Economic Research Institute for ASEAN and East Asia

NO. 2025-5, JUNE 2025
ISSN: 2086-8154

Policy Brief

The Double Exposure of Health Impacts and Micro/Nanoplastic Hazards in the Perspective of ASEAN One Health Studies

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In ASEAN countries, interest in and publication of research on micro/nanoplastics (MNPs) have significantly increased, reflecting growing political will to understand, regulate, and reduce MNP-related risks. However, the research agenda has largely focused on MNP distribution, exposure pathways, characterisation, and material properties, with limited attention to their toxicological effects. Although there is a rise in MNP-health research outputs, there has not yet been a systemic or holistic application of the One Health approach to assess the health risks of MNPs, nor to evaluate the hazardous nature of MNP constituents and their impacts on humans, animals, and ecosystems.

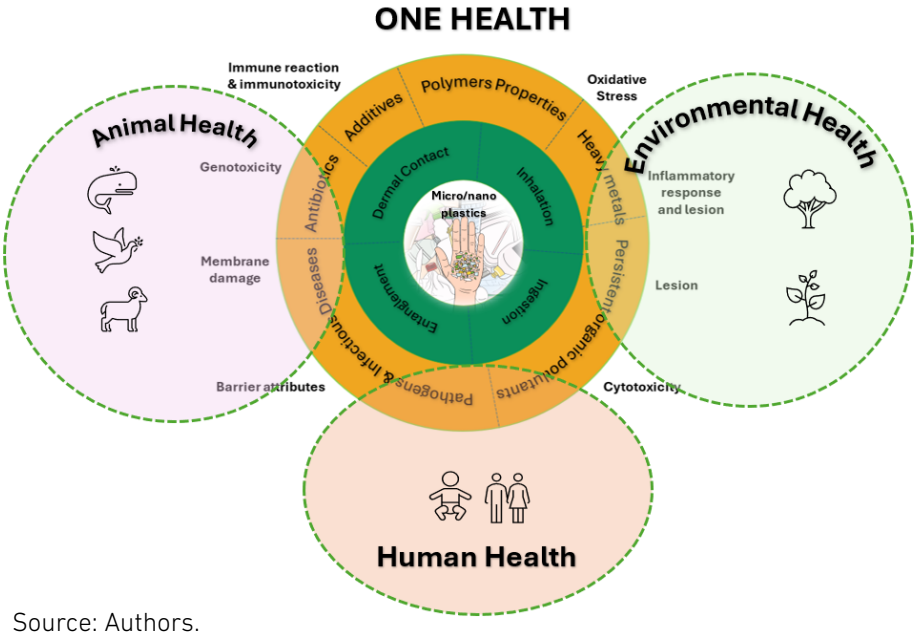
This policy brief calls for the mainstreaming of the One Health Framework into the MNP research agenda across ASEAN. One Health – a transdisciplinary and integrative approach – is particularly suited to addressing the complexity of MNP pollution by accounting for the interconnectedness of human, animal, and environmental health. Integrating One Health into MNP research would foster collaboration across scientific disciplines and enable a more comprehensive evaluation of the implications of MNP exposure. Such integration would allow for robust, multidisciplinary data collection on MNP instrumentations, exposure routes, constituent hazards, and toxicity effects.

To this end, ASEAN Member States are strongly encouraged to embed the One Health Framework in national and regional studies on MNPs. Doing so will enhance the capacity of the region to generate actionable evidence and support more informed, effective policy decisions on the intersection of health and micro/nanoplastic pollution.

Key Messages:

- Research on the nexus of micro/nanoplastics (MNPs) and health is increasing in ASEAN countries, supported by both member states and their dialogue partners. However, there remains a lack of in vivo and in vitro studies investigating the health impacts of MNPs. Amongst ASEAN Member States, Indonesia, Malaysia, Thailand, Viet Nam, and the Philippines have published the highest number of studies addressing the MNPs–health dyad.
- It is time to adopt and integrate the One Health approach into ASEAN MNP studies, given the complex and multilayered impacts of plastic pollution on human, animal, and environmental health. This integration can facilitate the generation of more robust multidisciplinary evidence on the interactions between health systems and micro/nanoplastics at the planetary level.
- The One Health Framework offers a valuable guide for assessing the risks associated with MNPs by examining their components, exposure routes, hazardous properties (including plastic polymers, additives, heavy metals, persistent organic pollutants, antibiotics, and associated pathogens), and their toxicological effects on humans, animals, and plants.
- MNPs have been detected in various organ systems of humans, animals, and plants through multiple exposure routes, including entanglement, inhalation, ingestion, and dermal contact. However, standardised characterisations for assessing MNPs and their toxic properties are not yet fully developed. Toxicity from MNPs may lead to a range of health effects such as oxidative stress, immune responses, inflammatory lesions, membrane damage, genotoxicity, cytotoxicity, and disruptions to biological barriers.

Graphical Abstract



Source: Authors.

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Chronicles of MNPs–Health Studies in ASEAN

As of 2 May 2025, a bibliometric analysis of Scopus-indexed publications confirms a growing trend in research interest and published studies on the nexus of micro/nanoplastics (MNPs) and health in the ASEAN region. This increase is likely driven by the evident and escalating risks that MNPs pose to human, animal, and ecosystem health, as well as the dramatic rise in plastic waste generation, facilitated by widespread plastic consumption and population growth.

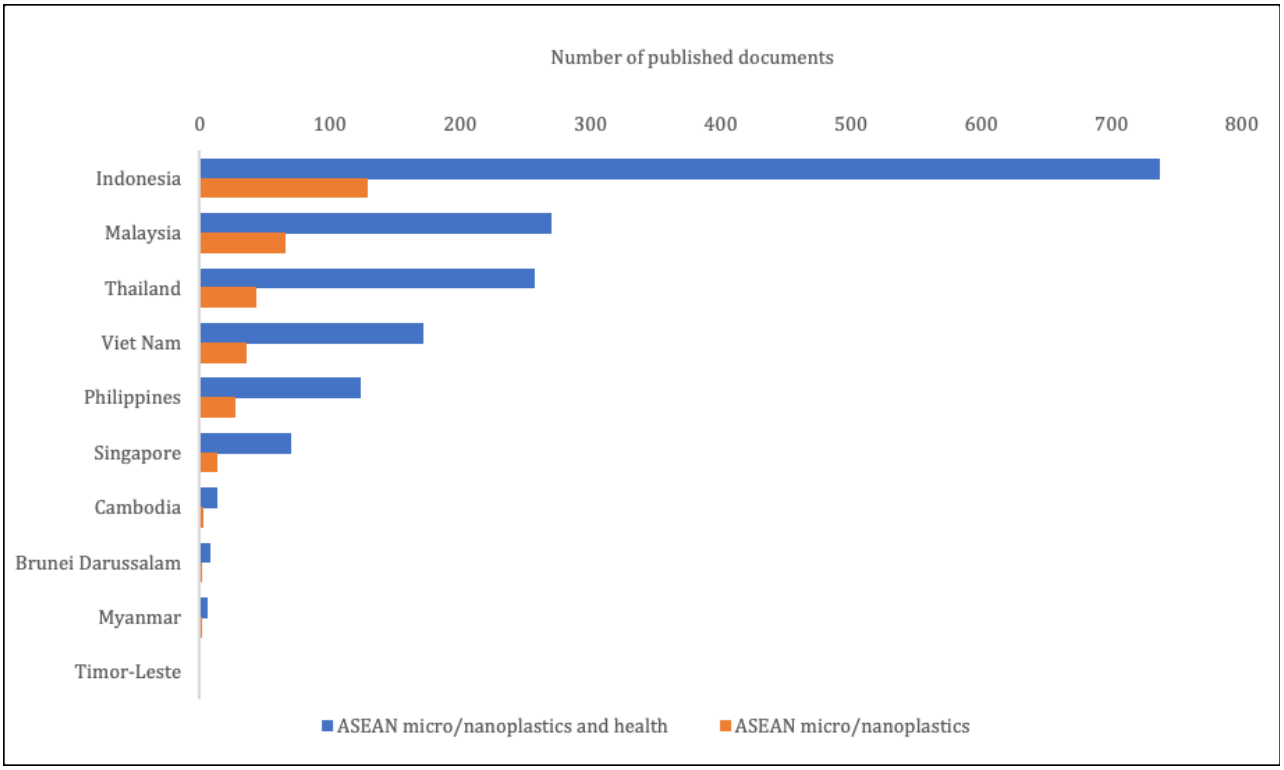
The analysis identified 327 published documents, with Indonesia, Malaysia, Viet Nam, and the Philippines amongst the top five contributors (Figure 1). Notably, Lao PDR has no recorded Scopus-indexed publications on the MNPs–health nexus, which may be attributed to the absence of indexed research or limited studies published in scientific journals on this subject.

Since the year 2000, published studies have documented the integration of health considerations into MNP research. Interest in this interconnected topic is projected to grow throughout 2025 and beyond. Initial studies focused on the health effects of plastics of varying sizes, from macro (bulk) and mesoplastics to micro- and nanoplastics. Network visualisation and metadata mapping reveal that existing research continues to centre on topics such as polymer types, particle sizes and concentrations, geographical distribution, fundamental properties, characterisation methods, policy frameworks, and environmental threats posed by MNPs. However, in vitro and in vivo studies examining the direct health impacts of MNPs remain scarce. Additionally, ASEAN-based studies on MNP exposure routes, organ-level accumulation, hazard analysis, and toxicological effects are still limited.

The One Health framework – an integrated, collaborative, and transdisciplinary approach – offers a comprehensive method to address the multifaceted nature of the MNPs–health nexus. This framework functions effectively through multisectoral and interdisciplinary engagement, supported by strong communication, coordination, collaboration, capacity-building, and governance mechanisms. While its application to MNP–health studies is relatively new in the ASEAN context, One Health encourages cross-sectoral expertise to generate scientific evidence and translate it into collective commitments and coordinated actions that address MNP-related health risks, hazards, and toxicity.

By placing the One Health approach at the centre of MNP research, ASEAN Member States can benefit from multidisciplinary insights into the health risks, trade-offs, co-benefits, and opportunities that support equitable and action-oriented responses to this growing environmental and public health challenge.

Figure 1: Bibliometric Analysis of ASEAN Studies and Publications on MNPs and Health



Note: Lao PDR has no record of Scopus-published documents in MNPs and health dyads.
Source: Authors.

Micro/Nanoplastics Perspectives on One Health Framework

Based on systematic evidence evaluation, no ASEAN-based studies have approached the health impact assessment of micro/nanoplastics (MNPs) in a holistic manner. However, by drawing from a limited number of global studies that incorporate the One Health framework into MNP research, four thematic areas emerge as key entry points: MNP exposure routes, instrumentations, hazard and risk assessments, and toxicity effects.

- Exposure Routes

  MNPs, which range in size from 5 mm to 1 nm and come in various forms – particles, beads, films, fragments, and fibres – can enter human, animal, and plant bodies through four primary routes: entanglement, dermal contact, ingestion, and inhalation. For example, fibrous MNPs can entangle microorganisms in a Velcro-like hook-and-loop mechanism, altering their mobility and making them more susceptible to predation. MNPs can penetrate dermal tissue due to their permeability and porosity, causing cutaneous alterations, inflammation, and disruption of tissue homeostasis. Ingestion of contaminated food, beverages, or other materials may lead to health risks such as cancer, immunotoxicity, gastrointestinal and pulmonary diseases, and prenatal exposure concerns. Airborne MNPs inhaled through respiration can accumulate in the lungs, leading to chronic obstructive pulmonary disease, fibrosis, tumors, asthma, and even lung cancer.

- Instrumentations

  Instrumentation represents the foundational stage for investigating MNPs' properties and associated health impacts. This includes examining MNPs' morphology and physical, chemical, and thermomechanical characteristics, as well as assessing their presence and effects in cells, tissues, and organs across species. Instruments used to characterise MNPs include electron microscopes, spectroscopy, spectrophotometry, gravimetry, and calorimetry. To assess health effects, methods such as cell viability assays, microarray analysis, cytotoxicity testing, wound healing assays, and oxidative stress tests are employed, often using in vitro and in vivo models. However, the lack of standardised instrumentation protocols – both globally and within ASEAN – limits the reproducibility, consistency, and comparability of research outcomes across disciplines. Establishing standardised tools and procedures is essential to support scientific coherence in One Health research.

- Hazards and Risk Assessment

  One Health also contributes to MNP studies through the lens of hazard and risk assessment. MNPs carry inherent risks through various agents, including polymer types, chemical additives, pathogens, heavy metals, persistent organic pollutants (POPs), and antibiotics. Polymer-related risks stem from their size, concentration, type, and surface functionalisation, which may induce toxic effects and disrupt biological functions. Additives such as bisphenol A, phthalates, styrene, acrylamide, and alkylphenols are known to trigger genetic and cellular disturbances, including apoptosis, altered cell proliferation and differentiation, immune system effects, and insulin pathway disruption (Sendra et al., 2021). MNPs also facilitate the spread of drug-resistant bacteria, vector-borne diseases, and pathogenic interactions by acting as carriers. Due to strong chemical and physical binding capabilities, MNPs can adsorb heavy metals and POPs. Combined exposure intensifies toxicity, particularly phytotoxicity, which is further amplified by increased pollutant concentration and longer exposure durations (Wu et al., 2024). Furthermore, MNPs can carry antibiotics and promote the development of antibiotic-resistant bacteria.

- Toxicity Effects

  From a One Health perspective, toxicity effects of MNPs are analysed by evaluating the consequences of exposure on human, animal, and plant health. Such exposures can cause oxidative stress, immune dysfunction, inflammatory lesions, membrane disruption, genotoxicity, cytotoxicity, and compromised cellular barriers. These effects arise from the overproduction of reactive oxygen species (ROS), dysregulated cytokine secretion, and damage to genetic material, ultimately resulting in cell and tissue injury (Weber et al., 2020; Chen et al., 2024).

Conclusions and Recommendations

Globally, the integration of One Health into MNP research remains limited, while in ASEAN, such efforts remain siloed and fragmented. Given the hazardous and toxicological implications of micro- and nanoplastics, the One Health framework offers a critical pathway to support evidence-based policy and scientific collaboration in the region. The following recommendations aim to enhance ASEAN's research and policy approaches on the MNP–health nexus:

1. Mainstream the One Health framework across all stages of MNP research project management – including planning, implementation, evaluation, and closure – by ensuring the inclusion of human, animal, and environmental health perspectives.
2. Promote One Health education and research collaboration by engaging multidisciplinary specialists across medicine, environmental science, veterinary medicine, and public health to enhance coordination and foster the next generation of experts prepared to address MNP-related challenges.
3. Prioritise in vitro and in vivo studies that centre on the four key One Health research themes: exposure routes, instrumentation, hazard and risk assessment, and toxicity effects on humans, animals, and plants.
4. Develop regionally harmonised protocols, laboratory infrastructure, and standardised instrumentation to assess MNP properties and evaluate their health impacts effectively and consistently across ASEAN.

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