Phytotoxicity of Sodium Fluoride and Uptake of Fluoride to Willow Trees

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Fluoride (F) is present in pristine air, soil and water. As exposure to F through food and beverages is unavoidable, the effects of F on human and mammalian health have been intensely investigated. Due to continued use of super phosphate fertilizers, F accumulates in agricultural soils. However, little is known about the phytotoxicity of sodium fluoride (NaF) and the uptake of F when exposed through roots. The aim of this study is to:

1) Assess the phytotoxicity of NaF to willows when taken up through the roots
2) Determine the uptake of F to willows when taken up through roots
3) Describe the uptake of F to willows with a non-linear mass balance model

**Intro and scope**

Fluoride (F) is phytotoxic at levels of EC10: 38.0 ± 34.2; EC20: 59.6 ± 40.7 and EC50: 128 ± 51 (values in mg F L⁻¹ ± 95% confidence interval)

Uptake of F can be described by a non-linear mass balance model assuming enzymatic removal

At external concentrations above 210 mg F L⁻¹ the willows can no longer pump out F from the plant cells and start to accumulate F

Enzymatic removal of F and Cl from plant cells is likely to be managed by the same “pump”-system

**Phytotoxicity results**

- Toxic effects observed within 48 h for conc. >100 mg F L⁻¹
- Clear dose-response relationship
- No statistically significant difference between toxicity of 50 mg F L⁻¹ and 100 mg F L⁻¹
- Wilting of the trees exposed to 400 mg F L⁻¹

**Experimental setup – the willow tree tox test**

- 40 cm willow sticks (Salix viminalis) were pre-grown and transferred to Erlenmeyer flasks
- Trees were exposed to solutions of various NaF concentrations
- Test duration: 96 h

**Model description and output**

The model assumes:

- Steady state
- Passive uptake of F with the transpiration stream
- Enzymatic removal described by Michaelis-Menten kinetics

**Model parameterization**

- Maximal enzymatic removal rate, \( v_{\text{max}} \): 9 g F kg⁻¹ d⁻¹
- Breakthrough point (BTP): 210 mg F L⁻¹ – On a molar basis the same as obtained by Trapp et al. (2008)* for chloride (Cl)
- Uptake slope approx. 1 for C > BTP – unhindered transport with water

**Conclusions**

- NaF is phytotoxic at levels of EC10: 38.0±34.2; EC20: 59.6±40.7 and EC50: 128±51 (values in mg F L⁻¹±95% confidence interval)
- Uptake of F can be described by a non-linear mass balance model assuming enzymatic removal
- At external concentrations above 210 mg F L⁻¹ the willows can no longer pump out F from the plant cells and start to accumulate F
- Enzymatic removal of F and Cl from plant cells is likely to be managed by the same “pump”-system