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Editorial Open Access

Systems Approaches for Understanding Environmental Toxicology

Zewei Miao*

Department of Agricultural and Biological Engineering, University of Illinois Urbana, USA

***Corresponding author:** Department of Agricultural and Biological Engineering, University of Illinois at Urbana-Champaign, 1304 West Pennsylvania Avenue, Urbana, IL 61801, USA, Tel: +1 (217) 333-1106; E-mail: zmiao@illinois.edu

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Editorial

Environmental toxicology (ENTOX) has been developing quickly since Rachel Carson raised the awareness of people for environmental pollution in 1960s. ENTOX aims to address impacts of toxic compounds on human/animal health and ecosystems, as well as response, resilience and adaptation of ecosystems to toxic environmental stress at macro and micro levels. ENTOX integrates biology, epidemiology, Pathobiology, chemistry, eco-environmental sciences, agricultural and food sciences, hydrological and soil sciences, human/animal health, and social risk management. Rapid development of new technologies such as informative chemical and Bioanalytical tools (transcriptomics, proteomics, and metabolomics) are changing the way Ecotoxicology is practiced [1]. With the popularization of wireless devices, an attention has been put on impacts of radio-frequency and extremely low-frequency electromagnetic field (RF-EMF and ELF-EMF) from cell phone towers and wireless devices on human biology, and ecosystems. Most of the ENTOX problems are complex and interdependent. A great challenge is how to efficiently analyze, respond and solve the complex ENTOX problems in a satisfactory quantitative manner.

Systems approaches that allow the integration of many different scales of interaction and information are driving a revolution in understanding ENTOX. A systemic viewpoint interprets and solves the ENTOX problems by starting with the analysis of fundamental elements and finally considering more complex related systems. For example, in some metropolitan cities of China, smoggy weather becomes more and more frequent and seriously affects human health and lifestyle. To solve the ENTOX problem, a concurrent economic, science, engineering and technology approach has to be employed. This includes biological and medical sciences to study the impacts of smoggy air on human/animal health and ecosystems, economic and energy policy to improve economic structure and energy use, environmental and energy engineering to upgrade heating equipment and facility, and clean technology to control and treat waste gas emission from traffic and heating systems. In particular, economic and energy policy takes an important part in optimization of energy use and control of waste gas from automobile vehicles and heating systems. The viable systems approach can also be applied to other issues such as soil pollution control, prevention and control of disease risk at the human-animal-environment interface (HAEI), e.g., severe acute respiratory syndrome (SARS), avian influenza H5N1, H7N7 and H9N2. For example, to control and prevent SARS epidemic, it is important to assess potential SARS risks of human-animal-environmental interface, develop rapid response of disease control and prevention, improve sanitary condition and reduce human and animal's exposure to related toxic virus medium.

The fundamental purpose of systems approaches is to develop rapid response mechanisms to ENTOX issues through systems modeling and informatics analysis. The modeling topic of ENTOX mainly comprise (a) identification of the pathogen-pollutants and toxic stressor–effect relationship; (b) fate, behavior and transport of organic/non-organic toxic compounds degradation in exposure medium [2-4] ; (c) absorption, distribution, metabolism and excretion of environmental contaminants within exposure sentinel species, human and animal [5-7]; (d) toxicokinetics (TK) and toxicodynamics (TD) mechanism at target sites [8]; and (e) risk assessment of toxic pollutant propagation from organisms to populations and variations in ecosystem sensitivities under various scenarios [5,9]. For chemical toxicology, two typical mechanisms are often applied: (a) the concentration addition model with the same toxic mode of action, and (b) the independent action with different toxic mode of action [9]. However, the above mechanism is not applicable to unknown or unpredictable modes of action and interactions among chemical compounds. The TKTD mechanisms include time- and tissue-dependent DNA damage/mutagenesis, endocrine disruption, neurological effects, and deficiencies in the human/animal immune.

At present, a large amount of modeling efforts in toxic pollutants is evolving to interrelate the interacting components of the exposure medium and the flow of information linking these elements. For example, OMICS technologies provide valuable insight into ecotoxicity, both in laboratory exposures with model organisms and with animals exposed in the field [1]. These technologies require a context of the whole animal and population to be relevant. Powerful modeling approaches using reverse engineering to determine interacting networks of genes, proteins, or biochemical reactions are able to uncover unique responses of human/animal to toxicants and quantitatively assess environmental exposure risks [1].

The ENTOX systems approaches should focus on the complex interactions in biological systems and ecosystems, with the intent to discover, understand, model and analyze emergent properties of the systems at various levels [10]. In recent times, except for typical process-based determinative models, heuristic, agent-based, stochastic operational programming, and artificial intelligent self-learning and self-adaptive models have also gained popularity and acceptance, especially in risk assessment and management of ENTOX. With heuristic and hierarchy modeling approaches (e.g., artificial neural network), the interdisciplinary development of ENTOX-Informatics and systems biology will facilitate fusing, mining, assimilating and analyzing of ENTOX meta-data and simulating the fate of environmental pollutants in ecosystems [5,10,11,9].Integrating the top-down or bottom-up meta-data analysis is essential to harmonize and analyze the reliability, relevance and adequacy of ENTOX meta-data at various spatial and temporal, macro and micro scales. The systems approaches will help the decision-makers to quantitatively assess ENTOX risks and develop best management practices of prevention and control of environmental contaminants.

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