Požega 2022

Using Waste Material For Purifying Wastewaters

Anastasia Trofilova , Sofia Scarani, Giorgia Simonelli, Matej Nemčić

Abstract

The rapid growth of the textile industry is accompanied by rapid economic expansion. The rising volume of wastewater released into the environment is an actual issue that is well acknowledged but not adequately addressed. Wastewaters contain synthetic dyes, which can be hazardous to both aquatic life and people. Consequently, dyeing is one of the most polluting processes in the textile industry. There are numerous established methods for treating wastewater today, however, work is being done to create solutions that are both more effective and affordable. Brewer's yeast is wasted in the beer industry by being discarded in big quantities after a period of time. The goal of this research was to develop a collective method for decolorizing wastewater using repurposed waste material by turning it into a biosorbent. First, wastewater was generated by simulating the textile industry's dyeing process. Brewer's yeast, which is wasted in the beer industry, then absorbed the hazardous dyes from previously prepared wastewater. To make the approach more effective, parameters including the yeast mass and pH of the dye solution were optimized along with the use of various dyes to determine which are most impacted by the yeast. In conclusion, the pH 2 for *Mordant Blue 16* and pH 3 for *Acid Green 25* are optimal for yeast activity. Yeast absorbed *Red Orange 16* the least.

Key words: RO16 , MB9, AG25, Brewer's yeast, dyeing

1. INTRODUCTION

1.1 TEXTILE DYES

Industrial pollutants such as textile dyes have a high toxicity and may be cancerogenic. The entire aquatic environment can be disrupted by even a small amount of additional color, which can block sunlight and hinder plant photosynthesis. Dyeing water lowers the oxygen content in the water, impairing the performance of aquatic plants and algae. One river in India affected by textile dye pollution is the Bandi River, which flows through the Pali area of Rajasthan. Pali is home to more than 800 textile factories, 600 of which the Central Pollution Control Board has classified as "red" due to their high pollution levels. While other rivers have no dissolved oxygen remaining in their water, the Chilai river is severely polluted by unauthorized buildings and factories. This is due to Bangladesh's development becoming the world's center for the production of low cost clothing items. As a result of the industry's poor regulation, its rivers and the health of the locals are put at risk.There are many ways to purify wastewaters, such as anaerobic wastewater treatment (biochemical oxidation, or sludge digestion), chemical processes (disinfection, flocculation), or membrane processes (filtration,

nanofiltration). Municipal wastewater effluents feature nutrients like phosphorus and nitrogen. Despite them being good for plants, excessive amounts might have negative effects. The receiving surface water bodies become eutrophicated as a result of excessive plant growth, particularly algae.

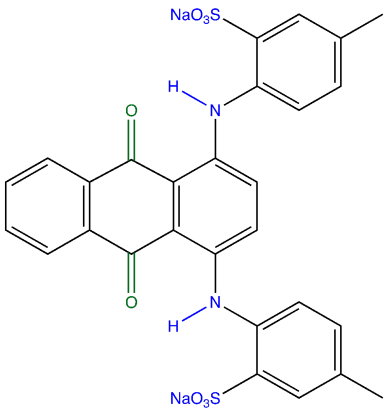
1.2 BREWER'S YEAST

One typical by-product of the brewing industry is brewer's yeast. At the completion of the bulk fermentation, the used yeast cells are discarded. The majority of the consumed yeast is disposed of, with a slight bit being used to begin the next round of fermentation. This research explores the ability of yeast to absorb industrial dyes and aims to find an efficient method for purifying wastewater with Brewer's yeast by the optimization of parameters.

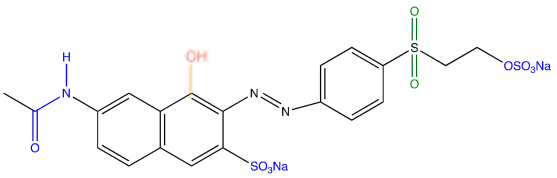
2. MATERIALS AND METHODS

2.1 DYE STRUCTURES

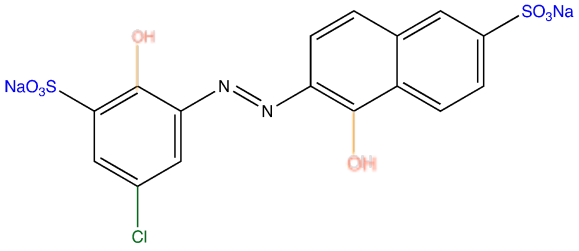
The dyes used in this research were Acid Greed 25 (AG25) , Mordant Blue 9 (MB9) and Red Orange 16 (RO16) (*see fig. 1)*.



Acid Green 25
Overall slightly basic molecule



Red Orange 16
Overall slightly basic molecule



Mordant Blue 9
Overall neutral molecule

Fig. 1 : Functional groups highlighted in blue are in basic form, in green are in neutral form and in orange are in acidic form/ protonated.

2.2 DYEING PROCESS SIMULATION

A dye solution was made by diluting dye in a volumetric flask to get a final concentration of 40 ppm for RO16. The mass of the dye was measured using an analytical balance . For AG25 and MB9 a concentration of 60 ppm was used to avoid the solution being too diluted.

2.3 SPECTROPHOTOMETRY

A technique called spectrophotometry uses light intensity measurements as a beam of light travels through a sample solution to determine how much a chemical compound absorbs light. The optimal wavelength was found for each dye using a spectrophotometer to measure the absorbance. The dye solutions were placed in a spectrophotometer to measure the value of the absorbance within a range of wavelengths comprising the visible spectrum - from 350 nm to 750 nm. The data was recorded and presented through graphs. To ensure that a slight change in the wavelength would not drastically interfere with the absorbance, the optimal wavelength for each dye was chosen as the highest absorbance maxima *(see fig. 2)*. The maximum wavelength peaks for MB9, AG25 and RO16 are 518, 638, and 496 respectively. The estimated maximum absorbance for MB9, AG25 and RO16 are 1.078, 1.107 and 1.075 respectively.

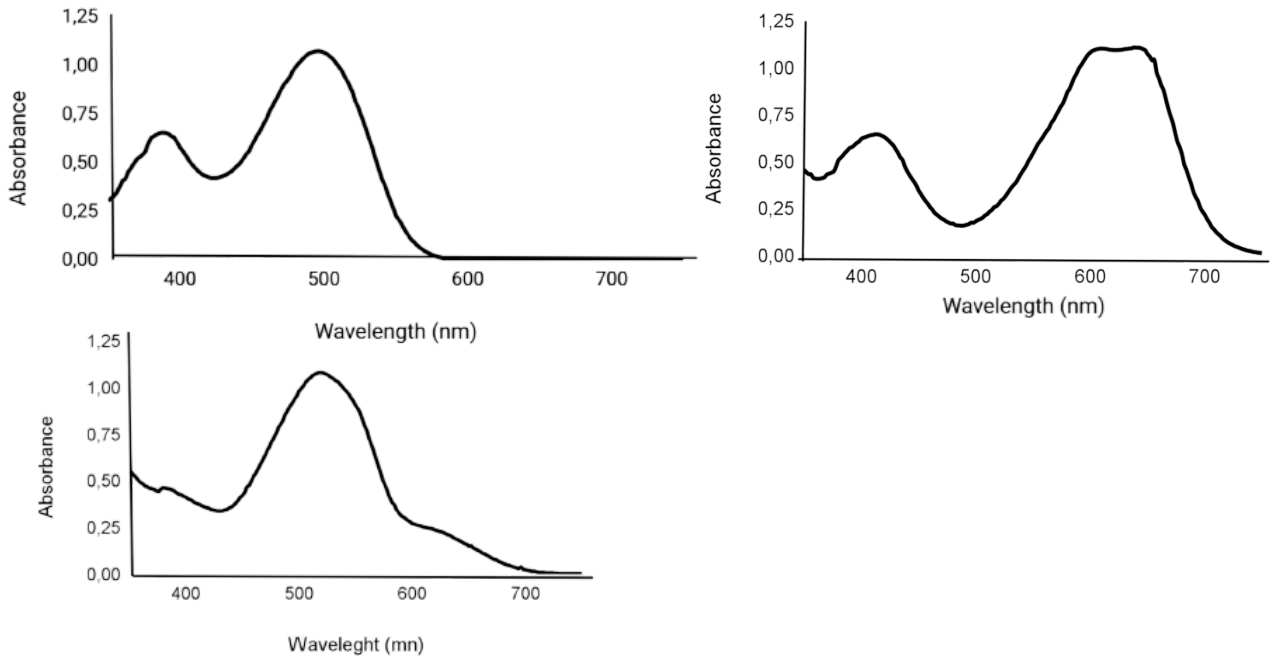


Fig 2: Absorbance and Wavelength graphs for MB9 (bottom left) , AG25 (top left) and RO16 (top right)

2.4 ABSORPTION BY YEAST

A mass of 0,125g of yeast was added to 50mL of dye solution. The final solution was placed in a beaker with a magnetic stirrer (Model: HYCC MX-8K) with a speed of 400 rpm, to help the yeast absorb the dye. Using a micropipette, a sample of 2mL of the solution was taken every set number of minutes: every 5 min for the first 55 min, then in 30-60 min intervals. The sample was centrifuged (Model: Heraeus Sepatech Biofuge A) for 4 min with a speed of 6000 rpm to separate the yeast and dye from the water. This sample was placed in the spectrophotometer (Model: 722G) to see the absorbance at the optimal wavelength. The efficiency was calculated using the following formula: $\eta = 1 - (At/A0)$, where "η" is efficiency, A is absorbance, t is time, and A0 is the absorbance at t=0. Graphs were plotted representing the efficiency of yeast on dyes progressively over time.

2.5 OPTIMIZATION OF pH

To ensure maximum efficiency of the yeast, pH of the dye solution was optimized. pH changes the availability of functional groups to attract molecules and the structure of the dyes. To change the pH, a buffer solution was used with pH values of 1,2,3,4,5 and 9.

2.6 INDUSTRIAL APPLICATIONS

To bring this method of purifying wastewaters into the industry, a system would have to be developed. The water can go through this system where the yeast is mixed with dyed water, before it is poured into the rivers. The yeast will absorb the dye and the water will be filtered to separate it from the absorbed dye and yeast. According to the dye concentration, mass, etc, the system's temperature, pH of solution, and yeast mass can all be effectively controlled. Then the purified water can exit the system into the river.

3. RESULTS AND DISCUSSION

Absorption is a physical process that occurs as dye interacts with the yeast through intramolecular interactions. These are mostly hydrogen bonds, but also dipole-dipole and induced dipole interactions. The groups of interest highlighted in *fig. 1* are the ones that participate in intramolecular interactions; they can change the structure of the molecule, become deprotonated or protonated and form hydrogen bonds. Such groups include phenol, amine, amide and sulfonate. There are pH-dependent and pH-independent interactions. NaSO3, NH, OH are pH-dependent, as based on the acidity of the solutions, these groups behave differently. The Cl and O atoms are not protonated, so their behavior does not depend on the pH of the solution and they similarly have the chance of forming weaker intramolecular interactions.

Sulfonate is currently in basic form in the dye structure. When the medium becomes acidic, the Na can get replaced by a Hydrogen atom, becoming available for hydrogen bonds with the yeast. Amines are likewise in basic form, where the two hydrogens can form bonds, likewise, when the medium becomes acidic, now the hydrogen and the sodium can form two hydrogen bonds with the yeast. Phenol, initially in acidic form, can also make hydrogen bonds.

As the overall efficiency of yeast was higher in an acidic medium, intramolecular interactions were more intense here rather than in a basic medium.. A reason for more intense interactions in acidic medium could be the protonation of the Sulfonate group, giving it the ability to interact with yeast. Furthermore, an acidic solution contains more hydrogen ions, which leads to more phenol hydrogen bonds that are more intense and lead to a better absorption of the dye.

In a basic medium, the intramolecular interactions were not intense, as the efficiency of the yeast was very low. A basic medium contains a smaller amount of hydrogen ions, leading to weaker phenol hydrogen bonds, which could explain the low absorption rate.

Acid Green 25 was better absorbed by yeast in a solution with a pH of 3 rather than 2 *(see fig 4)*, meaning that pH 2 was too acidic. Mordant Blue 9 was best absorbed by yeast in a solution of pH 2 rather than ph 1 (see fig 5). When the pH is too acidic, there is a substantial amount of hydrogen ions in the solution. These hydrogen atoms from the buffer can form bonds with the yeast, thereby blocking the yeast functional groups from interacting with the dye. Therefore a more acidic pH only means better efficiency only until a certain point where this phenomenon will occur.

When the efficiency of yeast is very high, a high amount of dye is used up. However, it is important to optimize the mass of the yeast, as the efficiency can be very high and all the dye absorbed, but with a high excess of yeast remaining, which can also mean unnecessary expenses on yeast . A sign of

overabundant yeast is when the yeast mass is lowered but the efficiency stays the same. This was tested with a new yeast mass of 0,05 on AG25, pH3. The results showed a slightly lower efficiency, which could indicate that 0,125 g of yeast is not an excessive amount of yeast *(see fig 3)*. .

The efficiency of the yeast was the lowest for both dyes with a pH 9. This pH was too low, as there were not enough hydrogen ions, which led to weaker hydrogen bonds between the yeast and the dye. In the case where the efficiency was very low, at a pH 9, all of the available yeast was used up. Some of the yeast molecules became unavailable for interaction with the dye, when deprotonated, leading to yeast that can no longer be used and a surplus of dye.

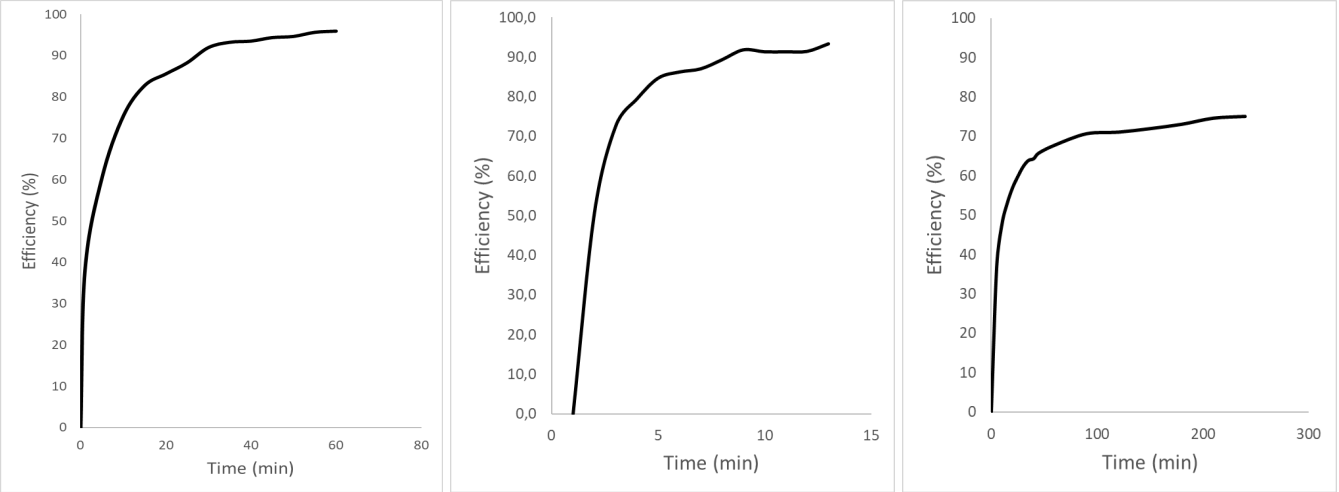


Fig 3: Graphs for Efficiency Ag25 (left) , Efficiency AG25 with yeast mass of 0.05 g (middle) and Efficiency MB9 (right)

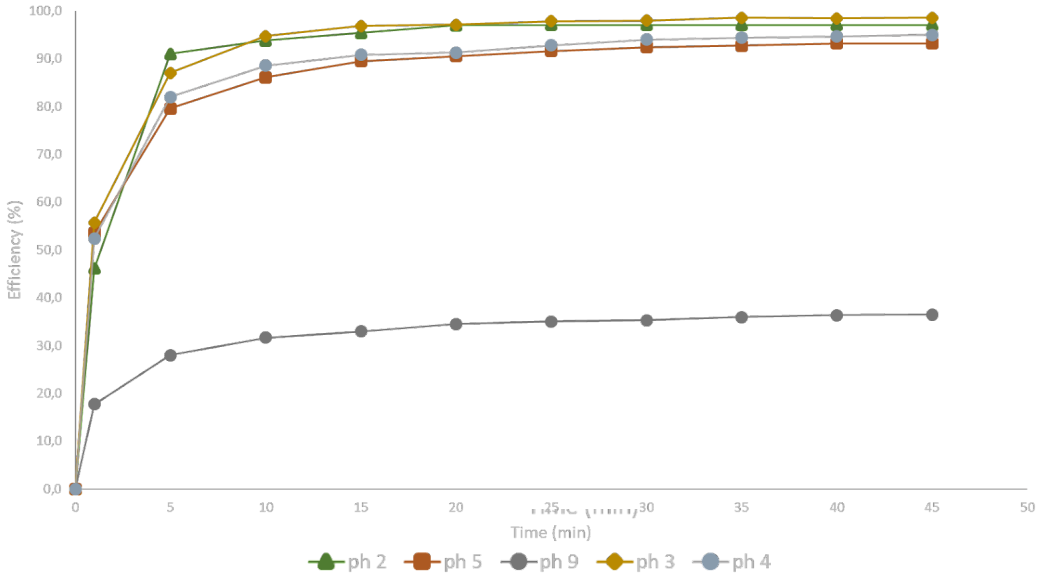


Fig 4: pH optimization graph of AG25

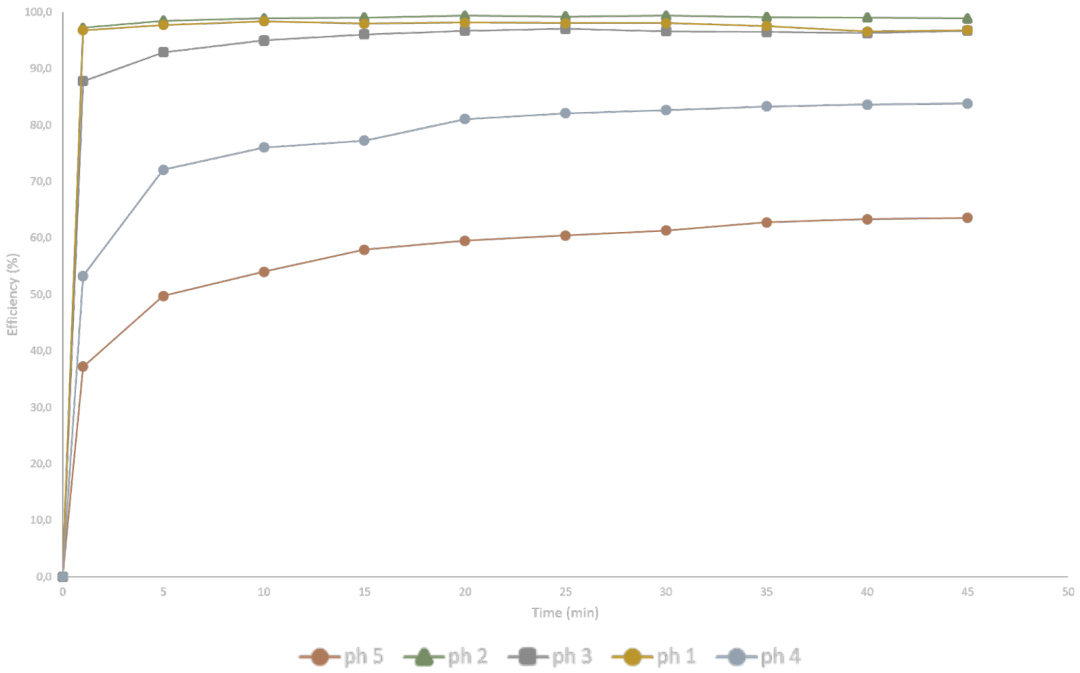


Fig 4: pH optimization graph of MB9

4. CONCLUSION

In conclusion, the results of the conducted experiments clearly show that, among the three dyes used in this experiment, the yeast was more effective on AG25 and on MB9. RO16 was poorly absorbed by the yeast, possibly due to lower availability of its functional groups for interaction. Equally, the procedure proved to be more effective in an acidic medium than in a basic one. A yeast mass of 0.125 g was proven to be efficient in absorbing dye and not excessive.

5. FURTHER RESEARCH

As further research, yeast mass of AG25 and MB9, and temperature of the yeast medium may be further adjusted until optimal. Parameters within the yeast and surrounding environment should all be adjusted to fit the conditions such as concentration, volume, type, etc. of the dyes in the wastewaters. Such absorption experiments may be further conducted on other industrial dyes. To better understand the interaction between yeast and dye functional groups, a structural analysis may be performed.

6. ACKNOWLEDGMENTS

We would like to thank Laura Busak and Luka Korov, the organizers of the Summer School of Science, for their continued support, as well as Jovana Dinic, technical assistant, and our project leader Filip Koldzic (University of Belgrade, Serbia).