QUALITY IN SPORT
eISSN 2450-3118 · Open Access · Peer-reviewed
apcz.umk.pl/QS Nicolaus Copernicus University in Toruń

KOGUT, Łukasz, JASTRZĘBSKA, Julia, GUNIA, Katarzyna, NYANKOVSKA, Yana, KOŁODZIEJ, Rafał, KOZDĘBA, Kacper, TENETA, Ania, HATALA, Ignacy, LULEK, Szymon and MICHALSKA, Wiktoria. Population exposure to microplastics from food and drinking water - challenges for public health. Quality in Sport. 2026;72:75680. https://doi.org/10.12775/QS.2026.72.75680

ARTICLE TIMELINE
Received: 26.08.2026. Revised: 30.08.2026. Accepted: 07.09.2026. Published: 15.09.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

Population exposure to microplastics from food and drinking water - challenges for public health

Julia Jastrzębska, ORCID https://orcid.org/0000-0001-9921-0881
E-mail: j.jastrzebska2105@gmail.com
Medical Centre in Łańcut LLC, Ignacego Paderewskiego 5, 37-100 Łańcut

Katarzyna Gunia, ORCID https://orcid.org/0009-0003-0111-5758
E-mail: katarzyna.gunia2000@gmail.com
Collegium Medicum, University of Rzeszów, al. Tadeusza Rejtana 16C, 35-959 Rzeszów

Łukasz Kogut, ORCID https://orcid.org/0009-0000-6151-4628
E-mail: lukasz.kogut2@wp.pl
Department of Bioenergetics, Food Analysis and Microbiology, Institute of Food Technology and Nutrition, Faculty of Technology and Life Science, University of Rzeszów, Aleja Rejtana 16C, 35-959 Rzeszów

Yana Nyankovska, ORCID https://orcid.org/0000-0003-0518-4753
E-mail: yana.nyankov@gmail.com
Clinical Regional Hospital No. 2 named after St. Queen Jadwiga in Rzeszów, Lwowska 60, 35-301 Rzeszów

Rafał Kołodziej, ORCID https://orcid.org/0009-0009-5029-600X
E-mail: rakolodziej@ur.edu.pl
Collegium Medicum, University of Rzeszów, al. Tadeusza Rejtana 16C, 35-959 Rzeszów

Kacper Kozdęba, ORCID https://orcid.org/0009-0008-7920-9400
E-mail: kacperkzd@gmail.com
Medical University of Warsaw, Żwirki i Wigury 61, 02-091 Warsaw

Ania Teneta, ORCID https://orcid.org/0009-0000-3000-5011
E-mail: at126307@stud.ur.edu.pl
Collegium Medicum, University of Rzeszów, al. Tadeusza Rejtana 16C, 35-959 Rzeszów

Ignacy Hatala, ORCID https://orcid.org/0009-0008-2428-8906
E-mail: Ignacy.hatala6@gmail.com
Medical University of Lodz, Al. Kościuszki 4, 90-419 Łódź

Szymon Lulek, ORCID https://orcid.org/0009-0000-3827-2907
E-mail: szymonlulek.z@gmail.com
Saint Queen Jadwiga Clinical Regional Hospital in Rzeszów, Rzeszów

Wiktoria Michalska, ORCID https://orcid.org/0009-0009-6436-2258
E-mail: michalskawika70@gmail.com
Ludwik Rydygier Specialist Hospital in Kraków, os. Złotej Jesieni 1, 31-826 Kraków

Corresponding Author
Łukasz Kogut, E-mail: lukasz.kogut2@wp.pl

Abstract

Background. Microplastics are widespread environmental contaminants increasingly detected in food, drinking water and human tissues, raising concerns about their potential health effects and public health implications.

Aim. This review aimed to assess population exposure to microplastics from food and drinking water, identify major dietary sources, evaluate potential health effects, and discuss challenges for monitoring, prevention and public health policy.

Material and methods. A narrative review of scientific literature on human exposure to micro- and nanoplastics was conducted, focusing on their occurrence in food and drinking water, exposure routes, mechanisms of toxicity, health effects, and regulatory challenges.

Results. Food and drinking water are major sources of microplastic exposure, supplemented by inhalation and contamination during food processing, packaging and preparation. Microplastics have been detected in water, seafood, salt, beverages, plant- and animal-derived foods, and human tissues. Evidence suggests that micro- and nanoplastics may cross biological barriers and contribute to oxidative stress, inflammation, impaired intestinal barrier function, gut microbiota alterations, and potential cardiovascular, reproductive, endocrine, respiratory and neurological effects. However, evidence for long-term health outcomes and causal relationships in humans remains limited. Key challenges include the lack of harmonised analytical methods, health-based exposure thresholds and comprehensive regulations.

Conclusions. Microplastic contamination is an emerging public health concern associated with widespread population exposure. Further research is needed to establish causal relationships and clinically relevant exposure thresholds. Risk reduction requires standardised monitoring, reduced plastic contamination at source, improved waste management, safer alternatives, and effective public health education.

Key words: microplastics, nanoplastics, contamination, drinking water, human exposure, public health, health effects

1. Introduction

Microplastics are a group of water-insoluble, synthetic solid particles or polymeric matrices whose size does not exceed 5 mm in their longest dimension [1–5]. This type of contaminant is now widely detected across all environmental compartments, including aquatic and terrestrial ecosystems as well as the atmosphere [6,7]. Owing to their high persistence, small size, large specific surface area and hydrophobic nature, microplastics can remain in the environment for decades or even centuries. These properties enable microplastic particles to act as effective carriers of harmful substances, including heavy metals, persistent organic pollutants and pathogenic microorganisms, thereby increasing their bioavailability and potential toxic effects [2,4,5].

Microplastics occur in a wide range of physical forms, including irregular fragments, fibres, pellets, spheroids, thin films and foams [2,3,5]. In terms of chemical composition, the predominant polymers are those widely used in industry, particularly polyethylene, polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate and polyamides [2,4,6,8]. Depending on their origin, microplastics can be classified as primary microplastics, which are intentionally manufactured at microscopic sizes for industrial, cosmetic and medical applications [1,5,6], and secondary microplastics, which are generated through the fragmentation of larger plastic items under the influence of UV radiation, temperature fluctuations, mechanical abrasion, wave action and biological processes [1–3,5,6].

Waste management infrastructure plays an important and crucial role in the environmental distribution of microplastics. Despite the high efficiency of wastewater treatment plants in removing particles from wastewater, these facilities contribute to their accumulation in sewage sludge, which is frequently applied to agricultural land as fertiliser, thereby introducing microplastics directly into soils [2,4,5,9]. Landfills and illegal dumping sites represent long-term sources of secondary microplastic emissions, from which particles may leach into groundwater or be transported by wind [1,2,5]. In addition, microplastics can be transported over long distances through the atmosphere, surface runoff and river systems, with rivers acting as major transport pathways to seas and oceans [2,4,5,9].

Although microplastic particles themselves constitute foreign material to living organisms, their potential impact is substantially associated with their ability to adsorb toxic chemical compounds and microorganisms onto their surfaces. In this way, microplastics may facilitate the transport and penetration of harmful substances into tissues and cells, increasing the risk of adverse biological effects and making microplastic pollution a significant challenge for environmental protection and public health [1,2].

1.1. Microplastics - a Public Health Problem

Microplastics represent a growing public health concern due to their widespread occurrence in the environment, multiple routes of human exposure, and their capacity to transport toxic substances and microorganisms. Human exposure to microplastics occurs primarily through the diet [1,5–7], inhalation of contaminated air [6], and dermal contact, with particularly high concentrations being observed in indoor environments [5,9]. Microplastic particles can act as chemical and biological vectors by adsorbing heavy metals and persistent organic pollutants [1,2,4,5,10], as well as by releasing additives such as bisphenol A and phthalates, which have endocrine-disrupting properties [1,3,5,7]. The smallest fractions are capable of crossing biological barriers, as demonstrated by their detection in human blood, lungs and placenta [1,5,6,9].

Experimental studies using animal models indicate that microplastics may induce oxidative stress, inflammatory responses [1,5,7], and metabolic disturbances [1,4,5]. However, the World Health Organization emphasises that evidence regarding the long-term health effects of microplastic exposure in humans remains limited. Given the continuing increase in plastic production and the widespread, largely unavoidable exposure of the population, microplastics constitute an important public health concern. At the same time, they represent a significant challenge requiring further research and the implementation of preventive measures within the field of public health [5-7].

Therefore, the aim of this article is to assess the extent of population exposure to microplastics originating from food and drinking water and to identify the associated public health risks. This review aims to analyse the main sources of microplastics in the human diet, the potential mechanisms underlying their biological effects, and current research gaps, as well as to identify the challenges facing monitoring and prevention systems and public health policy.

2. Research materials and methods

The present study was conducted as a narrative review of the available scientific literature concerning human exposure to micro- and nanoplastics, with particular emphasis on exposure through food and drinking water and the associated implications for public health. A literature search was performed using the PubMed/MEDLINE, Scopus, and Web of Science databases. Publications addressing the occurrence of micro- and nanoplastics in food and drinking water, human exposure, potential health effects, and public health implications were considered. In addition, the reference lists of relevant systematic reviews, narrative reviews, reports, and scientific articles were manually screened to identify additional publications relevant to the scope of the review.

The literature search was based on combinations of predefined search terms related to micro- and nanoplastic exposure, including: “microplastics”, “nanoplastics”, “microplastic exposure”, “human exposure”, “food contamination”, “drinking water”, “dietary exposure”, “food packaging”, “human health”, “public health”, “oxidative stress”, “inflammation”, “gut microbiota”, “cardiovascular effects”, “reproductive toxicity”, “endocrine effects”, “respiratory effects”, and “neurotoxicity”. The search terms were used individually and in appropriate combinations to identify publications covering the principal thematic areas of the review.

Eligible publications included peer-reviewed original studies investigating the occurrence of micro- or nanoplastics in food, beverages and drinking water, as well as studies evaluating human exposure and potential biological or health effects. Experimental *in vitro* and *in vivo* studies were considered when they provided mechanistically relevant information on micro- and nanoplastic toxicity. Systematic reviews, narrative reviews, and relevant reports from international organisations were also considered when they contributed information on population exposure, food safety, risk assessment, monitoring, regulation or public health implications.

Studies unrelated to human exposure or health, publications without sufficient relevance to food- or drinking-water-related exposure, conference abstracts, editorials, and publications lacking adequate scientific information were excluded from the main synthesis. Studies concerning environmental contamination were included only when they provided information directly relevant to the transfer of microplastics into the human food chain, drinking water, or other pathways contributing to population exposure.

The eligible evidence was qualitatively synthesised according to the principal areas addressed in this review: sources and routes of human exposure, potential health effects, and challenges for public health. Particular attention was given to differences among studies in analytical methodology, particle size ranges, polymer composition, exposure conditions, biological models, and reported outcomes. Due to substantial heterogeneity in analytical techniques, definitions of micro- and nanoplastics, particle characteristics, exposure assessment methods, and health outcomes, a quantitative meta-analysis was not performed. Instead, the available evidence was synthesised narratively to provide an integrated overview of population exposure, potential biological effects, and current challenges related to monitoring, prevention, and public health policy.

As this study was designed as a narrative review based exclusively on previously published data and did not involve the collection of primary data from human participants or animals, formal ethical approval was not required.

3. Main Sources and Routes of Exposure

The primary route through which microplastic particles enter the human body is ingestion via food and water [11-13]. It is estimated that approximately 39,000–52,000 microplastic particles are ingested annually, while in individuals whose sole source of drinking water is bottled water, this figure may increase by up to 90,000 particles per year [11,14,15]. Water represents a key vehicle for microplastic exposure due to its daily consumption and widespread use in food-processing operations [15,16]. Bottled water generally contains higher concentrations of microplastics than tap water, primarily as a result of particle migration from packaging made of polyethylene terephthalate, as well as polyethylene and polypropylene used in bottle caps, and the mechanical abrasion of plastic during repeated opening and closing of bottles [11,13,16,17]. In the case of tap water, although treatment processes can remove more than 90% of microplastics, trace amounts of particles, estimated at an average of approximately five particles per litre, may still reach consumers, mainly as a result of abrasion of pipes made of PVC and PE and degradation of tank coatings containing epoxy resins [11,12,15,16,18]. Microplastics have also been detected in other beverages, including beer, wine, energy drinks and soft drinks. A particularly notable source of exposure is tea packaged in plastic tea bags, which, when exposed to boiling water, may release billions of micro- and nanoplastic particles into a single cup of tea [11,12,16,19].

Seafood represents an important dietary source of microplastics and constitutes one of the most extensively investigated components of the food chain in terms of plastic contamination [11,14,16]. Bivalves such as mussels and oysters, as filter-feeding organisms, accumulate microplastics in their tissues, and because they are consumed whole, including the gastrointestinal tract, their consumption may directly expose humans to substantial numbers of particles [11,12,14,16]. In fish and crustaceans, microplastics accumulate predominantly in the gastrointestinal tract, which is generally removed before consumption. However, the smallest fractions may translocate into muscle tissues, indicating that even eviscerated organisms may constitute a source of exposure [3,11,19]. Microplastic contamination also affects sea salt, in which the presence of particles composed of polymers such as PET, PVC and PP reflects both the condition of the aquatic environment and the influence of processing and packaging practices [11,12,15,17].

Microplastics may also enter terrestrial food products through soil and agricultural and industrial activities [11,15,16]. Crop plants are capable of taking up small particles, particularly nanoplastics, from soil through their root systems, potentially leading to their accumulation in edible parts, including apples and pears, as well as vegetables such as carrots, lettuce and broccoli [11,15,16,20]. The main sources of microplastics in agricultural soils include sewage sludge applied as fertiliser and the degradation of agricultural plastic films [11,20]. Animal-derived products, including meat and milk, may also contain microplastics because livestock can ingest contaminated feed and water. Microplastic particles have been detected, among others, in goose eggs and cow's milk, where plastic filters and components of milking systems may constitute additional sources of contamination [11,15,16]. Microplastics have also been identified in rock and lake salt, sugar and honey, indicating the potential for contamination during processing and packaging [12,16,17].

Secondary sources of contamination arising during food preparation and consumption may contribute substantially to overall human exposure to microplastics. The use of plastic chopping boards, particularly those made of polypropylene, can result in the release of microparticles directly into food during cutting. Similarly, plastic spice grinders may release small particles of nylon or polyoxymethylene during the grinding of salt and pepper [13,15,16,19]. Heating food in plastic containers in microwave ovens can substantially increase the release of micro- and nanoplastics, while the everyday use of twist-off packaging, plastic food wraps and sealing tapes may further contribute to particle release [12,19]. Household dust containing synthetic textile fibres represents an additional and difficult-to-control source of exposure, as these fibres may settle directly onto food and, in some circumstances, constitute a more significant source of dietary microplastic exposure than the consumption of contaminated seafood [11,18].

4. Potential Health Effects of Microplastic Exposure

Human exposure to micro- and nanoplastics is increasingly recognised as a growing public health challenge due to their widespread presence in the environment, food, drinking water and air. One of the key mechanisms underlying microplastic toxicity at the cellular level is the induction of oxidative stress [21,22]. Plastic particles are recognised by human immune cells as foreign bodies, leading to excessive production of reactive oxygen species (ROS) [21,23]. This process may result in damage to membrane lipids, proteins and genetic material, thereby contributing to genotoxicity, cell-cycle disruption and potentially carcinogenic processes [22,24]. Nanoplastics, in particular, are capable of penetrating cellular organelles, including mitochondria, leading to disruption of the respiratory chain, reduced ATP production, and activation of apoptotic and autophagic pathways [21,22,25].

The prolonged presence of micro- and nanoplastics in tissues may promote chronic inflammation, which represents a common underlying mechanism in numerous non-communicable diseases. Microplastics can activate the NLRP3 inflammasome, initiating an inflammatory cascade involving pro-inflammatory cytokines such as interleukin-1β (IL-1β), IL-6 and tumour necrosis factor alpha (TNF-α) [21,22,26,27]. Persistent stimulation of the inflammatory response, combined with mechanical tissue damage caused by the sharp edges of polymer particles, may contribute to fibrotic processes observed, among others, in the lungs and liver. These processes may disrupt normal organ architecture and impair organ function [22,23,28].

The gastrointestinal tract represents the principal route of human exposure to microplastics, and its integrity may be adversely affected by these particles [24,28]. Studies have indicated an association between the amount of microplastics detected in faeces and the severity of inflammatory bowel disease, with significantly higher concentrations of plastic particles reported in patients with IBD than in healthy individuals [29]. Microplastics may compromise the intestinal barrier by reducing the expression of tight-junction proteins, such as occludin, resulting in increased intestinal permeability and facilitating the translocation of toxins and pathogens into the bloodstream [21,22,28]. Significant alterations in the composition of the gut microbiota have also been observed, including an increased abundance of potentially pathogenic microorganisms at the expense of bacteria with protective functions. Such alterations may substantially affect host metabolism and the regulation of immune responses [21,28,29].

An increasing body of research suggests a potential role of micro- and nanoplastics in the pathogenesis of cardiovascular diseases [24,30]. Microplastic particles, predominantly polyethylene and PVC, have been detected directly in carotid artery atherosclerotic plaques in 58% of the patients examined [27,30]. Their presence has been associated with a significantly increased risk of cardiovascular events, including myocardial infarction, ischaemic stroke or death, during approximately three years of follow-up [30]. The reported risk was approximately 4.5-fold higher among patients in whom micro- and nanoplastics were detected within atheromatous plaques [30]. Potential mechanisms include increased inflammatory activity within vascular walls as well as possible effects of microplastics on activation of the coagulation system and platelets, which may increase the risk of thrombosis and contribute to the destabilisation of atherosclerotic plaques [27].

Microplastics may also adversely affect the reproductive and endocrine systems, particularly through the transport and release of endocrine-disrupting chemicals, such as bisphenol A and phthalates [30,31]. Plastic particles have been detected in the testes, semen and ovaries, while experimental evidence suggests that their accumulation may contribute to oxidative stress, germ-cell apoptosis, and disturbances in spermatogenesis and folliculogenesis [22,24,29-32]. Of particular concern are reports demonstrating the ability of microplastics to cross the placental barrier, potentially resulting in fetal exposure during prenatal development. Their presence has also been reported in human breast milk, indicating the possibility of continued exposure during early development [22,24,30,33].

The respiratory system represents another important route of exposure to microplastics, primarily through the inhalation of particles present in airborne dust and indoor environments. Deposition of micro- and nanoplastic particles in the pulmonary alveoli may induce inflammatory responses, damage to the respiratory epithelium [22,24,29], and disruption of pulmonary surfactant function, including alterations involving surfactant protein B (SP-B), which is essential for maintaining normal pulmonary function and gas exchange [25]. These effects are of particular concern among individuals occupationally exposed to synthetic fibres, in whom prolonged exposure may contribute to the development of chronic respiratory disorders [24,25].

Due to their small size, micro- and nanoplastics may also pose a neurological risk because the smallest particles may be capable of crossing the blood–brain barrier, raising concerns regarding their potential neurotoxicity [24,30]. Experimental studies in animal models have demonstrated that plastic particles can accumulate in brain tissue. Such accumulation may contribute to microglial activation and neuroinflammatory responses accompanied by behavioural alterations. Preliminary human observations have suggested that microplastic concentrations in brain tissue may differ between individuals with neurodegenerative diseases and those without such conditions. These findings raise the possibility that microplastics could contribute to processes associated with neurodegeneration. However, the available evidence remains insufficient to establish a causal relationship, and the potential effects of micro- and nanoplastics on the human brain require further comprehensive investigation [21,24].

5. Discussion

5.1. Challenges for Public Health

One of the major challenges associated with microplastics is the lack of coherent legal standards and regulatory guidelines [34]. Current regulations remain fragmented, and internationally harmonised permissible limits for microplastics in environmental matrices, including wastewater, soils and biosolids, have not yet been established [34,35]. The use of sewage sludge in agriculture is particularly problematic, as it may contribute to the long-term contamination of soils and indirect human exposure through the food chain [36]. The absence of harmonised terminology and standardised analytical methods makes it difficult to compare findings across studies and conduct comprehensive global risk assessments. Furthermore, owing to the considerable heterogeneity of microplastics, it is currently not possible to establish definitive health-based threshold values, such as an acceptable daily intake [34,37].

The interpretation of the available evidence is further complicated by substantial methodological heterogeneity between studies. Differences in sampling procedures, analytical techniques, particle-size detection limits and polymer identification methods can lead to considerable variation in reported microplastic concentrations. This problem is particularly important in the case of nanoplastics, which remain difficult to detect and quantify using routinely applied analytical approaches. Consequently, estimates of population exposure should be interpreted with caution, and direct comparisons between individual studies may not always be justified. The lack of harmonised methodologies also limits the possibility of establishing reliable dose-response relationships and clinically relevant exposure thresholds [34,36-39].

Another important issue is the distinction between evidence of human exposure and evidence of adverse health effects. The presence of micro- and nanoplastics has been demonstrated in several human tissues, while experimental studies provide biologically plausible mechanisms involving oxidative stress, inflammatory responses, mitochondrial dysfunction, disruption of intestinal integrity and alterations in cellular signalling [21,22,24,26-30]. However, much of the mechanistic evidence originates from in vitro and animal studies, frequently using exposure conditions that may not fully reflect real-life human exposure. Therefore, although the biological plausibility of adverse effects is increasingly well documented, the current epidemiological evidence remains insufficient to establish causality for most chronic health outcomes.

From a public health perspective, particular attention should also be given to population groups with potentially higher or prolonged exposure. These may include individuals relying predominantly on bottled water, persons occupationally exposed to synthetic fibres and plastic dust, and vulnerable groups such as pregnant women and children. The detection of microplastics in the placenta, reproductive tissues and breast milk raises additional concerns regarding exposure during sensitive periods of development [22,24,29-32]. Nevertheless, because no validated exposure thresholds have yet been established, the actual magnitude of risk in these populations remains uncertain.

The development of integrated monitoring systems and sensitive detection methods is therefore of particular importance, especially for nanoplastics smaller than 1 μm, which may more readily cross biological barriers [34,36,38,39]. From a public health perspective, primary prevention remains the most effective approach, involving the reduction of contamination at source through restrictions on the intentional use of microplastics in products, improvements in waste management and recycling, and the development of biodegradable alternatives [35,37,40-44]. These measures should be complemented by consumer education and effective risk communication aimed at reducing the use of single-use products, promoting appropriate waste segregation, and encouraging informed choices regarding packaging materials. Successful implementation of these strategies requires cooperation between public institutions, non-governmental organisations and public health experts [34,35,40,42,44].

6. Conclusions

Microplastics represent a growing public health concern due to their widespread presence in the environment, water and food, as well as their potential to enter and accumulate in human tissues, including the brain, reproductive tissues and tissues associated with fetal development [21,24,29-32]. Human exposure occurs primarily through the diet, drinking water, inhalation and contact with contaminated materials, and may be associated with oxidative stress, inflammation, and metabolic, endocrine and cardiovascular disturbances [21,22,24,27,29-32].

However, the current evidence base, particularly regarding long-term effects and causal relationships in humans, remains incomplete [29,31–33]. The lack of harmonised regulations and standardised analytical methods further complicates risk assessment and the management of population exposure [33,36,37].

Effective public health protection therefore requires a combination of primary prevention, improved waste management, reduction of plastic contamination at source, development of safer and biodegradable alternatives, standardised monitoring systems, and public education aimed at reducing unnecessary exposure [34,36,38-41]. Further prospective human studies and harmonised analytical protocols are required to establish clinically relevant dose-response relationships, identify population groups at greatest risk and provide a stronger scientific basis for future regulatory standards and public health recommendations [31-33,36].

Disclosure

Supplementary Materials:

Not applicable.

Author Contributions:
Conceptualization: Julia Jastrzębska, Łukasz Kogut
Methodology: Julia Jastrzębska, Łukasz Kogut, Katarzyna Gunia
Resources: Katarzyna Gunia, Yana Nyankovska, Rafał Kołodziej, Kacper Kozdęba, Ania Teneta, Ignacy Hatala, Szymon Lulek, Wiktoria Michalska
Writing – original draft preparation: Julia Jastrzębska, Katarzyna Gunia, Łukasz Kogut, Yana Nyankovska, Rafał Kołodziej, Kacper Kozdęba, Ania Teneta, Ignacy Hatala, Szymon Lulek, Wiktoria Michalska
Writing – review and editing: Julia Jastrzębska, Łukasz Kogut, Katarzyna Gunia
Supervision: Julia Jastrzębska, Łukasz Kogut

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgements: Not applicable.

Conflicts of Interest: The authors declare no conflicts of interest.

Declaration of the Use of Generative AI and AI-Assisted Technologies in the Writing Process:

During the preparation of this work, the authors used ChatGPT for the purpose of language editing and stylistic refinement to improve clarity and readability of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the accuracy, integrity and conclusions of the publication.

References

1. Dissanayake PD, Kim S, Sarkar B, Oleszczuk P, Sang MK, Haque MN, Ahn JH, Bank MS, Ok YS. Effects of microplastics on the terrestrial environment: A critical review. Environ Res. 2022;209:112734. https://doi.org/10.1016/j.envres.2022.112734
2. Fan W, Qiu C, Qu Q, Hu X, Mu L, Gao Z, Tang X. Sources and identification of microplastics in soils. Soil Environ Health. 2023;1:100019. https://doi.org/10.1016/j.seh.2023.100019
3. Lusher AL, Hollman PCH, Mendoza-Hill JJ. Microplastics in fisheries and aquaculture: Status of knowledge on their occurrence and implications for aquatic organisms and food safety. FAO Fisheries and Aquaculture Technical Paper No. 615. Rome: Food and Agriculture Organization of the United Nations; 2017. ISBN: 978-92-5-109882-0
4. Yu J, Adingo S, Liu X, Li X, Sun J, Zhang X. Micro plastics in soil ecosystem—A review of sources, fate, and ecological impact. Plant Soil Environ. 2022;68(1):1-17. https://doi.org/10.17221/242/2021-PSE
5. Zhang X, Yu C, Wang P, Yang C. Microplastics and human health: Unraveling the toxicological pathways and implications for public health. Front Public Health. 2025;13:1567200. https://doi.org/10.3389/fpubh.2025.1567200
6. Kucharczyk E, Andrzejczak K, Sternak A, Witkowski W, Kazimierska M, Błaszczyszyn K, Gaweł-Dąbrowska D. The impact of microplastic pollution on human health—Current issues. Ecol Quest. 2025;36(1). https://doi.org/10.12775/EQ.2025.002
7. Oleksiuk K, Krupa-Kotara K, Grajek M, Wypych-Ślusarska A, Głogowska-Ligus J, Słowiński J. Health risks of environmental exposure to microplastics. J Educ Health Sport. 2023;13(1):79-84. https://doi.org/10.12775/JEHS.2023.13.01.012
8. Waldschläger K, Brückner MZM, Carney Almroth B, Hackney CR, Adyel TM, Alimi OS, et al. Learning from natural sediments to tackle microplastics challenges: A multidisciplinary perspective. Earth-Sci Rev. 2022;228:104021. https://doi.org/10.1016/j.earscirev.2022.104021
9. Hale RC, Seeley ME, La Guardia MJ, Mai L, Zeng EY. A global perspective on microplastics. J Geophys Res Oceans. 2020;125:e2018JC014719. https://doi.org/10.1029/2018JC014719
10. Huvet A, Frère L, Lacroix C, Rinnert E, Lambert C, Paul-Pont I. Microplastics as sorption materials of herbicides, persistent organic pollutants (POPs) and polycyclic

aromatic hydrocarbons (PAHs) in a coastal bay. Reg Stud Mar Sci. 2025;89:104279. https://doi.org/10.1016/j.rsma.2025.104279

11. Garrido Gamarro E, Costanzo V. Microplastics in food commodities: A food safety review on human exposure through dietary sources. Food Safety and Quality Series No. 18. Rome: Food and Agriculture Organization of the United Nations; 2022. https://doi.org/10.4060/cc2392en
12. Udovicki B, Andjelkovic M, Cirkovic-Velickovic T, Rajkovic A. Microplastics in food: Scoping review on health effects, occurrence, and human exposure. Int J Food Contam. 2022;9:7. https://doi.org/10.1186/s40550-022-00093-6
13. Zbucki Ł, Plażuk E. Mechanical grinding of spices in grinders with polymeric burrs and transfer of microplastics to food. Health Probl Civiliz. 2024;18(3):339-353. https://doi.org/10.5114/hpc.2024.135399
14. van Raamsdonk LWD, van der Zande M, Koelmans AA, Hoogenboom RLAP, Peters RJB, Groot MJ, et al. Current insights into monitoring, bioaccumulation, and potential health effects of microplastics present in the food chain. Foods. 2020;9(1):72. https://doi.org/10.3390/foods9010072
15. Das S, Gebremeskal YH, Maksimova BV, Zun P, Eremeeva NB. Microplastic contamination and detection in food systems: A review of machine learning, traditional methods, and other relevant factors. *Microchem J.* 2025;218:115440. https://doi.org/10.1016/j.microc.2025.115440
16. Cverenkárová K, Valachovičová M, Mackuľak T, Žemlička L, Bírošová L. Microplastics in the food chain. Life (Basel). 2021;11(12):1349. https://doi.org/10.3390/life11121349
17. De Nido CG, Centonze D, Palermo C, Gonzalez-Sálamo J, Hernandez-Borges J. Microplastics in salt: A critical review of contamination, analytical methodologies, and health implications. J Chromatogr Open. 2025;8:100276. https://doi.org/10.1016/j.jcoa.2025.100276
18. Maurizi L. Microplastic and nanoplastic analysis in drinking water and indoor air with Raman micro-spectroscopy [doctoral dissertation]. Aalborg: Aalborg University Press; 2023. https://doi.org/10.54337/aau617106604

19. Khatoon N, Ali S, Huang J, Yu Z, Liu H. Microplastics in essential food commodities: A systematic review of identification, detection, contamination, and health implications (2017–2024). Food Rev Int. 2025. https://doi.org/10.1080/87559129.2025.2514252
20. Porterfield KK, Hobson SA, Neher DA, Niles MT, Roy ED. Microplastics in composts, digestates, and food wastes: A review. J Environ Qual. 2023;52:225-240. https://doi.org/10.1002/jeq2.20450
21. Sutkar P, Dhulap V, Girigosavi S, Deshmukh S, Desai M. Microplastics in the human body: A comprehensive review of exposure, detection, and health risks. Wastewater Purification. 2025;1(1):20250317163738. https://doi.org/10.6084/m9.figshare.28845923
22. Sun A, Wang W-X. Human exposure to microplastics and its associated health risks. Environ Health. 2023;1:139-149. https://doi.org/10.1021/envhealth.3c00053
23. Jeong E, Lee J-Y, Redwan M. Animal exposure to microplastics and health effects: A review. Emerg Contam. 2024;10:100369. https://doi.org/10.1016/j.emcon.2024.100369
24. Pechcińska A, Malejczyk J, Tulewicz-Marti EM, Małkiewicz K. Multiple effects of microplastic particles on human internal organs: A narrative review. Ann Agric Environ Med. 2025. https://doi.org/10.26444/aaem/210744
25. Michelini S, Mawas S, Kurešepi E, Barbero F, Šimunović K, Miremont D, et al. Pulmonary hazards of nanoplastic particles: A study using polystyrene in in vitro models of the alveolar and bronchial epithelium. J Nanobiotechnology. 2025;23:388. https://doi.org/10.1186/s12951-025-03419-6
26. Prata JC. Microplastics and human health: Integrating pharmacokinetics. Crit Rev Environ Sci Technol. 2023;53(16):1489-1511. https://doi.org/10.1080/10643389.2023.2195798
27. Zheng H, Vidili G, Casu G, Navarese EP, Sechi LA, Chen Y. Microplastics and nanoplastics in cardiovascular disease—A narrative review with worrying links. Front Toxicol. 2024;6:1479292. https://doi.org/10.3389/ftox.2024.1479292
28. Domagała M, Wiewióra J, Domańska I, Sagan A, Piśkiewicz M, Duda W, Majewska E. A comprehensive review of the impact of microplastics on the respiratory, digestive and renal systems—Mechanisms of toxicity and health implications. Med Og Nauk Zdr. 2025;31(3):149-155. https://doi.org/10.26444/monz/208119

29. Winiarska E, Jutel M, Zemelka-Wiacek M. The potential impact of nano- and microplastics on human health: Understanding human health risks. Environ Res. 2024;251:118535. https://doi.org/10.1016/j.envres.2024.118535
30. Belmaker I, Anca ED, Rubin LP, Magen-Molho H, Miodovnik A, van der Hal N. Adverse health effects of exposure to plastic, microplastics and their additives: Environmental, legal and policy implications for Israel. Isr J Health Policy Res. 2024;13:44. https://doi.org/10.1186/s13584-024-00628-6
31. Tang KHD, Li R, Li Z, Wang D. Health risk of human exposure to microplastics: A review. Environ Chem Lett. 2024. https://doi.org/10.1007/s10311-024-01727-1
32. Chartres N, Cooper CB, Bland G, Pelch KE, Gandhi SA, BakenRa A, Woodruff TJ. Effects of microplastic exposure on human digestive, reproductive, and respiratory health: A rapid systematic review. Environ Sci Technol. 2024;58:22843-22864. https://doi.org/10.1021/acs.est.3c09524
33. Blackburn K, Green D. The potential effects of microplastics on human health: What is known and what is unknown. Ambio. 2022;51(3):518-530. https://doi.org/10.1007/s13280-021-01589-9
34. Magalhães S, Alves L, Medronho B, Svanedal I, Norgren M, Rasteiro MG. Innovative approaches to mitigating microplastic pollution in effluents and soils. Sustainability. 2025;17(20):9014. https://doi.org/10.3390/su17209014
35. Achoukhi I, El Hammoudani Y, Haboubi K, Benaabidate L, Bourjila A, El Boudammoussi M, et al. Impact of microplastics on human health and aquatic species. E3S Web Conf. 2024;527:02001. https://doi.org/10.1051/e3sconf/202452702001
36. Thornton Hampton LM, Bouwmeester H, Brander SM, Coffin S, Cole M, Hermabessiere L, et al. Research recommendations to better understand the potential health impacts of microplastics to humans and aquatic ecosystems. Microplast Nanoplast. 2022;2:18. https://doi.org/10.1186/s43591-022-00038-y
37. Rubio-Armendáriz C, Alejandro-Vega S, Paz-Montelongo S, Gutiérrez-Fernández ÁJ, Carrascosa-Iruzubieta CJ, Hardisson-de la Torre A. Microplastics as emerging food contaminants: A challenge for food safety. Int J Environ Res Public Health. 2022;19(3):1174. https://doi.org/10.3390/ijerph19031174

38. Pan Y, Gao S-H, Ge C, Gao Q, Huang S, Kang Y, et al. Removing microplastics from aquatic environments: A critical review. Environ Sci Ecotechnol. 2023;13:100222. https://doi.org/10.1016/j.ese.2022.100222
39. Kabir MS, Wang H, Luster-Teasley S, Zhang L, Zhao R. Microplastics in landfill leachate: Sources, detection, occurrence, and removal. Environ Sci Ecotechnol. 2023;16:100256. https://doi.org/10.1016/j.ese.2023.100256
40. Ziani K, Ioniță-Mîndrican C-B, Mititelu M, Neacșu SM, Negrei C, Moroșan E, et al. Microplastics: A real global threat for environment and food safety: A state of the art review. Nutrients. 2023;15(3):617. https://doi.org/10.3390/nu15030617
41. Li Y. Legislation and policy on pollution prevention and the control of marine microplastics. Water (Basel). 2022;14(18):2790. https://doi.org/10.3390/w14182790
42. Hota HN, Malathi H, Panigrahi R. Microplastics and human health: An emerging concern in aquatic and terrestrial environments. Health Leadersh Qual Life. 2022;1:125. https://doi.org/10.56294/hl2022125
43. Özbay S. Environmental food contaminants and control recommendations. J Biomed Res Environ Sci. 2024;5(7):872-879. https://doi.org/10.37871/jbres1966
44. Sharma P. Microplastic contamination in food processing: Role of packaging materials. Food Sci Eng. 2024;5(2):271-287. https://doi.org/10.37256/fse.5220244519