Salinity Effects on Short-Term C and N Mineralisation and Soil Microbial Properties in a Paddy Rice Soil under Aerobic and Anaerobic Conditions

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Background and Aims

Bangladesh is affected by flash floods and drought periods resulting in salt water intrusion and salt accumulation in the topsoil. The resulting soil **salinisation** negatively affects plant growth directly by osmotic stress and indirectly by altering microbially driven nutrient and carbon cycling, eventually reducing **soil fertility**. Addition of organic matter (OM) is known to ease salt stress effects on **soil microorganisms**. However, results are not consistent and OM sources used are heterogeneous. Evaluation of the potential of different OM sources is thus essential for recommendations. Further, it is also not well understood, how **OM addition alters microbial responses to soil salinity**.

Conclusions

- ✓ Microbial activity is more negatively affected by **salinity** than microbial biomass in the short term, indicating a certain level of buffering capacity.
- ✓ **Organic amendments** ease the negative effects of salinity on microbial activity and trigger microbial growth most likely by providing easily available carbon. In this study **rice** proved to be a good source of **available C**.
- ✓ However, **microorganisms** of different soils respond differently to salinity, most likely depending on **salinity legacy** effects and resulting adaptation.

Results

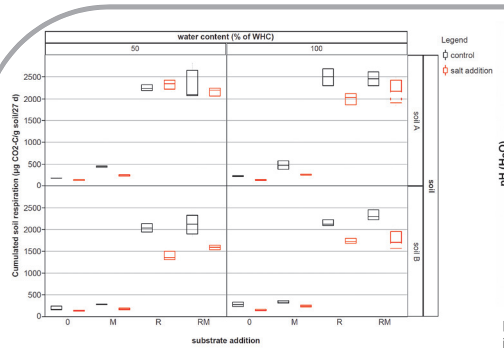


Fig. 1: Cumulated respiration (µg CO_2-C g^{-1} soil) of the two incubated soils (A & B) after addition of organic amendments at two different moisture and salinity levels (n=4).

→ Salt addition reducesdsoil respiration in both soils at 50 and 100% water holding capacity.
→ Rice straw addition increased respiration independent of moisture content. This increase was lower under saline conditions.

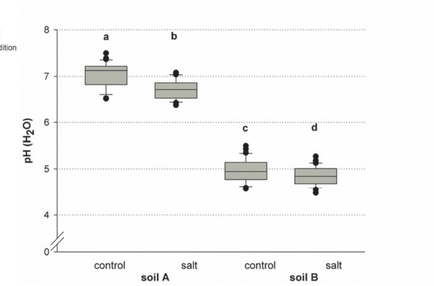


Fig. 3: pH-values of the two investigated soils after the incubation experiment. Different letters indicate significant differences between treatments at $p < 0.05$ (n=32).

→ Salt addition slightly reduces pH values most likely because of proton exchange from colloidal sites.

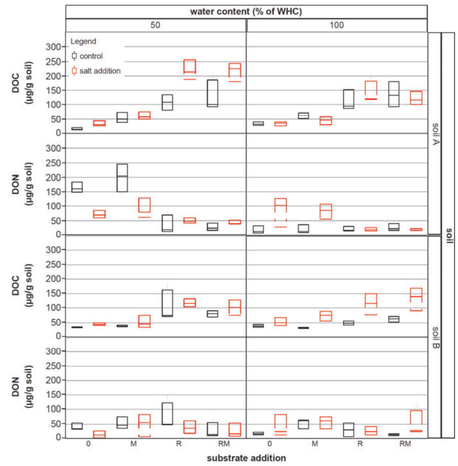


Fig. 4: Dissolved organic carbon (DOC) and nitrogen (DON) in the different treatments at the end of the incubation (n=4).

→ DOC and DON follow different patterns: DOC is increased after OM addition and DON is in most cases less affected.

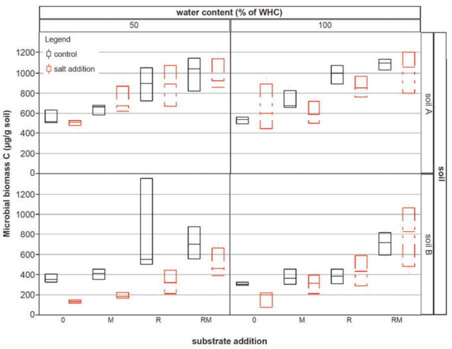
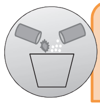


Fig. 2: Microbial biomass carbon content (µg g^{-1} soil) after incubation (n=4).

→ Soil microbial biomass increased after rice addition at both soil moisture levels. Effects of manure were less pronounced.
→ Salinity negatively affected soil microbial biomass mainly in the acidic soil (soil B) at 50% moisture.
→ Rice straw addition tended to increase the fungal biomass independent of salt level, as indicated by an increase in the ergosterol-to-microbial biomass C ratio (data not shown).

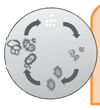
Overview

Soil salinity increases in Bangladesh.
Microbially driven nutrient and matter cycles and thus soil fertility are negatively affected.
Can organic amendments ease these negative effects on soil microorganisms?



Incubation experiment: 27 d, 25 °C, 50 or 100% WHC, non-saline or saline ( ).
With or without organic amendment ( ).
Soil chemical and microbial indicators.

Salinity decreased microbial activity (CO_2).
Organic amendments increased microbial activity and biomass.
In the pH neutral soil negative salt effects were substantially lower.



Organic amendments, especially rice straw, provide easily available C for microbes to adjust their metabolism to salt stress.
However, soil microbes can respond differently to salinity, due to salinity legacy.

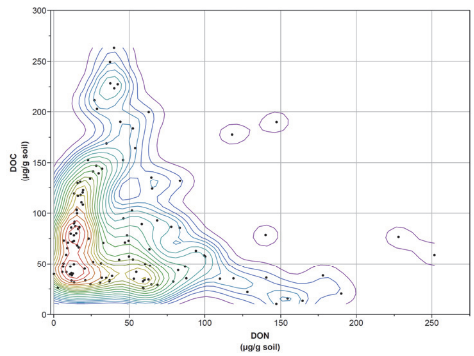


Fig. 5: Non-parametric bivariate density contour plot of DOC vs. DON. Contour lines show 5% quantils.

→ The results highlight that DOC and DON dynamics are not connected in the investigated paddy rice soils.

Materials and Methods





Soil and organic amendments

- Soils were collected from two non-saline paddy rice fields in Bangladesh with EC_e 1-1.5 dS m^{-1}.
- Soils varied in soil pH (7 and 5) and clay content (24 and 14%).
- Rice straw (R) and composted cattle manure (M) were collected from farms, dried and homogenized.

Experimental set-up

- A 27 day incubation experiment was set up with four replicates of every treatment (n=4).
- Soils were incubated either at 50% or at 100% of the maximum water holding capacity at 25°C
- Next to a control, rice straw, manure or both were mixed into the soil.
- Additionally, half of the treatments received NaCl resulting in saline soils with EC_e values of 25-29 dS m^{-1}.
- Microbial activity was measured as soil respiration throughout the experiment.
- At the end of the experiment, soil chemical and microbiological indicators were assessed.

Analyses

- pH was measured in water (1:5)
- Electrical conductivity (dS m^{-1}) was measured in the extract of the saturated paste (EC_e).
- Organic C was calculated from organic matter assessment using loss on ignition (550°C, 3 h).
- CO_2-evolution was measured after 3, 6, 13, 21 and 27 d (alkaline traps).
- Microbial biomass C and N were assessed by fumigation-extraction.
- Inorganic N, dissolved organic C and N were measured in K_2SO_4-extracts.
- Ergosterol was determined as indicator of saprotrophic fungi.

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