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Sustainable Coffee Based Adsorbents for Fluoride Removal

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INTRODUCTION & AIM

Fluoride contamination in drinking water is a global challenge due to its adverse health effects, including dental and skeletal fluorosis. The limitations of conventional removal methods, drive the search for sustainable and low-cost adsorbents. Coffee grounds, an abundant agro-industrial residue rich in carbon, show great potential as a precursor for activated carbon. Surface modification with citric acid, including its natural source from lemon juice, can significantly enhance adsorption capacity and provide a low-cost process accessible to rural communities, thereby promoting self-sufficiency in safe water treatment locally.

METHOD

Activated carbons derived from coffee grounds were prepared under different activation conditions: non-activated (N_2 160ml.min^{-1}) CO_2-activated (250ml.min^{-1}), and H_3PO_4-activated (25% 1:1) and subsequently impregnated with citric acid or lemon extract (0,3M). Adsorption experiments using sodium fluoride solutions were conducted to evaluate performance (Figure 1). The removal percentage (*R%*) and adsorption capacity (*qe*) were calculated using the following equations:

$$qe = \frac{(Co - Ce)}{m} \times V$$

$$R\% = \frac{(Co - Ce)}{Co} * 100$$

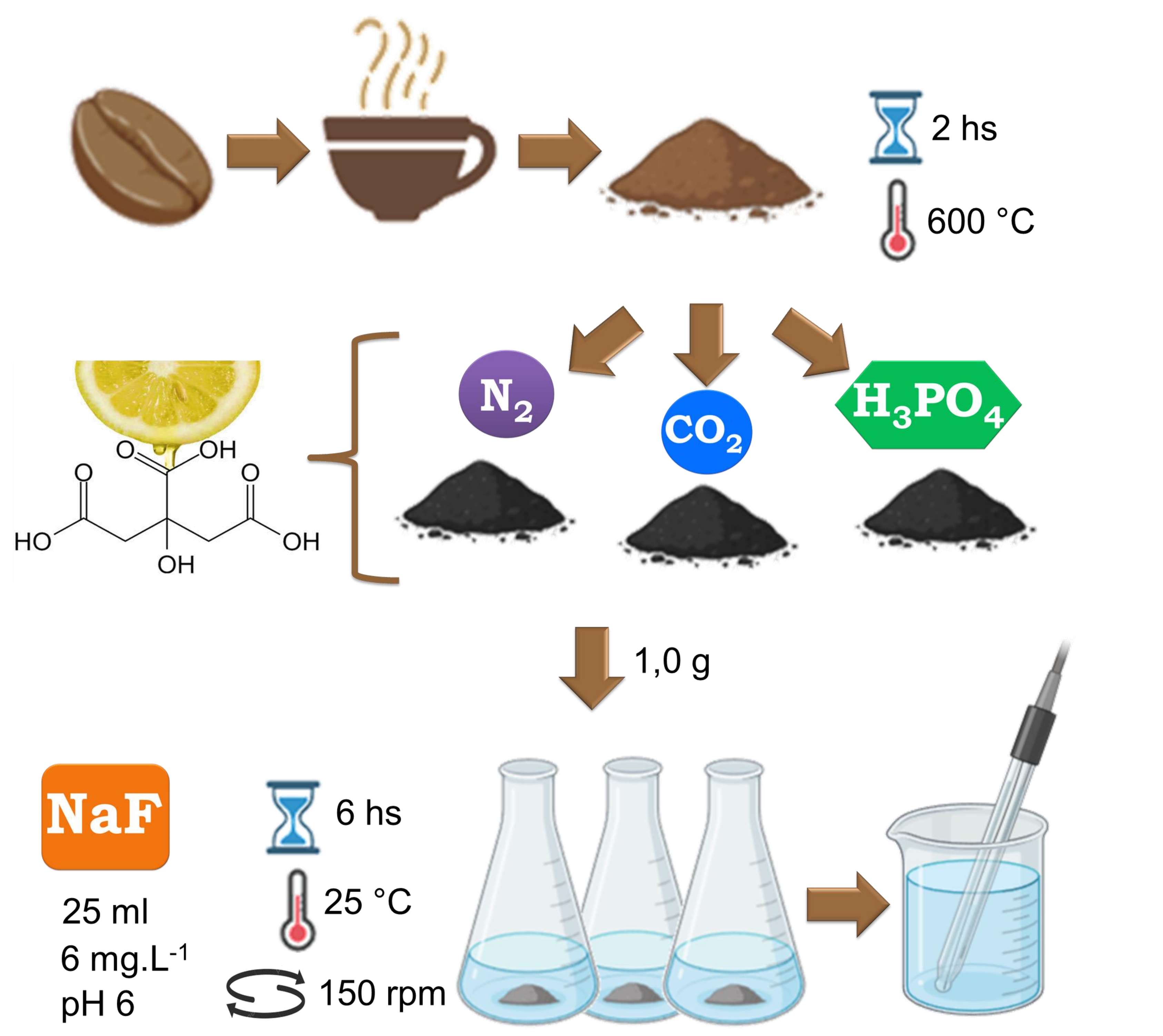

Figure 1: Preparation of adsorbent materials and adsorption experiments

RESULTS & DISCUSSION

Table 1 presents the removal percentages for all materials, highlighting the activated carbon produced with CO_2 and impregnated with citric acid, which achieved a removal efficiency of 98.46%.

Table 1: Removal percentage of diferentes materials

Material	R(%)
non-activated	8,32
CO_2-activated	24,35
H_3PO_4-activated	3,24
non-activated + citric acid	92,45
CO_2-activated + citric acid	98,46
H_3PO_4-activated + citric acid	17,57
non-activated + lemon extract	90,23
CO_2-activated + lemon extract	93,64
H_3PO_4-activated + lemon extract	20,15

CO_2-activated carbon impregnated with citric acid exhibited the highest adsorption capacity, reaching 0.16 mg g^{-1} after 6 hours of contact (Figure 2).

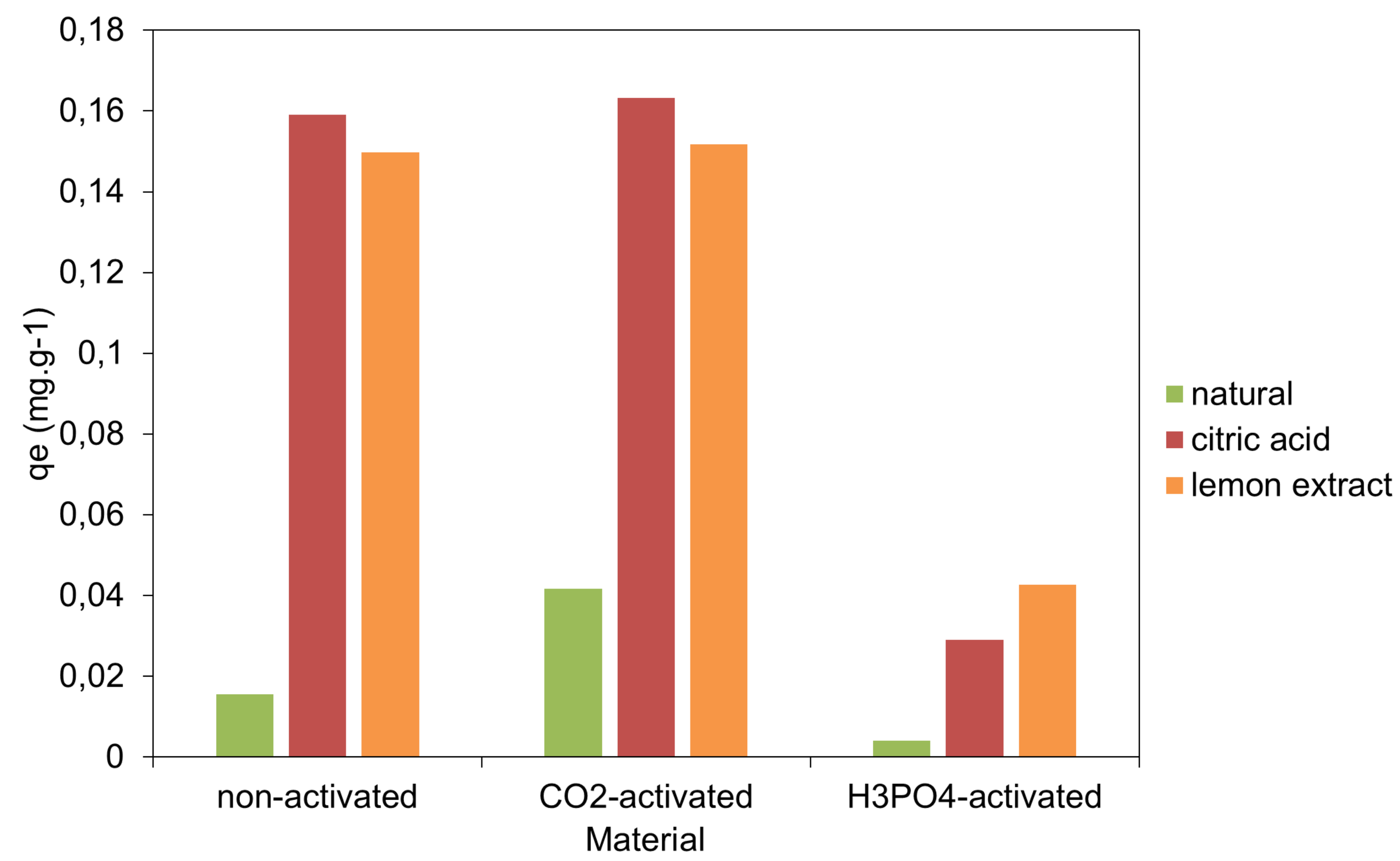

Figure 2: Adsorption capacity of diferentes materials

CONCLUSION

The results demonstrate that agro-industrial residues, when converted into functional adsorbents, can provide viable, sustainable, and low-cost alternatives for fluoride removal in drinking water. This innovative approach reinforces the role of circular economy strategies and technological innovation in decentralized sanitation, particularly in vulnerable rural communities lacking access to conventional solutions.

FUTURE WORK / REFERENCES

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