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Assessing the potential boron toxicity of soils irrigated with reclaimed water in Jordan

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Boron (B) is a potentially plant toxic ion and is present in domestic treated wastewater (reclaimed water) in Jordan in concentrations of around 1 mg L-1. As reclaimed water is used for irrigation in Jordan the concentration of B gives potential for detrimental effects on crop productivity. Such effects are dependent on the crop type and importantly, the concentration of B in the soil solution and on the readily exchanged component of the soil solid phase. Boron also behaves complexly in soil because it has sorbing tendencies. The sorption of B onto the soil solid phase removes it from solution and effectively reduces its toxicity potential to crops. However, desorption raises its availability in the soil solution and increases the potential for toxicity effects.

To investigate B sorption behaviour in Jordanian soils, experimental work was conducted to describe how B sorption and desorption is affected by the concentration of B in the soil solution. Boron isotherms (to show the amount of B sorbed onto the soil surface relative to the amount of B remaining in the soil solution at constant pressure and temperature) were created which showed that the soil had a high affinity to adsorb B and that desorption of B occurs as the concentration of the soil solution is reduced (for example, through the addition of freshwater) to create a new equilibrium between the concentration of B in the soil solution and the amount of B sorbed onto the soil particles. This suggests that freshwater inputs to soil to which B has previously sorbed onto the soil solid phase during irrigation with reclaimed water will lead to the desorption of B, possibly raising the concentration in the soil solution. To test this hypothesis, the B concentration in the soil solution (B in the soil saturation paste extract) of soils irrigated with reclaimed water was determined. This work confirmed that soils to which a greater volume of reclaimed irrigation water had been applied had a higher concentration of B in the soil solution compared to soils to which less water had been applied. The difference was particularly noticeable when the concentration of B was compared to the concentration of non-sorbing chloride in the soil.

Boron concentration was also determined by the established method of mannitol calcium chloride abstraction to give both the soluble and specifically and non-specifically sorbed B in the soil. This analysis showed good correlation between the concentration of B in the soil saturation extract and the concentration of B abstracted by mannitol calcium chloride. This correlation effectively describes the proportion of B in the soil which is soluble (determined in the saturation extract) and that which is readily desorbed (the concentration of B abstracted with mannitol calcium chloride minus the concentration in the saturation extract). Further work is needed into this relationship as it could offer a means by which the adsorption capacity of the soil can be rapidly appraised and the leaching requirement (the amount of water needed to desorb and transfer the B through the soil) can be better predicted.