Fertilizer-derived fluorine (F) in grazed pasture systems
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Introduction

- P fertilizers (1- 4% F) are the major input of F to clover-based pasture.
- SSP @10–30 kg P/ha/yr adds 1–6 kg F/ha/yr

<table>
<thead>
<tr>
<th>Phosphate fertiliser</th>
<th>F (%)</th>
<th>P (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sechura PR</td>
<td>3.4</td>
<td>13.1</td>
</tr>
<tr>
<td>Arad PR</td>
<td>4.0</td>
<td>14.1</td>
</tr>
<tr>
<td>Gafsa PR</td>
<td>4.1</td>
<td>13.4</td>
</tr>
<tr>
<td>North Carolina PR</td>
<td>3.5</td>
<td>13.0</td>
</tr>
<tr>
<td>SSP</td>
<td>1.08–1.84</td>
<td>9.0</td>
</tr>
<tr>
<td>TSP</td>
<td>1.3–2.4</td>
<td>21</td>
</tr>
<tr>
<td>DAP</td>
<td>1.2–3.0</td>
<td>20</td>
</tr>
</tbody>
</table>

PR - phosphate rock. Data from Loganathan et al. 2003.
Introduction

• F concentration in top soils (0-100 mm depth) are projected to double in <100 yrs with regular P application to wheat and potatoes in South Australia

<table>
<thead>
<tr>
<th>Crop</th>
<th>Input (g/ha)</th>
<th>Crop harvest (g/ha)</th>
<th>Net rate of addition (g/ha/yr)</th>
<th>Background soil conc. (mg/kg)</th>
<th>Years to double soil levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>4000</td>
<td>3.0</td>
<td>3997</td>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td>Potato</td>
<td>16000</td>
<td>10.0</td>
<td>15990</td>
<td>300</td>
<td>25</td>
</tr>
</tbody>
</table>

(McLaughlin et al. 1996)

• Very little F is removed by plants and crops

Introduction

• SSP applied at 30KgP/ha will double the F concentration in grazed pasture soils (0-100 mm depth) in <100 yrs

<table>
<thead>
<tr>
<th>New Zealand</th>
<th>Input (g/ha)</th>
<th>Pasture uptake (g/ha)</th>
<th>Animal intake (g/ha)</th>
<th>Animal (g/ha)</th>
<th>Net rate of addition (g/ha/yr)</th>
<th>Background soil conc. (mg/kg)</th>
<th>Years to double soil conc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazed pasture</td>
<td>6000</td>
<td>50</td>
<td>40</td>
<td>20</td>
<td>5880</td>
<td>300</td>
<td>51</td>
</tr>
</tbody>
</table>

(Loganathan et al. 2003)

• Very little F is removed by animals
Survey of total F in heavily-fertilised and lightly-fertilised, or unfertilised, topsoils (0-75 mm depth)

Survey of total F confirms topsoil F has doubled in less than 70 years of fertiliser use

F and P accumulation patterns are similar.
No significant downward F movement irrespective of rate. 85% remained within the top 120 mm depth.
Fertiliser F accumulates in soils as sparingly soluble calcium fluoride and fluoroapatites or is adsorbed to hydrous oxides of Al. At low soil pH’s it forms soluble complexes with Al.

- Grazing sheep and cattle ingest topsoil with pasture.
  (Healy 1968, 1973)

Soil ingestion is high:
- during winter (June, July, August).
- when stocking rate is high (low grazing and treading)

What happens to soil F when ingested?
Risk of chronic fluorosis increases with increased topsoil F concentration, and rate and duration of soil ingestion.

How much ingested soil F will be absorbed by the animal?

**Will soil ingestion cause Chronic fluorosis?**

A diet of > 60 mg available F/Kg DM on a continuous basis leads to symptoms of Chronic fluorosis (Clark and Stewart 1983).

- Lameness in cattle
- Tooth wear in sheep

**Soil F feeding trial on sheep** (Grace et al. 2003)

- Three groups of sheep fed daily for 63 days with (1) Lucerne, (2) Lucerne + low F soil, (3) high F soil. Amount of soil = one winter’s intake (100 g soil/day).

Blood serum F conc.
- (a) increased within 23 days
- (b) increased with soil F intake.
• Bone F conc. increased after 63 days but they were below toxic level (2000–4000 mg/kg).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Basal Diet</th>
<th>Low F soil</th>
<th>High F soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rib bone</td>
<td>739&lt;sup&gt;A&lt;/sup&gt;</td>
<td>797&lt;sup&gt;A&lt;/sup&gt;</td>
<td>1388&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
<tr>
<td>Radius bone</td>
<td>726&lt;sup&gt;A&lt;/sup&gt;</td>
<td>857&lt;sup&gt;A&lt;/sup&gt;</td>
<td>1271&lt;sup&gt;B&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

(Grace et al. 2003)

Rate of bone F accumulation per day is related to serum F concentration.

- Grazing sheep and cattle ingest topsoil with pasture.

(Healy 1968, 1973)

After 2-3 months of high soil ingestion sheep graze spring pastures with low soil contamination.

What happens to serum and bone F?
After 63 days of soil ingestion sheep graze spring pastures with low soil contamination. What happens to serum and bone F?

(Grace et al. 2007)

• Serum F responds rapidly to change in F intake

• Bone F reduces slowly and not all bone F is remobilised

Intake of high dietary F (30 -109 mgF/kg DM) raises serum F

• leading to F sequestration in bone and antler

• but not in soft tissues and milk

Deer velvet products consumed @ > 2.5 g/day may deliver >1mgF/day
**Conclusions**

1. F added via P fertilizers mainly accumulates in sparingly soluble forms in the topsoil. Therefore F risk to ground water is low in most pasture soils.

2. Main pathway of F intake by grazing livestock is by soil ingestion which is high during winter.

3. F accumulates mainly in animal bones, not animal products such as meat and milk.

4. Current soil F concentrations are unlikely to cause bone damage in cattle and sheep if pasture covers are high.

5. Fertiliser derived F continues to accumulate in soils. Studies are required to investigate the cumulative effects of F accumulation in bones with increasing soil F levels and age of animals.
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