PFOS, Land Application of Residuals, Dairy Farms and Milk

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What is PFOS?
(perfluorooctane sulfonic acid)

Carbon backbone

Octane

Acid Group

Perfluorooctane sulfonic acid (PFOS)
PFOS is Toxic

Toxicity Values for PFOS

Reference Dose (ng/kg/day)

* Proposed

Maine Department of Health and Human Services
Why are we concerned about PFOS?

We are all exposed to PFOS.

Source:
PFOS stays in our bodies for years.

Why are we concerned about PFOS?

Half-Life in Human Body for Selected PFAS (years)

<table>
<thead>
<tr>
<th>Per-fluorinated Alkyl Substances</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFOA</td>
<td>2</td>
</tr>
<tr>
<td>PFOS</td>
<td>3.5</td>
</tr>
<tr>
<td>PFHxS</td>
<td>5</td>
</tr>
<tr>
<td>PFHpA</td>
<td>1</td>
</tr>
<tr>
<td>PFNA</td>
<td>3</td>
</tr>
</tbody>
</table>

Sources:
PFOS is Persistent and Mobile
- Stoneridge Farm -

Soil / Hay in µg/kg, dw
Water / Milk in ng/L

Surface Soil Data - January - May 2017

Maine Department of Health and Human Services
Is it the hay or the water?

Kowalczyk et al. 2013.

- **Milk**: 1400 ng/L
- **Ground Water**: 40 – 130 ng/L
- **Hay**: 9.6 µg/kg, dw

PFOS levels for milk and water in nanograms / liter.
Based on USEPA RfD of 20 ng/kg/day, 95th percentile incidental soil ingestion rate for a 1-6 year old child, 150 days / year.
I would use the RAG here as the chapter 418 standard wouldn't necessarily be the applicable standard applied in this case, i.e., that is a new site with contaminated soils where you don't know the source. DEP would use the soil RAG to evaluate.

Simones, Thomas, 9/11/2019

I would also use the 2018 RAG of 1700 ug/kg to avoid any confusion and mention that at the time of discovery the RAG was 2700.

Simones, Thomas, 9/11/2019
What would be a PFOS soil screening level for the dairy farming scenario?

Soil → Hay/Corn → Cow → Milk → Child
EPA PRGR Soil Screening Level Equation

Agronomic Pathway

\[ SL_{soil} = \frac{C_{milk}}{TF_{milk} \times \left( I_{fodder} \times F_{onsite-f} \times F_{year-f} \times (TF_{plant} + MLF) \right) + (I_{soil} \times F_{onsite-g} \times F_{year-g})} \]

- **Milk Action Level**
  - "Adulterated"

- **Transfer Factor from Intake to Milk**

- **Fraction of time exposed to contaminated feed**

- **Plant uptake and soil loading**

- **Fraction of time exposed to contaminated soil**

Source:

Maine Department of Health and Human Services
Transfer pathways:

1. Root uptake
2. Translocation
3. Soil resuspension
PFOS Corn Transfer Factor ($TF_{plant}$)

$TF_{\text{corn}} = < 0.08$

$TF_{\text{corn}} = 0.04$

$TF_{\text{corn}} = 0.16$
PFOS Hay Transfer Factor ($T_{F_{plant}}$)

$T_{F_{hay}} = 0.07$

$T_{F_{hay}} = 0.1$

$T_{F_{hay}} = 0.5$

Maine Department of Health and Human Services
Plant Soil Mass Loading Factor (MLF)

**Processes for transfer of soil to plant surface**
- Rain splash
- Wind erosion
- Soil disturbance by mechanical equipment

**USEPA PRGR Defaults**
- Default = 0.25, range 0.001 to 0.5
- Geometric mean of 11 studies* = 0.034 (pasture plants only)

\[ \text{MLF} = 0.034 \]

Source:


Maine Department of Health and Human Services
## Dairy Farm Scenarios

<table>
<thead>
<tr>
<th>Grass-fed Dairy Farm</th>
<th>“Average” Maine Dairy Farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay (65%)</td>
<td>Hay (20%)</td>
</tr>
<tr>
<td>Corn Silage (20%)</td>
<td>Corn Silage (37%)</td>
</tr>
<tr>
<td>Grain (15%)</td>
<td>Grain (35%)</td>
</tr>
</tbody>
</table>
Soil Ingestion while Grazing

USEPA PRGR Defaults

- 2% of total dry matter intake
PFOS Milk Transfer Factor ($TF_{milk}$)

**PFOS in Milk Feeding Study**

- Observed $TF_{milk} = 0.005$
- Steady-state $TF_{milk} = 0.02$ to $0.08$

Source:
Action Level for “adulterated” Milk

- Toxicity Value: 20 ng/kg/day
- 90th Percentile Milk Intake: 0.074 L/kg/day
- Milk Exposure Limit: 270 ng/L
- Relative Source Contribution: 80%
- Action Level: 210 ng/L
Example Soil SL Calculation for Hay

\[
SL_{\text{soil}} = \frac{C_{\text{milk}}}{TF_{\text{milk}} \times \left[ \left( I_{\text{fodder}} \times F_{\text{onsite-f}} \times F_{\text{year-f}} \times (TF_{\text{plant}} + MLF) \right) + (I_{\text{soil}} \times F_{\text{onsite-g}} \times F_{\text{year-g}}) \right]}
\]

Source:
Example Soil SL Calculation for Corn Silage

\[ SL_{\text{soil}} = \frac{C_{\text{milk}}}{TF_{\text{milk}} \times \left[ (I_{\text{fodder}} \times F_{\text{onsite-f}} \times F_{\text{year-f}} \times (TF_{\text{plant}} + MLF)) \right]} \]

\[ \begin{align*}
31,300 \text{ ng/kg dw} \\
(31.3 \mu\text{g/kg dw})
\end{align*} \]

\[ 204 \text{ ng/kg} \]

\[ 0.02 \text{ day/kg} \]

\[ 8.7 \text{ kg/day} \]

\[ 1 \]

\[ 1 \]

\[ 0.04 \]

\[ 0.0014 \]

\[ 0.32 \text{ kg/day} \]

Source:
Modified equation from U.S. EPA Preliminary Remediation Goals for Radionuclides, consumption of milk back calculated to soil -
https://epa-prgs.orl.gov/radionuclides/users_guide.html

Maine Department of Health and Human Services
Example Soil Screening Levels for Dairy Farm Scenarios

EPA “Subsistence Dairy Farm”
- Diet: Hay (65%)  Corn (20%)  Grain (15%)

SSL = 6 μg/kg, dw

Average Maine Dairy Farm
- Diet: Hay (28%)  Corn (37%)  Grain (35%)

SSL = 10 μg/kg, dw
Ground-truthing Model Predictions

Soil / Hay in µg/kg, dw
Water / Milk in ng/L

Maine Department of Health and Human Services
**Model Estimated PFOS Milk Levels based on Stoneridge Farms Average Soil Levels**

<table>
<thead>
<tr>
<th>Stoneridge Farms PFOS site-wide soil level estimates (ug/kg dry weight)</th>
<th>Model estimated PFOS milk (ng/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>123 (arithmetic average)</td>
<td>3,808</td>
</tr>
<tr>
<td>25 (geometric mean)</td>
<td>734</td>
</tr>
</tbody>
</table>

Initial average measured PFOS milk levels at Stoneridge Farms = 1,117 ng/L

NOTE – Does not include water contribution, which could add 90 – 200 ppt to milk.
Next Steps

Soil-to-Corn PFOS Uptake Study (DEP, MECDC, DACF)

- Collected matched soil and silage corn samples for PFOS analysis
- Identified a laboratory to perform plant PFOS analyses
- Awaiting plant data to derive a transfer factor

Ongoing model refinements

- Evaluating consensus on toxicity values
- Monitoring new literature / reports on plant uptake
- Looking for more farms to test model against

Maine Department of Health and Human Services
Questions?

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