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Improvement of contaminant retention with the use of biochar in the groundwater infiltration basin of Korba (Tunisia)

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1. ABSTRACT

The over-exploitation of the Korba aquifer (Cap Bon, North Tunisia) has led to the drawing down of its static water level and the degradation of its quality due to the intrusion of saline water from the sea. To address this situation, treated wastewater is used for the artificial recharge of the aquifer through three infiltration basins. Treated wastewater is known to carry various emerging contaminants and pharmaceuticals as they are often not retained in traditional wastewater treatment plants. To tackle this problem the use of biochars is often recommended to conduct a second stage low-cost decontamination strategy. Indeed, biochar can be produced easily at a low cost, with different agricultural residues. In this study, the impact of biochar derived from Rosemary, Bamboo, St. John's Wort, Olive Trees, Cypress, and Palm Trees on the mobility and retention of emerging contaminants was evaluated.
The first stage of this work was to evaluate the potential retention capacity of the different biochars produced in a low-cost metallic kiln with local biomass residues. Therefore we used Methylene Blue (MB) as a proxy for organic contaminants to establish adsorption isotherms to quantify their respective specific surface area and adsorption capacities.
The second stage was to test the dynamic retention properties of biochar on soil monolith experiments, where the MB elution curves were analyzed with and without the addition of biochar.

2. STUDY AREA

The Korba recharge site covers an area of 4.4 hectares. This project is designed for a volume of 1500 m3/day. The site is located 500 meters north of the Korba wastewater treatment plant. It is 1.5 kilometers from the coast and is at an altitude of 15 meters "Geodetic Level of Tunisia".

Figure 1. Location of the study area.

3. METHODOLOGY

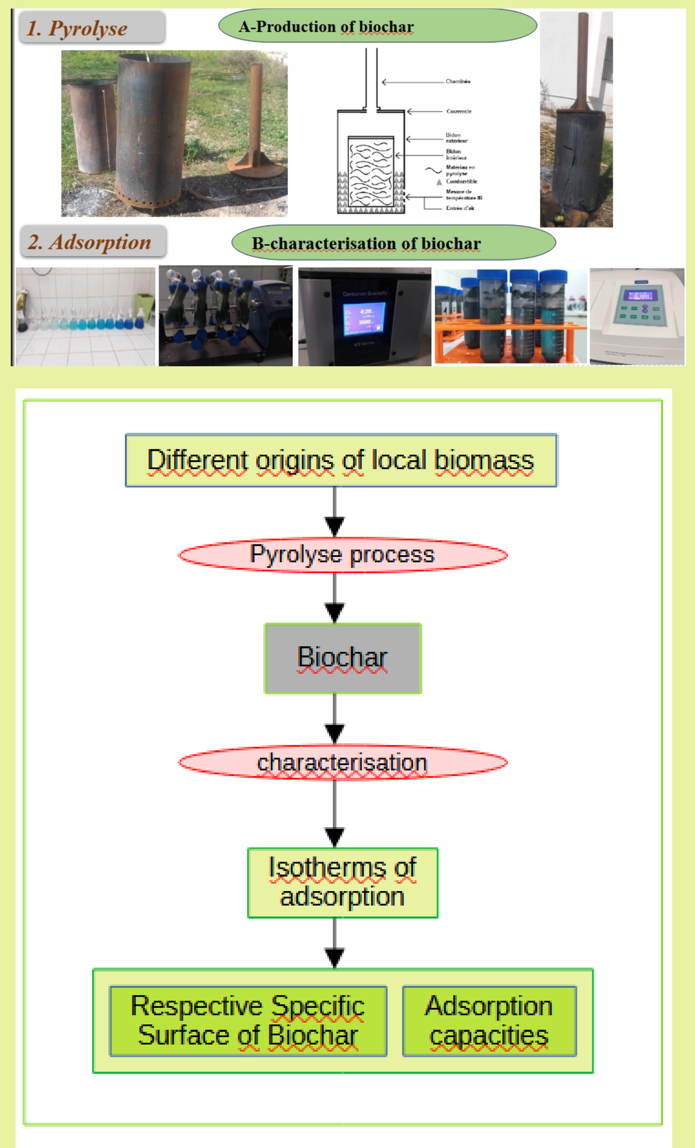


Figure 2. Biochar production and characterisation process

To develop a conceptual model explaining biochar's effects on soil hydrodynamic properties, we conducted a series of well constrained laboratory experiments using a sand column matrix to test the effects of biochar on methylene blue retention.

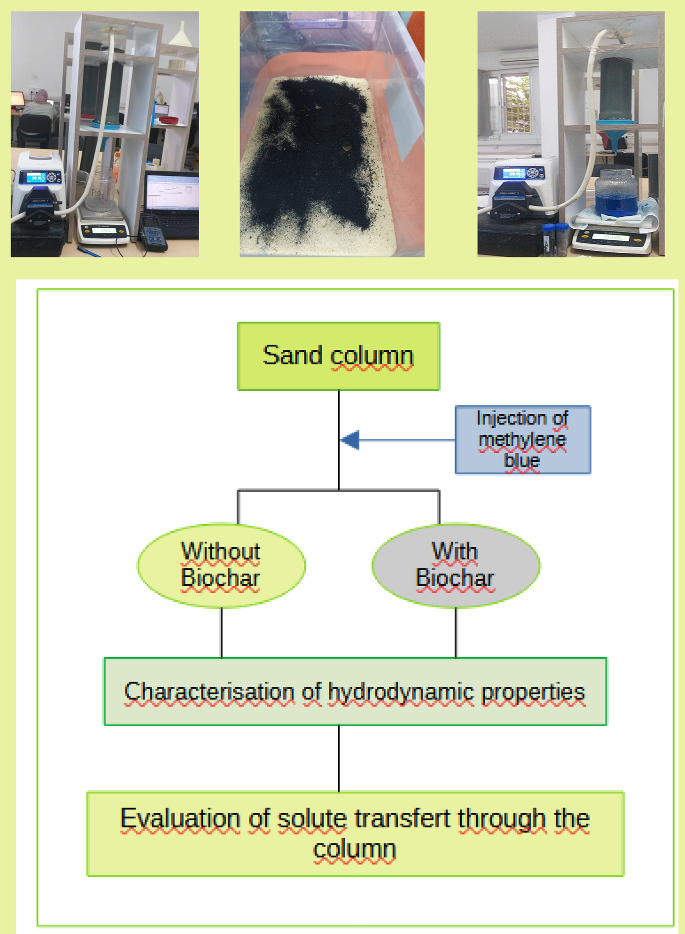


Figure 3. Column's laboratory experiment

4. RESULTS

Figure 4. Different produced Biochars

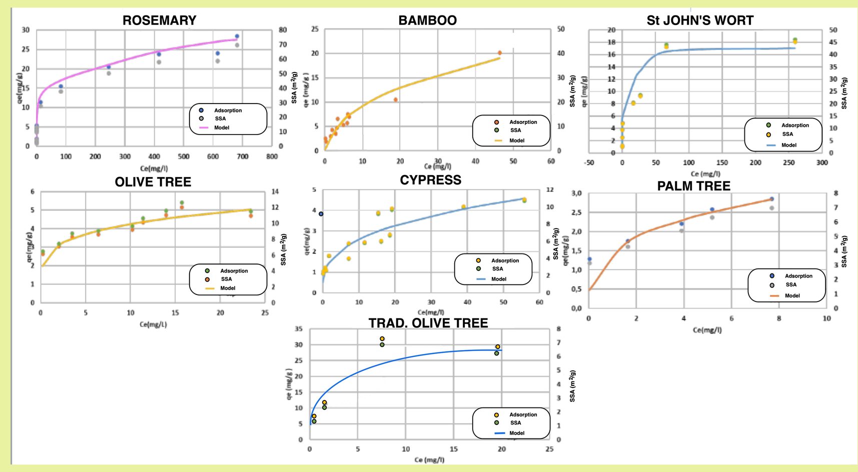


Figure 5. Isotherms of adsorption of different biochars

Freundlich isotherm: $Q_e = K_f \times C_e^n$

Langmuir isotherm: $Q_e = \frac{K_l \cdot C_e \cdot Q_{max}}{1 + K_l \cdot C_e}$

SSA derivation: $SSA = \frac{Q_{max}}{M_{MB}} \times MS_{MB} = \frac{Q_{max}}{320} \times 7.829 \cdot 10^5$

	FREUNDLICH			LANGMUIR			SSA
	Kf	n	r^2	Kl	Qmax	r^2	m^2/g
Rosemary	6.15	4.51	0.97	0.01	27.93	0.85	62.14
Palm tree	1.48	3.12	0.98	0.82	3.05	0.95	6.85
Olive tree	2.67	4.99	0.87	0.77	11.98	0.85	12.83
Bamboo	2.76	2.12	0.81	0.2	12.32	0.83	47.97
Cypress	2,68	5,00	0,84	1.66	1.94	0,43	10.91
St John wort	3.63	3.18	0.82	1.38	17.09	0.93	45.2
Trad Olive tree	7.74	2.13	0.797	0.25	32.36	0.825	7.28

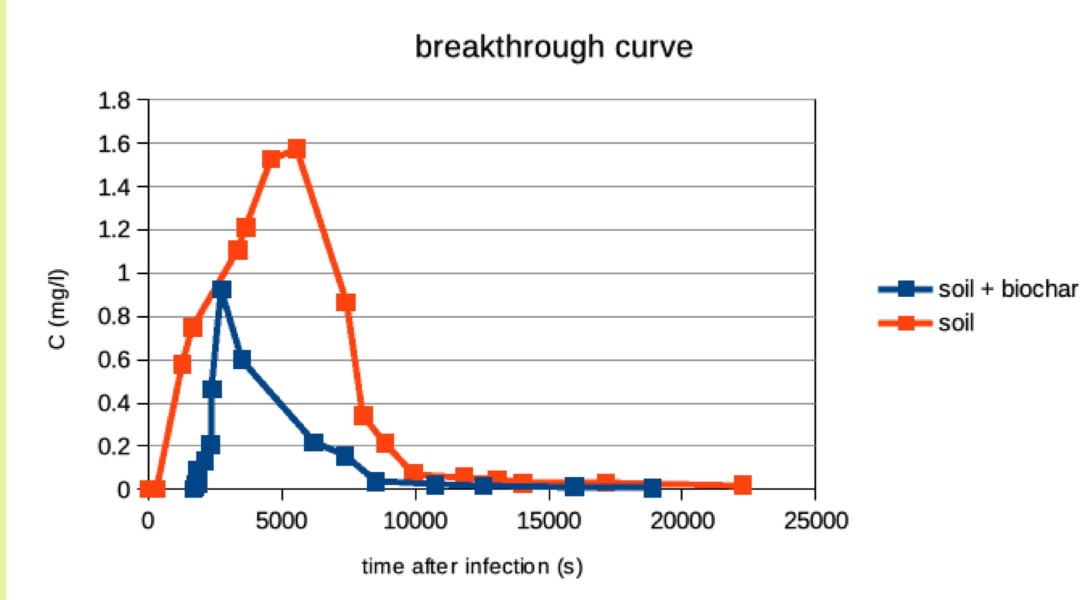
Table 1. Specific Surface Area of different produced Biochars

→ Rosemary biochar has the highest SSA and was therefore used for the column experiment.

The presence of biochar appears to influence the interaction of the solution with the column, thereby modifying its behavior and distribution within the environment.

Figure 6. Core drilling of columns

Figure 7. on the left side results without taking in consideration the SSA of soil and the right side is with.



In the case of the column without biochar, a larger amount of water was needed for drainage after injection before observing clarification of water.

→ The rosemary biochar has adsorbed to 62% of the initial quantity of MB used in the column, while the soil only retained 3%.

5. CONCLUSIONS

→ Based on the origins of biomass, biochars shows differents properties illustrated by their specific surface area.

→ Biochars issued from non ligneous biomass (rosemary, bamboo, St. John's Wort) seem to have the highest SSA.

→ The presence of rosemary biochar in the soil monoliths drastically increased the retention of MB, demonstrating its efficiency as an adsorbent filter. These results underscore the strong potential of biochar in water treatment to enhance quality by reducing pollution.

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HS8.1.3 | Contaminants in the urban and peri-urban runoff-groundwater continuum: Occurrence, transport, fate, and sustainable treatment at different scales