Dreaming of Sustainable Urban Ecosystems: resilience of garden, park and forests soils in contaminated landscapes

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Synopsis

The pressure on urban ecosystems to function under increased urban development is a widely appreciated factor in modern urban management. However the beneficial impacts from "nature based solutions" NBS are difficult to untangle when it comes directly to human health beyond the direct mechanism of exposure to potentially harmful substances. In some situations it appears that our traditional approach to remediation through development can clash with ecosystem principles and sustainability is widely used but seldom confirmed. At the centre of the story are soil services performed under natural conditions or formed synthetically in response to urban disruption. Green space is the key land uses where human interaction is most intense and is a strong component for development of NBS in the future. This presentation will review aspects of soil quality as part of international studies on the resilience and use of urban soils, highlighting lessons from marginal land, public open spaces and woodland as part of our pursuit of reliable and resilient urban infrastructure.

Biography

Professor Andrew Hursthouse obtained his Ph.D. in Environmental Radioactivity at the University of Glasgow in 1989. He is professor of Environmental Geochemistry at the University of the West of Scotland (UWS) with over 30 years' experience applying an earth-systems approach to research which covers the transport/behaviour of pollutants in the environment (air quality, land degradation and remediation, and aquatic biogeochemistry), evaluating their impact on ecosystems and for human health. He holds a high-end expert fellowship at the Regional Key Laboratory for Shale Gas Exploitation, Hunan University of Science & Technology, Xiangtan, China. He is a Trustee of Environmental Protection Scotland (http://www.ep-scotland.org.uk/) and Past President of the Society for Environmental Geochemistry & Health (www.segh.net).

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Summary points from presentation to the Central Scotland group of the Geological Society

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Why consider urban soils?

- Planning & management of urban systems + link to health and "well being"
- They are "unusual" – outside normal domains
- Support the risk assessment of land contamination
- e.g. delineation of areas of concern for remediation
- Future legislation
- Increase "function" & ESS context

Associations between Soil Lead and Childhood Blood Lead in Urban New Orleans and Rural Lafourche Parish of Louisiana, Meikle et al, Environmental Health Perspectives Volume 105, Number 9, September 1997

Ecosystem services and nature based solutions

- Supporting; provisioning, regulating and cultural services
- Ecological balance, community self reliance, participatory democracy – sustainable human settlement.
- Soil and water demands
- Productivity for green infrastructure

What are urban soils?

- normal soils + "additions"
- Location defined, not structure
- Likely to change?

Temporal trends in impact?

Heavy-metal accumulation trends in Yixing, China: an area of rapid economic development Wu et al, Environ Earth Sci (2010) 61:79–86

Mercury in urban soils: A comparison of local spatial variability in six European cities , Rodrigues et al, Science of the Total Environment 368 (2006) 926–936

- Variability of urban soils – URBSOIL
- HgT , central parkland, 6 European cities, 25m (regular!) spacing,

- Impact of the city on the soil

The influence of a large city on some soil properties and metals content, Biasioli et al, Science of the Total Environment 356 (2006) 154– 164

Urban soil variability

- Typical chemical influences on soil properties e.g. Glasgow v Aveiro:
- 3-4 distinct factors (each = 30-10% of variance in PCA)
- POLLUTION: Cu, Pb (Zn, Cr and Organic matter)
- URBAN INPUTS: pH + Ca
- PARENT MATERIALS - Ni, Al, Cr, Fe,
- TEXTURE

Land use (gardens, public open space, riverside, roadside) show some "special" contributions, with general chemical features the same

Rodrigues et al, Environ Chem Lett (2009) 7:141–148

Urbanisation & Forests

- Green infrastructure in the urban ecosystem provides valuable contributions to buffering environments and improving public health and well-being
- The impact of urbanization on soils is becoming clearly established but information on soil function effects relatively poorly addressed
- The resilience of green infrastructure to urbanization needs to be understood – particularly increased and changing loading from harmful substances e.g. potentially toxic elements (PTEs), and the biologically available components

- Preliminary assessment of the relationship between soil and urban forest properties, mobile forms of PTEs and biomass accumulation (C-stock)

Miglena Zhiyanski, Andrew Hursthouse, Svetla Doncheva (2015) Role of different components of urban and peri-urban forests to store carbon – a case-study of the Sandanski region, Bulgaria, Jour Chem Biol Phys Sci; Section D; May 2015 – July 2015,Vol. 5, No. 3; 3114-3128.

Forest Soils: proportion (% of total) mobile PTEs Urban (U) v rural (R) soils

- Totals – within previous range for urban open spaces
- Mobility:
- Cd > Pb ≥ Zn > Cu
- Urban>Rural

Vania Doichinova, Miglena Zhiyanski, Andrew Hursthouse, Jaume Bech, (2014) Study on the mobility and bioavailability of PTEs in soils from Urban Forest Parks in Sofia, Bulgaria, Journal of Geochemical Exploration, Volume 147 (B) pages 222-228.

Relationships between mobile forms of PTE and concentration in soils, assimilative organs and tree health

- fine roots accumulate more PTEs and play role as a barrier for the transfer of these elements from soil to aboveground plant organs.
- Pb and Cd have higher concentration in the leaves of Urban Parks in comparison with rural.

- PCA of soil properties for urban and non urban forest soils highlight:
- association of N with CEC,
- bulk density and depth
- With land use included, little difference seen for associations
- statistically significant ($p<0.0001$) differences in forest floor carbon stock are seen for urban v non urban forest soils

- forest floor Carbon stock in forest floor layers accumulation estimated between 2.82 -7.49 t C/ha
- urban forest parks < non-urban controls

- Soil Carbon stock in urban forests 44-125 tC/ha v non urban 32-103:
- higher variability with depth than controls,
- enhanced by higher bulk density
- Some evidence of urban impacts within data sets – particularly within urban sites in Sofia.

- Above ground biomass carbon stock : urban = 34.5 - 61.7 tC/ha v non urban 33.9 - 67 tC/ha
- urban sites< non urban – due to tree density

Urban allotments

Urban Allotment Gardens in Europe, Edited by Simon Bell, Runrid Fox-Kämper, Nazila Keshavarz, Mary Benson, Silvio Caputo, Susan Noori, Annette Voigt, Routledge ISBN: 978-1-138-92109-2 (2016)

- *Chapter 7. Lessons Learned: Indicators and Good Practice for an Environmentally Friendly Urban Garden Annette Voigt, Teresa E. Leitão, Andrew S. Hursthouse, Ari Jokinen, Avigail Heller, Monika Latkowska, Paulo Brito da Luz, Yvonne Christ, Béatrice Béchet, Mart Külvik and Johannes Langemeyer*
- *Chapter 6. Environmental Pressures on and the Status of Urban Allotments, Andrew S. Hursthouse and Teresa E. Leitão*
- *Chapter 5. Ecosystem Services from Urban Gardens, Andrew S. Hursthouse, Teresa E. Leitão, Annette Voigt, Avigail Heller, Béatrice Bechet and Paulo Brito da Luz*

http://www.urbanallotments.eu/

- A space and a place….
- Rising trend across Europe - Planning and public interest – 3 million AGs in Europe
- Potential to improve human well-being, health & recreation
- Provisioning and regulating ecosystem services, wide range of conditions, policy and regulations
- Diverse pressures on environmental quality (contamination)
- Poorly understood “user” behaviour to help with planning and management decisions

- Diverse historical reasons from 1700’s to 2000’s
- Conflict, economic blight, transport/communication, cultural variation
- Northern & Western Europe, Mediterranean and Eastern Europe contrasts
- Formal planning process, regulations and guidance
- Spontaneous, reactionary
- Soil quality status – residual accumulation of “time” and “place” within local historical context

Human Health Risk assessment and urban allotments

- Urban residues - Soil-plant-human/soil-human transfer driven
- plants a barrier to accumulation of pollutants
- Exposure through ingestion, inhalation, contact with soil
- Modelled transfer factors and exposure assessment related to health impact end points
- Difficult to describe likely exposures or validate modelled results
- Can we improve our understanding of site behaviour to put assessments in the right context?

Impacts of User's Behavior

- insufficient sanitation → threat to groundwater
- activities such as the burning of garden waste

Gardens as sources of invasive species

Soil contamination – a reflection of urban and industrial development

Background geological contributions

Béatrice Bechet, Sophie Joimel, Liliane Jean-Soro, Andrew Hursthouse, Alaba Agboola, Teresa E. Leitão, Hugo Costa, Maria do Rosário Cameira, Cécile Le Guern, Christophe Schwartz, Thierry Lebeau. (2018) Spatial variability of trace elements in allotment gardens of four European cities: assessments at city, garden, and plot scale, J Soils Sediments. 18(2), 391-406 doi:10.1007/s11368-016-1515-1,

- across site variability

Vegetable Transfer factors

- Generally low, TFs consistent for plant type
- Lower TF as soil [metal] incr
- Similar effect with bioavailable fractions

Defining human activity in urban allotment gardens

- Cross European understanding
- Pilot study in Austria, Poland, Estonia, Scotland & Portugal
- Parallel development of questionnaire and recruitment of participants

Annette Voigt, Monika J. Latkowska, Lidia Poniży, Andrzej Mizgajski, Jürgen Breuste, Andrew Hursthouse, Mart Külvik, Teresa Leitao, Kathrin Haas, Martina Artmann, Aleksandra Rutecka, Alaba Joshua Agboola, Alan Olonen, Hugo Costa, (2015) Environmental Behaviour Of Urban Allotment Gardeners In Europe Peer Reviewed Proceedings ECLAS 2015 Conference: Landscapes In Flux, pp78-82; ISBN: 978-9949-536-97-9.*

- What have you changed in the last few years?
- More lawn space, flowers …..fewer vegetable patches
- What do you do to improve soil?
- Organic compost, manure
- Chalk, mineral fertilizers, N, P
- Why consume products?
- Quality/taste, healthier, financial, fun (…..I don't!)

- Pesticide use

- Disputes over produce – thefts, poisoning
- Noise and disruption – gardening when drunk!
- Drift of pesticide spray onto organic plots

- Keeping large animals
- Contravening usage “rules” …….flowers not vegetables!
- Destroying other’s crops
- Waiting lists >20 years (UK)

Informal Urban Agriculture - The Secret Lives of Guerrilla Gardeners Authors: Hardman, Michael, Larkham, Peter, Springer 2014 ISBN 978-3-319-09534-9

The Changing face of urban allotments?

- Aging population – health benefits but intensity of activity decreasing
- Financial motivation for younger participants
- Innovative management to meet urban space and climate change challenges
- Unconventional use of urban space