BIOSOPRTION OF AMOXICILLIN FROM WASTEWATER ON BIOCHAR FROM BUCKWHEAT HULLS

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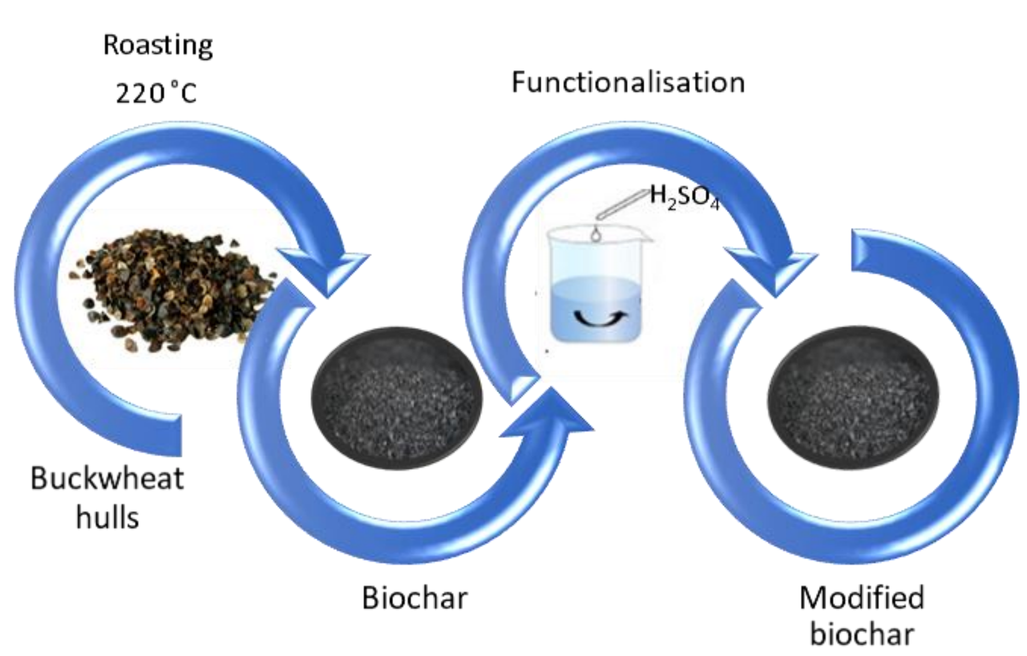
INTRODUCTION

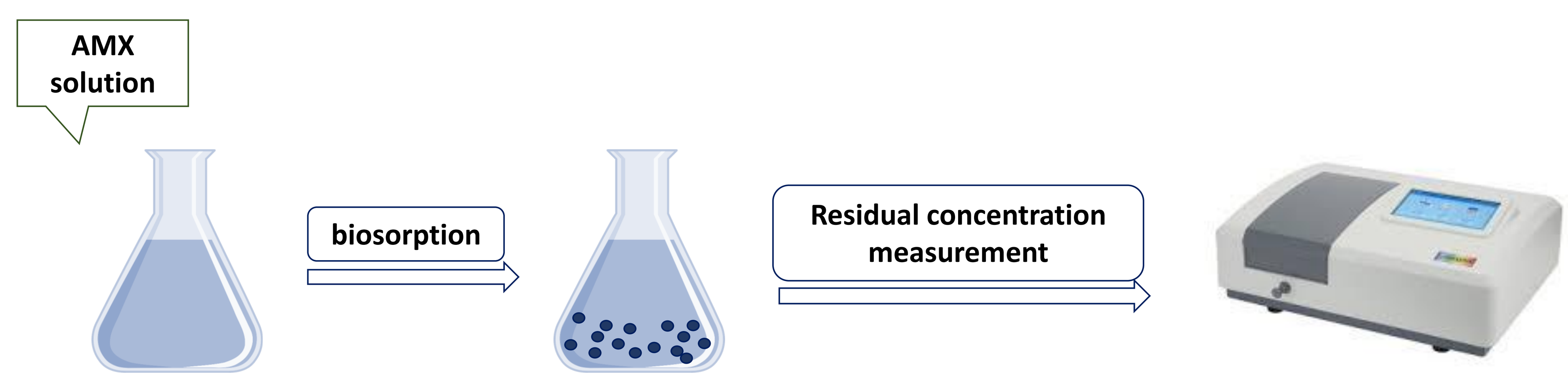
Worldwide, the concentration of pharmaceuticals in nature has increased significantly in recent decades, not only because of their increased consumption, but also because of their inadequate removal in wastewater treatment. It is important to refer to the terminology according to which pharmaceuticals found in the environment that are not in their original form (tablets, capsules, etc.) are referred to as active pharmaceutical ingredients. Pharmaceuticals enter the environment primarily through hospital, livestock and household wastewater, sewage treatment plants and the pharmaceutical industry, but also through improper storage or disposal of discarded pharmaceuticals.

Amoxicillin (AMX) is a semi-synthetic antibiotic that, like penicillin, belongs to the β-lactam group of antibiotics. This group accounts for 65% of global consumption of antibiotics. It came onto the market in 1972 as an alternative to ampicillin, to which bacteria had developed resistance. It consists of 6-aminopenicillic acid, which is characteristic of this group of antibiotics, and a side chain with an amino group.

Since wastewater from sewage treatment plants is considered one of the largest sources of pharmaceuticals, it is obvious that the existing conventional methods are not successful in removing this type of compounds. Among all the methods mentioned, adsorption stands out as it is effective even at low concentrations, is inexpensive and simple. Many materials of organic and inorganic origin can serve as adsorbents, but recently more and more emphasis has been placed on the use of by-products from the food and other industries. In this way, it is approaching the circular economy model. Organic materials and their pyrolysis products are suitable for adsorption due to their large specific surface area, micro- and mesoporous structure and the presence of surface functional groups. In this study, buckwheat hull-based biochar functionalized with H_2SO_4 was investigated for the removal of amoxicillin (AMX) from model solutions and synthetic wastewater.

MATERIALS AND METHODS





RESULTS

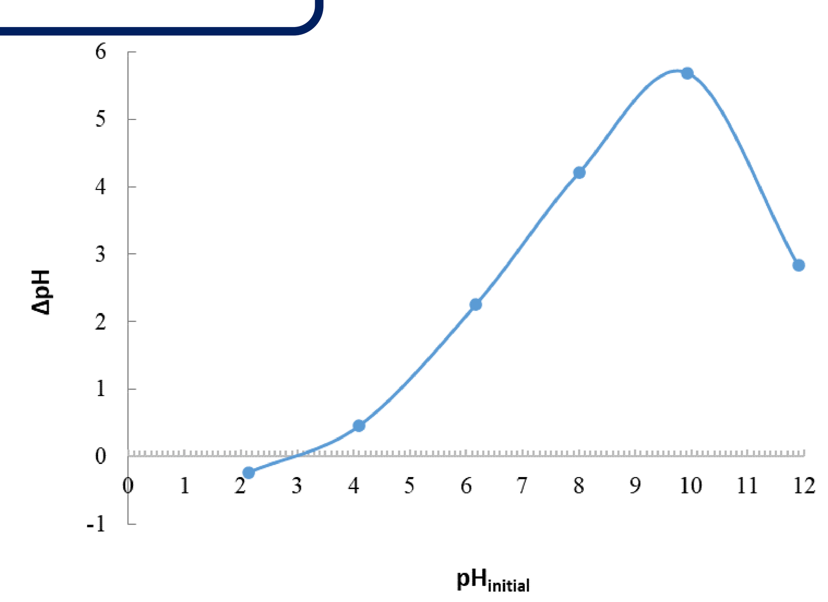


Figure 1 Point of zero charge of biosorbent

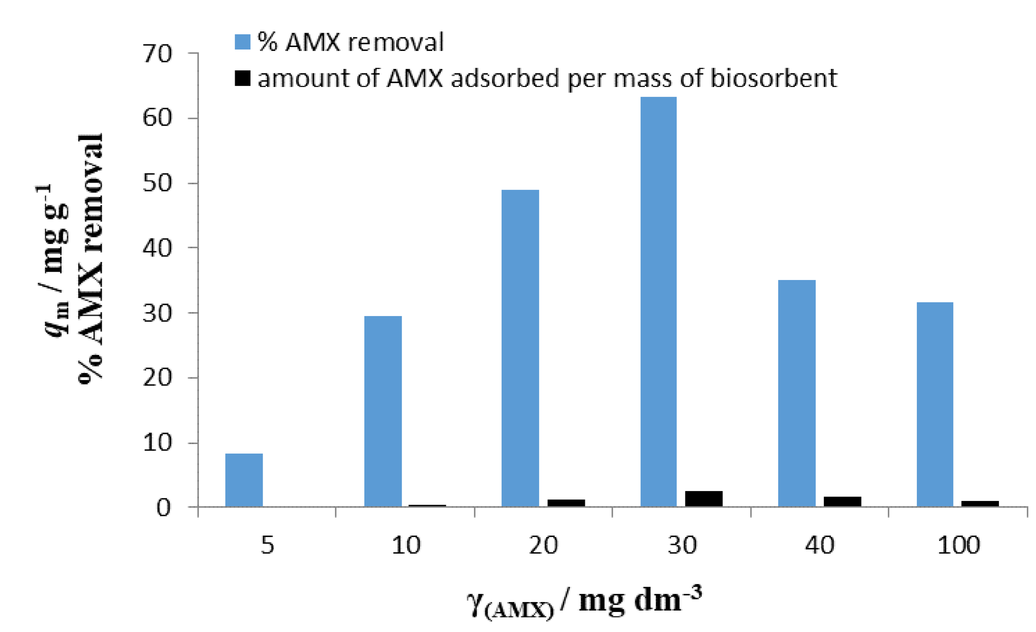


Figure 2 Effect of initial AMX concentration on AMX removal ($V_{AMX\ solution}$ = 25 cm^{-3}, γ_{AMX} = 5 - 100 mg dm^{-3}, $\gamma_{biosorbent}$ = 8 g dm^{-3}, t = 180 min, Θ = 25 °C, 150 rpm)

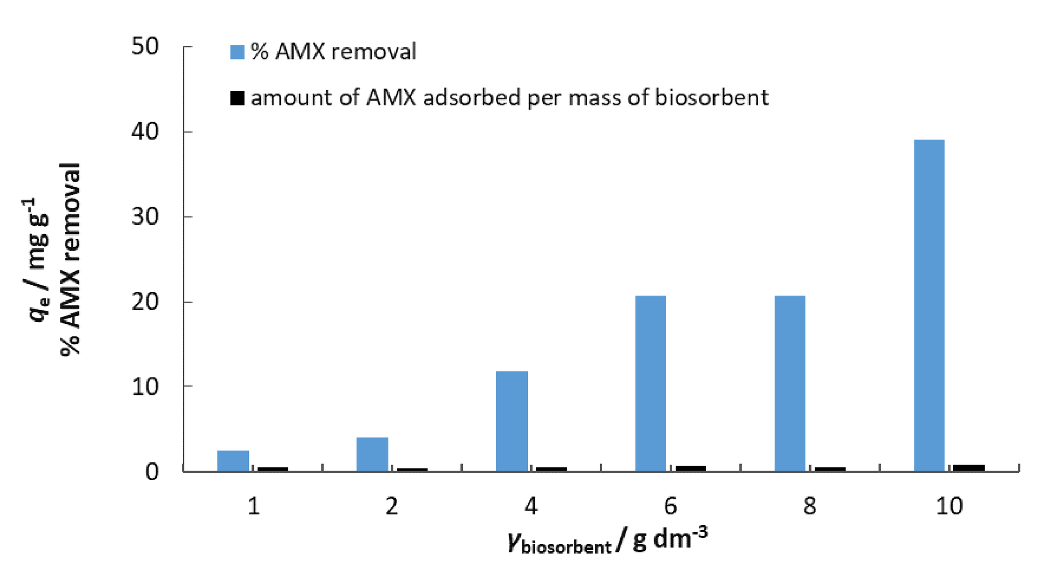


Figure 3 Effect of biosorbent concentration on AMX removal ($V_{AMX\ solution}$ = 50 cm^{-3}, γ_{AMX} = 50 mg dm^{-3}, $\gamma_{biosorbent}$ = 1 -10 g dm^{-3}, t = 120 min, Θ = 25 °C, 150 rpm)

Table 1 Non-linear adsorption isotherm and kinetic parameters for biosoprtion of AMX onto buckwheat hulls biochar (γ_{AMX} = 50 mg dm^{-3}, $\gamma_{biosorbent}$ = 8 g dm^{-3}, t = 15 - 360 min, Θ = 25 °C, 150 rpm)

Isotherm models		***Kinetic models***	
$q_{m\ exp.}$ / mg g^{-1}	2.420	$q_{m\ exp.}$ / mg g^{-1}	
Langmuir		***Pseudo-first order***	
$q_{m\ cal.}$ / mg g^{-1}	14.992	$q_{m\ 1}$ / mg g^{-1}	1.040
K_L / L mg^{-1}	0.005	k_1 / min^{-1}	0.015
R_L		R^2	0.902
R^2	0.755	RMSE	0.096
RMSE	0.285	MSE	0.009
MSE	0.081		
Freundlich		***Pseudo-second order***	
K_F / (mg g^{-1} (L/mg)$^{1/n}$)		$q_{m\ 2}$ / mg g^{-1}	1.296
n	0.074	k_2 / g mg^{-1} min^{-1}	0.011
R^2	0.753	R^2	0.875
RMSE	0.286	RMSE	0.108
MSE	0.082	MSE	0.012

DISCUSSION

Fig. 1 shows the point of zero charge for the biosorbent buckwheat hulls biochar with a pH of 3. Since AMX is a zwitter ion in the pH range of 2.7 to 7.5, its removal will be more effective at a pH of 2.7 to 7.5 due to electrostatic interactions, while these interactions become weaker at a pH > 7.5 since both the AMX molecule and the biochar surface are negatively charged and repulsion occurs. The results presented in Fig. 2 show the influence of the change in AMX concentration on the percentage of removal and the amount of adsorbed AMX per gram of biosorbent. It can be seen that when the AMX concentration is increased from 5-100 mg dm^{-3} , the percentage of removal increases from 8 % to 63 % and then decreases to 30 %. Also, the amount of adsorbed AMX per gram of biosorbent increases with the increase in AMX concentration from 0.06 mg g^{-1} to 2.42 mg g^{-1} and then decreases to 0.989 mg g^{-1}. As can be seen in Fig. 3, the increase in biosorbent concentration leads to an increase in the percentage of AMX removal (from 2.49 % to 39.04 %). It can be concluded from Table 1 that both the Langmuir and Freundlich adsorption isotherms describe the experimental data well, as does the pseudo-first order model in the kinetic analysis (higher correlation coefficients).

CONCLUSION

Buckwheat hulls biochar showed the ability to remove AMX from both the AMX model solutions and the synthetic wastewater (data not shown). However, the relatively low adsorption capacity of the material indicates the need for further investigations to improve the biosorption properties of the tested material, e.g. by various chemical or other modifications.