

PUBLIC CONSUMPTION OF MICROPLASTICS AND AWARENESS ABOUT POTENTIAL HEALTH EFFECTS AND PREVENTION

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Abstract. Worryingly widespread and extremely durable, microplastics are harmful because they release toxins and contaminants all over the world. Microplastics are also thought to be vectors for transmitting diseases and toxic substances, posing potentially serious health risks when inhaled and ingested by humans. The aim of the study was to investigate public consumption habits of microplastics and awareness about potential health effects and prevention. The tasks of the study were to investigate awareness of microplastics forms and possible routes of entry into the human body, to detect the knowledge of the presence of microplastics in human's different tissues and organs and potential harmful health effects, to reveal plastics and microplastics consuming habits and awareness about prevention measures. Conclusions: Half of respondents were familiar with polyethylene, polyester, polyethylene terephthalate, one third of styrene, nylon and polypropylene to be microplastics. Two third of participants reported that microplastics are found in human excretions and all human's body. The majority of respondents were aware about the main routes of microplastics' entry into human's body, but there were gaps in their knowledge. More than half of respondents indicated hormonal disruption, cancerogenicity, allergies or asthma, weakening immunity and causing chronic inflammation as microplastics harmful health effects. The majority of respondents are using plastic bags and packages for foodstuffs, water and drinks in plastic bottles. Prevention measures, offered by the majority of respondents, were to sort plastic waste, to avoid plastic packages and bottles of foodstuffs and water, heating food in plastic dishes, though only half of respondents are sorting plastic waste, heating food in plastic-free dishes and wearing clothes made of natural fibers. Despite increased awareness, behaviors reflecting preventive actions remained inconsistent. The findings highlight the urgent need for better public education and regulatory action to mitigate microplastic exposure and its associated health risks.

The TOPSIS multi-criteria approach allows for a comprehensive and integrated assessment of the financial autonomy of municipalities by providing a single summary indicator composed of several revenues ratios.

The empirical research analyses the situation of the revenue potential of Panevėžys region municipalities, assessing the financial autonomy of municipalities in the period 2009-2022. The research shows that all municipalities in the region are very homogeneous in terms of revenue indicators and have a moderately low level of financial autonomy. The empirical results also show that municipalities' financial autonomy is changing slowly compared to the results of previous research. This confirms the dependence of municipalities on centralised financial management, which is governed by the legal acts that have a strong impact on the development of municipalities' financial autonomy and financial capability. Hence, the results in a way also show a lack of capacity on the part of municipalities themselves to seek opportunities to create sustainable, stable perspectives from an economic and social perspective.

Keywords: microplastics; public awareness; health effects; prevention; environmental pollution

INTRODUCTION

Currently, accurate statistics are unavailable regarding the sources of microplastics and the total amount of microplastics deposited in the land and sea. Various human activities and products, such as washing, worn tires, city dust, road paint, ships, and cleaning products, have been reported as sources of microplastics (Lee et al., 2023). Currently, four major routes of exposure have been identified including entanglement, contact, ingestion and inhalation. Humans may be the most exposed organism because they are at the peak of the food chain. Humans can be exposed to microplastics through direct ingestion, direct contact, and inhalation (Enyoh et al., 2020). These micro-nanoplastics (MNPs) in the gut can change the composition of gut microbiota populations and impact the production of gut microbiota metabolites. MNPs can damage intestinal structure, induce intestinal inflammation, and alter the expression of intestinal tight junction proteins and mucosal proteins. Ultimately, MNPs in the gut can lead to an increase in intestinal permeability and a disruption of the intestinal barrier function (Zhang et al., 2023). Polypropylene microplastics were found in human placentas (Ragusa et al., 2020). The synthetic fiber industry is a representative example of potential workplace exposure to microplastics through inhalation. The results of many studies have demonstrated that microplastic inhalation can lead to respiratory and lung diseases among workers in factories using synthetic fibers (Lee et al., 2023). In addition, studies have indicated that workers in plastic-related industries develop many kinds of cancer because of chronic exposure to high levels of airborne microplastics (Wang, Lee, Chiu, Lin, & Chiu, 2020). It was suggested that plastic particles can easily cross all biological barriers and reach different organs, especially the cardiovascular system, with the potential to modulate several molecular pathways. It is postulated that the direct interaction of PPs with cellular and subcellular components induces genotoxicity and cytotoxicity within the cardiovascular system (Yalameha et al., 2024). Patients with carotid artery plaque in which MNPs were detected had 4,5 times higher risk of a composite of myocardial infarction, stroke, or death from any cause (Marfella et al., 2024). Microplastics disrupt hypothalamic-pituitary axes, including the

hypothalamic-pituitary-thyroid/adrenal/testicular/ovarian axis leading to oxidative stress, reproductive toxicity, neurotoxicity, cytotoxicity, developmental abnormalities, decreased sperm quality, and immunotoxicity (Ullah et al., 2023).

The object of the study: public consumption of microplastics and awareness about potential health effects and prevention

Objective of the study: to investigate public consumption habits of plastics and microplastics and awareness about potential health effects and prevention

Tasks of the study:

1. To investigate awareness of microplastics forms and possible routes of entry into the human body.
2. To detect the knowledge of the presence of microplastics in human's different tissues and organs and potential harmful health effects.
3. To reveal respondent's plastics and microplastics consuming habits and awareness about prevention measures.

THE RESEARCH METHOD

The research employs a quantitative survey conducted in August-September 2024, involving 108 respondents. Respondents were randomly selected. 106 questionnaires were collected. The data were obtained and analyzed from 102 questionnaires. The respondents were interviewed using social media and by direct contact. The majority of respondents were females (68% / 32%). The data were evaluated and processed using the Microsoft Office Excel program.

THE RESULTS AND DISCUSSION

The survey enrolled people of different ages between 18 and 89 years, including young and elderly adults. The results show that the majority of respondents were between the ages of 18-39 years. The results revealed that one third of the respondents had obtained secondary, one fourth-master, one fifth-bachelor educational degree. The minority had obtained a vocational bachelor or associate professor educational degree. The education of the respondents also can influence the knowledge about microplastics.

It was estimated that more than half of respondents reported being employees, one fourth were students. The lesser part were retired or unemployed people (see Figure 1).

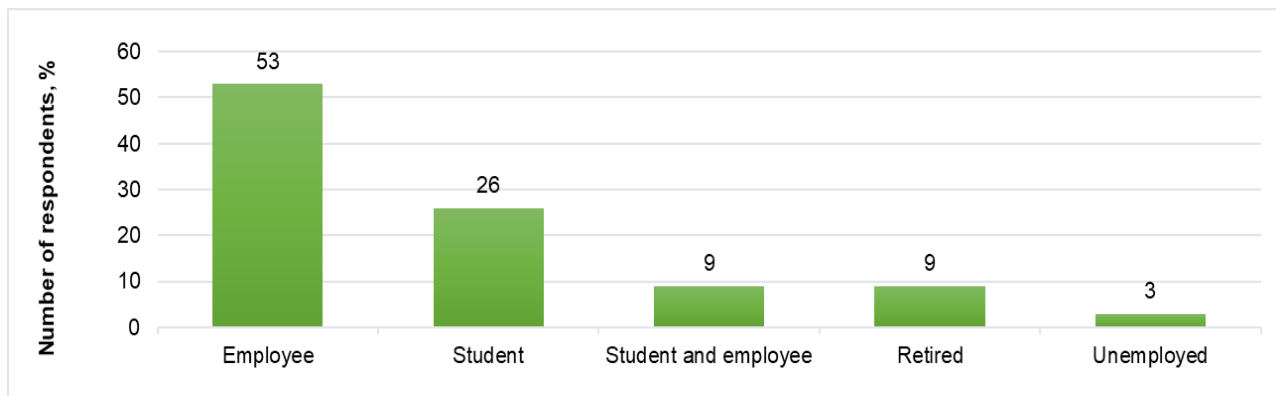


Figure 1. The occupation

Primary microplastics is directly released in the environment as small particles and are estimated to represent between 15-31% of microplastics in the oceans. The main sources: laundering of synthetic clothes (35% of primary microplastics); abrasion of tyres through driving (28%); intentionally added microplastics in personal care products, for example microbeads in facial scrubs (2%). Secondary microplastics originate from degradation of larger plastic objects, such as plastic bags, bottles or fishing nets. Account for 69-81% of microplastics found in the oceans (European Parliament, 2018). Microplastics are easily ingested due to their micro-level sizes and move easily through the food chain and persist in the environment since they are refractory to biodegradation. Due to these characteristics, microplastics pose potential hazards to humans and the environment (Lee et al., 2023). The results indicate that more than half of the respondents are familiar with polyethylene, polyester, less than half-polyethylene terephthalate and styrene to be the source of microplastics, but significantly lesser part of the respondents were aware that polyvinyl chloride, polypropylene, nylon, acrylic and polyurethane also are the source of the microplastic particles (see Table 1).

The microplastics can physically block the digestive system, stimulate the mucous membrane, and injure it. When the size of microplastics becomes smaller than 1 micrometer to form nanoplastics, they can pass through the primary tissue barrier in the body and penetrate the capillary blood vessel through the bloodstream, which can be dispersed throughout the body (Lee, et al., 2023).

Table 1

The microplastics sources

The substance	Agree, %	Don't know, %	Disagree, %
Macroplastics	47	24	29
Polyethylene terephthalate (phthalates)	44	56	-
Bisphenol (BPA)	18	82	-
Polyvinyl Chloride (PVC)	20	71	9
Stirene, polystyrene	38	62	-
Polyethylene (PET)	56	44	-
Polypropylene (PP)	32	68	-
Polyester	53	46	1
Nylon	32	62	6
Acryl	15	83	2
Polyurethane	11	85	4

The majority of respondents stated that micro- or nanoplastics is found in feces, urine, and the entire human body, more than half were aware about micro- or nanoplastics presence in breastmilk, brain and atherosclerotic plaques, less than half of the respondents stated that microplastics particles can be found in humanembryo's tissues. The results indicate that the awareness of the presence of the micro- and nanoplastics in human's bodies and excretions is insufficient (see Table 2).

Table 2

The micro- and nanoplastics in human's body and excretions

The tissues or secretions/ excretions	Agree, %	Don't know, %	Disagree, %
Breastmilk	56	35	9
Urine	65	32	3
Feces	78	21	1
Human fetus (embryo)	41	50	9
Brain	56	31	13
Blood	47	50	3
Atherosclerotic plaques in blood vessel walls	51	44	5
Entire body	65	26	9

Humans are exposed to between tens of thousands and millions of microplastics each year, or several milligrams per day. The main exposure route could be the inhalation of indoor air and drinking water in plastic bottles. Exposure to microplastics through food intake is likely the main exposure source (Wright, & Kelly, 2017). The majority of respondents agree that microplastics enter the human's body with drinking water, especially drinking water from plastic bottles, from takeaway food plastic packages, especially when heated, or heating baby formula in plastic bottles and other foodstuff packages. Half of respondents were aware that fish, seafood, body care products also contain microplastics which enter the body. The lesser part were aware that inhaling air, eating fruits and vegetables, meat or other agricultural products, which are polluted with micro- and nanoplastics particles from the soil also can serve as the routes of

microplastics entry into human's body. The results revealed that the majority of respondents were partially aware about the main routes of microplastics' entry into the human body, but there were significant gaps in their knowledge (see Table 3):

Table 3

The routes of microplastics entry into human's body

The route of entry	Agree, %	Don't know, %	Disagree, %
Inhaling air	38	36	26
Drinking water	70	12	18
Drinking water from plastic bottles	74	23	3
From foodstuffs packages (meat, fish, etc.)	62	29	9
From takeaway food packages	68	27	5
Heating food in microwave oven in takeaway package	74	20	6
Eating fruits, vegetables	26	48	26
Eating meat and other agricultural products	35	44	21
Eating fish and seafood	56	26	18
Through body care products	50	38	12
Heating baby formula in plastic bottles	65	29	6

Microplastics may cause oxidative stress in the airways and lungs when inhaled, leading to respiratory symptoms such as coughing, sneezing, and shortness of breath due to inflammation and damage, as well as fatigue and dizziness due to a low blood oxygen concentration (Wright, & Kelly, 2017). According to Ali et al., (2024), it is suggested that exposure to micro- and nanoplastics can lead to health effects through oxidative stress, inflammation, immune dysfunction, altered biochemical and energy metabolism, impaired cell proliferation, disrupted microbial metabolic pathways, abnormal organ development, and cancerogenicity. The research results indicate that more than half of respondents were aware about negative impacts on the endocrine and immune systems, development of cancer, asthma or other allergies, and oxidative stress and inflammation. It is important to state that only half of respondents indicated microplastics' negative impact on gut microbiota, development of cardiovascular diseases, one fourth were aware that microplastics binds to and transfers to organism pesticides, fungicides and other toxins, the lesser part knew that microplastics can be the cause of the premature birth, the increased resistance to antibiotics, high levels of low density lipoprotein (bad cholesterol). According to these findings it can be stated that the knowledge about the potential negative health effects was limited and society needs more information and education (see Table 4).

Table 4

The potential negative health effects

The health effects	Agree, %	Don't know, %	Disagree, %
Asthma and other allergies	56	44	-
Premature birth	15	79	6
Increases resistance to antibiotics	17	68	15
Due to cancerogenicity promotes oncological diseases	59	38	3
Increases low density lipoprotein (bad cholesterol) levels	15	76	9
Increases risk of cardiovascular diseases	47	53	-
Causes oxidative stress and chronic inflammation	53	44	3

Has negative impact on gut microbiota	50	47	3
Has negative impact on the endocrine system, disrupts hormone secretion	62	38	-
Has negative effect on the immune system	53	46	1
Binds to and transfers to organism pesticides, fungicides, other toxins	26	73	1

Participants' plastic consumption patterns were also evaluated. The majority of respondents reported using plastic bags, bottles, and containers for food storage, despite knowing the associated risks. The results reveal a significant gap between public awareness and behavioral changes concerning plastic consumption. The majority of participants were not aware that polystyrene takeaway food packages and plastic tea and coffee cups had been replaced by other sort plastic packages since 2021 in Lithuania, like in other European Union countries. While most respondents are aware of the major routes of microplastic entry into the human body and some health risks, many continue to use plastic products that exacerbate microplastic pollution of the environment and human's body (see Table 5).

Table 5

The consumption of plastics

The plastic products	Agree, %	Don't know, %	Disagree, %
Plastic bags for food stuffs	91	-	9
Plastic packages for food stuffs	97	-	3
Takeaway food in polystyrene packages	76	6	18
Plastic bottles (drinking water, other beverages)	82	-	18
Disposable plastic coffee, tea cups	71	-	29
Plastic baby bottles, spoons, dishes	29	3	68

Where sustainable alternatives are easily available and affordable, single-use plastic products cannot be placed on the markets of EU Member States. Cotton bud sticks, cutlery, plates, straws, stirrers, and sticks for balloons, cups, food and beverage containers made of expanded polystyrene, and all products made of oxo-degradable plastic are banned since 2021. For other single-use plastic products, the targets are: reducing consumption through awareness-raising measures; introducing design requirements, such as a requirements to connect caps to bottles; introducing labeling requirements, to inform consumers about the plastic content of products, disposal options that are to be avoided, and harm done to nature if the products are littered in the environment; introducing waste management and clean-up obligations for producers, including Extended Producer Responsibility schemes (Directive on SUP, 2021). The measures suggested by the majority of the respondents were to sort plastic waste, to prevent nature from pollution, to avoid plastic food stuff bags, to avoid heating food in plastic packages, to avoid drinking water in plastic bottles, and use their own metallic cup for the takeaway coffee (see Table 6).

Table 6

The measures suggested to avoid microplastics

The measures	Agree,%	Don't know,%	Disagree,%
Avoid heating food in plastic packages	88	6	6
Consume reusable baby pampers	53	21	26
Consume reusable feminine hygiene pads	38	36	26
Avoid drinking water in plastic bottles	88	6	6
Refuse from plastic food stuff bags	91	6	3

Takeaway coffee in own metallic cup	88	12	-
Don't use plastic water filters	73	26	1
Wear clothes made of natural fibers	68	29	3
Refuse from plastic baby bottles, spoons, dishes	56	29	15
Choose laminate or natural floor covering instead of PVC	50	38	12
Clean frequently dust from all surfaces	62	23	15
Avoid seafood	21	58	21
Avoid body care/cosmetic products containing microplastics	65	29	6
Sort plastic waste, prevent nature from pollution	98	2	-
Prefer ecologic journeys	68	31	1

Countries around the world are strengthening related laws on primary microplastics. The European Union is taking various measures to recycle plastics, develop biodegradable plastics, distinguish harmful substances in plastics, and prevent marine waste generation (Directive on SUP, 2021). The results of the study revealed that more than one fourth of the respondents agree with the fact that that it is impossible to remove microplastics from nature, food chains and human body, the minority stated that microplastics can be removed totally. The optimism about removing plastics from the nature, food chains and human's body was reserved, as the majority of respondents stated that it can be achieved only partially (see Figure 2):

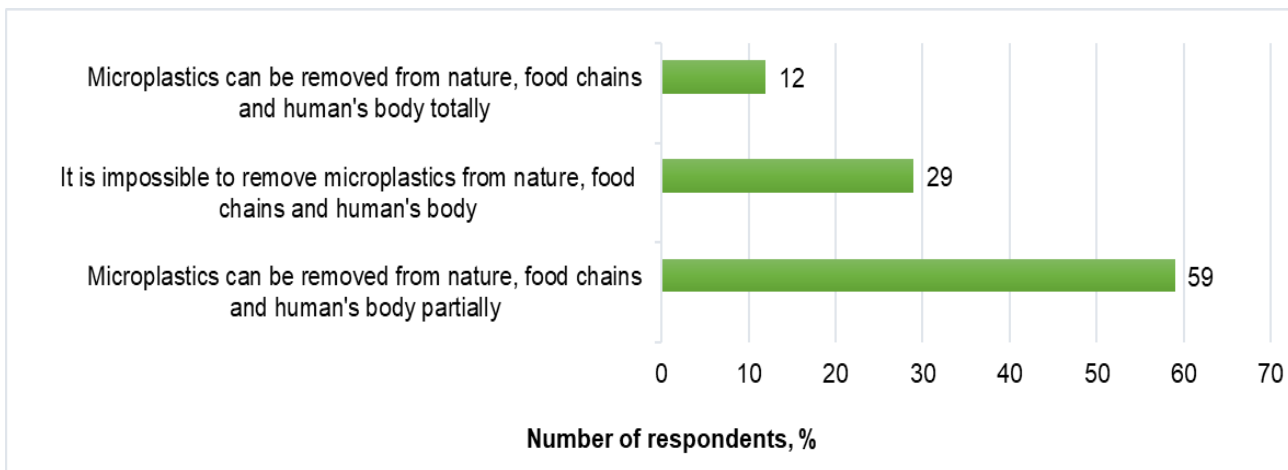


Figure 2. **The positivity**

The respondents reported the measures for diminishing plastics and microplastics pollution they already implemented. The majority are sorting plastic waste, not polluting nature, and heating food in non-plastic packages. Choosing natural fiber clothing was practiced by a smaller portion of the participants. Despite increased awareness, behaviors reflecting preventive actions remained inconsistent (see Figure 3):

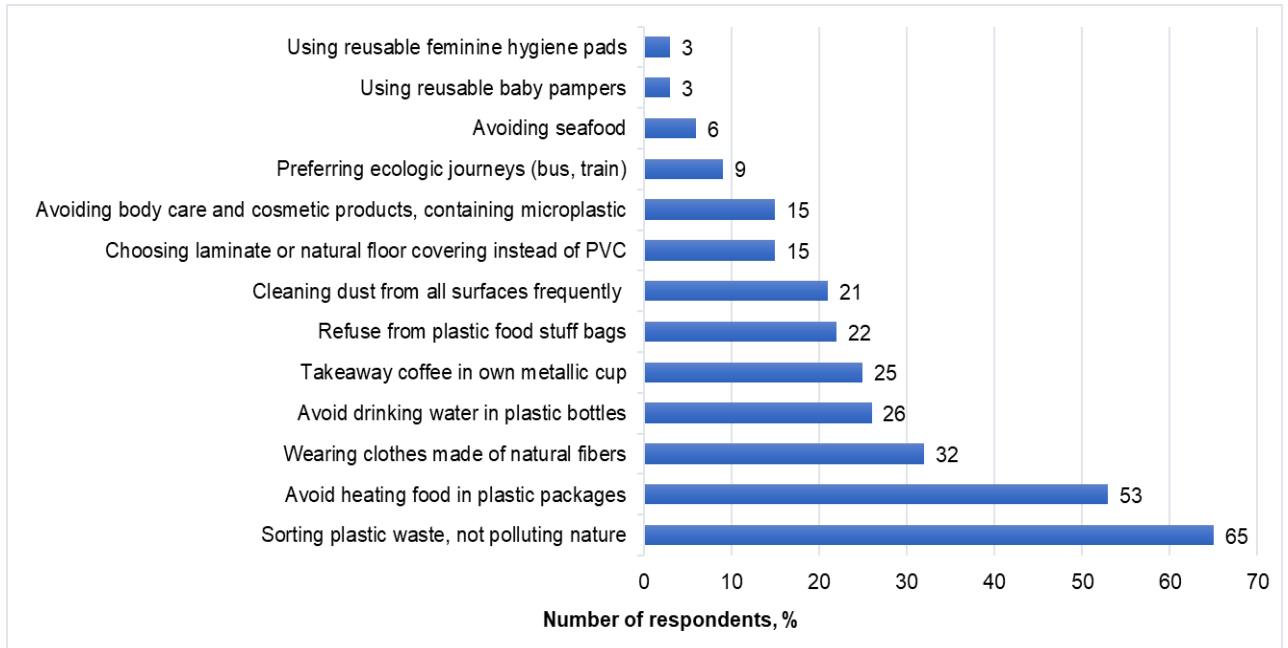


Figure 3. **The implemented measures**

The results reveal that half of the respondents recognize polyethylene, polyester, and polypropylene as microplastic sources. A significant portion is aware of microplastics' entry routes into the human body and their presence in various tissues. Notably, over half of the participants identify health risks such as hormonal disruptions and cancerogenic effects. Consumption habits indicate reliance on plastic packaging, but many respondents advocate for prevention measures like sorting plastic waste. These findings underscore the urgent need for increased public awareness and targeted interventions to mitigate health risks associated with microplastics. Governments and regulatory bodies, particularly in the European Union, have started implementing measures such as banning single-use plastic, promoting plastic waste recycling, and promoting fully biodegradable plastics. However, more comprehensive global action is needed, including public education to reduce plastic pollution and mitigate its health impacts.

CONCLUSIONS

1. Half of respondents were familiar with polyethylene, polyester, polyethylene terephthalate, one third-of styrene, nylon and polypropylene to be the source of microplastics. The majority of respondents were aware about the main routes of microplastics' entry into the human body, but there were gaps in their knowledge.
2. Two third of participants reported that microplastics are found in human excretions and all human's bodies. More than half of respondents indicated hormonal disruption, cancerogenicity, allergies or asthma, weakening immunity and causing chronic inflammation as microplastics harmful health effects.
3. The majority of respondents are using plastic bags and packages for foodstuffs and takeaway food, water and drinks in plastic bottles. Prevention measures, offered by the majority of respondents, were sorting of plastic waste, avoiding plastic packages and bottles of foodstuffs and water and heating food in non-plastic dishes. Two third of respondents are sorting plastic waste, more than half are heating food in plastic-free dishes and one third are wearing clothes made of natural fibers. Despite increased awareness, behaviors reflecting preventive actions remained inconsistent.

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