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Perspective

Risk assessments of contaminants of environmental concern need to address future scenarios to effectively protect human health and ecosystems

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Abstract: This article intends to discuss some limitations of the current approaches used to assess human health and environmental risks caused by contaminants of emerging concern (CECs). Human health and environmental risk assessments of CECs are normally based on a relationship between measured and predicted environmental concentrations (MECs and PECs, respectively) often estimated based on past conditions, and the respective predicted no-effect concentrations (PNECs). However, for most of chemicals, emissions continue to increase following the population growth and increasing polluting activities, resulting in a continuous rise of contaminants concentrations in the environmental compartments and the consequent increase of risks associated with them. Therefore, risk predictions based on past data may be unreliable and ineffective to support actions aimed to protect the environment, particularly in developing countries where pollutants monitoring are lacking or regulations are based on few academic studies. In this context, new tools need to be incorporated to improve the risk assessment protocols. Projections of future scenarios may predict the environmental concentrations of chemicals, allowing decision makers to establish appropriate actions to control the emissions and avoid the emergence of risks to human health and ecosystems before critical conditions are achieved. Thus, effective policies to control pollution and its effects would be taken.

Keywords: environmental risk assessment; human health risk assessment; aquatic pollution; ecotoxicology; chemicals regulation; CECs

Chemical pollution poses increasing threats to human health, biodiversity, and ecosystem services [1]. Chemical substances associated with environmental pollution include legacy contaminants, such as metals, nutrients, and hydrocarbons, and an increasing number of unregulated substances, generically named as contaminants of emerging concern (CECs), which involve pesticides, pharmaceuticals and personal care products, nanomaterials, hormones, flame retardants, aqueous film-forming foams, and plasticizers.

The adverse effects of chemicals on human health and the environment have been historically unveiled and reported, leading to the establishment of national regulations worldwide [2] and international agreements aimed at assessing and regulating chemical contamination (e.g., the Stockholm Convention and Marpol Convention). Consequently, strategies have been adopted at the local, national, and global levels to assess environmental pollution and reduce the levels of contaminants in the environment [2]. Such scientific, technical, and political efforts have led to the design of approaches to support and guide control policies and regulations based on human health and/or environmental risk assessments [3,4].

Risk assessments can be defined as approaches that evaluate the probability of adverse human health and/or ecological effects that occur as a result of exposure to one or more chemical substances. They provide support for decision-making for emission control, environmental remediation, or regulation of new and existing substances [5,6]. Risk assessments consist of flexible tools that combine different lines of evidence to detect effects at subchronic levels and estimate risks due to single or multiple substances [3,4]. In the phase of exposure characterization, these studies often consider the measured or estimated concentrations of chemicals in environmental compartments (i.e., the measured or predicted environmental concentrations, MECs and PECs, respectively) and associate them with their potential effects on humans and ecosystems (or some of their components) through a comparison with their respective predicted no-effect concentrations (PNECs). The environmental concentrations often used consist of those reported in the literature, measured in the field, or estimated through models normally based on current or past emission rates [6].

However, the global use of various potentially toxic chemical substances is still increasing, as result of population growth, aging, and industrial production [7]. In particular, the production, commerce, and use of CECs are rapidly increasing worldwide [8,9], normally without proper regulations that depend on robust information that is not rapidly obtained. Many of these chemicals are persistent or have relatively long half-lives, resulting in increased environmental levels over the long term. Vane et al. [10] reported increasing levels of pharmaceuticals and personal care products in sediment cores from the estuary of River Thames between the late 1960s and 1990s, in particular antibiotics have increased 50-fold and anti-inflammatory and anti-epileptics 3-fold. Similarly, Carr et al. [11] reported an increase in the concentrations of plastic additives and new flame retardants in sediments of Cienfuegos Bay (Cuba) over the last decade. On the other hand, improvements in the sewage collection and treatment systems can reduce CEC emissions along time leading to decreasing environmental concentrations of contaminants, as observed in some regions in the state of São Paulo, Brazil [12]. However, because conventional wastewater treatments are often inefficient to remove CECs or raw sewage is discharged in the environment [13–15], in the long term the concentrations of CECs in water bodies may start to increase again [15]. Therefore, future CEC concentrations are expected to be higher than the current or past concentrations. Consequently, risks to human health and ecosystems tend to increase, and even chemicals currently found at low levels can become a threat in the future.

This situation increases the complexity to the environmental agencies responsible for implementing regulations for CECs at the local or national levels. The presence of CECs in waterbodies demands the establishment of guideline values and acceptable limits for drinking waters and environmental compartments (e.g., water and sediment) by the environmental and human health agencies [13,14,16]. These guidelines are intended to guide policies for drinking water treatment, effluents and wastewater treatment, and environmental management, aiming at protecting human health and biodiversity. The establishment of such guidelines should be based on environmental risk assessments; however, because CECs are not routinely monitored in most countries, particularly in developing countries, which correspond to approximately 85% global population, and the available information on their specific MECs/PECs and PNECs is scarce, decisions involving such compounds have frequently been made based on existing literature (i.e., current or past information) [17], that in most cases consist of a few published papers. In this sense, a chemical that is not routinely monitored becomes a CEC after being detected in a determined site, and because of technical or economic limitations, further regulations at the local or national levels will be established based on this information or data obtained in other regions and available in the literature. Normally, emissions of such contaminants tend to remain authorized by the authorities until legal standards are established, with exception of cases when critical threats to important targets are identified.

The way human health and ecological risk assessments have been used in most developing countries, especially at local and national levels, probably fails to predict future risks, since decisions proposing the regulation of CECs have been made, practically as a rule, looking towards the past (i.e., data obtained prior to the publication of regulations) or at most to the present. Moreover, the way current studies are employed overlooks (and often disregards) relevant factors that influence CECs emissions, such as demographic (population increase, aging, increase of chronic diseases, increase of agricultural lands), economic factors (increase of fossil fuels and pesticide consumption, increase of mining and industrial production), and the improvement of emissions control.

Studies aimed at assessing the risks associated with CECs could be improved by including future scenarios in the short- and long-term based on sound models or projections, with the purpose of properly guiding governments, society, and decision-makers. Prospection of future scenarios constitutes important elements to, and is intensely used in, decision-making in important forums, such as those routinely published by the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES) discussing global warming and biodiversity protection, respectively. Statistical or complex models are useful because they allow the establishment of different scenarios, as well as the consequences of adopting different strategies to deal with the factors that interfere with the final results. For example, for triclosan (TCS), a widely used antimicrobial agent whose production presents an annual growth of approximately 4.8% [18], future environmental concentrations can be estimated based on data available in the literature. Independent of the current scenario, considering that the TCS environmental concentrations increase proportionally to emissions, the current concentrations at any place would be expected to double in approximately 15 years. In this hypothetical case, some regions currently considered no-risk for TCS would present environmental risks in the future, and actions could be taken to avoid such risks. Obviously, predictive models can be refined to mimic real conditions, or simulate multiple scenarios, such as improvements in effluent collection and treatment or chemicals substitution in industrial processes (reducing emissions) or the expansion of existing emissions, thereby providing more reliable information for policymakers. Moreover, projections and models can incorporate probabilistic approaches to estimate the probabilities of different scenarios, as normally reported in IPCC and IPBES publications.

The incorporation of prediction models into human health and environmental risk assessments could allow for the detection of possible future risks and adoption of control actions before the estimated scenario occurs. By incorporating future predictions, human health and environmental risk assessments will become much more powerful tools to support decision-making aimed at reducing or avoiding pollution, and providing adequate protection for humans and ecosystems in the long term.

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