Mindert die heterogene Kupferverteilung in deutschen Weinbergsböden mögliche Auswirkungen auf die Funktion von Bodenorganismen?

Does the heterogeneous distribution of copper in German vineyard soils reduce potential effects on the functions of soil organisms?

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Copper research at JKI-ÖPV: 2009 to 2014

Behavior and function of soil organisms - Comparison of field and laboratory studies

Soil:
- pedological parameter, metal content and mobility

Earthworm:
- habitat, diversity, copper accumulation

Microorganism:
- sum and activity parameters

Sampling sites
- Vine growing regions:
  - Ahn
  - Baden
  - Franken
  - Hessische Bergstraße
  - Mittelrhein
  - Mosel-Saar-Ruwer
  - Nahe
  - Pfalz
  - Rheingau
  - Rheinhessen
  - Saale-Unstrut
  - Sachsen
  - Württemberg

Nov. 16th/17th, 2017
European Conference on Copper in Plant Protection
Copper distribution per sample point in the field

1. Heterogeneous copper distribution is common.
2. The older a yard, the more often a wide range.

<table>
<thead>
<tr>
<th>Cu_{total}</th>
<th>&lt; 100</th>
<th>100 - 200</th>
<th>&gt; 200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proben</td>
<td>66</td>
<td>34</td>
<td>20</td>
</tr>
<tr>
<td>(n = 120)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Impact on earthworm abundance

1. Copper content and soil type take more influence on endogeic earthworms than anecic species.
2. Juveniles don’t seem more susceptible than adults.
Impact on microorganisms

1. Copper impacts on microorganisms couldn’t be observed.
2. Maybe, microorganisms can adapt and/or tolerate for higher copper contents.
Possible ideas to explain impacts of the heterogeneous copper distribution on soil organisms for risk assessment.

Laboratory biotests for
- earthworms behavior, growth and reproduction
- functions of soil microorganisms
## Biotests in altered soils

<table>
<thead>
<tr>
<th>Code</th>
<th>Soil origin</th>
<th>pH</th>
<th>Me\text{KW} [mg/kg DM]</th>
<th>Me\text{NH4NO3} [mg/kg DM]</th>
<th>Soilt texture [%]</th>
<th>OM [%]</th>
<th>C [%]</th>
<th>N [%]</th>
<th>C/N</th>
<th>KAK [cmol/kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR</td>
<td>vineyard</td>
<td>7.4</td>
<td>80</td>
<td>0.2</td>
<td>Lt3</td>
<td>25</td>
<td>37</td>
<td>38</td>
<td>6.0</td>
<td>1.8</td>
</tr>
<tr>
<td>RH</td>
<td>vineyard</td>
<td>7.4</td>
<td>138</td>
<td>0.4</td>
<td>Lu</td>
<td>15</td>
<td>63</td>
<td>22</td>
<td>5.4</td>
<td>5.8</td>
</tr>
<tr>
<td>MO</td>
<td>vineyard</td>
<td>5.4</td>
<td>368</td>
<td>0.5</td>
<td>Sl4</td>
<td>54</td>
<td>29</td>
<td>17</td>
<td>7.5</td>
<td>2.9</td>
</tr>
<tr>
<td>Hett</td>
<td>arable</td>
<td>6.9</td>
<td>725</td>
<td>16</td>
<td>Ul3</td>
<td>11</td>
<td>70</td>
<td>19</td>
<td>8.2</td>
<td>3.4</td>
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<tr>
<td>DD</td>
<td>arable</td>
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<td>4</td>
<td>0.2</td>
<td>Slu</td>
<td>45</td>
<td>47</td>
<td>8</td>
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<tr>
<td>LB</td>
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<td>24</td>
<td>0.9</td>
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<td>77</td>
<td>14</td>
<td>9</td>
<td>2.5</td>
<td>1.3</td>
</tr>
</tbody>
</table>
Avoidance behavior biotest

*Eisenia andrei*

non-adapted species
Avoidance behavior (Robustness of the test)

Avoidance test: distribution of earthworms in two identical control soils (n = 102)

In $\frac{2}{3}$ of all samples, earthworms were optimal distributed.
Avoidance behavior for “self-protection”

Copper doesn’t kill earthworms!
It chases earthworms from the “stress zone” into the “comfort zone”.
BUT in the fields, this depends on heterogeneous copper distribution.
Relative performance of growth rate of earthworms in copper contaminated soils

1. Growth of earthworms is drastically reduced by copper (and other traits?).
2. There was NO mortality (both on adults and juveniles) observed, even by high copper contents.
Reproduction of earthworms in copper contaminated soils

Similar to the field!  

Reproduction of earthworms is reduced, even by low copper contents.
Growth rate and reproduction after transferring into friendly soil after 4 weeks

Copper impact on growth and reproduction of earthworms is reversible under “comfortable” soil condition.
Relative performance of microbial biomass

[mg C * kg\(^{-1}\) DM]

Microorganism population adapts to high copper contents.
Relative performance of **microbial metabolic quotient** [\(mg \text{ CO}_2-\text{C} \cdot h^{-1} \cdot g^{-1} \text{ C}_{\text{mic}}\)]

Soil conditions (carbon, organic matter content, soil type) take a higher impact on microorganism behavior than copper.
Does the heterogeneous distribution of copper in German vineyard soils reduce potential effects on the functions of soil organisms?

YES!

Heterogeneous copper distribution within a sampling area supports resilience of soil organism populations, because:

- Soil organisms can handle soil copper contents (tolerance, avoidance)
- Earthworm can reproduce in areas with lower copper contents
- Microorganisms don’t show constraints in their function (after decades of living together with copper)

BUT we need…

- Monitoring concepts for endogeic earthworms at areas of higher copper contents (> 200 mg Cu\text{total}/kg)
- Maintain comfort zones at cultivated areas to compensate effects of higher copper areas to soil organisms (for example targeted application technique, site specific management in hot spot areas)
The authors are very grateful to all supporters for assistance in the field and lab. They all did a great job!

Thank you for your attention!