ET&C – Points of Reference

Terra (Aqua) Incognita: Knowledge Gaps in Global Ecotoxicology

Schoenfuss HL[1*], Propper CR[2], Kolok AS[3], Forbes PBC[4.]

[1] *Aquatic Toxicology Laboratory, St. Cloud State University, USA*

[2] *Department of Biological Sciences, Northern Arizona University, USA*

[3] *Idaho Water Resources Research Institute, University of Idaho, USA*

[4] *Department of Chemistry, University of Pretoria, South Africa*

* Address correspondence to: hschoenfuss@stcloudstate.edu

Supplemental Data: n/a

Acknowledgments: n/a

Data Availability: n/a

Author Contributions Statement: all authors contributed equally to this manuscript.

The peer-reviewed toxicological literature contains twice as many studies pertaining to the River Thames (UK) than to the Congo River (Central Africa), despite the latter's watershed being roughly 250 times larger and sustaining a five-fold greater human population (Web of Science, 2021). Protecting such under-researched natural resources from chemical contamination requires local research to fill knowledge gaps, attention to regional expertise and incorporation of local communities into the decision-making process. The support and of regional, collaborative networks may be the most important of these as they will be most responsive to new emerging ecotoxicological concerns as they develop.

The historic dearth of ecotoxicological data from less intensively researched regions of the world exist due to constraints that remain to this day. Logistic challenges, are often more formidable and fundamental in the less resourced regions of the world and represent barriers of entry for even the most rudimentary experiments to be accomplished successfully.

Furthermore, baseline and supporting information taken for granted in Europe, North America, and parts of Asia (for example, seasonal variation in precipitation and river/stream flow, aquifer dynamics, permitted discharge, land use characteristics, etc.) may be unavailable, even while physical access to study sites may be limited by lack of infrastructure, political instability, cultural beliefs, and safety concerns. Should samples be collected, processing may be hindered by a lack of resources (i.e., dry ice, ice, analytical standards), timely sample transport (regulatory permitting), and analytical capacity (unreliable electricity, lack of availability of temperature-controlled rooms and analytical instrumentation).

Beyond the plethora of logistical challenges, the abiotic and biotic realities of these regions present another barrier to scientific progress. Many tropical regions, rich in biodiversity, yet vulnerable to pollution, experience annual hydrological cycling more severe than that experienced at temperate latitudes. Furthermore, the biota within these regions are well suited to the existing cycles, and bear little resemblance, both species assemblage and in their contribution to ecosystem dynamics, to that which occurs in more temperate latitudes. The cyprinid and salmonid species, common to the northern latitudes may scarcely resemble the endemic species found in most of the rest of the world. Equally important, the role those native animals play in their home ecosystems may not be easily characterizable, but rather may be finely tuned to regional conditions. Furthermore, critical aspects of their natural history, for example migrations, may not be accounted for when modeling a potential ecosystem susceptible to chemical contaminants.

Lastly, agricultural, regulatory, economic and cultural practices vary widely between regions and contribute substantially to local pollution. North American row cropping of corn and soybeans bears little resemblance to rice cultivation, palm groves, or banana plantations. Pesticide regulation, application rates, and application frequency will also differ substantially based upon the target pest, and the extent (plot size, proximity to population centers) to which the pesticide is applied. Sanitation infrastructure in low- and middle-income regions may lag behind standards expected (albeit not always met) in wealthier regions of the world. Consequently, the composition and concentration of contaminants of emerging concern in

aquatic environments may bear little resemblance when compared between high-, middle- and low-income regions. Considering these differences, it is critical to accept that solutions from a narrow strip of the developed world are insufficient to protect natural resources as well as the health of local communities, from anthropomorphic chemicals.

To fill knowledge gaps regarding emerging contaminants within these regions, an important step may be recognizing and supporting the scientific networks and expertise that already exist therein. Support may include transfer of resources, capacity building for local sample analysis, and assistance with the publication process. Scientists, both local and foreign, who have struggled with these challenges for years have developed innovative solutions, work-arounds, and substitutions in their experimental designs that need to be acknowledged as representing acceptable alternatives for standard procedures common in economically advantaged laboratories. Scientific publishers can aid in this process by developing a peer review process that does not require a "one-size-fits-all" approach. Limitations regarding replicability, sample size, appropriate sample storage and refrigeration and the treatment of water or sediment samples with internal standards may need to be relaxed to catalyze the scientific process in remote and relatively inaccessible regions of the world. An investigation of contaminants of emerging concern within the Upper Congo River, despite potential methodological shortcomings, may be of similar or greater scientific, political or economic value than yet another high-quality analysis of samples from the River Thames.

Beyond a tailored peer review process, the removal of paywalls for publication and for access to toxicological studies by affected populations in low- and middle-income countries would support increased dissemination. Including study summaries in a local language may provide an excellent opportunity for the scientific community to reach out and (re-)establish public trust in the scientific endeavor. Lastly, broadening training on some of the tools available for risk assessment, such as the ECOTOX Knowledgebase (https://cfpub.epa.gov/ecotox/), will complement the field and bench data and help support management and policy decisions.

The chemical burden that humans have exerted on the biosphere has been changing ecosystem function and causing adverse health impacts upon local communities. Environmental justice

issues associated with the placement of toxic industries and the use of noxious chemicals, combined with the disproportionate impact of climate change on low- and middle-income countries and indigenous peoples, underscore that chemical contamination is a world-wide issue. Support of research needs and dissemination within low- and middle-income countries is essential to protect human and environmental health at a global scale.

References

US Environmental Protection Agency. 2018. ECOTOX Knowledgebase. Washington, DC. [cited 2021 July 7]. Available from: https://cfpub.epa. gov/ecotox/