Taylor & Francis
Taylor & Francis Group

Monitoring of Exposure to and Potential Effects of Contaminants in the Environment

JOHN P. GIESY[1] AND JOHN L. NEWSTED[2]

[1]Dept. of Biomedical Veterinary Sciences and Toxicology Centre, University of Saskatchewan, Saskatchewan, Canada
[2]ENTRIX, Inc., Okemos, Michigan, USA

In our lifetimes, much of what was once considered science fiction: space ships, monitoring the environment from space, satellite phones and biomedical advances in the diagnosis and treatment of disease at the molecular level have now become realities. These advances in technology have changed our perceptions and how we interact with the world around us. Also during this time, the world population has doubled several times, our use of natural resources has increased exponentially and we continue to release natural and synthetic compounds to the global environment at an ever-increasing rate. These actions have altered the face of the planet in a multitude of ways.

In the ultimate irony, technology has proven to be a double-edged sword that can both threaten to destroy us while also possibly providing the means of our salvation, our means of achieving sustainable development. How can we harness the rapidly developing technological means at our disposal to predict and manage environmental changes? There are exciting changes in technology that may provide the ability to monitor the environment, providing the information we need to allow us to make wise environmental policy decisions. However, even with these advances in technology, the basic dilemma still facing environmental scientists is complexity of ecosystems where known and unknown natural and anthropogenic factors may adversely influence natural processes, resulting in degradation of living resources, environmental services, and human health. Conversely, failure to effectively monitor will lead to our failure to detect threats to human health and reductions in biodiversity, resulting in higher costs associated with after-the-fact remediation and restoration, with the ultimate risk of irreversible damage to environmental resources.

Within this context, it is important that as environmental scientists, we provide the necessary information to the general public and regulatory stakeholders that is readily interpretable and is related to valued resources and functions of ecosystems, allowing these stakeholder groups to make informed and effective resource-management decisions in real-time. Efforts are still needed to develop programs to detect, monitor and assess impacts in bio-diverse ecosystems by measuring the right things, in the right places, at the right frequency over sufficient time periods in a cost-effective manner.

To increase the efficiency and effectiveness of monitoring programs focusing on "known" chemicals and the potential effects and risks they may pose to biota, including humans, we propose that risk-based monitoring programs be developed incorporating chemical and biological techniques that are rapid, readily implemented, and provide

Address correspondence to John P. Giesy, Dept. of Biomedical Veterinary Sciences and Toxicology Centre, University of Saskatchewan, Sasdatoon, Saskatchewan, Canada. E-mail: jgiesy@aol.com

ecologically relevant data useful to environmental managers. As an example, the use of bio-analytical methods based on genetically modified cells that read out in toxicity equivalents can provide information integrating effects of complex mixtures that reads out in units directly used in risk assessments (Blankenship and Giesy 1999). Furthermore, this type of approach can be used to identify emerging issues concerning chemicals not yet monitored. Candidates to support this monitoring approach include the use of bioindicators and biomarkers, integrative bio-analytical techniques, and bioassay-directed fractionation methods capable of providing guidance to identifying possible chemical stressors, while also providing insights into potential health problems of organisms exposed to these chemicals (Reijnders et al. 2002).

Many real-time monitoring programs to evaluate water quality on a local and regional basis currently exist (Glasgow et al. 2004). While some of these programs have been constrained by technological and other limitations, developments in the fields of molecular biology, nanotechnology and micro electronics have led to new inexpensive biosensors that can be used to monitor environmental variables such as temperature, dissolved oxygen, nutrients, pesticides and endocrine disruptors (Kroger et al. 2002). Furthermore, development of new data management systems, including the advent of web-based databases, has also lead to improvements in geographic databases that can be integrated with GIS systems to provide flexible informational database systems for both content providers and users to address environmental problems (Graham et al. 2007). In addition, the development of new virtual ecosystems is allowing researchers to evaluate the inter-relationships between biota and environment in a cost-effective and timely manner (Heleno et al 1998).

However, as the increased amount of information from these programs becomes available, the need for biologists and chemists to interpret and summarize these data for environmental managers and the public in a timely manner will also increase. Thus, while we environmental scientists have made great strides in understanding natural ecosystems over many decades, we still have a great deal of work before us to provide our information in formats useful to regulators and public stakeholders.

References

Blankenship AL, Giesy JP. 1999. Use of Biomarkers of Exposure and Vertebrate Tissue Residues in the Hazard Characterization of PCBs at Contaminated Sites: Application to Birds and Mammals. In: Sunahra GI, Renoux AY, Thellen C,. Gaudet CL, Pilon A, editors. Environmental Analysis of Contaminated Sites: Toxicological Methods and Approaches. New York: John Wiley and Sons, Chapter 9, pp. 153–180.

Glasgow HB, Burkholder JM, Reed R, Lewitus AJ, Kleinman JE. 2004. Real-time remote monitoring of water quality: A review of current applications, and advancements in sensor, telemetry, and computing technologies. Journal of Experimental Marine Biology and Ecology, 300: 409–448.

Graham J, Newman G, Jarnevich C, Shory R, Stohlgren TJ. 2007. A global organism detection and monitoring system for non-native species. Ecol. Informatics, Doi:10.1016/j.ecoinf.2007.03.006.

Heleno P, dos Santos MP. 1998. Artificial animals in virtual ecosystems. Comp. Networks and ISDN Systems 30: 1923–1932.

Kroger S, Piletsky S, Turner APF. 2002. Biosensors for marine pollution research, monitoring and control. Mar. Poll. Bull. 45: 24–34.

Reijnders P, Giesy JP, Ankley GT, Matthiessen P, Depledge M. 2002. Wildlife. In: Global Assessment of the State-of-the-Science of Endocrine Disruptors (EDCs). World Health Organization/ United Nations Environment Programme, International Programme of Chemical Safety, Geneva, Switzerland.