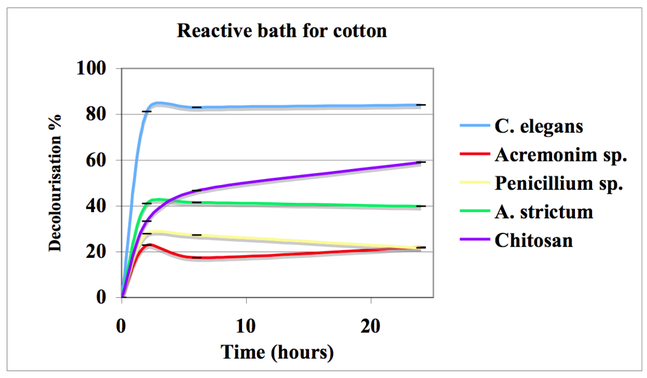
The lyophilisation process provided very stable and porous biomass, which fasten the biosorption process irrespective of the biomass particle size.

4. Challenge between *C. elegans* biomass and other alternative biosorbents

The performance of *C. elegans* biomass was compared to other alternative and promising biosorbents, such as industrial by-product fungal biomasses and chitosan, which could be attractive from an economical point of view.



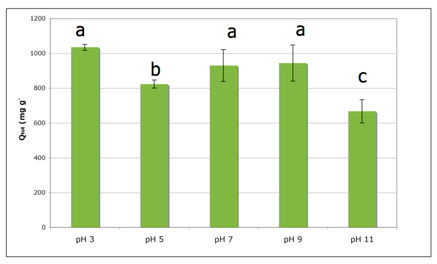




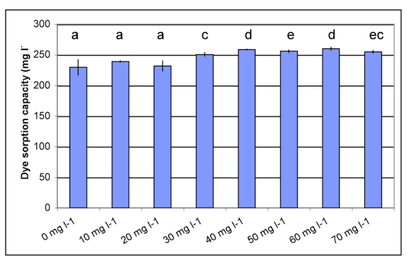
- ***C. elegans* resulted the most effective and versatile in decolourisation of the wastewater models;**
- **Different cell wall components other than chitosan are involved in dyes biosorption.**

5. Assessment of versatility and saturation of *C. elegans* biomass

C. elegans was tested in a wide range of pH (3-9), temperature (25-60 °C), and salt concentration (0-70 g l^{-1}).

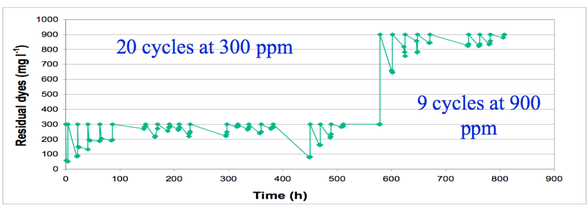


pH and temperature are not limiting factors for the decolourisation yields of *C. elegans* biomass.



Dye adsorption slightly increased by increasing salt concentration: **dyes and salt have different binding sites!**

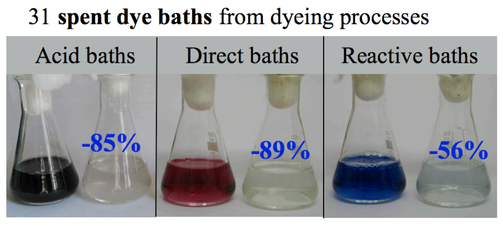
In consecutive feeds experiments (29 cycles), the total sorption capacity (q_{tot}) was **1035 mg g^{-1}**



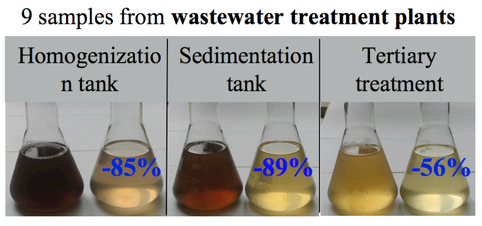
6. Exploitation of *C. elegans* in the treatment of real wastewaters: two approaches

C. elegans biomass was exploited in 2 h treatment of 40 real samples:

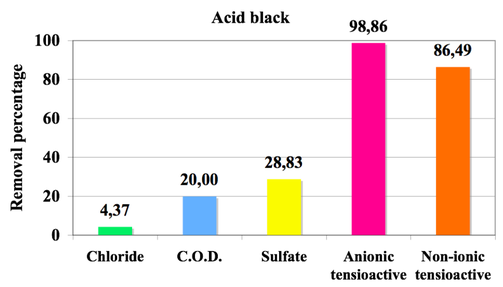
31 **spent dye baths** from dyeing processes



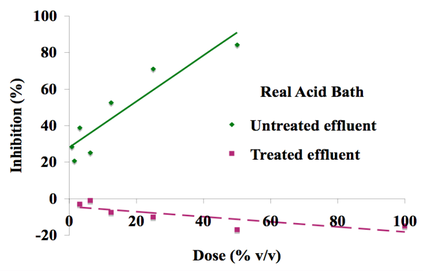
9 samples from **wastewater treatment plants**



Also COD, salts and surfactants were removed.



P. Subcapitata test showed an actual detoxification under the legal threshold value.



Conclusion

The high applicative potential of *C. elegans* brought to an **Europen patent deposition** on February 10th:

FUNGAL BIOMASS PREPARATION FOR THE TREATMENT OF INDUSTRIAL WASTEWATERS CONTAINING POLLUTANTS
EP10153195.2

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PATENTED

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