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Editorial: Detection, risk analysis and monitoring of chemical contaminants from agro-aqua food production and processing: implications on the One Health triad

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Editorial on the Research Topic
Detection, risk analysis and monitoring of chemical contaminants from agro-aqua food production and processing: implications on the One Health triad

Introduction

Meeting the food and nutritional needs of the global population heavily relies on the interconnectedness of food production systems. However, the intensification and expansion of these activities, particularly using synthetic chemicals, has exacerbated the prevalence of chemical contaminants within food supply chains (Jacob et al.). These contaminants including microplastics, antibiotics, pesticide residues, heavy metals, allergenic substances, pharmaceuticals like endocrine disruptors, nanomaterials, etc. pose significant threats not only to human health but also to biodiversity and environmental sustainability. As such, it is crucial to detect, analyze, and monitor these contaminants effectively. The recently compiled *Frontiers in Sustainable Food Systems* special issue article collection "*Detection, risk analysis and monitoring of chemical contaminants from agro-aqua food production and processing: implications on the One Health triad*" is primarily focused on the detection, measurement, risk analysis, and monitoring of chemical contaminants in agro-aqua foods as well as from their production and processing. This editorial highlights the critical importance of these processes within agro-aqua food production systems and discusses their broader implications for the One Health triad, which connects humans, biodiversity, and environmental health.

Challenge of emerging and novel contaminants of agro-aqua foods

Chemical contaminants, including pesticides, heavy metals, antibiotics, mycotoxins, and industrial pollutants such as polychlorinated biphenyls (PCBs) and persistent organic pollutants (POPs), enter food chains during various stages of production and processing (Ogwu and Izah, 2023). These contaminants originate from numerous sources, such as excessive agrochemical use, industrial waste discharges, and improper waste management practices. Once introduced into the environment, many of these substances like mercury as highlighted by Vergara et al. persist and move through the food chain leading to bioaccumulation, biomagnification, and higher hazard quotients within aquatic and terrestrial ecosystems. In addition, mercury contamination, exacerbated by mining and agricultural practices, disproportionately affects predator fish species used as food like *Clarias batrachus* and *Chrysichthys nigrodigitatus* poses significant risks to human health, particularly in regions where fish consumption is high (Izah et al., 2024). Prolonged exposure to emerging and novel contaminants from agro-aqua production and processing processes has severe implications for human and animal health, contributing to gastrointestinal disorders, neurological dysfunctions, endocrine disruptions, and carcinogenesis (Imarhiagbe et al., 2023). Antibiotics in food, for example, further exacerbate the risk by fostering antimicrobial resistance. Long-term exposure to low doses of antibiotics through food not only alters human intestinal microbiota but also promotes microbiota-related disorders and the emergence of antibiotic-resistant pathogens (Sadighara et al.). According to Sadighara et al., the change in gut microbiota structure and function was caused by residual tetracycline, sulfamethoxazole, cefquinome, florfenicol, and tylosin in food. Beyond health risks, these contaminants disrupt nutrient cycles and biodiversity, further compromising ecosystem integrity.

Advancements in detection and monitoring of agro-aqua food contaminants

In response to these growing risks, advancements in detection technologies are critical for ensuring food safety and environmental protection. Techniques such as chromatography, mass spectrometry, and biosensors have greatly enhanced the accuracy and sensitivity of contaminant detection in food products, enabling timely interventions before contaminated products reach consumers (Jeon et al.). Furthermore, integrating remote sensing technologies with data analytics has proven beneficial in monitoring large geographical areas for contamination hotspots. For example, satellite imagery helps track agricultural land use and potential contamination sources, while machine learning algorithms can analyze complex datasets to predict contamination trends (Hossain et al.). Innovative processing technologies also contribute to improving food safety. High-pressure processing (HPP), for instance, has demonstrated its effectiveness in reducing viral contamination in food products like fermented shellfish without compromising product quality. This technology offers a promising solution for ensuring food safety while maintaining the sensory attributes of traditional foods (Zhang et al.).

Risk analysis and management of agro-aqua food contaminants

To effectively manage the risks posed by chemical contaminants, comprehensive risk analysis frameworks are essential. These frameworks evaluate the likelihood and severity of contamination by considering factors such as exposure pathways, population vulnerabilities, and dose-response relationships (Izah et al.). Such assessments inform the development of risk management strategies that include regulatory policies and sustainable practices. Integrated pest management (IPM) is one such strategy that reduces reliance on chemical pesticides, while sustainable aquaculture practices limit the discharge of pollutants into aquatic ecosystems. Collaboration between governments, industries, academia, and communities is equally important for ensuring the successful implementation of these strategies. Moreover, international cooperation is needed to address transboundary contamination issues and ensure that food safety standards are met across global supply chains (Obahiagbon and Ogwu, 2024).

Implications of agro-aqua food contaminants on the One Health triad

The One Health concept emphasizes the interconnectedness of human, animal, and environmental health. Chemical contaminants introduced through agro-aqua food production can significantly affect all components of the One Health triad (Meijaard et al., 2023; Ogwu, 2023).

- **Pesticides:** While pesticides boost agricultural productivity, their residues pose serious health risks, including neurotoxicity and endocrine disruption in humans. In animals, pesticides can cause reproductive harm and disrupt biodiversity by impairing ecosystem services such as pollination and pest control.
- **Heavy metals:** Contaminants such as lead, mercury, and cadmium are absorbed through contaminated water and soil, causing neurological disorders, kidney damage, and physiological changes in animals. These metals also disrupt microbial communities, affecting nutrient cycling and overall ecosystem health (Yin et al.).
- **Antibiotics:** The use of antibiotics in agriculture contributes to the development of antimicrobial resistance (AMR), leading to "superbugs" that threaten both human and animal health. Residues in food may cause allergic reactions and disturb gut microbiota, while aquatic ecosystems experience altered microbial diversity due to the presence of these antibiotics.

- **Mycotoxins:** Produced by fungi, mycotoxins contaminate crops and animal feeds, leading to liver and kidney damage in humans. In livestock, mycotoxins reduce growth rates and reproductive efficiency. Additionally, they impair soil health and reduce agricultural productivity.
- **Industrial pollutants:** Industrial pollutants, such as PCBs and POPs, persist in the environment and bioaccumulate in food chains. These pollutants cause endocrine disruption and reproductive disorders, contributing to biodiversity loss and destabilizing ecosystems.

To address these challenges, a holistic One Health convergence approach is necessary. This approach integrates interdisciplinary research, sustainable agricultural practices, and stringent regulatory frameworks to reduce contaminant levels, mitigate their impacts, improve the resilience of food production systems, safeguard public health, and preserve ecosystem integrity.

Conclusion

The detection, risk analysis, and monitoring of chemical contaminants within agro-aqua food production and processing systems are essential for ensuring food safety, public health, and environmental sustainability. As food systems evolve globally, it is critical to adopt sustainable practices that minimize harmful chemical use and prioritize conservation from a One Health perspective. Collaborative efforts between experts in agriculture, environmental science, and public health, along with the development of clear guidelines and standards by regulatory bodies, are necessary for building a resilient and sustainable food system. Addressing these challenges head-on will help us protect ecosystems, ensure food safety, and support long-term public health and environmental goals.

Author contributions

MO: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. SI: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AA: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. CN: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

AA was employed by Infra Pipe Solutions Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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