# Agronomic benefits of biochar after its use as waste water filtration media in a Sudano-Sahelian soil

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## Introduction

Urban agriculture contributes significantly to food security and diversity in developing countries. Untreated waste water is frequently used for irrigating vegetable crops and may cause health risks for farmers and consumers. Activated carbon is a commonly used filter media for water purification. Biochar, the solid residue of pyrolysis, has the potential to retain pathogens and harmful substances during filtration and possibly accumulate nutrients. In this study, we tested the hypothesis that biochar after its use in water filters has specific properties and therefore may have growth enhancing effects on vegetables.

## Aims

1. Test the suitability of biochar as a filter medium for pathogen and nutrient removal from waste water
2. Assess the agronomic benefits of Filterchar (FC) compared to untreated Biochar (BC)

## Methods

Biochar was produced from rice husks in a custom made kiln at approx. 450°C. In the water filtration experiment we compared biochar and sand fillings in 80 cm columns with three replicates for three months. *E. coli* and *Enterococci* as indicator organisms were determined with MPN methods according to DIN EN ISO 7899-1 and DIN EN ISO 9308-3.
A pot experiment was done with spring wheat for eight weeks. Treatments were biochar and filterchar at 20t/ha and a control (soil only). All treatments were tested with and without addition of fertilizer (85ml of 1.5% fertilizer solution containing 8% N, 8% $P_2O_5$ and 6% $K_2O$) in five replicates. The test soil was a sandy loam (FAO) from Sadore, Niger with 0.2% C, 0.003% N and a pH of 5.5.

Fig. 5: Left: Custom biochar kiln. Right: Filtration columns with biochar

## Results

| | | Biochar | Filterchar |
|---|---|---|---|
| pH | [-] | 9.08 *a* | 7.41 *b* |
| EC | [mS m$^{-1}$] | 21.73 *a* | 9.97 *b* |
| Volatile matter | [%] | 8.76 ±0.42 a | 8.69 ±0.57 a |
| Ash | | 52.27 ±0.77 a | 52.12 ±1.31 a |
| N | | 0.78 ±0.03 *a* | 0.80 ±0.06 *a* |
| C | | 41.82 ±0.86 a | 41.18 ±2.84 a |
| Al | [g kg$^{-1}$] | 1.27 ±0.20 a | 1.32 ±0.36 a |
| Ca | | 1.78 ±0.11 b | 3.27 ±0.24 a |
| Fe | | 1.06 ±0.25 a | 0.98 ±0.22 a |
| K | | 4.08 ±0.72 a | 0.73 ±0.08 b |
| Mg | | 1.26 ±0.11 a | 0.82 ±0.04 b |
| Na | | 0.65 ±0.05 a | 0.66 ±0.08 a |
| P | | 1.22 ±0.12 a | 0.63 ±0.12 b |
| BET Surface area | [m$^2$ g$^{-1}$] | 143.03 | 145.10 |

Tab. 1: Properties of biochar before and after filtration. Letters indicate significant differences of mean (t-test, p<0,05).

- During filtration K, Mg and P were depleted while N, C, Fe and Na did not change. No significant changes of surface area, ash and volatile matter content, but pH and EC of BC was reduced (Tab.1) due to filtration process.

## Highlights

- Retention of pathogen in biochar filters was at least the same as in sand filtration but no nutrient accumulation were found.
- Biochar and Filterchar increased spring wheat biomass production by 72% and 37%, respectively.
- Biochar provides plant available P (BC +106%; FC +52%) in P limited soil.

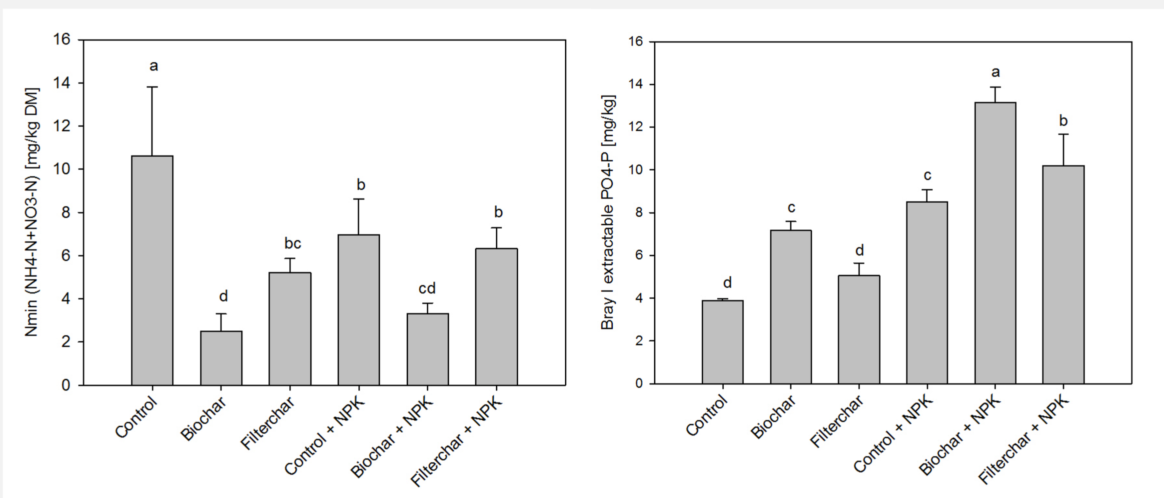

Fig. 3 and 4: Left: Mineral nitrogen content in soil after the experiment. Right: Bray I extractable PO4-P in soil after the experiment. Letters indicate significant differences of mean (ANOVA, p<0,05) and error bars show standard deviation (n=5)

- Soil mineral nitrogen ($N_{min}$) contend were strongly decreased by BC and FC. While FC decreased $N_{min}$ to lesser extend (Fig. 3). In the fertilized treatment $N_{min}$ in FC was not statistically different from the control.
- After the experiment plant available P (Bray I) was found significantly in-creased with BC addition. FC only increased plant available P in the fertilised treatments (Fig. 4).

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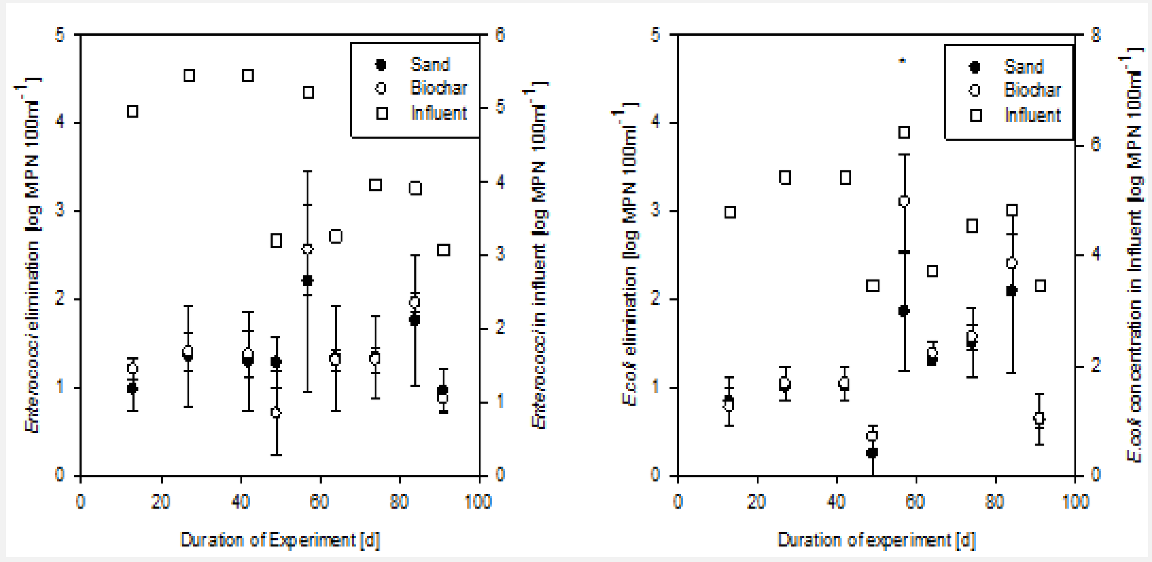

Fig. 1: Elimination of E.coli and Enterococci in water after filtration and influent concentrations. Error bars shows standard deviation and asterisk indicate significant difference between sand and biochar filter effluent (Whitney-Mann U-Test, p<0,05).

- Biochar and sand filter removed 1.4 and 1.2 log units of *E.coli*, respectively (Fig. 1), but was only significantly different on day 58.

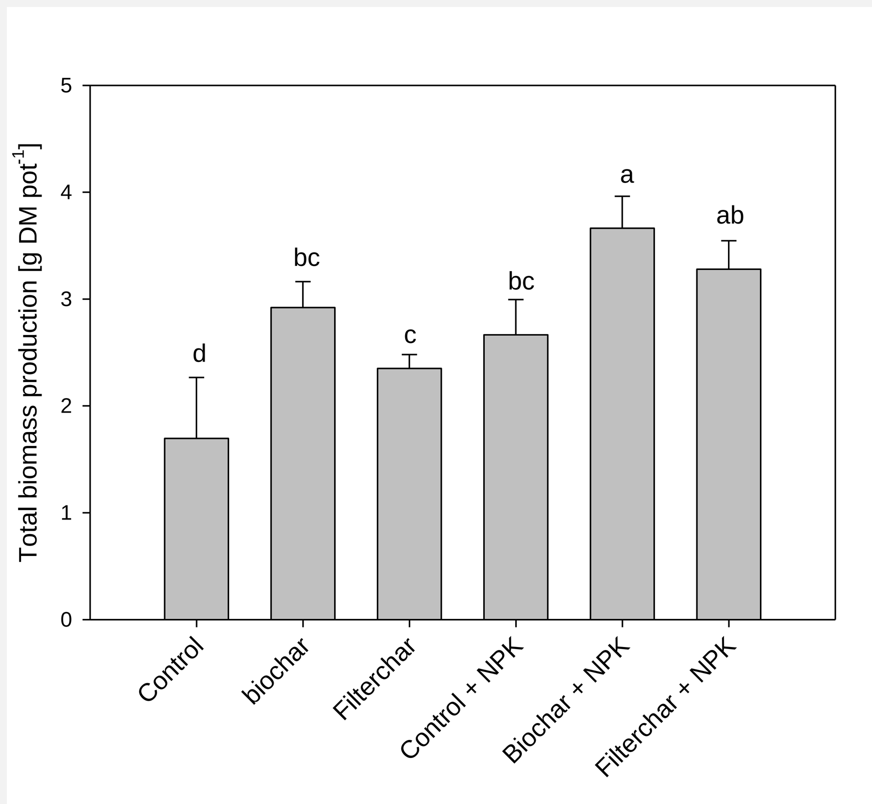


Fig.2: Total biomass production at the end of the experiment. Letters indicate significant differences of mean (ANOVA, p<0,05) and error bars show standard deviation (n=5).

- BC and FC increased biomass production with and without fertilisation (37% and 23%; 72% and 37%) compared with control (Fig. 2). There were no significant differences between BC and FC at the same fertilization.

## Conclusions

BC is suitable for waste water treatment and removes pathogens in the range of common sand filters. However, nutrients did not accumulate on biochar, but were rather washed out. This is in contrast to findings from other researchers. In the pot experiment both treatments increased biomass production compared with the control. We observed contradicting effects of P and N in BC and FC treatments on biomass production. BC provided more plant available P but deceased $N_{min}$ more strongly. The higher $N_{min}$ in soil in FC compared with BC is likely due to reduced sorption affinity of FC.

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