CARBONIZATION OF TREE OF HEAVEN FOR BIOCHAR PRODUCTION: A PROMISING UTILIZATION OF INVASIVE SPECIES FOR PESTICIDE ADSORPTION

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INTRODUCTION

The increasing presence of pesticides in soil and water systems has raised concerns about their adverse effects on ecosystems and human health. To address this issue, biochar has emerged as a sustainable solution due to its high adsorption capacity [1]. This study focuses on utilizing **Tree of heaven (Ailanthus altissima, AA)** biomass as a feedstock for biochar production [2], aiming to develop an efficient and environmentally friendly approach for pesticide adsorption.

OBJECTIVES

Tree of Heaven, a fast-growing and invasive species, poses a significant challenge to ecosystems. By converting this biomass into biochar through carbonization, we can simultaneously address the issue of invasive species while creating a valuable resource for environmental remediation. The carbonization process involves pyrolysis under controlled conditions to transform the biomass into a stable carbon-rich material with a high surface area and porosity.

In this study, we investigate the influence of carbonization parameters, such as temperature (500, 650 and 800 °C), and $ZnCl_2$ activation on the physicochemical properties and adsorption capacity of prepared biochar samples (AAc).

Neonicotinoid pesticide concentrations were measured spectrophotometrically using a UV/Vis/NIR spectrometer Evolution 220 from Thermo Scientifc using 1 mm quartz cuvettes.

The AA leaves were first carbonized for 2 h at 500 °C (AAc/500), and then additionally carbonized for 2 h at 650 °C (AAc/650) and at 800 °C (AAc/800).
Sample AAc/500 was activated with $ZnCl_2$, in a mass ratio of 3:1, and then carbonized at 650 °C (AAc/650/$ZnCl_2$) and 800 °C (AAZ/800/$ZnCl_2$).
Carbonization was performed in an Ar atmosphere (60 mL/min) and at a heating rate of 10 °C min^{-1}.

RESULTS AND DISCUSSION

Batch adsorption experiments are conducted to assess the performance of the Tree of Heaven biochar in removing neonicotinoid pesticides from aqueous solutions. The effects of initial pesticide concentration and suspension composition (single components or pesticide mixtures) on the adsorption process are investigated (**adsorption doses 1 mg/mL**).

Effect of temperature on carbonization and $ZnCl_2$ activation

In order to obtain an effective adsorbent, it is necessary to carry out carbonization at a temperature higher than 650 °C. The $ZnCl_2$ activation doubles the adsorption efficiency, Fig. 1.

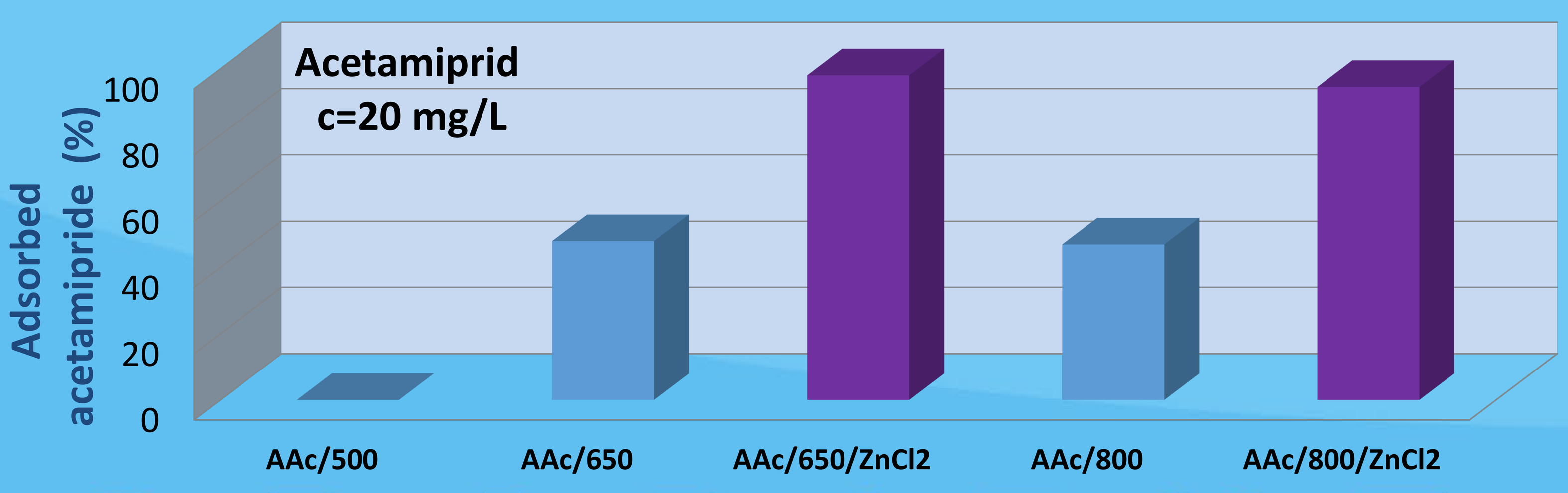


Fig. 1. Experimentally determined adsorption capacities (initial pesticide concentration 20 mg/ L) of AAc samples for acetamiprid removal

The effect of initial acetamiprid concentration

At initial concentrations of acetamiprid higher than 100 mg/L, the efficiency of adsorption decreases, Fig. 2.

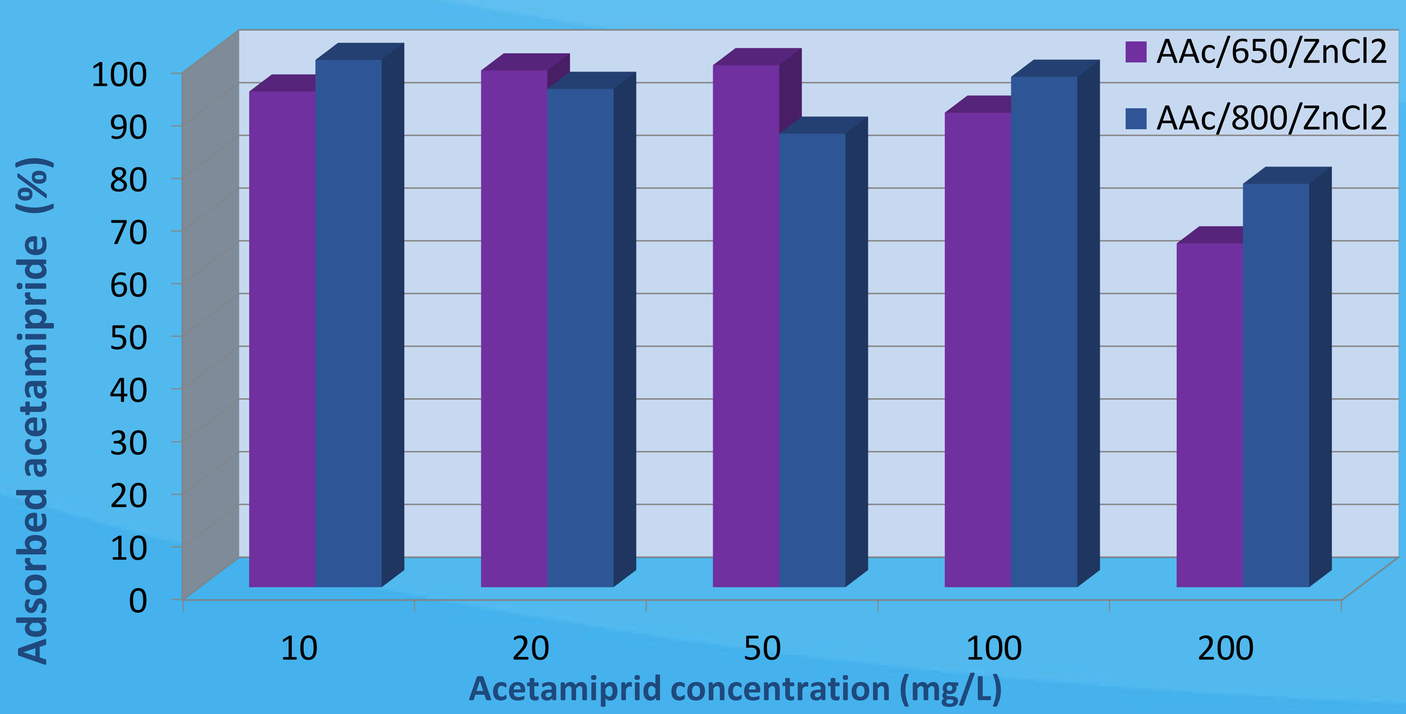


Fig. 2. Experimentally determined adsorption capacities (initial pesticide concentration 10-200 mg/ L) of activated samples for acetamiprid removal

The maximum adsorbed amounts of single neonicotinoids (mg/g)

200 mg/g	AAc/650/$ZnCl_2$	AAc/800/$ZnCl_2$
Pesticide	**Adsorbed mg/g**	
Acetamiprid (A)	**130.4**	**153.2**
Imidacloprid (I)	**152.0**	**160.6**
Thiamethoxam (T)	**101.3**	**122.2**

Pesticide mixtures

UV/Vis spectra show that the characteristic absorption maxima of single pesticides are located closely – **245 nm** (Acetamiprid), **254 nm** (Thiamethoxam) and **270** (Imidacloprid) **nm,** Fig. 3.

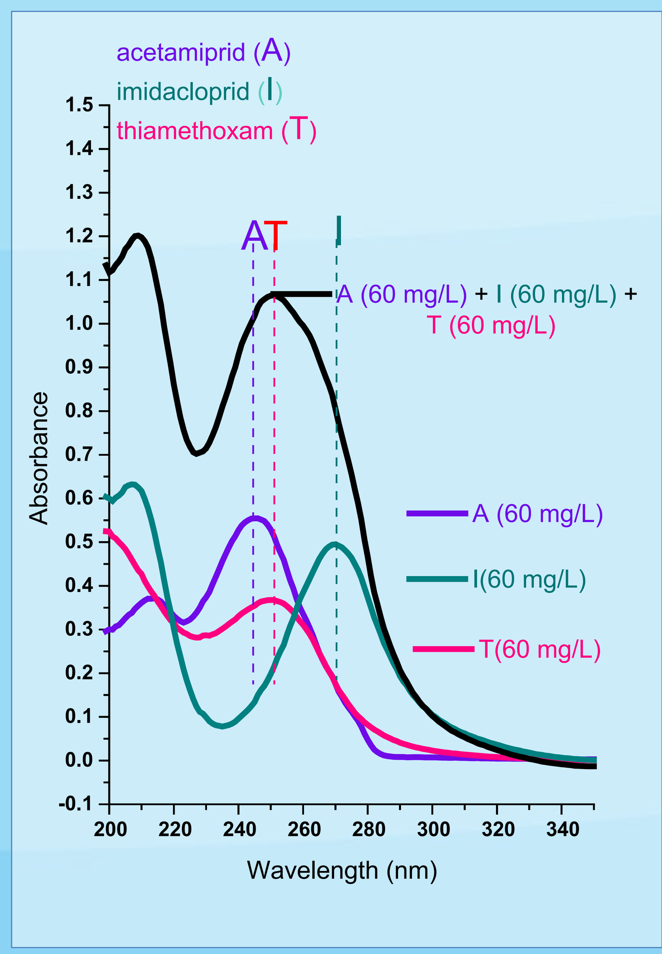
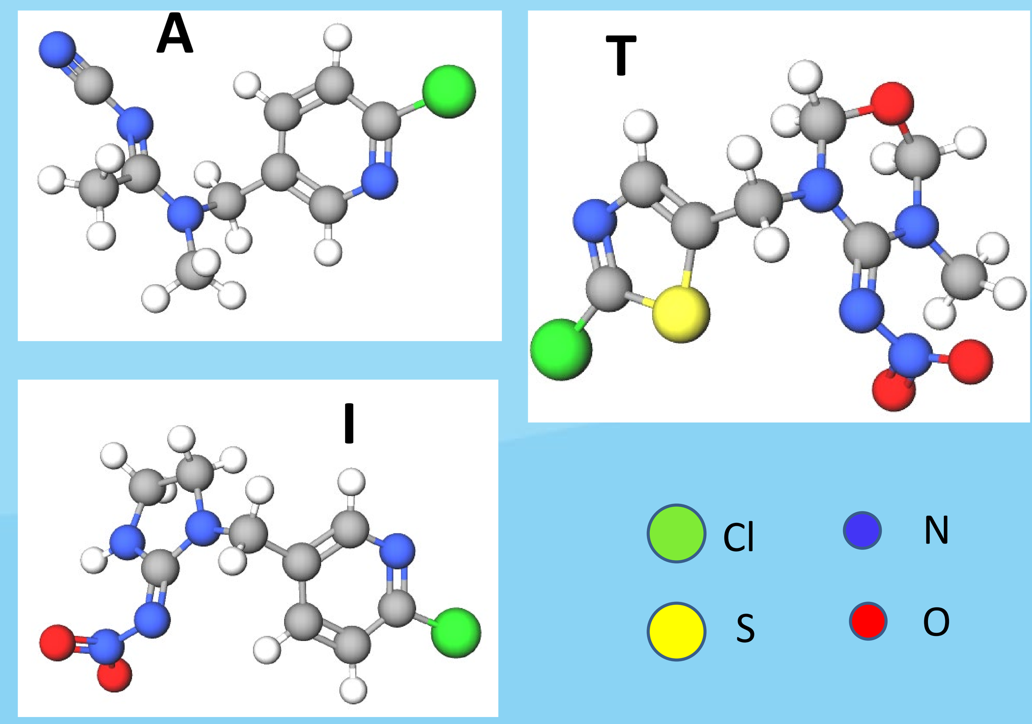


Fig. 3. UV spectra of pesticides, single and mixtures

The total absorbance of the pesticide mixture at the characteristic wavelengths represents the sum of the individual absorbances for each species, indicating the absence of chemical interaction between them.



Activated samples are equally efficient for adsorption of individual pesticide and pesticide in two- or three-component mixtures. In all cases, the sample activated at a higher temperature AAc/800/$ZnCl_2$ is more effective, that is, the remaining concentration is lower.

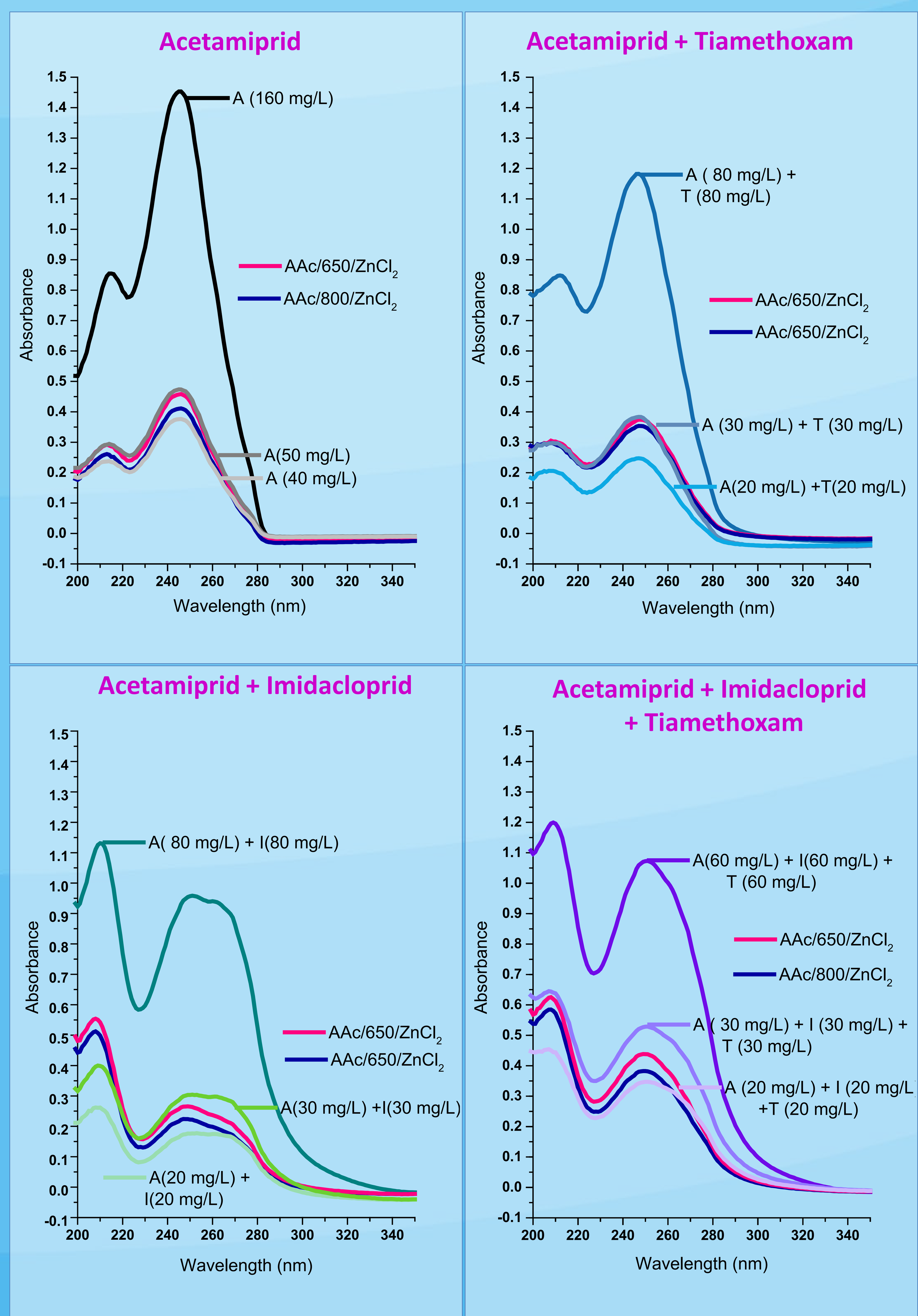


Fig. 4. UV spectra of initial single pesticide or pesticide mixtures solutions before, and supernatants after adsorption with activated samples. The spectra of solutions with lower concentrations than the initial ones are given for comparison.

CONCLUSION

Preliminary results demonstrate that the activated tree of heaven-derived biochar exhibits a remarkable adsorption capacity for neonicotinoids. Tested biochar samples represent promising adsorbents due to their porous structure and abundance of functional groups, enabling hydrogen bonding with investigated pesticides. Furthermore, the invasive species-derived biochar shows promising stability and reusability, making it a sustainable alternative for long-term pesticide removal applications. These findings contribute to the development of efficient and sustainable solutions for environmental remediation, addressing both the issue of invasive species and pesticide contamination.

REFERENCES

1. Safaei Khorram M, Zhang Q, Lin D, Zheng Y, Fang H, Yu Y. J. Environ. Sci. 2016, 44:269–79.
2. Bieser JMH, Al-Zayat M, Murtada J, Thomas SC. Can. J. Soil. Sci. 2022, 102:213–24.