A field-based approach to linking biological responses of freshwater organisms to sediment contamination by metals

J Iwan Jones[1], John F Murphy[1], Adrian L Collins[2], Kate Spencer[1], Philip S Rainbow[3], Abby Moorhouse[4], Victor Aguillera[5], Paul Edwards[6], Hugh Potter[7], Paul Whitehouse[7]

[1]Queen Mary University of London, London E1 4NS, UK
[2]Rothamsted Research, North Wyke, Okehampton EX20 2SB, UK
[3]Natural History Museum, Cromwell Rd, London SW7 5BD, UK
[4]The Coal Authority, Mansfield, Nottinghamshire, NG18 4RG, UK
[5]Defra, Nobel House, 17 Smith Square, London, SW1P 3JR, UK
[6]Natural Resources Wales, Cambria House, 29 Newport Road, Cardiff, CF24 0TP, UK
[7]Environment Agency, Horizon House, Deanery Road, Bristol, BS1 5AH

Phone: +00-(44)-1929-401892
E-mail: j.i.jones@qmul.ac.uk

Introduction: Whilst controlled ecotoxicity studies in the laboratory can provide an indication of the sensitivity of biota to polluted sediments, it can be difficult to relate this to the response of organisms in the field. In the field a variety of factors influence the uptake of contaminants, such as metals, from the sediment by biota. These can be difficult to accommodate in deriving environmental limits that are relevant to field conditions. Here we have used a data-intense, correlative approach to determine the response of aquatic biota to field estimates of the metal content of river sediments.

Methods: Using data from the British Geological Survey's Geochemical Baselines Survey of the Environment (G-BASE) describing stream sediments in England and Wales, 2833 river reaches were matched, spatially and temporally, to Environment Agency monitoring data describing the biological quality elements (BQEs) diatoms, macrophytes, invertebrates and fish.
A threshold biological response to sediment metal concentration is expected as the toxic effects of trace metals are not expected to occur until the uptake rate exceeds the combined rates of efflux and detoxification [1]. Where sediment metal concentrations are below the toxic threshold, other factors could potentially influence the biological response. To estimate a threshold concentration below which no adverse effects are seen, quantile regression was used to model the 95%ile biological response to sediment metal concentrations of antimony, arsenic, cadmium, chromium, copper, iron, lead, nickel, silver, tin and zinc.

Results: Indices based on the number of taxa showed the best responses to sediment metal concentrations. However, there were considerable differences in sensitivity across the BQEs. The rank order from most sensitive to least sensitive was diatoms > invertebrates > fish > macrophytes. Thresholds derived from this study were compared to existing sediment quality guidelines.

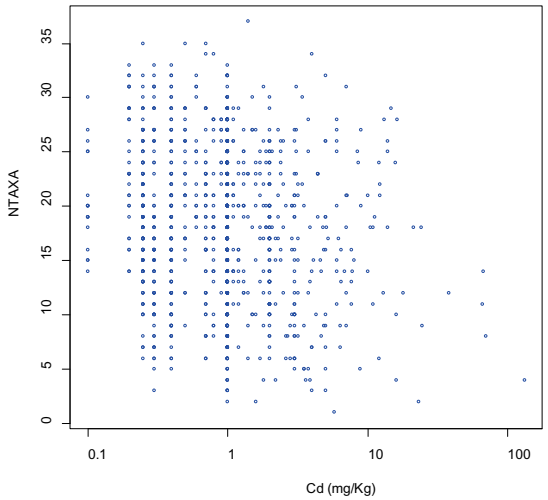

Fig. 1: *Threshold response of invertebrate NTAXA to sediment Cd concentration from matched field sites across England and Wales (red dashed line – Canadian interim EQS, yellow dotted line – ANZECC and ARMCANZ low trigger value, black dot dashed line – 95%ile threshold)*

Discussion: Our findings based on field data suggest that existing sediment quality guidelines may be too stringent, at least for fish and invertebrates. Further work is underway to understand biotic responses to sediment metal concentrations more precisely, where we are linking field determinations of metal uptake to the abundance of sensitive taxa to establish thresholds for metals based on bioavailability.

Acknowledgements
We are grateful for access to the various data sources used to produce this work. This work is funded by Defra through project WT0970 Characterisation and targeting of measures for (non-coal) polluted mine waters – Impacts of contaminated sediment on ecological recovery.

References: [1] Luoma & Rainbow (2008). *Metal Contamination in Aquatic Environments: Science and Lateral Management.* CUP