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Effect Of Soil Moisture On Soil Solution Chemistry And Concentrations Of Some Minerals in Calcareous Soil.

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ABSTRACT

This paper reviews the effect of Soil Moisture on Soil Solution Chemistry and Concentrations of Some Minerals in Calcareous Soil. Spatial occurrence of processes affecting metal mobility and availability in floodplains are largely determined by the topography. At the oxic–anoxic interface and in the anoxic layers of floodplain soils, especially redox-sensitive processes occur, which mainly result in the inclusion of metals in precipitates or the dissolution of metal-containing precipitates. Kinetics of these processes are of great importance for these soils as the location of the oxic–anoxic interface is subject to change due to fluctuating water table levels. Other important processes and factors affecting metal mobility in floodplain soils are adsorption/desorption processes, salinity, the presence of organic matter, sulphur and carbonates, pH and plant growth. Many authors report highly significant correlations between cation exchange capacity, clay or organic matter contents and metal contents in floodplain soils. Iron and manganese (hydr)oxides were found to be the main carriers for Cd, Zn and Ni under oxic conditions, whereas the organic fraction was most important for Cu. The mobility and availability of metals in a floodplain soil can be significantly reduced by the formation of metal sulphide precipitates under anoxic conditions. Ascending salinity in the flood water promotes metal desorption from the floodplain soil in the absence of sulphides, hence increases total metal concentrations in the water column. The net effect of the presence of organic matter can either be a decrease or an increase in metal mobility, whereas the presence of carbonates in calcareous floodplain soils or sediments constitutes an effective buffer against a pH decrease. Moreover, carbonates may also directly precipitate metals. Plants can affect the metal mobility in floodplain soils by oxidising their rhizosphere, taking up metals, excreting exudates and stimulating the activity of microbial symbionts in the rhizosphere.

Keywords: moisture soil, minerals, calcareous, spatial

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INTRODUCTION

Soil moisture is an important forcing variable in terrestrial environments (Vereecken *et al.* 2008; Robinson and Coauthors 2008; Seneviratne *et al.* 2010; Legates *et al.* 2011). Soil moisture significantly influences weather and climate, plant growth and productivity, hydrology, and soil ecology (i.e., carbon/nitrogen dynamics, and trace gas emissions). As such, the need for compilation of extensive and intensive soil moisture information has been recognized for several decades (Robock *et al.* 2000; Western and Grayson 1998).

Water content is an important property of soils, affects both chemical and physical properties of soils. The availability of water in the soil affects plant growth and especially the capability to absorb nutrients needed for plant growth and development. Although nutrients in the upper soil layers represent important resources for plants (Grime *et al.*, 1986; Robinson, 1994), these are the layers that undergo the largest fluctuations in moisture as well as temperature (Cui and Caldwell, 1997).

Chemical concentrations buffered in soil solution to varying degrees against changes in soil moisture by the exchangeable, precipitated, or adsorbed the solid soil phase (Menzie and Bell, 1988; Wolt, 1994). Moisture could regulate plant competition changing soil solution chemistry not only available water, but also for nutrients and influence the field distribution of plant species. Variation in soil moisture within ranges occurring in the field may greatly influence soil solution composition (Wolt, 1994). Mineral nutrients concentration in soil solution is an indicator of the nutrient's mobility towards the root and in the soil (Marschner, 1995). Menendez *et al.* (1995) demonstrated a strong dependence of soil solution composition on soil water content. Increases in soil moisture content led to change in the ion distribution, free hydrated metal concentrations, and complexation (Fotovat *et al.*, 1997). Soil chemical properties may exert a profound influence on growth and performance of plants (Grime and Curtis, 1976). By influencing root hair growth of plant, nutrient uptake efficiency may also be affected (Mackay and Barber, 1985).

Ion transport mechanisms, nutrient supply and uptake by plants are influenced by soil water content. They are mainly based on interception, mass flow and diffusion (Dunham and Nye, 1976). Interception occurs as growing roots displace soil and the nutrients contained therein. This mechanism plays a minor role in nutrient supply, because roots take less than 1% of the soil volume, and soil solution nutrient content in that volume is usually insignificant compared to the total amount taken up (Smethurst, 2000). Nutrients in soil water transport by mass flow as water moves towards a root due to plant transpiration, this mechanism supplies a significant amount of nutrients are present at high concentrations in soil solution or are almost limited in the solution phase, (like nitrate in most soils). If nutrient supply by mass flow is less than the rate of uptake, the concentration in solution at the root surface decreases. Nutrients will then diffuse down a concentration gradient towards the root. This mechanism of nutrient supply is particularly important for nutrients that are relatively immobile (like phosphate in most soils). The relative importance of mass flow and diffusion depends on soil water content, the rate of uptake, the degree of nutrient interaction with the solid phase, the concentrations of nutrients in solution, and nutrient demand by the plant. The importance of mass flow is minimal in dry soil.

Calcareous soil is defined as having the presence of significant quantities of free excess lime (calcium or magnesium carbonate). Lime dissolves in neutral to acid pH soil, but does not readily dissolve in alkaline soil and, instead, serves as a sink for surface adsorbed calcium phosphate precipitation.

Effect of moisture on soil solution concentration:

Many researches showed that increased soil moisture on calcareous soil could increase HCO_3^- and CO_2 in the soil solution (Inskip and Bloom, 1986, Menge *et al.*, 1984, 1988, McCray and Matocha, 1992), increasing soil moisture could be added more water to the system and CO_2 that produced by soil microorganisms is less able to diffuse and escape from the soil, resulting in an increased CO_2 partial pressure replacing the carbonic acid equilibria to of HCO_3^- . In results changing in soil pH consequent increased HCO_3^- could change the concentration of ions, which are pH dependent.

Phosphorus (P) is an essential macronutrient, being required by plants in relatively large quantities (Mengel and Kirkby, 1987; Mills and Jones, 1996). The bioavailability of P is strongly tied to soil pH. (Tyler, 1992;

1996a). Phosphorus is mainly soil water content dependent as diffusion is a dominating mechanism transporting phosphate ions to the root. (Dunham and Nye, 1976). Inorganic phosphorus in calcareous soils is an insoluble apatite like Ca phosphate. Misra (2003) and Barber and Chen (1990) reported increase of P in the soil solution at high soil moisture which could be a result of increased pH. In high pH soils, dissolution of CaCO_3 controls the Ca level and may therefore increase the solubility of P (Aoetal., 1987).

Calcium and Mg are not limiting on calcareous soil but high concentrations of these elements interact with other elements. In alkaline soils the Ca concentration of the soil solution is generally regulated by precipitation and dissolution of CaCO_3 . Lower Ca and Mg concentrations in soil solution at high soil moisture was observed (Misra, 2003; Bloom and Inskeep, 1986; Inskeep and Bloom, 1986).

Calcareous soils are often deficient in soluble Zn and easily available Mn. Exchangeable Zn is generally sorbed on soil surfaces as Zn^{2+} or ZnOH^+ . Zinc nutrition of plants in dry soils is often considered limiting due to low plant available concentration of Zn (Cakmaketal., 1996). High soil moisture due to rain may limit the supply of Zn and Mn to the plant roots because the dilution, and these elements do not readily return to their original levels in the saturated soil solution (Gammon, 1976). The concentration of Zn in the soil solution depends on factors such as concentrations of HCO_3^- and macronutrients. The decreased Zn concentration with increasing soil moisture might be the result of high HCO_3^- concentration, which can decrease Zn availability by precipitation of franklinite-like solid material (Sajwan and Lindsay, 1986). Combination of high pH and CaCO_3 can also be considered major factors causing Zn deficiency (Cakmaketal., 1996).

Manganese is often considered a limiting element on calcareous soils. Manganese availability in soil is dependent on pH and redox reaction. The increase in Mn concentration followed the same pattern as HCO_3^- with increasing soil moisture; being closely correlated to HCO_3^- concentration.

Amounts of K and S in soil solution seem less influenced by soil moisture change. Concentrations of K in soil solution were highest at high soil moisture though differences were not great. Diffusion rate of K is mainly controlled by supply of water to the soil but supply of K is also much dependent on soil fixation which often may occur during drying of soil (Barber, 1995). Misra (2003) did not find any significant influence of soil moisture on Fe concentration in soil solution and it is also possible that decreased availability of Fe might be indirectly influenced by soil moisture as a result of increased pH and HCO_3^- .

Misra and Tyler (1999) performed an experiment in a glasshouse to study the influence of soil moisture level on soil solution chemistry in calcareous, results showed soil solution HCO_3^- , P, Mn concentrations, and pH, increased, whereas Ca, Mg and Zn concentrations decreased, with increasing soil moisture. The results showed increased of soil moisture slightly increased K in soil solution.

Zheng and Zhanga (2011) study the dynamics of solid-phase transformation of added Cu, Pb, Cd, and Hg under three moisture regimes (75% field capacity, wetting-drying cycle, and flooding). The heavy metals spiked in the soil were time-dependently transferred from the easily extractable fraction (the exchangeable fraction) into less labile fractions (Fe-Mn oxide- and organic matter-bound fractions), and thus reduced lability of the metals. They found that soil moisture regime did not change the direction and pathways of transformation of metal speciation, but it significantly affected the transformation rate. In general, the paddy soil under flooding regime had higher metal reactivity compared with 75% field capacity and wetting-drying cycle regimes, resulting in the more complete movement of metals toward stable fractions. This might be related to the increased pH, precipitation of the metals with sulfides and higher concentration of amorphous Fe oxides under submerged condition.

Most metals, including Zn and Ni are generally less available at high soil moisture due to the effect of reducing conditions on the metal ion. In waterlogged soils, most metals, including Zn, Cd, and Ni exhibit complicated solubility with generally reduced solubility due to low redox potential (Rieuwertsetal., 1998) and formation of sparingly soluble sulfides (Marschner, 1995).

Angle *et al* (2003) found the extractable soil concentrations of Ni decreased with increasing soil moisture content. Few significant effects related to Zn extractability were observed for any of the soil moisture

treatments. The biomass of all tested species was generally greater at higher soil moisture and inhibited at low soil moisture. Further, plants accumulated large amounts of metals from soil at higher soil moisture.

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