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Determination of Michaelis-Menten kinetics for the removal of cyanide by plants

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Abstract

Uptake and toxicity of cyanide were measured with the willow toxicity test in hydroponic solution and in sand; metabolism was measured with a closed-bottle test. The results were used to evaluate a model that calculates accumulation of cyanide inside plants. Willow roots and leaves were able to metabolize 7.8 and 10.0 mg CN/(kg plant h), respectively. Accumulation of cyanide was seen when the plants were exposed to concentrations > 30 mg CN/L. The plants can according to model calculations survive internal concentrations of 2 mg CN/kg.

Introduction

Vascular plants possess the enzyme β-cyanoalanine synthase which makes them capable of incorporating free cyanide (CN) into the amino acid asparagine. Removal of cyanide by plants is relevant for evaluation of phytoremediation of cyanide polluted soils and water. The present work had three primary objectives. The first was to measure the phytotoxicity of cyanide to willow trees (Salix viminalis). The second was to determine Michaelis-Menten kinetics for removal of cyanide by willow trees. This provided data for the third objective, a model that describes uptake and degradation of cyanide.

Materials and methods

Toxicity test

Willow cuttings are grown in hydroponic solution or sand and irrigated with cyanide solution. Detached leaves or roots or thin slices of stem are placed in a 200 mL solution containing cyanide. Uptake and toxicity of cyanide were measured with the willow toxicity test in hydroponic solution and > 20 mg CN/L when grown in sand were toxic. This provided data for the third objective, a model that describes uptake and degradation of cyanide.

Closed-bottle test

Detached leaves or roots or thin slices of stem are placed in a 200 mL solution containing cyanide. Removal of cyanide by plants is described by Michaelis-Menten parameters. The removal rate of cyanide as a function of substrate concentration for leaves is monitored over time.

Modelling

Experimental values of $v_{max}$ and $K_M$ are used to calculate concentrations of cyanide inside the different plant compartments. The model is only valid when no toxic effects are observed. The model is only valid when no toxic effects are observed.

Results

Concentrations > 2 mg CN/L when grown in aqueous solution and > 20 mg CN3 when grown in sand were toxic for the plants. When grown in sand, accumulation of cyanide inside the tree was only seen at concentrations > 30 mg CN/L. At this point the trees died.

Conclusion

Concentrations > 2 mg CN/L when grown in aqueous solution and > 20 mg CN3 when grown in sand were toxic for the plants. When grown in sand, accumulation of cyanide inside the tree was only seen at concentrations > 30 mg CN/L. At this point the trees died.