

Perspective: Senselessness in ecotoxicological investigation

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ARTICLE INFO

Received: 2 November 2023
Accepted: 20 December 2023
Available online: 31 December 2023

doi: 10.59400/jts.v1i1.423

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ABSTRACT: Whether openly stated or not by the authors of nearly all ecotoxicology studies published in the peer-reviewed literature, the studies are conducted with the thinking that the furnished information is valuable for the field of ecological risk assessment. Reasonably too, those reading these published works share the same sentiment. These situations are unfortunate, for a closer inspection of the research conducted reveals that commonly, one or more study aspects render the data generated to be not utilizable for ecological risk assessment purposes. Some frequently encountered complications include using test species that are never assessed for health effects in the wild, the mode of chemical dosing deviating radically from the manner in which actual chemical exposures occur, and lacking an assessment methodology for expressing health impacts. Because ecotoxicological investigation often does not align with the applied-science needs of ecological risk assessment, this article wonders why the studies proceed. Moreover, this article recommends that authors caution their readership about the limited or lacking utility of the research they describe in the area of fostering assistance and embellishment to ecological assessment science.

KEYWORDS: ecotoxicology, ecological risk assessment, research, contaminants, chemicals

1. Introduction

As toxicologists and toxicology enthusiasts, I trust it is our solemn dream to see our science continue to grow. While thousands of studies have already been conducted and published to date over decades, we know there are still thousands more waiting to unfold. Through amassing knowledge in our chosen field and applying it in conjunction with cues we take from the environment, we commonly find ourselves directed to formulate new questions to explore. It would seem then, that I am supporting the case for endless toxicological investigation reigning supreme. I am in fact doing just that, albeit with one rather critical qualification; I see no need for ecotoxicological study to continue, and this contention is supported by reliable and readily available science.

2. An absent need for ecotoxicological study: Absence of impacts in the field

Although ecotoxicology, like any research discipline, has its pure and applied components, for all intents and purposes, ecotoxicology studies are of the latter genre. With only minor exceptions, the studies are used only to support the field of ecological risk assessment (ERA)—the concern that plants and animals living in contaminated terrestrial and aquatic locations will develop health effects or die. It is here though, that the well-intended nature of the many studies we know of and continue to read

about, breaks down. Since ERA's inception some four decades ago, there has yet to be a singular instance of an ecological receptor bearing signs of stress, illness, disease, or population decimation due to the chemical footprint left behind by those who accidentally or deliberately contaminated a local environment^[1]. Given this reality, one that is undoubtedly difficult for would-be research ecotoxicologists to absorb, there is no purpose served in chemically dosing animals (e.g., via intubation, injection, etc.) or exposing them to contaminated environmental media (e.g., earthworms placed into jars of amended soil, fish placed in contaminated aquaria, etc.). If animals and plants in the wild bear no signs of having toxicologically succumbed to the chemically contaminated media with which they live, why perpetuate the myth that additional study is needed to afford species with health protection? To put it very simply, animals and plants at contaminated sites do not need our help; over multiple decades of chemical exposure, they have demonstrated their keen resilience^[2]. They are functioning well, providing the ecosystem functions they should, and most importantly, are perpetuating their own while doing so.

3. Ecotoxicological studies fail to furnish useful information

At this early point, it's also worth noting that the design of classical/conventional ecotox studies leave much to be desired. The field of ecotoxicological research has yet to recognize that there are no environmental science or ERA gains to be had when testing the standard way. Thus, testing chemicals singly for the effects they might pose, when contaminated sites almost always present with a chemical suite, is a wasted endeavor. Injection and intubation as modes of chemical delivery are not replacements for the natural dietary inputs that animals in the wild experience. The fixed ambient temperatures and supplied artificial laboratory lighting for caged animals that have never lived in the outdoors, in no way mimic the environmental settings of the animals in the wild that might concern us. And the list of disconnects between the imposed chemical exposures of laboratory and mesocosm studies, and the actual chemical exposures occurring in nature, goes on.

We would do well to review several recurrent ecotoxicology study types, including those pertaining to the earlier-mentioned pure science arena, for they will secure the overarching point that we are generating data for which no valid need exists. A first example is that of amending jarred soils with varying concentrations of explosives and tracking several endpoints (e.g., survival, growth, reproduction) in exposed soil invertebrates such as earthworms, Collembolans (i.e., springtails), and Enchytraeids (i.e., potworms). These animal groups are virtually never collected from the field at contaminated sites and are never health-assessed in ERAs. More to the point, ERA guidance does not exist for these groups, and realistically, there is no anticipation that springtail and potworm protection concerns will someday serve as triggers for hazardous waste site remedial actions. It should be noted too, that fueling the drive to ascertain supposed protective soil concentrations for springtails and potworms is the argument that sizeable accumulations of explosive residues occur at military test ranges. The reality is that due to safety concerns, down-range soil sampling can't ever proceed for the most part. Thus, we don't truly know that sizeable explosive accumulations actually occur, and we can never know if soil invertebrates in down-range areas are at risk. Again, what need is there for developing toxicological benchmarks for soil and litter invertebrates^[3]? For a given soil contaminant, why would anyone need to know if potworms develop toxicological endpoints sooner than do springtails, or vice-versa?

Ecological risk assessors know that the contaminant inhalation pathway is never assessed for any ecological receptor group (e.g., mammals). While it is true that chronic mammal inhalation studies do not occur, and no formal methods exist for the assessment of the mammal inhalation pathway, there is a much simpler explanation for ERA's non-attention to ecological receptor inhalation risk. Plainly, ERA

recognizes that in terms of contribution to overall risk, inhalation plays a relatively minor role, and to the point that ERA uncertainty sections routinely avow the same. Why then, are there occasional research attempts to quantify the chemical inhalation exposures of fossorial mammals^[4-6], even if we ignore artificially constructed tunneling made of flexible irrigation hose likely bearing little or no resemblance to the actual burrowing systems that small mammals construct?

The dermal contaminant uptake route is also never evaluated in ERAs, and legitimate defenses for the pathway's non-consideration take two forms. First, ecological receptors have relatively impervious integuments that greatly limit dermal transfer (e.g., a thick fur coat). Second, ongoing preening behavior converts would-be dermal transfer events to chemical uptake events via ingestion. Here it is fair to ask why certain focused research occasionally proceeds wherein human placental tissue is suffused with a contaminant-bearing aqueous solution, with the goal of estimating a bird's chemical uptake through its foot pads. Realistically, with the mounds of uncertainty associated with a study design like this, can such research produce helpful information to support ERAs? Does anyone honestly think that more research of this kind will lead to the dermal uptake route coming to be regularly assessed for birds in ERAs in the future?

4. Senselessness in ecotoxicological investigation

Fairly, senselessness in ecotoxicological investigation today might be epitomized by the research efforts that proceed for perfluoroalkyl and poly-fluoroalkyl substances (PFAS). As of this writing, distinct PFAS forms, that for more than a half-century have taken up residence in matrices of every kind, number close to 1500, and there is every reason to suspect that the count of these 'forever chemicals' will continue to climb. With PFAS having been detected in the blood of 97% of Americans^[7], there is no question that PFAS residues are present as well, in all animal tissues everywhere. While it is understandable that PFAS-ecotox investigation took off once the toxicity of the family of compounds was publicly established in the late 1990s, it is fair to take the ongoing investigation to task, asking if serviceable ecotoxicological information can possibly be brought forward at this late date. Whatever the testing scheme and whatever the species studied, from where is a researcher to procure his/her experiment controls (i.e., animals that have not been exposed to one or more PFAS forms and that do not bear a PFAS body burden)? Does it make sense to dose birds with a singular PFAS form, so that a toxicity reference value (TRV) can subsequently be derived for it, when birds in the wild are exposed to tens of PFAS forms at a time, in addition to numerous other environmental contaminants? Does it make sense to develop PFAS form-specific TRVs while the list of PFAS forms is still growing? Why are researchers publishing books on PFAS TRVs and couching such TRV information within a risk context^[8] when these hard-hitting challenges to ecotoxicological investigation abound? And one more hard-hitting question: Assuming there are workarounds for the many confounding factors at play while conducting PFAS ecotoxicological investigation, should study outcomes point to birds everywhere being health-imperiled, have we ways to retract PFAS from environmental matrices to ameliorate the dismal projections? The answer is, of course not. What utility lies in PFAS ecotoxicological investigation?

There is more; through the novelty of developing TRVs for PFAS, scientists and risk assessors are likely to forget that the hazard quotients (HQs) computed from TRV usage, are not risk measures altogether^[9,10]. This brief treatment on PFAS then, puts the spotlight on an overarching problem for ERA that ecotoxicological investigation only fosters, namely giving the impression that such investigation is assisting ERA when in fact, no ERA inroads are being made at all.

5. Cautionary notes

Assuming that animal care and use protocols are followed in ecotoxicological investigations, surely there are no illegalities at play. So long as researchers are able to assemble the resources they need to conduct their studies of interest, they may do as they please. There are though, other considerations that could make for cases of ‘wrongdoing’ in the ecotoxicology arena. The potential is high for those working in the applied field of ERA to be misled, looking at newly published ecological findings as constituting a windfall for the development of the ERA science they embrace. Researchers though, have a responsibility to let their readership know that due to the particulars of their studies (e.g., the choice of test species, the way in which a study has been conducted), their work is not adaptable to ERA in the main. By way of example, research ecotoxicologists who unveil bioaccumulation/bio uptake data for any species and for any somatic compartment, need to caveat their work, reminding their audience that, still to the present day, means do not exist for equating chemical body burdens with health effects in the animals that have them. In a similar way, researchers need to openly state other critical points in their works, such as a) the species they have elected to work with being one that is never being assessed in ERAs (to include any amphibian, reptile, or soil microbe), and b) their tested species lacking ecological protection concerns (e.g., insects), unless it should be classified as being of special status. It is hoped that ecotoxicological investigation of the future will only involve species we truly aim to protect (or their reasonable surrogates), and that good sense is exercised in research protocols.

Conflict of interest

The author declares no conflict of interest.

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