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Manganese oxide-coated redox bars as an indicator for reducing soil conditions

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Field identification of reducing soil conditions is of concern not only for soil pedogenesis but also for nutrient and pollutant dynamics in soils. We manufactured manganese (Mn) oxide-coated polyvinyl chloride (PVC) bars and proved their suitability for identification of reducing soil conditions in both the laboratory and field. Birnessite (δ-MnO_2) was synthesized according to a recently published method and was coated onto white PVC bars. We used microcosm devices with adjusted redox potentials (EH) to distinguish the onset and intensity of depletion patterns along the Mn oxide-coating and soil column experiments combined with field application to validate the enhanced removal of Mn against Fe oxide-coated bars under anaerobe soil conditions. Field application was performed at a site with shallow and strongly fluctuating water tables where water table depth and soil temperature were monitored. Three microcosm experiments adjusted to oxidizing (EH ∼500 mV, pH 7), weakly reducing (EH ∼175 mV, pH 7) and moderately reducing conditions (EH ∼25 mV, pH 7) showed depending on the EH no, slight, or intense removal of the Mn oxide-coating, respectively. Moreover, the removal of Mn oxide (225 mm2 d–1) in soil column experiments exceeded the removal of Fe oxide (118 mm2 d–1). The enhanced removal of the Mn oxide-coating was also found under anaerobe conditions in field application. Consequently, identifying of reducing conditions in soils by Mn oxide-coated bars is possible. We recommend using this methodology for short-term monitoring, e.g. on weekly basis, since tri- and tetravalent Mn is the preferred electron acceptor compared with trivalent Fe.