European Commission

Science for Environment Policy

How can 'omics' technologies – which enable large-scale, speedy biological data analysis – improve environmental risk assessment and management?

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Source: Leung, K.M.Y. (2018). Joining the dots between omics and environmental management. *Integrated Environmental Assessment and Management*, 14(2): 169–173. DOI: 10.1002/ieam.2007.

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High-throughput 'omics' technologies, which allow exact and synchronised study of thousands of DNA, RNA, proteins and other molecules, are rapidly becoming more advanced and affordable. As these technologies develop, it is becoming quicker, easier and more affordable to generate unprecedented amounts of biological data, much of which could usefully inform environmental management. So far, however, the application of omics information in environmental management has failed to keep pace with the rapid development of omics-based research, meaning there is untapped potential. A recent study highlights the value of bringing omics information into environmental management and outlines practical ways in which omics can contribute to the risk assessment and management of chemicals.

'Omics' refers to the fields of study within biology that aim to characterise and quantify pools of biological molecules that translate into an organism's structure, function and dynamics. Examples of omics fields include genomics (an interdisciplinary field of science concerned with the structure, function, evolution, mapping and editing of genomes), proteomics (the large-scale study of proteins within a cell, tissue or organism) and metabolomics (the large-scale study of small molecules, known as metabolites, within cells, biofluids, tissues or organisms). However, there are over 1 000 omics fields in biology today[1].

Examples of high-throughput omics technologies include next-generation genetic sequencing (advanced sequencing technologies used for DNA and RNA analysis), mass spectrometry (a process used to identify chemicals in a substance by their mass and charge) and nuclear magnetic resonance spectrometry (a technique used by chemists for determining the structure of organic compounds). Such technologies enable the analysis of an unprecedented amount of biological data in a relatively short period of time. These technologies are not only advancing rapidly, but also becoming more affordable. While peer-reviewed publications on omics have increased exponentially in recent years, publications discussing omics in relation to environmental risk assessment and management have not risen at anywhere near the same rate. This suggests that the translation of omics information into environmental risk assessment and management applications is not keeping pace with omics-based research.

This gap represents an area of untapped potential, since omics technologies can provide information and evidence relevant to environmental management. The paper identifies six management domains in which omics approaches can generally be applied:

1. Screening and grouping chemicals based on their toxicity and mode of action;
2. Revealing toxic mechanisms of individual chemicals, chemical mixtures or multiple stressors, and identifying their associated adverse outcome pathways (AOPs);
3. Providing additional lines of evidence for setting predicted no-effect concentrations or no-observed adverse effect levels (i.e. effect thresholds) of chemicals;
4. Identifying biomarkers and developing rapid-detection tools for pollution monitoring;
5. Allowing rapid detection of pathogen and antibiotic-resistant genes in environmental samples;
6. Establishing the relationship between species richness, or ecosystem function, and chemical levels in the environment, from which ecologically relevant environmental-quality benchmarks can be derived.

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1. Pirih, N. & Kunej, T. (2018). An Updated Taxonomy and a Graphical Summary Tool for Optimal Classification and Comprehension of Omics Research. *OMICS: A Journal of Integrative Biology*, Vol 22, No 5. http://doi.org/10.1089/omi.2017.0186

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How can 'omics' technologies– which enable large-scale, speedy biological data analysis – improve environmental risk assessment and management? *(continued)*

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The study also describes a number of examples that illustrate how omics can be used to assist the environmental risk assessment and management of chemicals. For example, by integrating omics into *in vitro* bioassays (tests for determining the presence or concentration of a compound in a tissue sample), it is possible to screen new chemicals for their relative toxic potency and identify their mode of action. This approach has already been adopted by the US Environmental Protection Agency in its Toxicity Forecaster (ToxCast) programme, which ranks and prioritises over 1 800 chemicals for risk management based on toxicity and genomic data from over 700 high-throughput bioassays.

While omics information is increasingly being applied to a range of environmental-management domains, it has yet to be regularly adopted and used by environmental authorities worldwide. Further efforts are needed if omics results are to be translated into easy-to-use tools and useful information for environmental management. The researcher outlines the key recommendations that emerged from several workshops on the topic hosted by the European Centre for Ecotoxicology and Toxicology of Chemistry (ECETOC) between 2010 and 2016:

1. Increase efforts to stimulate the use of omics in risk assessment of chemicals;
2. Build up more relevant case studies of the application of omics information for regulatory risk assessment;
3. Strengthen the capability and capacity of bioinformatics and computational toxicology analytics;
4. Establish standardisation and provide guidance on the best practices of acquirement, analysis, reporting/sharing and application of omics data so that they can be reliably verified and confidently integrated into regulatory risk assessment.

The researcher concludes by calling for key stakeholders — including environmental authorities, chemical industries, and researchers — to make a concerted effort to work together to join the dots between omics and environmental management.