The chemical quality of urban soils in Glasgow, UK, with reference to anthropogenic impacts and current toxicologically-based soil guideline values.

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1. Introduction

Until recently systematic data on the chemical quality of urban soils was lacking in many countries as traditional soil survey programmes focussed on rural environments and avoided urban areas. The advent of environmental protection legislation in the UK in the 1990s and drivers to reutilise brownfield sites for development prompted a need for urban soil quality information to aid sustainable planning and urban regeneration and create healty environments. Since 1992, the British Geological Survey (BGS) has completed urban soil surveys in 27 United Kingdom (UK) cities as part of the national Geochemical Baseline Survey of the Environment (G-BASE) Project[1,2,3]. This includes a survey of the Glasgow urban and surrounding rural areas to link to a wider geoenvironmental assessment that the BGS is carrying out in the region - the Clyde and Glasgow Urban Super Project (CUSP)[4]. Glasgow is Scotland's largest city and was a major centre of heavy engineering and industrialisation until the mid 20th century. Much of this industry has now declined leaving tracts of derelict/brownfield land, which are gradually being regenerated. The G-BASE survey provides an overview of land quality in Glasgow and the results have a variety of applications to environmental quality assessments including greater understanding of the impacts of anthropogenic pollution and potential threats to ecoystems and human health.

2. Materials and methods

The G-BASE Glagsow soil survey collected 1381 urban and 241 rural soils from the urban perhiphery. The latter were sampled to establish the normal or geological background chemical element concentrations around the city. Samples were collected on a systematic grid at a sample density of 1 per 2 km^2 in rural and 4 per km^2 in urban areas respectively. The survey covered the main conurbation of Glagsow as well as the urban areas of East Kilbride, Paisley, Renfrew, Johnstone and Dumbarton. At each sample location, a top (5 – 20 cm) and deeper (35 – 50 cm) soil were collected by hand-held Dutch auger. Each sample comprised a composite of five sub-samples collected from the centre and corner of a 20-m square. Samples were air and oven dried at < 30°C to avoid volatilisation of Se and sieved to <2 mm. The samples were analysed for total concentrations of approximately 50 inorganic chemical elements by X-ray fluorescence spectrometry according to standard G-BASE procedures[5,6]. This included the concentrations of potentially harmful metals of concern under current UK environmental protection legislation such as As, Cd, Cu, Cr, Pb, Ni, Se and Zn[7,8].

3. Results and discussion

The results of the Glasgow soil survey reveal that despite many decades since the major decline in heavy industry and numerous regeneration programmes, the industrial legacy remains. The concentrations of many metals are elevated in urban soils relative to the rural background regardless of the geological parent material (Figure 1). Elements that occur in nature in trace amounts in most environments but that are associated with urban and industrial sources (waste, construction, trasnportation, power generation, industry etc.) such as Cu, Mo, Ni, Pb, Sb, Sn and Zn show greatest enrichment in urban versus rural soils (2.6 – 3.3 times, based on median values). Calcium is similarly enhanced in urban versus rural soils and along with these other metals is elevated in soils developed over made ground versus non-made ground reflecting the calcarous nature of many fill materials such as concrete. This is a typical indicator suite of elements that is symptomatic of urban anthropogenic pollution found not only in Glasgow but in other cities surveyed by the G-BASE project[6].

Median topsoil Cr (108 mg kg^{-1}) and Ni (47 mg kg^{-1}) concentrations in Glasgow are higher than in many other UK cities due to the presence of volcanic bedrock in the area as well as the history of metal processing in the city. Until 1968, Glasgow was home to the world's largest chromite ore processing plant and Cr-waste was

dispersed across the city. In contrast, median top-soil Pb (127 mg kg^{-1}) concentrations are similar and As (9.2 mg kg^{-1}) and Cd (0.25 mg kg^{-1}) concentrations are low relative to those in other UK cities [6].

In terms of toxicologically-based soil quality assessments, with the exception of Cr, only a small proportion of soils exceed the current UK human Contaminated Land Exposure Assessment (CLEA) residential Soil Guideline Values (SGV)[8] despite the city's industrial heritage – Cr (22%), Pb (5%), As, Cd, Ni (2%) and Se (0%). Of these only approximately 10 are garden soils. However, a much greater proporton exceed the proposed UK Ecotoxicity Soil Screeing Values SSV[7] – Cr (100%), Ni (94%), Zn (86%), Pb (30%), Cu (17%) and Cd (4%). The high proportion of Glasgow soils that exceed the SSVs is a consequence of the low concentrations at which the SSVs are set rather than a reflection of very poor soil quality in Glasgow *per se*. Only a small number of soils lie within nature conservation areas to which the SSVs refer, nonetheless, the G-BASE data allow these thresholds to be assessed in terms of typical soil element abundances to aid ecotoxicological assessments and inform policy.

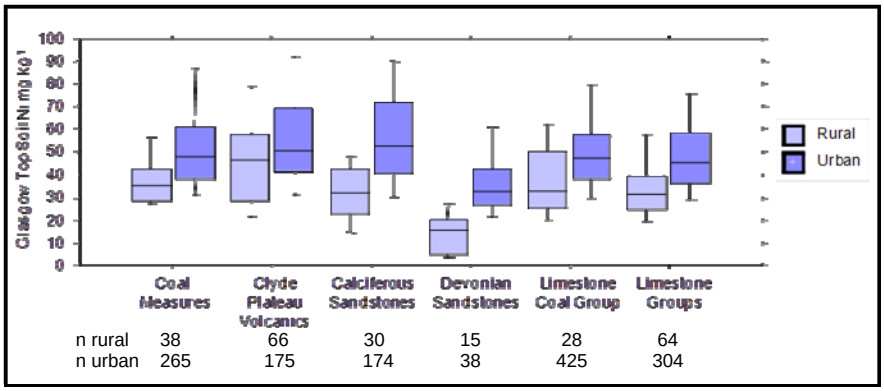

Figure 1: Example of higher soil metal concentrations in Glasgow urban versus rural soils over different geological soil parent materials. Box and whisker plot shows the 10th, 25th, 50th, 75th and 90th percentiles of Ni concentrations in topsoils.

4. Conclusions

The G-BASE Glasgow soil results demonstrate the extent of increased metal concentrations in urban relative to rural soils and quantify the effect of anthropogenic activity on environmental quality. With growing concerns about the ecological and human health impact of potentially harmful metals in the environment, such data are a valuable tool to aid the understanding of soil-ecology-health systems for environmental protection.

5. References

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