Using higher-tier data in the nickel terrestrial effects assessment: reducing residual uncertainty?

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Introduction

The terrestrial risk assessments of nickel under both the ESR Programme (EC 2008) and REACH identified the absence of higher tier data for nickel effects in the field as a source of potential uncertainty in the effects assessment. However, since these assessments were made field-based terrestrial ecotoxcity data have become available at nickel ore processing sites in Canada impacted by a mixture of current and historic emissions. In this poster we provide an assessment of these data from one site, and one study at Port Colborne, Ontario, to provide an illustration of the similarities and differences between laboratory-spiked and field-contaminated effects for nickel for similar tests.

Methods

The Port Colborne site is located on the north shore of Lake Erie and was the location of a nickel refinery that operated from 1918-1995. Surrounding soils, especially downwind of the refinery, received considerable inputs of aerial particulate material, primarily in the form of Ni-Fe oxides and hydroxides, but also copper, cobalt and sulphur. It is reasonable to consider that the metals in these soils are well aged. Dan et al. (2008) identified four key soil types in the area, however the data from only three have been presented here (the last soil was had > 80% organic matter). Also identified by these authors were corresponding soil types, but outside the area of aerial deposition, so without elevated metal concentrations (Table 1). These control soils were used to develop a range of doses of nickel exposures for pot trials. Oats (*Avena sativa* L.) where grown in these pots for 70 days and the final endpoint assessed was that of shoot dry weight.

These data, along with those for the same species, used in the ESR and for the REACH registration, albeit slightly different endpoints, are shown in Table 2. Through the normalisation of these data all to one soil type using relationships based on soil properties, and specifically eCEC, developed in the ESR (EC 2008) it is possible to compare the effects of nickel from laboratory nickel chloride spiked soils to those receiving relevant anthropogenic nickel inputs in the field.

Table 1: Selected physico-chemical properties of the Port Colborne soils and respective controls as used by Dan et al. (2008) in the pot trials.

Soil	Concentrations in mg/kg			eCEC (meq/100 g)	Total C (%)	pH
	Nickel	Copper	Cobalt			
Sand	3920	446	80	12	5.0	6.9
Sand Control	46	14	2	5	3.5	6.9
Clay	2545	338	47	15	16	6.5
Clay Control	51	17	7	12	6	5.7
Heavy Clay	8655	1026	120	63	8.5	6.2
Heavy Clay Control	45	18	4	14	6.5	5.8

Normalising nickel plant effect concentrations.

The methodology to undertake the normalisation process is outlined in Smolders et al. (2009) and uses the relationship specifically developed for nickel and monocotyledon plants ($\log[Ni] = 1.12 \log eCEC + 1.57$). Effectively, this normalisation process is equivalent to undertaking all of the testing in the same soil, and so should remove the inter-test variability due to soil factors. The data shown in Table 2 were normalised to the Dutch Loamy Soil type from the ESR (pH 7.5, eCEC 20.5, clay content 26%).

Table 2: Data used for comparison exercise, pink cells are the laboratory generated soluble nickel salt spiked soils and the green cells are the data generated by Dan et al. (2008), using field-contaminated soils from Port Colborne.

Test	Endpoint	Value (mg/kg)	pH	eCEC (meq/100 g)	OC (%)	Cb (mg/kg)	Reference
Straw yield	EC10	47	6.4	6.0	0.81	14	Halstead et al. 1969
Straw yield	EC10	53	6.1	6.0	0.81	14	Halstead et al. 1969
Straw yield	EC10	49	5.7	11.9	2.38	14	Halstead et al. 1969
Yield	N0EC	80	7.5	14.6	1.34	8.0	Liang and Schoenau 1995
Shoot dry weight	EC10	874	7.3	5	3.5	46	Dan et al. 2008;
Shoot dry weight	EC10	1540	5.8	12	6	51	Dan et al. 2008;
Shoot dry weight	EC10	1840	6.2	14	6.5	45	Dan et al. 2008;

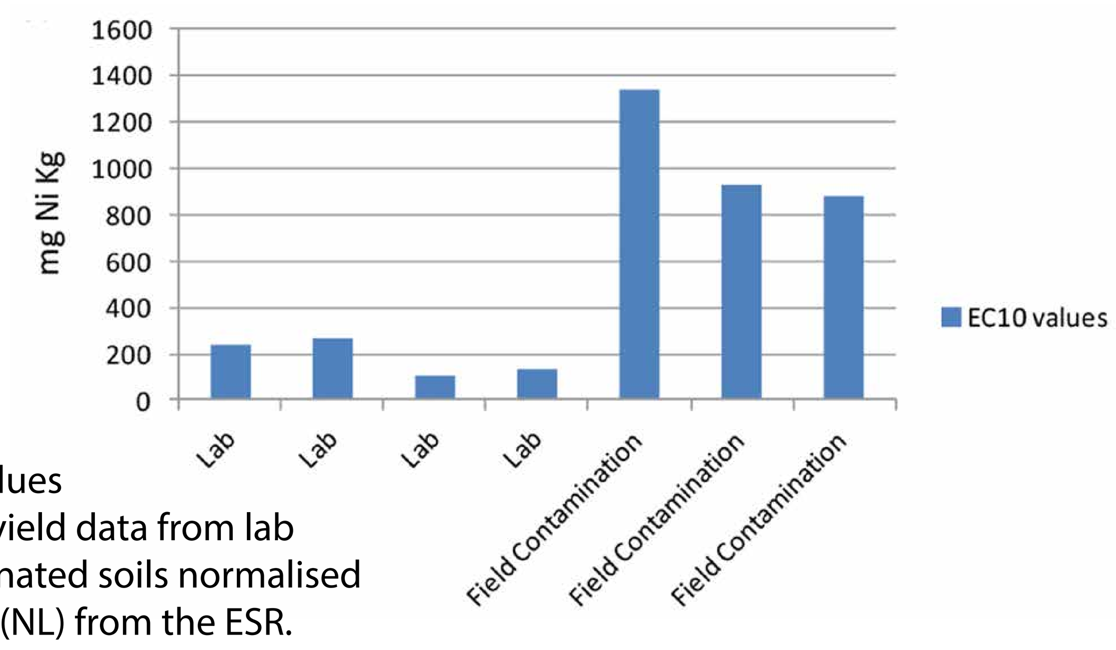

Figure 1: EC10 values for the oat shoot yield data from lab and field contaminated soils normalised to the Loamy Soil (NL) from the ESR.

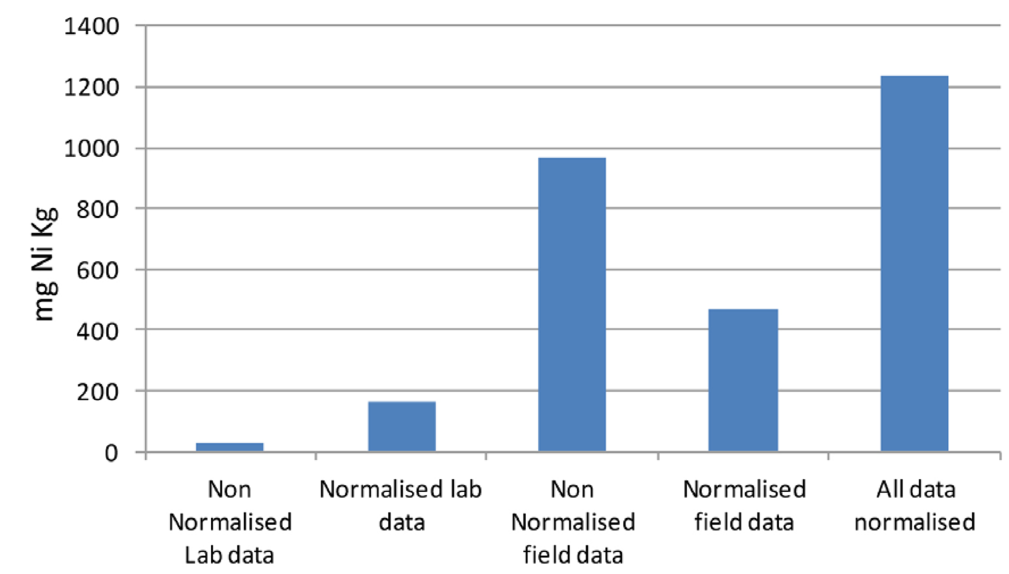

Figure 2: Comparison of differences between the maximum and minimum ECx values of nickel for oats in laboratory spiked and field contaminated data.

Results

- The nickel effects data shown in Table 2 from the laboratory spiked soils are at least an order of magnitude less than those from the anthropogenic nickel contaminated soils .
- The influence of normalising these data to one soil type, still results in a considerable difference between the effects of nickel on oat yield metrics when using soluble salts or aerially deposited nickel particulate material from the smelting and processing of sulphurous ores.
- The variability in the effects seen for the field contaminated data is reduced post normalisation, where as that for the laboratory tests shows an increase.
- Figure 2 shows the ratio between the maximum and minimum concentrations for the lab and field data, pre and post normalisation. This figure indicates that for the laboratory data there is an increase in variability when the soil properties are accounted for, but a dramatic reduction in variability in the field data.
- The difference between the maximum and minimum values of non-normalised EC10s in the field contaminated soils is nearly 36 times more than that for the laboratory spiked soils.
- Following normalisation this difference falls to just three times. However, when the normalised data are combined the greatest difference is seen for the maximum and minimum EC10 values.

Challenges of using higher-tier and field data

- The effects shown on oat yield in the field-contaminated nickel data are considerably less that those from the laboratory generated effects data for the same species.
- The normalisation relationships developed for nickel during the ESR are based upon the behaviour of nickel salts, not the anthropogenically sourced nickel. These relationships seem to hold, for the aerially deposited nickel particulate material as indicated by Figure 2.
- The endpoints in the ecotoxicity data from the laboratory tests, specifically straw yield, are probably comparable to dry matter yield in the Dan et al. (2008) study, but they are not the same. All studies were conducted over extended periods and the nickel in these experiments can be considered aged. However, this is likely to be a commonly encountered challenge in field studies when trying to link back to equivalent laboratory generated data.
- The effects concentrations in the field contamination soil reflect exposures to nickel, but also other trace elements that could also be considered to reduce the effect concentrations (Table 1).
- Interpretation of higher-tier data, such as presented here, needs to be undertaken as part of weight of evidence approach. Often these types of data have not been generated for the purpose of risk assessment, and therefore need to be viewed in a broad and pragmatic context.

References

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Conclusions

- Effects data generated using soils that have been exposed to nickel typical of field-contaminated situations show considerably less toxicity than those effects data generated in soils spiked with soluble nickel salts for the same plant species.
- The form of nickel from the anthropogenic, but typical, emissions likely influences the bioavailability of the nickel to soil dwelling organisms and indicates that field effects are over predicted using laboratory generated soluble nickel spiked test data.
- These data, and those from other sites historically contaminated predominantly with nickel can be considered to indicate a reduction in the regulatory certainty associated with the current terrestrial effects assessment.

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