The Dynamics of Potassium in some Australian soils

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Abstract

Potassium (K) is a macro element in plant, animal and human nutrition and is regularly applied to agricultural land as a fertiliser or as a component of nutrients in irrigation wastewater. Soils contain variable quantities of potassium-bearing minerals and differ in their inherent K supplying capacity. Improving knowledge of the potassium cycle in soils is considered to be important for a better understanding of the productivity and sustainability of many ecosystems. This work combines soil analysis and mineralogical methods for characterising and quantifying the movement of different forms of potassium in Australian soils.

Dispersion of clay particles is one of the major processes responsible for the degradation of soil structure. Adsorbed sodium is traditionally considered to be a primary cause for poor soil structural stability. However, there is a knowledge gap in understanding the effect of adsorbed monovalent potassium on soil structure. Mixed results from the literature point to more research being required to explore the potential effect of applied K^+ on soil dispersive properties and the role of clay minerals in it.

Potassium is common in a wide variety of wastewaters and in some wastewaters is present at several hundred to several thousand mg/L. Potassium is taken up by expandable clays leading to its fixation and illitisation of smectitic and vermiculitic layers. Clays have a major effect on soil physico-chemical properties, and hence the addition of wastewaters to soils may lead to mineralogical changes in the soils that affect these properties.

The aim of this work was to improve our understanding of potassium dynamics in Australian soils with emphasis on soil clay mineralogical properties. Soils from different regions of Southern Australia were used. Studies on pure clays have been included to understand the fundamental processes involved in potassium cycle in soils.

The results show that applied potassium can cause dispersion of soil but to a lesser extent than sodium. Potassium cations also could increase soil hydraulic conductivity to some extent when applied to a soil with high sodium content by substituting the Na^+ on exchange sites. Exchangeable potassium can cause dispersion of soil even if it is present in relatively small amounts (Exchangeable Potassium Percentage < 4%), particularly in soils with dominant illite/kaolinite mineralogy. The use of Exchangeable Cation Ratio is tested as an indicator of soil dispersion because it reflects the combined effects of potassium and sodium as dispersive agents.

Illitic and illitic-kaolinitic soils are more prone to dispersion than soils with dominant smectitic clay. This is due to their differences in clay microstructure and fabric when interacting with water. Turbidity and zeta potential could effectively reflect soil clay dispersive properties. But to understand the meaning of zeta potential for dispersive properties of soils we should have prior knowledge of the mineralogy of the soil studied. TEM and XRD methods could assist in providing a better understanding of the processes occurring in soil.

Application of potassium rich wastewater on four clayey soils from Southern Australia induced changes in the 2:1 clay assemblages of the soils. XRD diagrams and chemical composition of clays extracted from untreated and treated soils were determined. Characterisation of the effect of wastewater treatment on clay fraction either by decomposition of XRD patterns into their component phases or chemical analysis of the mineral content of the studied clays gave consistent results. In 3 of the 4 soils, shifts in peak positions occurred towards more illitic components along with increases in K and sometimes also Mg and Na contents of soil clays. Peak decomposition showed trends towards the formation of interstratifications of illite with smectite at the expense of smectite and an alteration of poorly-crystallised illite into its more well-ordered forms. The results show that illitisation may occur as a result of the addition of K-rich wastewaters to clayey soils. Growers and agricultural managers should consider soil clay mineralogy before irrigating with potassium-rich wastewater.

Declaration

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