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# Multivariate analysis of pharmaceutical pollutants adsorption in aqueous media with tailored waste-based carbonaceous adsorbent materials and commercial activated carbons

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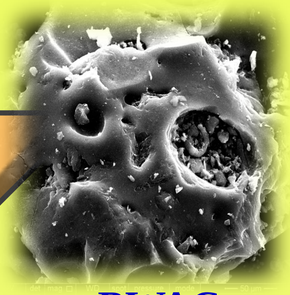
## Introduction

- The purpose of this research is to determine the effectiveness of various biocollagenic waste-based activated carbons (BWAC) and a sludge biochar (SBC) in removing emerging pharmaceutical pollutants (phenol, salicylic acid, paracetamol, diclofenac and iodixanol) present in aqueous media and its comparison with commercial and manufactured adsorbent from different origins.
- Principal component analysis is applied to develop multiple lineal regression models to predict maximum adsorption capacities for future new waste based-activated carbons.

"VEGETABLE-TANNED LEATHER WASTES (BW)"


BW

CHEMICAL ACTIVATION



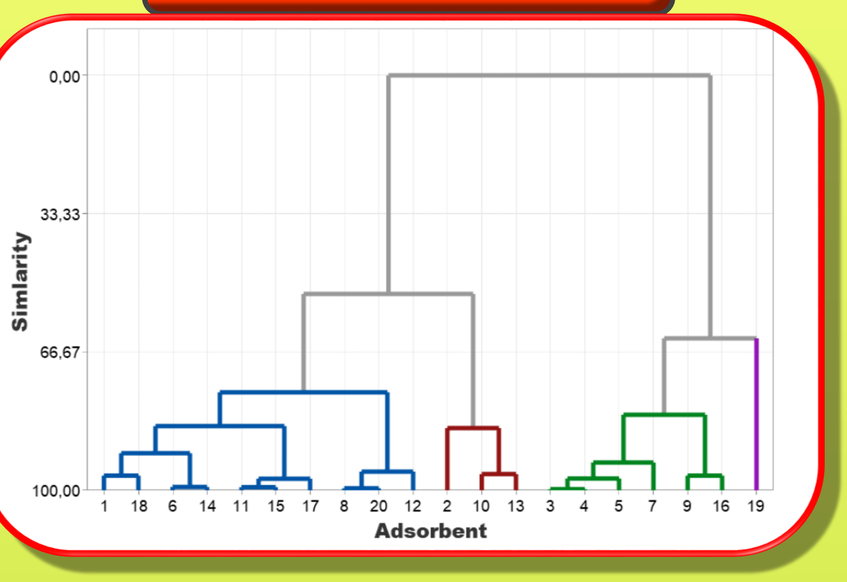
BWAC

BIOCOLLAGENIC WASTE-BASED ACTIVATED CARBON (BWAC)

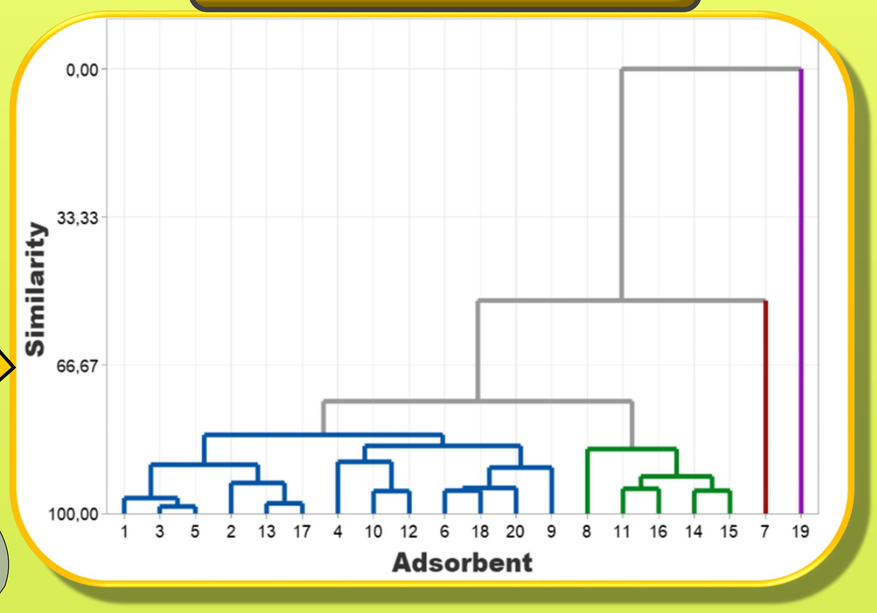
| Nº | Name | Kind | Raw material | Activation |
|---|---|---|---|---|
| 1 | BAC | Commercial | Petroleum pitch | Industrial process |
| 2 | CNAC | Experimental | Anthracite | NaOH |
| 3 | CX19 | Experimental | Xerogel | Microwave |
| 4 | CX45 | Experimental | Xerogel | Microwave |
| 5 | CX8 | Experimental | Xerogel | Microwave |
| 6 | F400 | Commercial | Bituminous coal | WA |
| 7 | HYDC | Commercial | Lignite | vapor |
| 8 | MAC | Experimental | Lignite | KOH |
| 9 | NPK | Commercial | Peat | vapor |
| 10 | BWA | Experimental | Biocollagenic waste | KOH |
| 11 | BWB | Experimental | Biocollagenic waste | KOH |
| 12 | BWPC | Experimental | Biocollagenic waste | KOH |
| 13 | BWPD | Experimental | Biocollagenic waste | KOH |
| 14 | BWD | Experimental | Biocollagenic waste | $K_2CO_3$ |
| 15 | BWE | Experimental | Biocollagenic waste | $K_2CO_3$ |
| 16 | BWPF | Experimental | Biocollagenic waste | $K_2CO_3$ |
| 17 | BWPG | Experimental | Biocollagenic waste | $K_2CO_3$ |
| 18 | ROW | Commercial | Charcoal | vapor |
| 19 | SBC | Experimental | Sludge WWTP | vapor |
| 20 | YAO | Commercial | Coconut shell | vapor |

## Results & Discussion

### TEXTURAL CHARACTERIZATION




### CHEMICAL CHARACTERIZATION



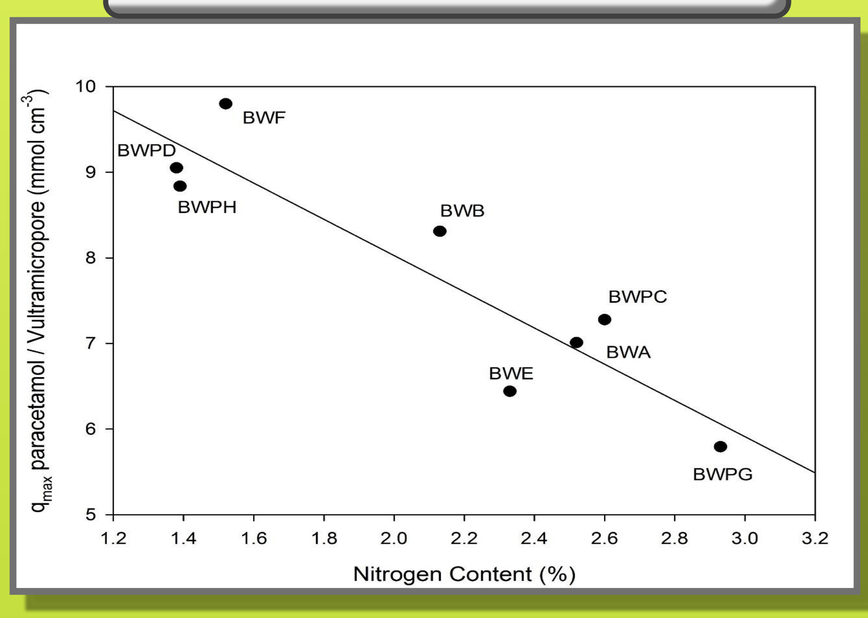

Textural

Chemical

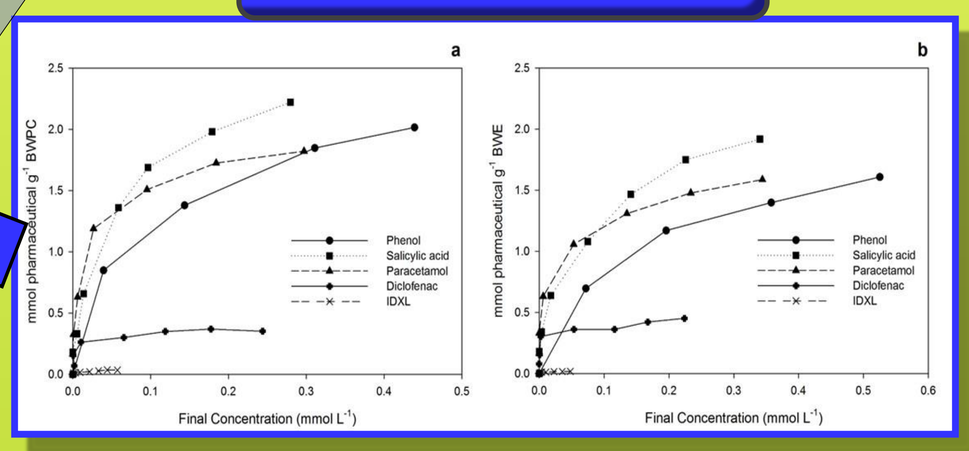
Process

PCA

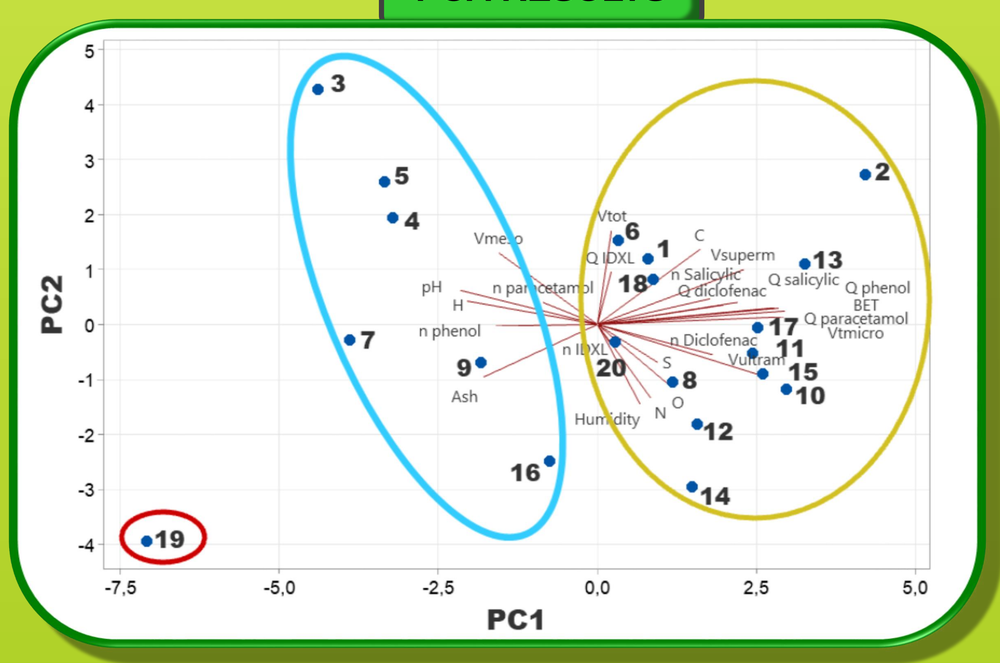
### CHEMICAL INFLUENCES ON BWACs




### ADSORPTION PARAMETERS




### PCA RESULTS




### Qmax MULTIPLE REGRESSION MODEL

| Model | $r^2$ |
|---|---|
| $Q_{phenol}$ = 0.059 +0.02496·C-1.101·H-0.0565·O+0.863·$V_{SUPERM}$ | 87.71% |
| $Q_{salicylicl}$ = 0.087+ 0.0238·C -0.985·H -0.3215·S +0.0455·O + 2.55·$V_{ULTRAM}$ + 1.51·$V_{SUPERM}$ | 86.67% |
| $Q_{paracetamol}$ = 1.920+ 0.0103·C-0.476·H-0.1155·S-0.0321·O-0.3081·N -0.1206·pH +3.065·$V_{ULTRAM}$ | 98.30% |
| $Q_{diclofenac}$ = 0.998 – 0.00445·C-0.861·H+0.0243·O+ 1.76·$V_{SUPERM}$+0.672·$V_{MESO}$ | 71.31% |
| $Q_{iodixanol}$ = -0.1962 +0.00164 Ash + 0.001922 $S_{BET}$ -5.83·$V_{ULTRAM}$ -5.10·$V_{SUPERM}$+0.01288·Humidity | 75.12% |

## Conclusions

- The presence of nitrogenated groups in BWACs decrease the adsorption of paracetamol due to water compete for the same sites of adsorption.
- The adsorption of phenol, salycilic acid and paracetamol was on micropores. Diclofenac and IDXL adsorption was preferably physical in the wider micropores and narrower mesopores.
- Multiple lineal regression models were proposed to predict maximum adsorption capacities of pharmaceutical. In the IDXL model the textural properties predominated, while in the paracetamol model the nitrogen content had a negative influence.

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