David Spurgeon
Centre for Ecology and Hydrology
Wallingford

A comparison of laboratory vs field effects for non-radioactive pollutants
### Factors influencing toxicity in the field

*(Van Straalen and Denneman, 1989)*

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<th>Increase toxicity in the field</th>
<th>Reduce toxicity in the field</th>
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Factors influencing toxicity in the field

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Studie have shown no effect, additive (according to the principle of response addition) and also interactions. Case by case.

**Additive**

**Synergistic**
Lots of studies of this type

Review

Interactions between effects of environmental chemicals and natural stressors: A review

Martin Holmstrup a,*, Anne-Mette Bindesbøl a, Gertie Janneke Oostingh b, Albert Duschl b, Volker Scheil c, Heinz-R. Köhler c, Susana Loureiro d, Amadeu M.V.M. Soares d, Abel L.G. Ferreira d, Cornelia Kienle c,e, Almut Gerhardt e, Ryszard Laskowski f, Paulina E. Kramarz f, Mark Bayley g, Claus Svendsen h, David J. Spurgeon h

a National Environmental Research Institute, Aarhus University, Department of Terrestrial Ecology, Vejlavej 25, DK-8600 Silkeborg, Denmark
b Department of Molecular Biology, University of Salzburg, Hellbrunner Strasse 34, A-5020 Salzburg, Austria
c Animal Physiological Ecology, Institute of Evolution and Ecology, University of Tübingen, Konrad-Adenauer-Str. 20, D-72072 Tübingen, Germany
d Department of Biology & CESAM, University of Aveiro, 3810-193 Aveiro, Portugal
e LimCo International, Oststrasse 24, 40477 Idenburg, Germany
f Institute of Environmental Sciences, Jagiellonian University, Grudziadzka 7, 30-387 Kraków, Poland
g Zoophysiology, Department of Biological Sciences, Aarhus University, Building 131, DK-8000 Aarhus C, Denmark
h Centre for Ecology and Hydrology, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, Oxon, OX10 8BB, United Kingdom

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ABSTRACT

Ecotoxicological effect studies often expose test organisms under optimal environmental conditions. However, organisms in their natural settings rarely experience optimal conditions. On the contrary, during most of their lifetime they are forced to cope with sub-optimal conditions and occasionally with severe environmental stress. Interactions between the effects of a natural stressor and a toxicant can sometimes result in greater effects than expected from either of the stress types alone. The aim of the present review is to provide a synthesis of existing knowledge on the interactions between effects of “natural” and chemical (anthropogenic) stressors. More than 150 studies were evaluated covering stressors including heat, cold, desiccation, oxygen depletion, pathogens and immunomodulatory factors combined with a variety of environmental pollutants. This evaluation revealed that synergistic interactions between the effects of various natural stressors and toxicants are not uncommon phenomena. Thus, synergistic interactions were reported in more than 50% of the available studies on these interactions. Antagonistic interactions were also detected, but in fewer cases. Interestingly, about 70% of the tested chemicals were found to compromise the immune system of humans as
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Based on the assumption that toxicity is time dependent

- Time dependence based on assumption that body concentrations increases with time

- So time dependent patterns in body concentration give insight into effects of exposure duration
Metal uptake *Eisenia fetida* in field soil

Non-essential metals

- Cadmium
- Lead

- Low rates of elimination
- Body burden is time dependent

Essential metals

- Copper
- Zinc

- High rates of elimination
- Body burden only time dependent over 7 days
Time dependence of toxicity

Dimethoate

Clothianidin

Cadmium

Arsenic

Propiconazole

Center for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL
Time dependence of toxicity

**Dimethoate**

**Clothianidin**

**Cadmium**

**Arsenic**

**Propiconazole**
Does long-term increase toxic effects in the field

Yes, but extent chemical dependent

Need time series data
Pollution is persistent
Multigenerational change in sensitivity?
Multigenerational change in sensitivity?
## Multigenerational change in sensitivity?

<table>
<thead>
<tr>
<th>Species</th>
<th>Chemical</th>
<th>Generations</th>
<th>Observed phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. elegans</em></td>
<td>Gamma radiation</td>
<td>P-F2</td>
<td>Greater reproduction effects in multigenerationally and transgenerationally exposed F2s than P generation</td>
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<tr>
<td><em>D. magna</em></td>
<td>Gamma</td>
<td>P-F2</td>
<td>Toxicity on multiple traits increased from P to F2</td>
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<tr>
<td><em>D. magna</em></td>
<td>Americium</td>
<td>P-F2</td>
<td>Threshold for effects on reproduction reduced from 1.5 mGyh(^{-1}) in P generation to 0.3 mGyh(^{-1}) in F2 and F3</td>
</tr>
<tr>
<td><em>D. magna</em></td>
<td>Uranium</td>
<td>P-F1</td>
<td>Greater reduction in fecundity in F1 than P at 50 μg/L</td>
</tr>
<tr>
<td><em>D. magna</em></td>
<td>Nickel</td>
<td>P-F1</td>
<td>Greater reduction of ATP levels in F1 compared to P</td>
</tr>
<tr>
<td><em>C. elegans</em></td>
<td>Ag nanoparticles</td>
<td>P-F10</td>
<td>Greater (10 fold) sensitivity in F2, F5, F8 and F10 generations compared to P generation</td>
</tr>
<tr>
<td><em>D. magna</em></td>
<td>Ag nanoparticles</td>
<td>P-F10</td>
<td>Population growth rate at 10 μg/L reduced by 80% in F2s compared to 21% in P generation</td>
</tr>
<tr>
<td><em>D. magna</em></td>
<td>Penta-chlorophnol</td>
<td>P-F3</td>
<td>Population growth rate reduction increases from 28.2% to 34.9% to 46.3% in P, F1, F2 generations</td>
</tr>
<tr>
<td><em>D. magna</em></td>
<td>Tetracyclin</td>
<td>P-F1</td>
<td>NOEC decreased from 5 mg/L to 0.1 mg/L from P to F3</td>
</tr>
<tr>
<td><em>D. magna</em></td>
<td>Enrofloxacin</td>
<td>P-F1</td>
<td>Reproduction NOEC decreased from 30 mg/L to 3.1 mg/L from P to F1 generation</td>
</tr>
</tbody>
</table>
• Body concentration are time dependent: more so for some chemicals than others

• Effect of exposure time on sensitivity is time dependent: more so for some chemicals than others

• Multigenerational exposure can lead to greater effects: widely reported in the literature - but beware publication bias (and what about adaptation long-term)!
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Exposed worms to

1. A field contaminated by smelter emissions over many decades

2. A laboratory soil containing the same concentrations of metals added as a solution of the nitrate salt as in a standard lab test.
Field vs spike bioavailability

![Graph showing % Survival vs Zinc concentration for Field soil and Spiked soil. The graph indicates a sharp decrease in % Survival for Spiked soil at high Zinc concentrations.]
Field vs spike bioavailability

Now part of EU policy

3 fold lab - field extrapolation factor in metals risk assessment
## Factors influencing toxicity in the field

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*Lumbricus rubellus* exposed to As - 6 populations

- Rapid mortality of the naive population and partial mortality of on-site controls
- High survival of most polluted population.
- Tolerance is conserved over 2 generation - genetic basis.
**Lumbricus rubellus** exposed to Zn - 3 populations

Significant differences in the shapes of the dose response curves

Toxicity (as EC$_{50}$) lowest in reference population

Considering site exposure histories, difference is small
For Arsenic
Evidence of development of genetic adaptation.

For Zinc
No clear evidence of substantial adaptation for polluted site populations even after 400 years exposure. EC$_{50}$s similar for the three populations.
Adaptation reduces observed toxicity in the field?

Not necessarily. Evidence of adaptation for some pollutants but not all.
EXTRAPOLATION FACTORS - CONCLUSIONS

**Increases toxicity in field**

Exposure to non-optimal conditions increases field toxicity - can depend on factor and the extent of change.

Mixed stressor increase effects - additive and can be synergistic.

Long-term exposure in the field increases toxicity in the field - chemical dependent.

**Reduces toxicity in field**

Lower availability reduces toxicity in the field - lab to field comparative work indicates this is important.

Adaptation reduces effect - not in all cases.
OVERALL CONCLUSION

Not always simple relationships.
Need to think in the context of the biology of the stressor and species being considered
Mechanistic info valuable.
It's Over