# BIOCHAR IMPACTS ON PHYSICAL AND HYDROLOGICAL PROPERTIES OF ALLOPHONIC SOILS

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## Background

1. Biochar is black carbon manufactured through pyrolysis in a low oxygen environment with the final aim to add it to soils to obtain an environmental and/or agricultural gain.
2. Because of its aromatic structure, biochar is very stable, with turnover times of a few hundred to thousands of years in soil.
3. New Zealand has over 1 million hectares planted in exotic forest, primarily *Pinus radiata*. Currently, large amounts of sawmill waste is burnt or otherwise destroyed in the Bay of Plenty.
4. Pyrolysis systems have been developed that uses sawmill waste as raw material to generate biooil and biogas, that can then be used to generate electricity for drying timber on site at the sawmill. These systems produce biochar as a byproduct.

## Objective

The aim of this study was to investigate the impact of pine chips and biochar incorporated as soil amendments on physical and hydrological properties of allophanic soils.

## Materials and Methods

The experiment was conducted under controlled condition at the PlusGroup laboratory. Two allophanic soils (Rich allophanic soil: Soil A and poor allophanic soil: Soil B) were collected from a kiwifruit orchard located at Tauranga, Bay of Plenty, New Zealand. Soil samples were air-dried and sieved through a 2.0 mm aperture and physio-chemical properties were measured. Pine chips and biochar generated from pine *(Pinus radiata)* chips, produced at Lakeland Steel Limited, Rotorua, New Zealand by pyrolysis at 600-630°C with a residence time of 30 min in a low oxygen environment were used as a soil amendment. The individual pine biochar and chips samples were dried in a forced-air convection drier at 105°C for 72h and crushed to pass through a 2.0mm sieve before incorporation into the soil. Biochar and pine chips were incorporated with soils at the rate of 0 t/ha, 25 t/ha and 50 t/ha. Bulk density and three phase distribution of biochar/soil and woodchip/soil mixes were measured according to Kezdi, 1974. Maximum water holding capacity, field capacity, gravitational drainage (using the sand column method) and hygroscopic moisture (Rahman, 1991) of biochar/soil and woodchip/soil mixes were measured. Hydraulic conductivity of mixtures was measured in a saturated core by the constant head method.

## Results

Incorporation of biochar and wood chips showed an increase in total porosity and an associated decrease in bulk density for both soils (Table 1).

**Table 1. Phase composition of soils amended by pine biochar and wood chips.**

| Soil | Treatment | Bulk Density ($Mg\ m^{-3}$) | | Total Porosity (%) | | Solid Phase (%) | | Liquid Phase (%) | | Air Phase (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ($t\ ha^{-1}$) | Biochar | Chips | Biochar | Chips | Biochar | Chips | Biochar | Chips | Biochar | Chips |
| Soil A | 0 | 0.75 | 0.74 | 70.74 | 71.00 | 29.26 | 29.00 | 63.92 | 64.08 | 6.82 | 6.91 |
| (Rich) | 25 | 0.71 | 0.70 | 72.21 | 72.74 | 27.79 | 27.26 | 62.83 | 63.47 | 9.37 | 9.27 |
| | 50 | 0.69 | 0.68 | 73.24 | 73.59 | 26.76 | 26.41 | 62.54 | 62.91 | 10.69 | 10.68 |
| Soil B | 0 | 0.78 | 0.77 | 69.64 | 70.07 | 30.36 | 29.93 | 63.92 | 63.39 | 5.73 | 6.68 |
| (Poor) | 25 | 0.74 | 0.72 | 71.28 | 71.89 | 28.72 | 28.11 | 62.92 | 63.24 | 8.36 | 8.66 |
| | 50 | 0.72 | 0.69 | 72.05 | 73.08 | 27.95 | 26.92 | 61.49 | 62.05 | 10.56 | 11.03 |

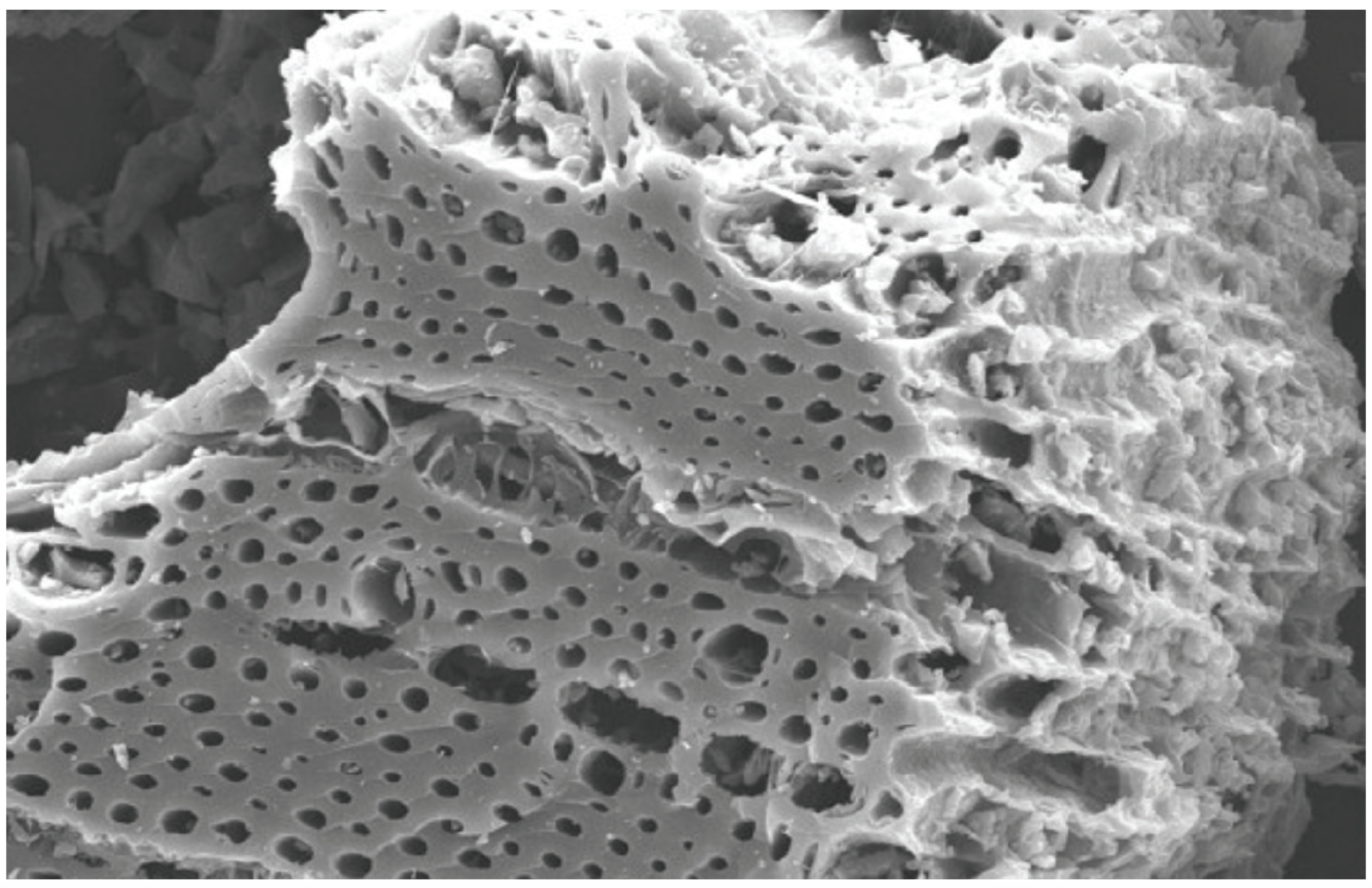

*Fig 1. Pine biochar under scanning electron microscope (SEM).*

The hydrological properties such as maximum water holding capacity, field moisture capacity, and hydraulic conductivity of both soils increased with increasing rates of biochar and wood chips (Table 2).

**Table 2. Hydrological properties of soils amended by pine biochar and pine woodchips.**

| Soil | Treatment | Maximum Water Holding Capacity (%) | | Field Capacity (%) | | Gravitational Drainage (%) | | Hydraulic Conductivity ($cm\ h^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|
| | ($t\ ha^{-1}$) | Biochar | Chips | Biochar | Chips | Biochar | Chips | Biochar | Chips |
| Soil A | 0 | 90.14 | 91.22 | 85.34 | 86.31 | 4.80 | 4.91 | 12.79 | 12.93 |
| (Rich) | 25 | 93.34 | 97.91 | 88.34 | 90.97 | 5.00 | 6.94 | 23.15 | 20.57 |
| | 50 | 98.23 | 99.81 | 91.31 | 93.07 | 6.93 | 7.74 | 35.16 | 32.34 |
| Soil B | 0 | 87.35 | 88.52 | 82.26 | 82.76 | 5.08 | 5.77 | 26.98 | 27.05 |
| | 25 | 91.48 | 95.97 | 85.59 | 87.89 | 5.89 | 8.09 | 35.13 | 32.41 |
| | 50 | 92.98 | 99.36 | 85.96 | 90.07 | 7.02 | 9.29 | 40.90 | 69.36 |

The increase in hydraulic conductivity can be attributed to the reduction of solid phase of the biochar/soil and woodchip/soil mixes. As both amendments decreased the solid phase of soils it is likely that the use of biochar or woodchip would reduce soil resistance thereby soil compaction.

The changes in hydrological properties were more greater in the Rich allophanic soil than the Poor allophanic soil with the application of biochar, while the reverse response was true for the application of wood chips. Our results show that the soil properties are largely changed due to the physical introduction of a material, rather than any inherent property of those materials.

The positive effects of biochar on allophanic soils physical and hydrological properties suggested that the addition of biochar can improve soil physical quality for sustainable production of kiwifruit. The incorporation of biochar in soils with high C/N ratios and abiotic buffering of mineral N may lead to lower N availability to crops. Therefore, non-legume crops (like kiwifruit) may require addition of N based fertilizer at the same time as biochar application to maintain optimum yields

## Conclusions and Recommendations

Remarkable variations in soil physical and hydrological properties of the studied soils indicated that the addition of biochar to soils from pine tree as well as kiwifruit prunings (Holmes et al., 2010) would improve soil fertility and may have higher retention of heavy metals as well as agrochemicals. As increasing global pressure is being placed on food producers to minimise their environmental footprint, carbon rich pine waste can be composted with waste kiwifruit; and biochar can be introduced to orchard soils. This will reduce the carbon footprint; and by increasing the soils water holding capacity also the water footprint of kiwifruit. The incorporation of biochar in soils with high C/N ratios and abiotic buffering of mineral N may lead to lower N availability to crops. Considering the above, in future studies we intend to optimise the application rate of biochar with N, aiming to improve allophanic soil quality, and minimise any reduction in soil quality caused by kiwifruit production.

## References

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