Challenges and Opportunities of Building a Collaborative Chemicals Biomonitoring Framework Today, for the Chemicals of Tomorrow

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Abstract summary

A proposed collaborative terrestrial chemicals biomonitoring framework for England is presented, as part of a shared mission to achieve a common vision and aims. The Natural England vision is that "*Biodiversity is protected and enhanced through the way chemicals are approved, regulated, managed and monitored"*. The shared aims are:

Aim 1: Deliver "fit for purpose terrestrial chemicals monitoring and indicators" that are representative of direct and indirect, lethal and sublethal effects, for multiple trophic levels, over a landscape and decadal temporal scale.

Aim 2: Build a system that enables chemicals and environmental risks horizon scanning and effects-based early warning systems.

Hypotheses

H1: There is a temporal trend in exposure as measured by media and tissue concentrations;
H2: "X" proportion of samples have contaminant residues that exceed a threshold of concern;
H3: There are adverse effects related to contaminant exposure in the receptor (species or media).

Regulatory context

There is a need for chemical monitoring data, as well as exposure and effects indicators in the terrestrial environment to inform evidence-based decision making on policy, regulation, and nature conservation. In the UK, monitoring of chemicals in the freshwater and marine environment are legislated for under the Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD). There is, however, a lack of a regulatory framework to deliver a government operated and funded integrated chemical monitoring programme for the terrestrial environment. A partnership approach has been developed to meet the data needs (Fig. 1).

Figure 1. Approach to a collaborative Gov-NGO terrestrial biomonitoring framework [2,3] .

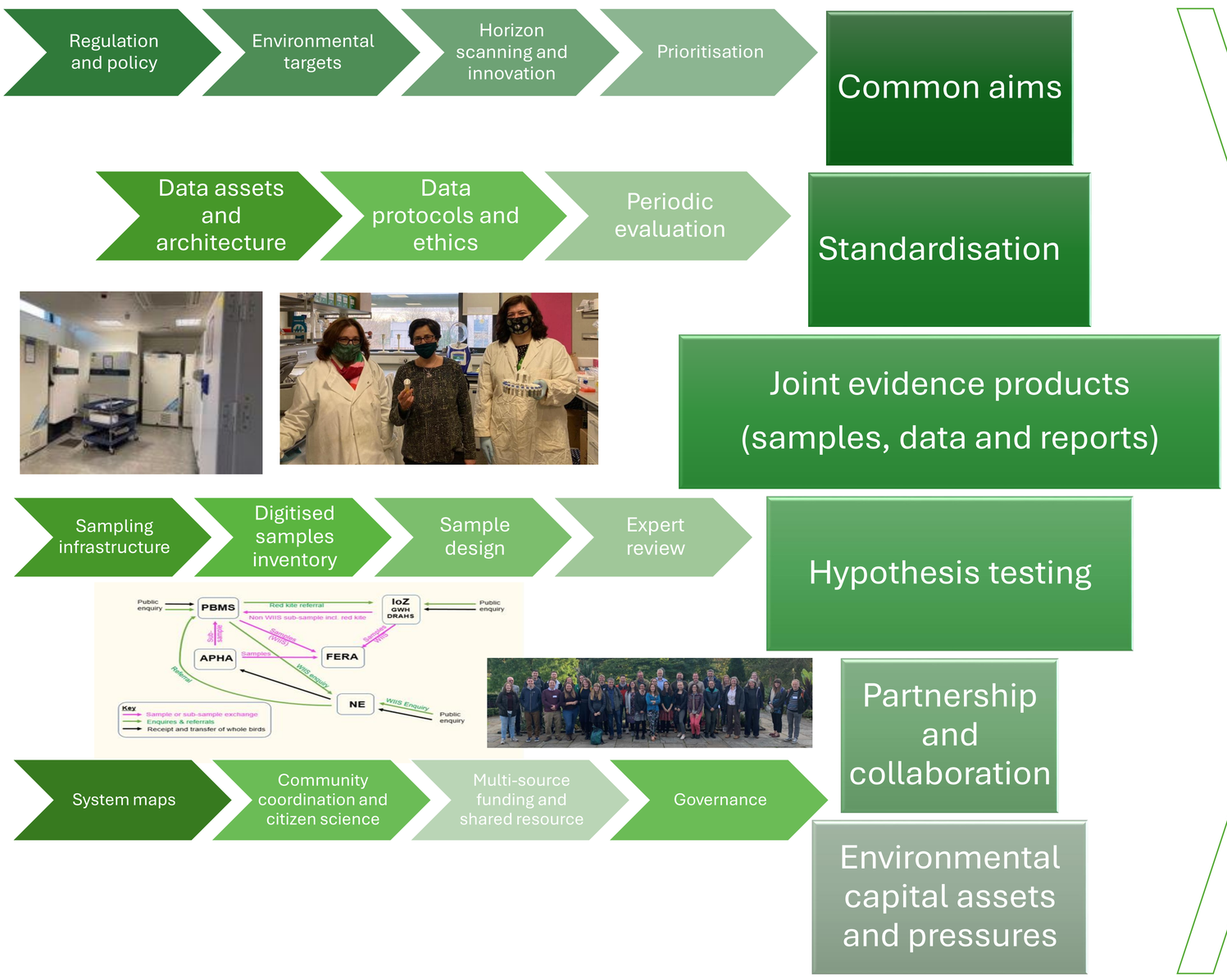


Figure 2. England development terrestrial chemicals monitoring programme.

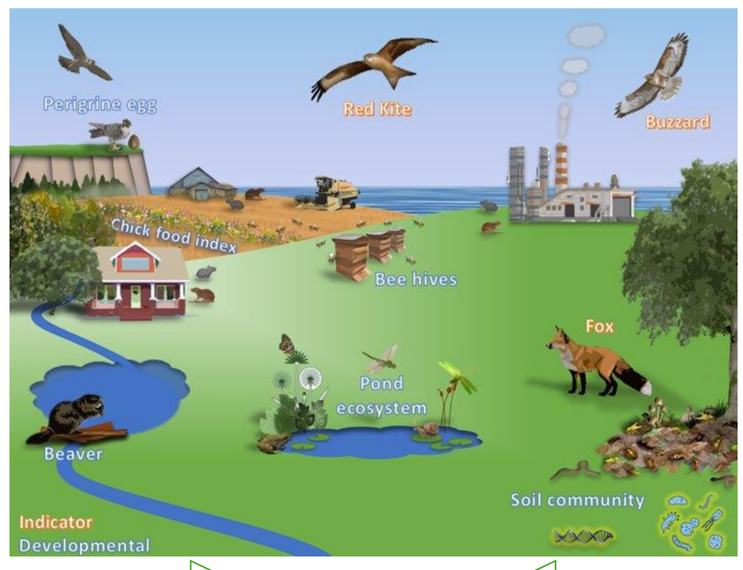
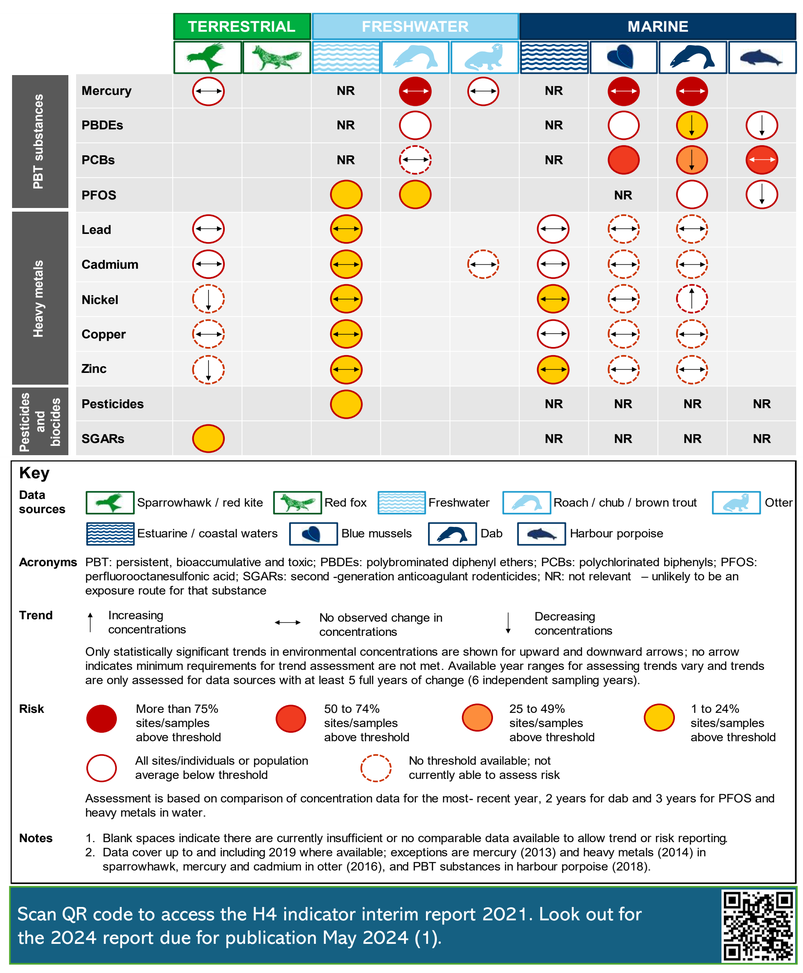


Figure 3. England terrestrial indicators on the Interim H4 Indicator Dashboard (2021) [1] .



Scan QR code to access the H4 indicator interim report 2021. Look out for the 2024 report due for publication May 2024 (1).

"Fit for purpose monitoring and indicators": Challenges and opportunities

1. Lack of an existing government-funded and -managed terrestrial chemical monitoring and biomonitoring programme results in delivery challenges, and absence of evidence, but opportunity to be innovative.
2. Selecting representative and strategic sentinel species and sites.
3. Understanding the effects of specific chemicals in a multiple-stressor environment with chemical mixtures.
4. Evidence are dependent on co-creation between disconnected and interlinking NGOs and exploring multiple funding options.
5. Higher sample demand versus sample supply: finite archives and size of samples (tissues and substrate) requiring a robust sampling design and decision-making tools.
6. There are 100,000s of chemicals of interest and data needed to enable prioritising what investigations to undertake using samples today versus in the future.
7. Requires innovation in a) field and lab methods/capability (method development funding) and lab capacity (steady funding); b) data architecture and tools for data analysis, management, visualisations and communication; and c) effects-based indicators for early warnings.
8. A need to deliver environmental risks horizon scanning, meeting the changing evidence and policy needs over time.

The recipe to the monitoring framework

Key activities undertaken between 2018-2024 in enhancing biomonitoring and reporting capabilities in England are listed below and are represented in Figure 1:

A. Development of a common vision and mission with partners and stakeholders.
B. Co-development of terrestrial indicators of chemical exposure and effect.
C. A proposal for terrestrial environmental monitoring of Plant Protection Products.
D. Application of systems thinking to develop data and samples process maps.
E. Assessment and enhancement of capacity and capabilities through mapping, cataloguing and digitising monitoring platforms and sample archives.
F. Development of hypothesis through evidence reviews and targeted investigations.
G. Establishment of a prioritised list for 'targeted' substances monitoring based on protentional conservation and policy impact.
H. Maximise data outputs to sample volume ratios through:
   i. Sample archive cataloguing and digitisation.
   ii. Sample design: considering both target analysis and potential for substances suspect screening.
   iii. Opportunistic analyses based on maximising the laboratory analytical suites.
I. Development of samples and data protocols (including carcass post-mortem, archive standards, data management and analysis, data quality assurance standards and data ethics).

Next steps for terrestrial horizon scanning early warning?

- Enhance and mature the data architecture to enable storage and processing of a range of data outputs (incl. non target analysis data).
- Explore cost-effective models that enable chemicals prioritisation through 'suspect screening' followed by targeted screening for substances of concern.
- Build and utilise evidence more effectively to investigate the impacts of chemicals on vulnerable/sensitive wildlife, alongside the impacts of multiple stressors (e.g. climate change, land use change, and disease).

Successes

- Built a community and framework for a collaborative Gov-NGO terrestrial biomonitoring programme that is deployable long term.
- Demonstrated the programmes capabilities for delivering data for legacy contaminants and substances that are persistent bio-accumulative and toxic (PBT).
- Produced data on SGARs (9) , PFAS (34), PCBs/dioxins (62), PBDEs (28), metals and heavy metals (18) across five birds and mammals.
- Maximised value per liver through sampling design and commenced horizon scanning for fire suppressants (36).
- Used data to delivery indicators for regulatory reporting and to inform UKREACH and biocides policy.

Lessons learned

- Map the systems and get the data architecture right first to enable future data use and publication.
- Generating samples for regulatory purposes using NGO platforms and citizen science increased the need for robust data ethics principles.
- Digitise sample meta data (incl. tissues volume) catalogue within archives to enable better sample management and (sub)sampling decision making.
- Need strong governance and co-design with a large collaborative community to enable expert review and policy impact.

Acknowledgements: Thanks to the UK partners, in particular the monitoring platforms and labs at UKCEH, Fera ltd., Animal and Plant Health Agency (APHA), Institute of Zoology, and Cefas; as well as the advice received from the University of Cardiff; collaborations at the Environment Agency, and Defra funding contributions.

Ref: (1) Environment Agency, 2021. Exposure and adverse effects of chemicals on wildlife in the environment: interim H4 indicator Supporting information and data; (2) Natural England 2023, Monitoring in Natural England 2023-2026 Technical Information Note (TIN21; (3) Walker, L.A, Shore, R.F, Chaplow, J.S., Barnett, E.A., and Spurgeon, D. 2023. A proposal for terrestrial environmental monitoring of Plant Protection Products. NECR377. Natural England.;)