

# Nano Plastics in Food Chain

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**Abstract**—The pervasive presence of NANO PLASTICS in the food chain has emerged as a critical environmental and public health concern. These microscopic plastic particles, often originating from the degradation of larger plastics and industrial activities, infiltrate ecosystems through soil, water, and air. Current research highlights their accumulation in aquatic organisms, agricultural produce, and even processed foods, posing potential risks to human health. NANOPLASTICS have been detected in seafood, salt, bottled water, and other consumables, raising alarms about their impact on the gastrointestinal system and potential for endocrine disruption. Despite their widespread presence, the full extent of their health implications remains under investigation. Analytical techniques, such as Fourier-transform infrared spectroscopy, are being employed to better understand their behavior and effects. This paper explores the sources, pathways, and consequences of NANOPLASTICS in the food chain, emphasizing the urgent need for comprehensive mitigation strategies to address this growing threat to food safety and environmental sustainability

**Index Terms**—Nano plastics, Food chain, Health impact, Contamination

## I. INTRODUCTION

Plastics have become ubiquitous, infiltrating various industries such as food, health, and textiles. In recent years, the emergence of MNPs has intensified environmental concerns, as they result from the continuous fragmentation of macro plastics. Microplastics, defined as fragments smaller than 1 mm, and nano plastics, less than 1  $\mu\text{m}$  in size, are increasingly prevalent in the environment, posing a significant threat to both ecosystems and human health. Various factors contribute to the formation of MNPs, including photooxidation, ultraviolet radiation-induced degradation, weathering, mechanical abrasion, and microbial degradation. Despite their small size, these particles accumulate in

water bodies, evading removal by conventional sewage and cleaning systems. The inefficiency of regular filtration systems exacerbates environmental contamination and bio-logical uptake. Particles of plastics are often categorized according to their size. Despite the absence of agreement on how to describe and categorize plastic particles, this report considered the following classifications. macro plastics, mesoplastics, microplastics, and Nano plastics are plastic particles with size diameter range that are  $>200\text{ mm}$ ,  $4.76\text{--}200\text{ mm}$ ,  $0.01\text{ }\mu\text{m}\text{--}1\text{ mm}$ , and less than  $0.1\text{ }\mu\text{m}$ , respectively. However, categorize plastic particles as microplastics ( $>1\text{ cm}$ ), mesoplastics ( $1\text{--}<10\text{ mm}$ ), microplastics ( $1\text{--}<1,000\text{ }\mu\text{m}$ ), and Nano plastics ( $1\text{--}<1,000\text{ nm}$ ). Although there is no consensus on categorizing plastic particles, in this manuscript, microplastics (MPs) are regarded as the category of plastics with a diameter of  $1\text{ nm}\text{--}<5\text{ mm}$ , and Nano plastics (NPs) are characterized as plastic particles having a lower size less than  $1\text{ nm}$ . They disrupt the food web by transferring harmful contaminants across trophic levels. Nano plastics can cause DNA damage, oxidative stress, and reproductive toxicity in marine life. Their presence in the food chain poses risks to human health through seafood consumption. The persistence and widespread distribution of Nano plastics make them a growing environmental concern.

## II. METHODOLOGY

The key sources of MNPs include fragmentation of macro plastics, MF shedding, micro breads in personal care products, industrial and agricultural impacts, and waste management gaps. The disintegration of macro plastics including bottles, packaging materials, and synthetic textiles release MNPs into the environment catalyzed by mechanical forces, ultraviolet radiation, and fluctuating

temperatures and pressures. The use of synthetic textiles such as polyester (PES) and nylon sheds MFs during daily use and washing infiltrate into water bodies, and consequently the food chain. The activities including tire wear on roads and fields, breakdown of plastic mulches also contribute to micro plastic contamination. Improper disposal of plastic waste, inadequate recycling, and waste treatment contribute to the MNPs contamination. MNPs accumulate in the soil through contaminated irrigation water, which leads to the uptake of microplastics by plants. The water bodies such as rivers, lakes, and oceans contaminated with plastics act as reservoirs for microplastics. Aquatic organisms, such as fish and shellfish, ingest microplastics directly or indirectly through consumption of contaminated prey. MNPs are ingested by aquatic organisms, from zooplankton to large marine animals and incorporate them into the food chain. MNPs can adsorb harmful contaminants and pollutants that magnify the toxicological effect throughout the food chain. Smaller organisms such as planktonic species ingest MNPs suspended in water, and as the larger species feed on smaller organisms MNPs are biomagnified reaching higher concentration in predators through bioaccumulation. Detecting Nano plastics in the food chain is a challenging task due to their tiny size and complex interactions with biological and environmental systems. However, researchers have developed several advanced methods to identify and analyze these particles:

- Spectroscopic Techniques – Methods like Fourier Transform Infrared (FTIR) Spectroscopy and Raman Spectroscopy help detect nano plastics by analysing their molecular vibrations.
- Microscopy-Based Approaches – Electron Microscopy (such as Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM)) provides high-resolution images to visualize Nano plastics.
- Mass Spectrometry – Pyrolysis-Gas Chromatography Mass Spectrometry (Py-GC/MS) is used to chemically analyse plastic particles by breaking them down into identifiable components.

- Microfluidic Biosensors – These innovative sensors can detect Nano plastics in food and agricultural samples with high sensitivity.
- AI-Driven Classification – Machine learning algorithms are being developed to enhance detection accuracy by analysing complex datasets from spectroscopic and microscopic techniques.

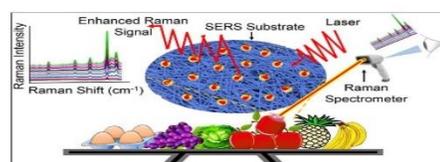


Figure 1: Finding the Nano Plastics in food using RAMAN SPECTROSCOPY



Figure2: Finding nano plastics in food using MASS SPECTROSCOPY

### III. METHODS TO FIND MNP'S IN AQUATIC SYSTEM

*Above methods which are used but there are some of the additional techniques to find out the mnp's (MICRO NANO PARTICLES):*

**Chromatographic Methods:** Techniques like pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) help analyze the chemical composition of Nano plastics.

**Filtration and Separation:** Specialized filters and centrifugation techniques help isolate Nano plastics from water samples.

**Biological Indicators:** Some studies examine how aquatic organisms accumulate Nano plastics, providing indirect evidence of their presence.

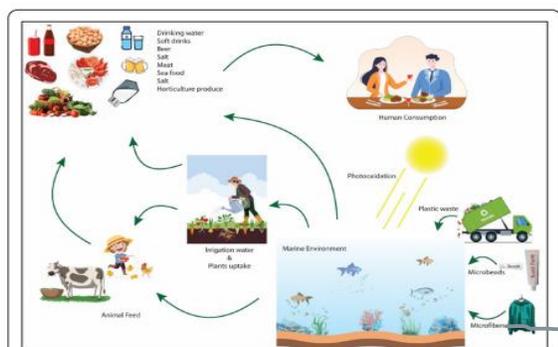
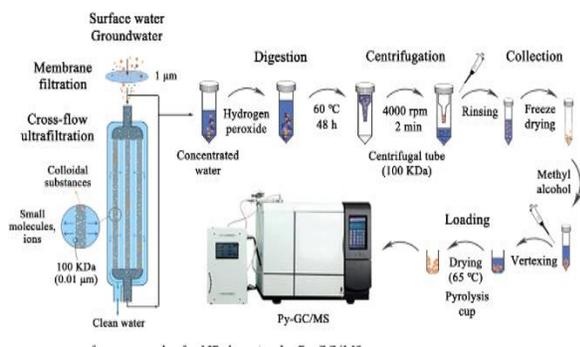


Figure 3: chromatography method to find out the nano plastic in water

- As we can see from the figure 1 “NANO PLASTICS” are there in food which is consumed by
- Us, which may lead to the damage of the health.
- As we can see from the figure 3 “Nano plastics” are present in the water.
- So finally, we can conclude from figure 4 that nano plastics are affecting the food web.

Beverages ranging from bottled water to soft drinks have become the carriers of MNPs. Plastic bottles caps and water used in manufacturing the beverages can introduce the MNPs into final products. Salt is one of the major products that are getting contaminated with MNPs. As the production of salt involves evaporation of seawater it concentrates the MNPs that contaminate the food materials added with salt containing MNPs. Distribution of MNPs in the ecosystems ultimately lead to the potential human exposure through various pathways. Consumption of seafood, contaminated water, and foods contaminated with MNPs contributes to the ingestion of MNPs into humans Figure 1 illustrates the potential routes of plastic contamination and their entry into the food chain

#### IV. RESULT

Type of food	Microplastics concentration (Particles/L or kg)	Analytical technique	Type of plastic	Ref.
Drinking water	193	Micro-Raman spectroscopy	PET and PP	[16]
Table salt	550 - 681	Stereo microscope µ-FTIR	PET, PES, and PE	[17]
Honey	440 - 660	Dissection microscope, FTIR, and Raman spectroscopy	PE and PP	[5]
Packaged meat	10 - 221	FTIR	PS	[18]
Skim milk	34 - 254	10X lens inverted microscope and FTIR	PE, PP, and Polyamide (PA)	[16]
Industrial honey	20 - 166			
Refreshing beverage	10 - 144			
Industrial beer	18 - 98			
Canned fish	2 - 128	Epifluorescence microscope and Micro-Raman	PET, PE, PP and Polyvinyl chloride (PVC)	[1]
Vinegar	4.9 - 21.2 mg/kg	Stereo microscope and FTIR	PE	[19]

Figure 4: Potential routes of MNPs contamination and entry into food chain

Leaching and migration of plastics and their constituents is one of the major concerns in food safety. Migration of compounds depends on various factors such as contact surface area, nature of migrant, kinetics and thermodynamics of migration process, nature of food material, temperature, and duration of contact.

Type of plastics	Food products packed	Analytical technique	Chemicals identified	Ref.
PS, PP, PE, and PLA	Drinking water, yogurt cups, and milk	UPLC-QTOF-MS	Mono(2-acryloyloxyethyl) succinate; Pentaethylene glycol; 12-Aminolauric acid; 6-Deoxy-D-mannono-4-lactone; Solketal; Laurilactam; and Hexanoyl fluoride.	[16, 17]
PET	Drinking water	GC-MS	Styrene; Ethyl benzene; Toluene; p-Xylene; 2-Phenyl propanoic; Propyl benzene; 1-ethyl-4-methyl benzene; o-methyl styrene; (1-methyl)ethyl benzene; 2-propenyl benzene; and 1-ethyl-3-methyl benzene.	[1]
PE, PET, and PP	Milk, drinking water, and juices	GC-MS	Cyclohexanone; Cyclohexanone, 3,3,5-trimethyl; Benzaldehyde, 4-methyl; 2-Butoxyethyl acetate; 2-Phenyl-2-propanol; Ethanol, 2-(2-ethoxyethyl)-, acetate; 2,4-Dimethylbenzaldehyde; Butoxyethoxyethyl acetate; Hexanoic acid, 2-ethyl-, 2-ethylhexyl ester; Octadecanoic acid, methyl ester; Benzophenone, 4-phenyl-, and Octadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester.	[2, 3]
PET, PP, PS, and PE	Drinking water, carbonated beverages, and fruit juices	GC-MS	Phthalate esters, and bisphenol A.	[7, 9, 26]
PVC	Drinking water	UPLC-QTOF/MS	1-oleoyl-3-linoleoyl-rac-glycerol; Tetraosenamide; Docosanamide; 2-(2-hydroxyethyl)-hexadecylamino)ethyl palmitate; and Bis(2-ethylhexyl) 2,2'-disulfinediylacetate.	[19]
Polyurethane	Fruit juices, milk, and sea food	UPLC-QTOF/MS	1,4,7-trioxacyclotridecane-8,13-dione; 1,6-dioxacyclododecane-7,12-dione dimer; 1,4-dioxacyclododecane-5,13-dione; 1,4,14,19-tetraoxacyclooctadecane-5,13,20,25-tetra one and 1,4-dioxacyclotridecane-5,13-dione; 1,1-(Methanediyl)benzene-4,1-dihydro[5-(2-hydroxyethyl)urea]; 4-(7-acetoxy-5-methoxy-8,8-dimethyl-2-oxo-7,8-dihydro-2H,4H-pyranol[3,2-g]chloro[2,3-yl]-1,3-phenylene diacetate; and Bis[2-(diethylamino)ethyl] 4,4'-(2-methyl-1,3-propanediyl) bis(oxy carbonyl amino) dibenzoate.	[26]

Chromatographic techniques, such as gas chromatography (GC) and liquid chromatography (LC), coupled with mass spectrometry (MS), offer high sensitivity and specificity in detecting and quantifying plastic additives and associated chemicals. These methods are fast, cost-effective, portable, and ecofriendly techniques for identification of MNPs. Pollard et al. developed a three-dimensional printed microfluidic resistive pulse sensor that can identify the microplastics of 2 - 30 µm in size shed from tea bags. The device is stable and can measure at salt concentrations of 2.5 × 10<sup>-4</sup> - 0.1 M at a flow rate of 1 mL/min. Impedance spectroscopy is another technique gaining attention for detecting MNPs that works based on electrical properties of individual particles.

## V. DISCUSSION

Micro- and Nano plastics (MNPs) have infiltrated the global food supply chain, raising concerns about potential health risks for consumers. These tiny plastic particles can enter the human body through ingestion, potentially crossing intestinal barriers and entering systemic circulation. MNPs can interact with digestive cells, possibly affecting nutrient absorption and gut health. They also absorb contaminants such as persistent organic pollutants and heavy metals, which can be released into the body upon ingestion, leading to chronic exposure risks including endocrine disruption, neurotoxicity, and carcinogenicity.

Additionally, MNPs may trigger inflammatory responses in the gastrointestinal tract, contributing to oxidative stress and chronic inflammation. Animal studies suggest these particles can cross biological barriers and accumulate in organs like the liver, kidneys, and spleen, raising concerns about systemic distribution. The combination of MNPs' physical properties and the toxic chemicals they carry may result in complex health risks, potentially leading to cellular damage and long-term bioaccumulation.

The environmental impact of MNPs is also significant, as they disrupt ecosystems and wildlife. Microplastics accumulate in soil and water, affecting biodiversity and species interactions. Studies on earthworms exposed to polyethylene microplastics and zinc oxide nanoparticles have shown weight loss, oxidative stress, and tissue damage. Research indicates that bioplastic microplastics, such as PLA, may be more toxic than fossil-based ones due to their biodegradation products.

MNP contamination poses risks for vulnerable populations, such as infants, pregnant women, and the elderly. Addressing these concerns may require regulatory measures and industry adaptation to mitigate food contamination risks, though this could result in increased operational costs.

Overall, the widespread presence of MNPs in food and the environment necessitates further research to understand their long-term health and ecological impacts.

## VI. CONCLUSION

The key points focused on how micro- and nano plastics (MNPs) impact the food chain:

- Contamination of Food Sources: MNPs infiltrate food through environmental contamination, affecting crops, seafood, and livestock.
- Human Ingestion and Absorption: MNPs consumed via contaminated food may cross intestinal barriers, enter systemic circulation, and accumulate in organs.
- Toxic Chemical Carriers: These particles adsorb pollutants like persistent organic chemicals and heavy metals, leading to potential chronic exposure.
- Nutrient Absorption Disruption: MNP interactions with digestive cells may impact nutrient absorption and gut health.
- Inflammatory Responses and Oxidative Stress: Consumption of MNP-contaminated food can trigger inflammation, oxidative stress, and potential gastrointestinal disorders.
- Bioaccumulation in Aquatic Food Chains: MNPs ingested by marine life can transfer up the food chain, affecting fish and seafood consumers.
- Plant Uptake and Growth Disruption: Studies show that plants like *Arabidopsis thaliana* absorb MNPs, influencing gene expression and oxidative stress, which could impact agricultural productivity.
- Long-term Health Risks: Continuous exposure to MNP-contaminated food may increase risks for neurotoxicity, endocrine disruption, and carcinogenic effects.
- Vulnerable Populations: Infants, children, pregnant women, and the elderly are more susceptible to the effects of food chain contamination.
- Regulatory and Industry Challenges: Ensuring food safety may require stricter regulations and changes in agricultural and food processing practices.

These points highlight the cascading effects of MNP contamination across different levels of the food chain.

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