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Depth distribution of abiotic drivers of N mineralization and methane emission from a continuously and intermittently flooded Bangladeshi paddy soil

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Water-saving irrigation such as AWD may significantly alter depth profiles of moisture content, pH, Eh and soil microbial activity. Modelling the effect of irrigation management on soil N mineralization, therefore requires detailed insight into depth distribution of these variables and dissolved organic carbon (DOC), and evolution of electron acceptors. We set up a field experiment at Bangladesh Agricultural University from January to May' 2015. The cultivated rice variety (BRRI dhan28) was grown under continuous flooding (CF) and alternate wetting and drying (AWD) management, with 120 kg N ha-1(N120) or without (N0)N fertilizer application. We measured soil mineral N and plant N uptake to evaluate N mineralization. CH4 emissions were monitored with timely gas sample collection and GC-analysis. Soil Eh at four depths and temperature at two depths were monitored continuously by Eh/T°-probes connected to a HYPNOS III data logger (MVH, The Netherlands). Simultaneously, soil solution from three depths were sampled with rhizon samplers to track DOC, Fe and Mn in solution.

Over the growing season soil and air temperature increased by 8°C, and soil pH stayed near neutral (6.7 to 7.8). In all depths of AWD and CF, Eh dropped sharply to methanic conditions within 21 days after transplanting (DAT). Low redox-potential continued until 77DAT in all cases, except in the puddle layers under AWD, where redox raised to -200mV during drainage. Fe and Mn in soil solution increased gradually over the growing season, indicating continued reductive dissolution of Fe and Mn (hydro-)oxides. DOC increased continuously as well in all depths. Besides to release of DOC bound to pedogenic oxides upon their reductive dissolution, higher plant and soil microbial activity with increasing soil temperature (till 28°C) through the growing season explains the increasing DOC levels. Increasing methanogenic activity as indicated by the high CH4 emissions at 70-84DAT under both CF and AWD is logically linked. The elevated redox potential in puddle layer depth increments during AWD drainage events, significantly ($p<0.01$) declined the cumulative CH4 emission by 47% when compared to CF management. Moreover, seasonal CH4 emissions in N-fertilized fields (N120) decreased by 29 and 8% under CF and AWD, respectively relative to the control (N0), possibly due to promotion of methanotrophs, which were N-limited in N0. Mostly, mineral N content in N120 plots of AWD and CF exceeded contents in the N0 fields. Contrary to CH4 emission, irrigation management did not affect evolutions of pH, Fe, Mn and DOC in soil solution. Likewise, soil exchangeable N content evolution was unaffected and followed zero-order kinetics (N120: R2=0.53 to 0.81; N0: R2=0.12 to 0.48). Our results generally indicate that in Northern Bangladesh's Boro season, evolutions in paddy soil solution chemistry and CH4 emission are strongly depending on course soil temperature and only secondarily on irrigation management. Whether temperature steers microbial activity and methanogenesis directly or via concomitant plant activity and exudation is not known.

Key words: Redox, CH4, emission, mineralization, Fe, Mn, DOC, water management