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Temporal and spatial variability of redox values and its implications for nitrate reduction in a tile-drained area in Fensholt subcatchment, Denmark

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Tile-drained agricultural areas are generally considered to enhance nitrate leaching into the aquatic environment. However, this is an overly simplified assumption since tile drainage systems present a unique hydrology of extremely fluctuating water table levels and redox values over a relatively small area. It is then assumed that nitrate reduction in what we consider as the unsaturated zone may be higher than expected. In this study, the relationship between redox dynamics and nitrate reduction were explored in a highly drained subcatchment in Denmark. Piezometers and redox probes were installed on an average of three depths reflecting the depths near the tile drains, each nest at approximately 20 m apart between each other, to account for fine scale variability. In each nest, pH, temperature, redox values, and inorganic nitrogen concentrations were measured. A total of 150 piezometers and redox probes were installed throughout the different parts of the subcatchment. These areas were chosen to represent variations in hydrotopographic settings. Physico-chemical measurements and water samples were obtained approximately every three weeks. As predicted, the redox values and nitrate values were highly spatially and temporally variable even within the single subcatchment. Redox values were generally stratified where the redox values decreased with depth. The layer of higher redox values generally expanded during the warmer months of June to July, which is probably due to greater evapotranspiration. Naturally depressed areas tend to have low redox values (i.e. more reducing conditions) even during the warmer months. Pockets of higher redox values at the deeper parts of the profiles may indicate high local, subsurface flow conditions that bring oxic waters into the deeper parts of the soil. The interplay of temperature, rainfall, soil texture, and gradient seems to ultimately dictate the redox conditions in the tile-drainage depth.