From hazard to risk assessment of contaminated soils: from single chemicals to chemical mixtures

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FACTORS AFFECTING SOIL ECOSYSTEMS

- Changes in Land Use
- Invasive Species
- Climate Change
- Chemical Pollution

Soil

Human Pressure
“GREEN REVOLUTION”
How is evaluated soil quality and what are the constraints?

#1 Constraint...

No specific soil regulation or legislation (similar to the Water Law or the Water Framework Directive)

Ontario Ministry of the Environment de 2011

#2 Constraint...

Chemical hazard assessment one-by-one basis
Independently from climacteric conditions, soil type

#3 Constraint...

It’s Hard to Assess Hazard accurately!
Case Study #1: Repeated Application

**Folsomia candida**

**AIM:** Study on effects of molluscicide baits (metaldehyde)

**APPLICATION:** Surface; repeated accordingly to the manufacturer

**Usual HAZARD ASSESSMENT:** soil incorporation and single dose

**New Approach:** double application

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**APLICATION #1**

<table>
<thead>
<tr>
<th>Metaldehyde (mg a.i..kg⁻¹)</th>
<th>Nr. Juveniles</th>
<th>Nr. Adults</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10.6</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>31.8</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>53</td>
<td>30</td>
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<td>74.2</td>
<td>40</td>
<td>8</td>
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<tr>
<td>106</td>
<td>50</td>
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**APLICATION #2**

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<th>Metaldehyde (mg a.i..kg⁻¹)</th>
<th>Nr. Juveniles</th>
<th>Nr. Adults</th>
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<td>64</td>
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<td>80</td>
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<td>128</td>
<td>500</td>
<td>100</td>
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</tbody>
</table>

Case Study #2: Pesticides and Climate

AIM: Study how temperature influences the effects of pesticides chlorpyrifos and mancozeb

Usual HAZARD ASSESSMENT: optimum laboratory conditions single chemical exposure

New Approach: Temperature fluctuation and Binary mixtures assessment
Case Study #3: Agro-ecology and Ecosystem Services

AIM: Study agroecosystem services, integrating parameters

Usual HAZARD ASSESSMENT: species toxicity

New Approaches: integrate parameters evaluating soil support, regulation, biodiversity and yield.

INDICATORS
- Soil OM
- Carbon
- Nitrogen
- Soil aggregation
- Photosynthetic capacity
- Radicular system
- Functional Biodiversity
- Microbial Biomass
- Bait-Lamina
- Field traps for invertebrates

SUPORT and REGULATION
- Fertility
- Soil Formation
- Biological Activity
- Disease and Pest control
- Primary Production
- Nitrogen Cycle

YIELD
- Yield
- Sustainability
- Profit

INTEGRATE SEVERAL SERVICES
Case Study #4: Improving Soil Quality

Fertilizers and biochar with or without pesticides

Usual HAZARD ASSESSMENT: No Assessment

New Approach: integrate exposure and assessment
How to deal and integrate chemical mixtures in Environmental Risk?

#1 Constraint...
No specific threshold concentrations for comparison with hazard outputs

Ontario Ministry of the Environment de 2011

#2 Constraint...
Risk Coefficient Calculation on a chemical one-by-one basis
Independently from climacteric conditions, soil type

#3 Constraint...
Risk is Underestimated! Not even additive!
PNEC- Predicted No Effect Concentration

- Based on *hazard assessment and standardized tests*
- Different traits/trophic level-position
- NOEC
- Application of safety factors

HC$_5$- Hazard Concentration 5% species

- Based on *hazard assessment and Species Sensitivity Distribution*
- Number of species (>8)
- NOEC, EC$_{10}$, EC$_{50}$ (lack of data)
- Application of safety factors

**Constraints:**
- long-term tests (compared with water)
- Lack function assessment
- Lack integration
- Lack applied strategy
- Lack of data (reliable data)
**PREDICTED NO EFFECTS CONCENTRATION – PNEC (or HC₅)**

![Mapping risk diagram]

NOEC, EC₁₀, EC₅₀

- **PREDICTED ENVIRONMENTAL CONCENTRATION**
- **MEASURED ENVIRONMENTAL CONCENTRATION**

\[
Risk = \frac{PEC_i}{PNEC_i}
\]
What is Cumulative Risk?

**Cumulative risk** is the combined risks from aggregate exposures to multiple agents or stressors, which may include chemicals, biological or physical agents.

**Cumulative risk assessment (CRA)** is an analysis, characterization, and possible quantification of the combined risks to human health or the environment from multiple agents or stressors.

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Response Addition Method

\[ R_m = \sum_{i=1}^{n} r_i \]

Where:
- \( R_m \) = mixtures risk
- \( n \) = number of components
- \( r_i \) = component risks

Needs to be implemented!
Sustainable Agriculture

http://www.groundswellinternational.org/
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