

## Innovative Polysaccharide-Derived Hydrogels for Sustainable Decontamination of Antibiotic-Polluted Matrices

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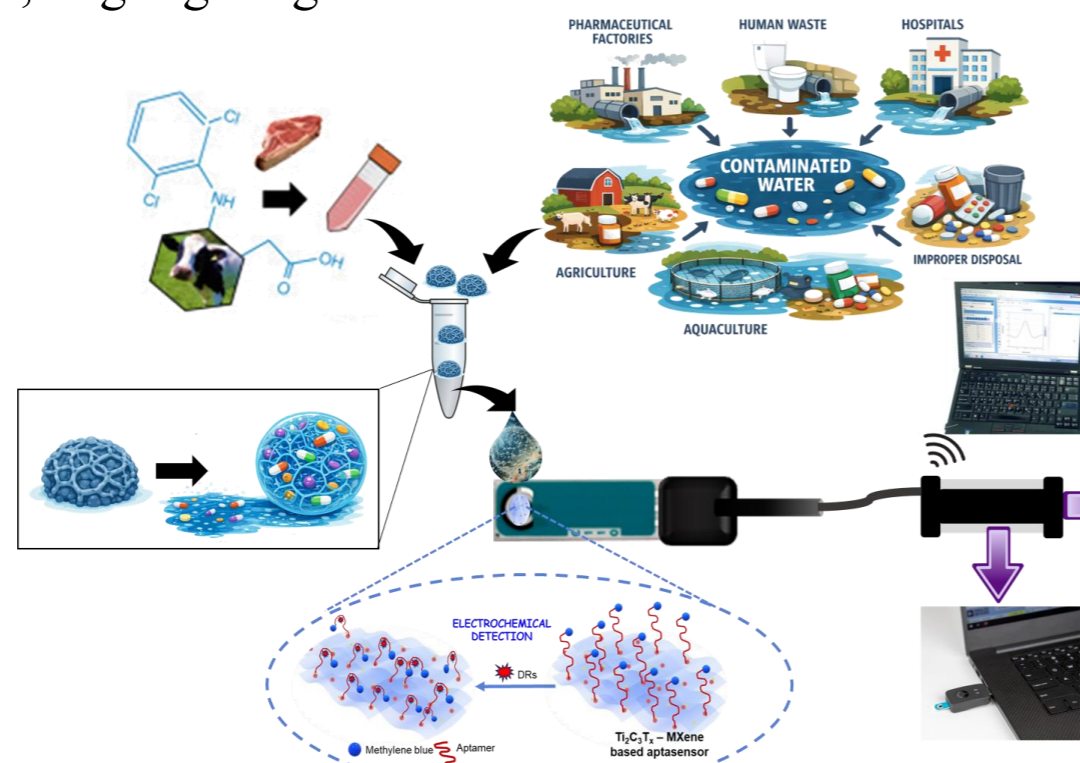
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### INTRODUCTION & AIM

- The continuous increase of antibiotic residues in water and food poses significant environmental and public health risks, highlighting the need for efficient and sustainable decontamination methods.
- The novelty of this study lies in the direct coupling of an adsorption system based on polysaccharide hybrid hydrogels with an electrochemical aptasensor platform, allowing real-time monitoring of the efficiency of the tetracycline removal process from water
- The proposed system integrates the remediation and detection in a novel architecture, providing continuous feedback on the process efficiency<sup>1</sup>.

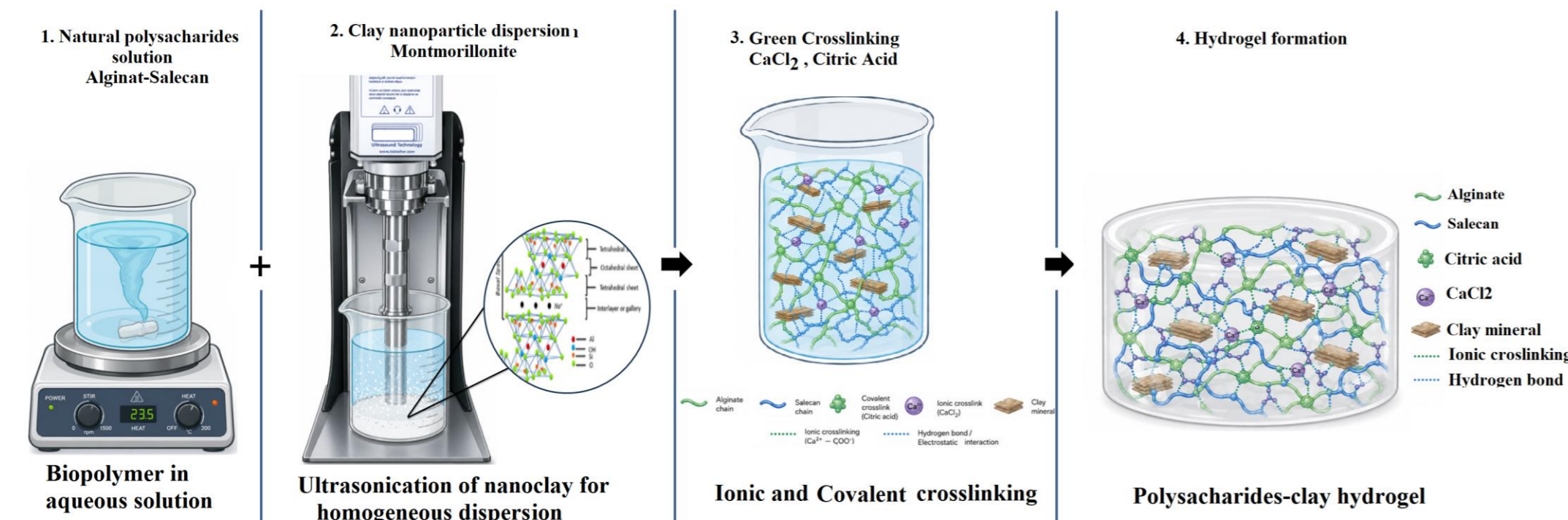


Conceptual framework of the integrated hydrogel-based antibiotic removal and on-site aptasensing platform

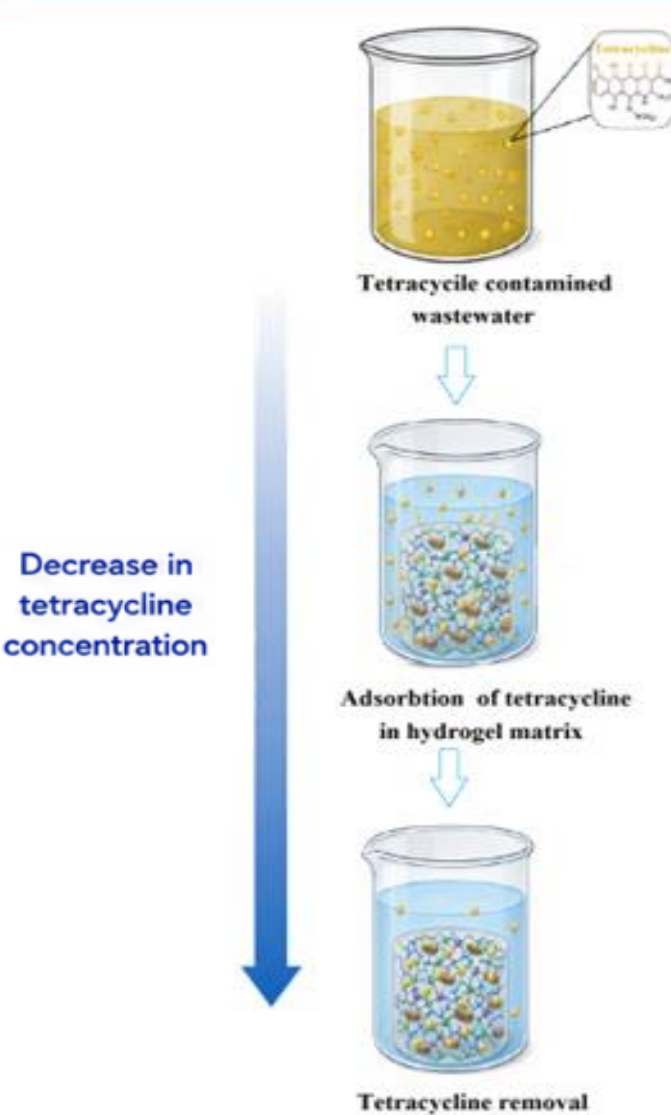
### METHOD

#### Synthesis of polysaccharide clay mineral hydrogel

- M0- alginate-salecan (1:1)
- M1-M4 alginate-salecan (1:1) with increase amount of montmorillonite (1.5 -3.0 g)
- Green crosslinking method with 15% citric acid
- Thermal treatment (50 °C) and thermal shock (130 °C)



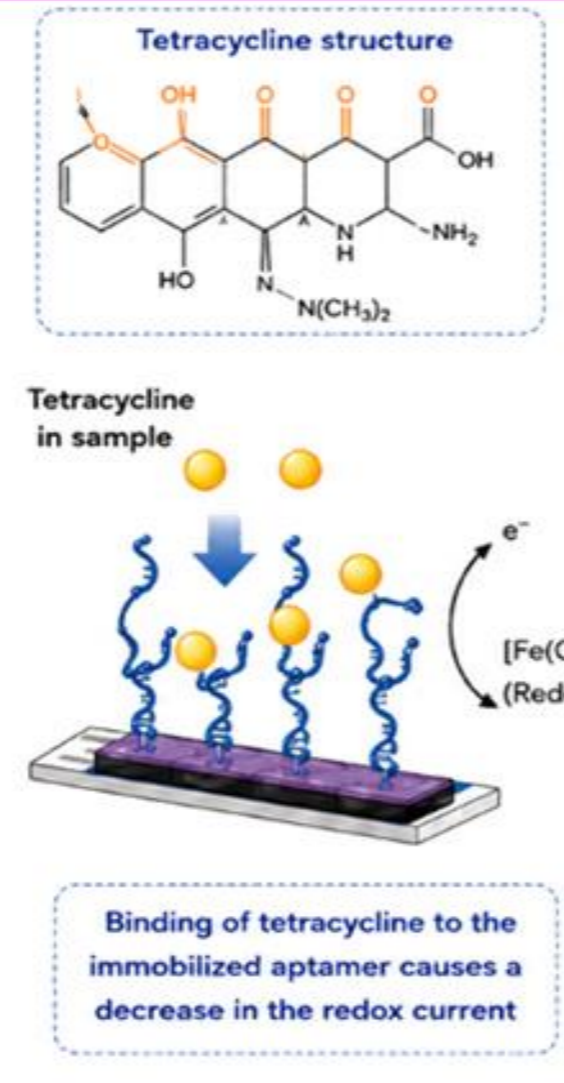
#### Adsorption and Monitoring Tetracycline Concentration



#### Aptasensor fabrication



#### Electrochemical detection (sensing mechanism)



### CONCLUSION

- Innovative materials obtained by combining salecan-alginate with montmorillonite fillers develop enhanced structural organization, mechanical strength, swelling capacity and strong structural stability;
- High tetracycline removal efficiency (>90%) from contaminated wastewater using high amount of clay-based polysaccharides hydrogel, through multiple adsorption mechanisms;
- The aptasensors enable sensitive and selective monitoring of the decrease in tetracycline concentration in water sample.

### FUTURE PERSPECTIVES

- The microbial polysaccharide-based composites demonstrate strong potential for future water decontamination technologies which could be adapted for the removal of other emerging contaminants from wastewater.

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### REFERENCES

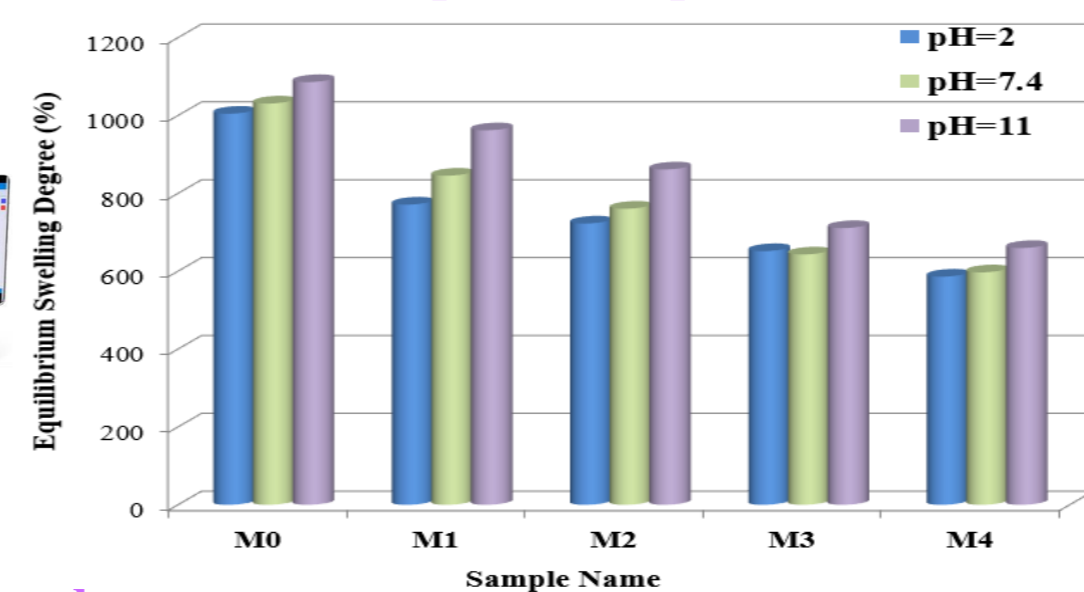
- R. Ianchis, R. Leu Alexa, I. C. Gifu, et. al, *Pharmaceutics*, 2023, 15, 373.
- P. Sharma, M. Sharma et. al, *J. Mol. Liq.*, 2025, 426, 127383.

### RESULTS & DISCUSSION

#### Crosslinked biopolymer-clay composite samples



#### Equilibrium swelling degree of the biopolymer composite samples

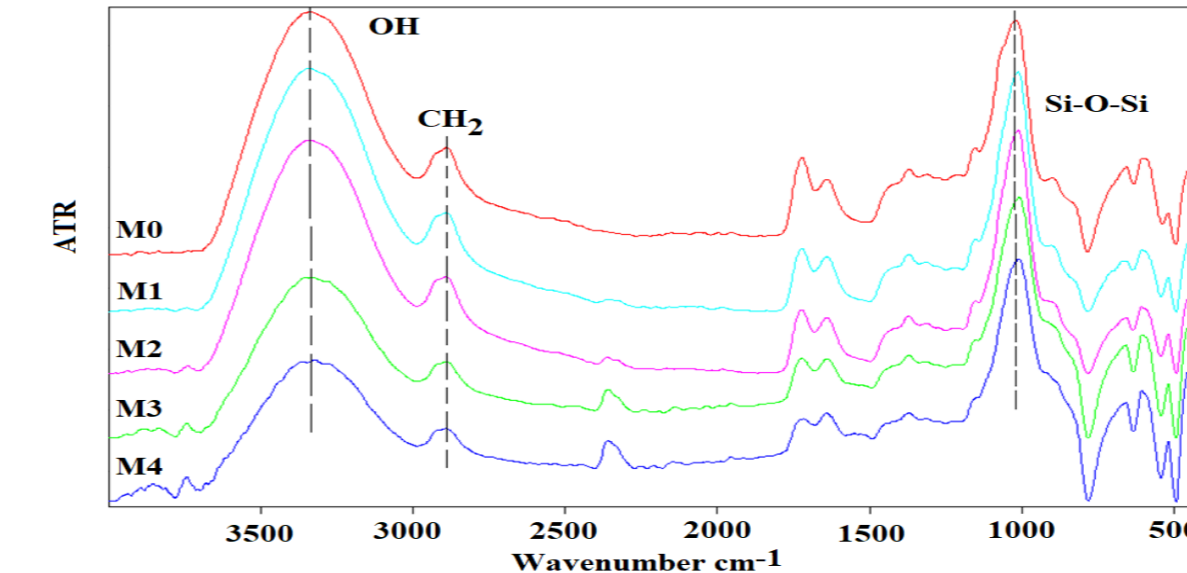


#### Water swollen biopolymer-clay composite samples

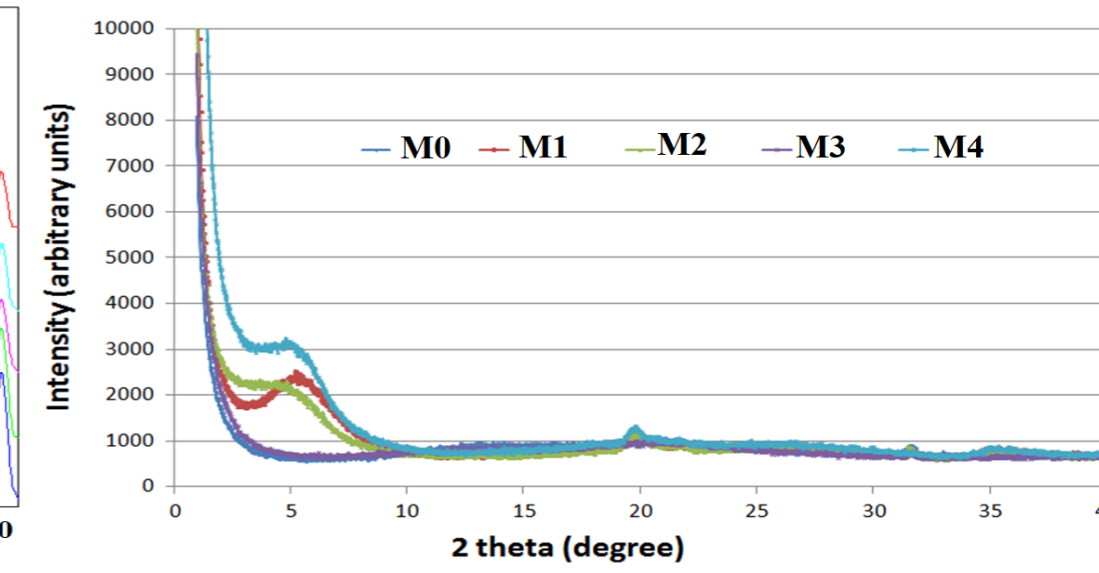


- M0 (without clay) showed the highest swelling capacity: more open and flexible polymer network, enhanced water uptake and retention.
- Swelling ratio decreased with increasing clay content (M1-M4): clay acts as a reinforcing component within the hydrogel matrix.
- Incorporation of clay increases network density, reduces the free volume available for water absorption
- Polymer-clay interactions restrict polymer chain mobility, limiting the expansion of the hydrogel during swelling

#### FT-IR spectra of nanocomposite samples

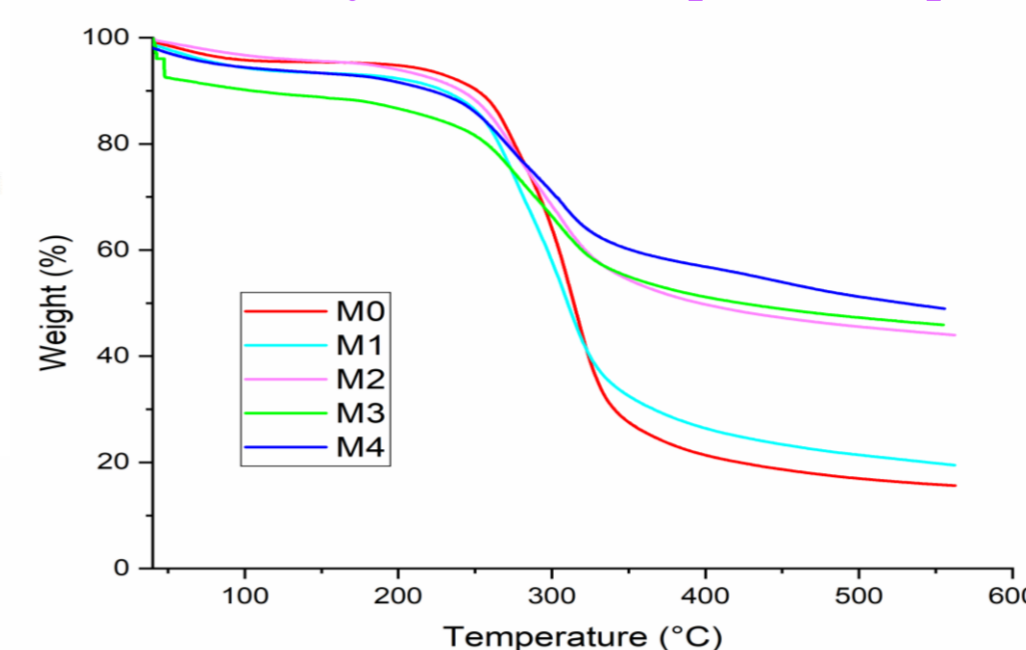


#### XRD spectra of nanocomposite

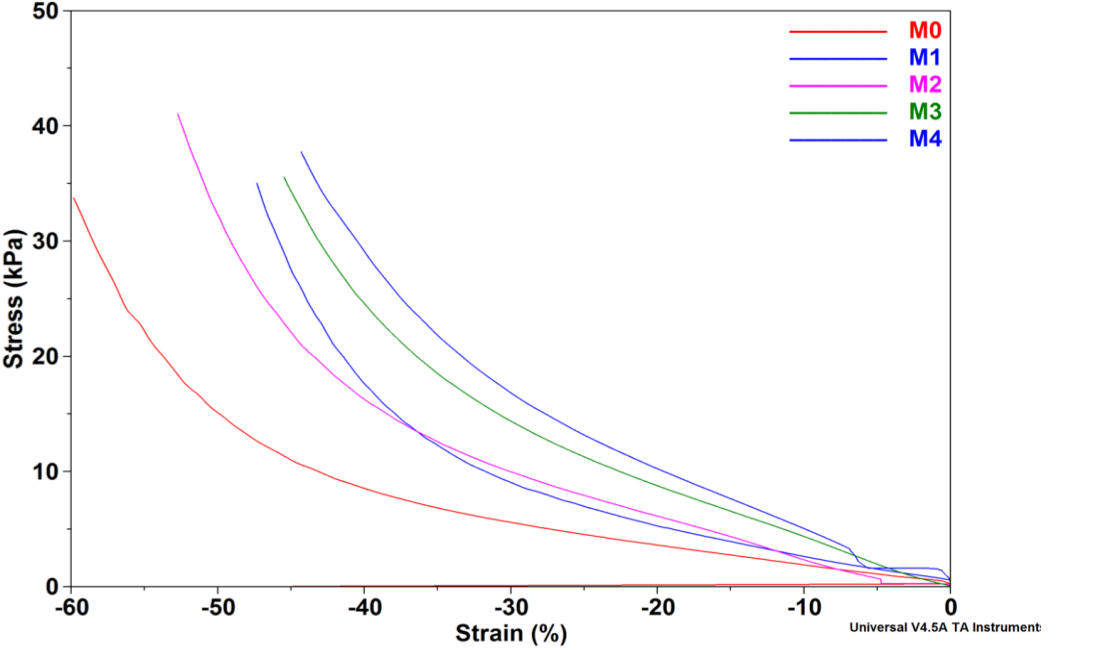


- Clay was successfully incorporated into the alginate-salecan matrix through hydrogen bonding and electrostatic interactions.
- No new crystalline phases were generated homogeneous polymer-clay network with enhanced structural organization

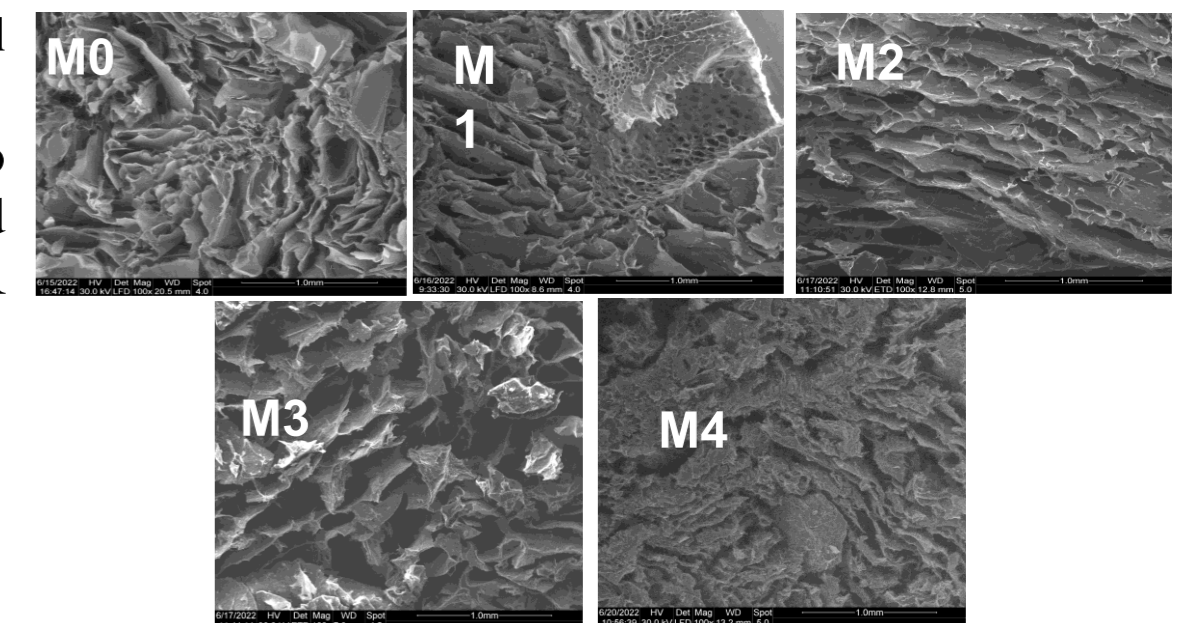
#### TGA analyses of the composite samples



#### Mechanical properties of water swollen composite

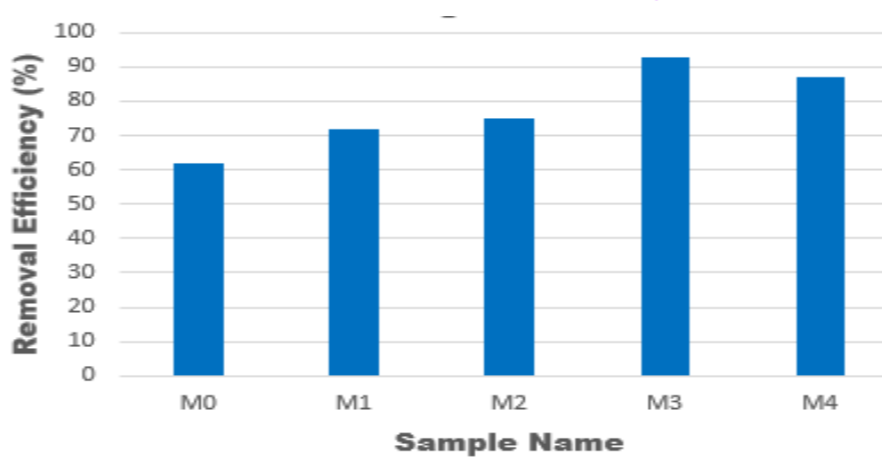


#### SEM images of nanocomposite sample

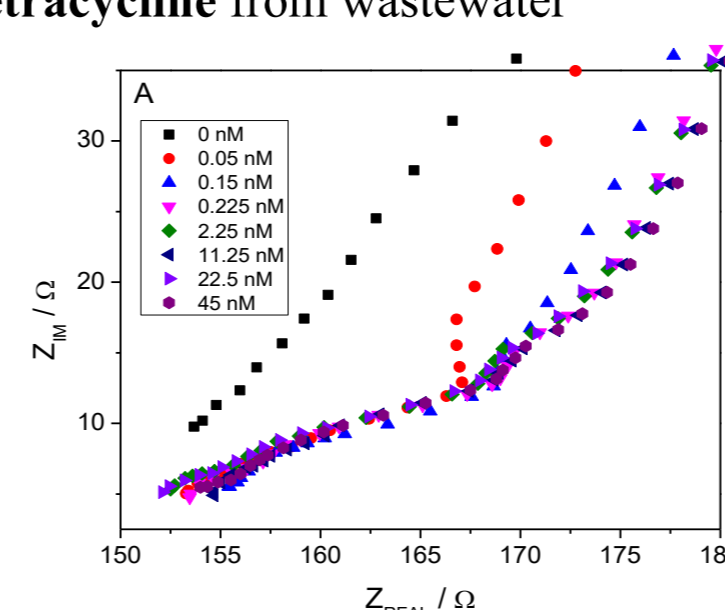


- Increasing clay concentration shifts degradation toward higher temperatures and increases residual mass.
- Enhanced mechanical properties attributed to strong interactions between the clay surface and the polysaccharide chains, as suggested by FTIR analysis.

#### Removal efficiency

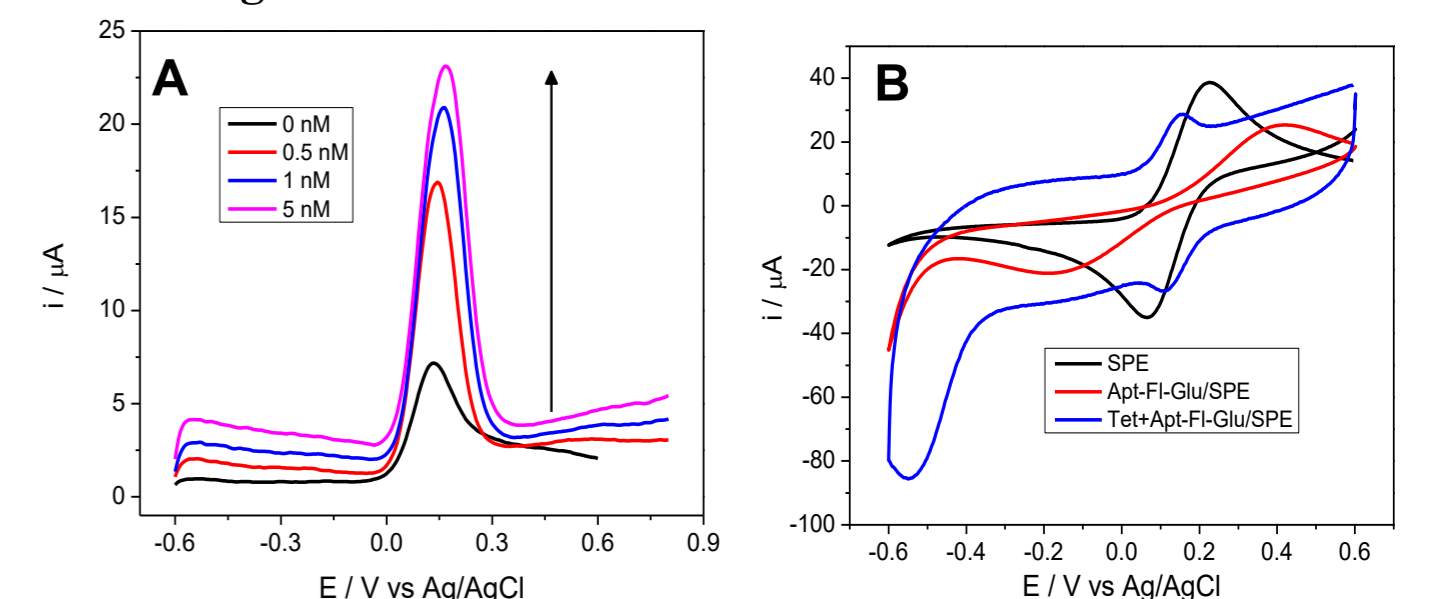


- M3 & M4 (2.5-3g clay) removed ≈ 90% tetracycline from wastewater



- Nyquist plots recorded for the Apt-FL-Glu/SPE aptasensor: 0.05–45 nM tetracycline (frequency: 10 kHz–1 Hz, amplitude 5 mV, E = 0.1 V).

- A reduction in pore size was observed with increasing clay content: formation of additional polymer-clay interactions;
- More compact microstructure is consistent with the decrease in swelling capacity and the improvement in mechanical strength.



- Voltammetry studies of tetracycline detection using Apt-FL-Glu/SPE aptasensors (A-Square Wave Voltammograms in the presence of 0, 0.5, 1 and 5 nM tetracycline);
- Electrocatalytic behavior of Apt-FL-Glu/SPE aptasensors toward tetracycline (B-Cyclic voltammograms recorded in 1 mM Fe(CN)<sub>6</sub><sup>3-/4-</sup> in 0.1 M KCl, 0.1 V/s).