REPORT

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Micro- and Nanoplastics from a Human Health Perspective

Report from a seminar jointly organized by the Norwegian Environment Agency and the Norwegian Institute of Public Health

NIPH
Norwegian Institute of Public Health

Report

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Background for this seminar

Plastic is a versatile material with many useful applications in modern society. The increasing amounts of plastics produced and subsequently also ending up in the environment cause harm to the environment and have a possible impact on human health. Plastic production, use and disposal results in emissions and exposure to micro- and nanoplastics (MNPs) as well as chemicals that can leach from plastics throughout their entire life cycle. As global plastic production is projected to triple over the next 30 years, increasing attention is being directed towards the potential health effects associated with plastics.

Plastic pollution is a high-priority topic for Norwegian authorities. Growing concern about the potential health impacts of MNPs, as well as plastic-related chemicals, has highlighted the need to compile and assess existing knowledge, identify key knowledge gaps, and review ongoing regulatory efforts in this area. To address this, the seminar aimed to bring together research communities and representatives from health and environmental authorities working on plastic-related issues linked to human health. The objective was to share knowledge, develop a common understanding of the current state of science and its limitations, identify knowledge gaps and discuss possible priorities and future directions.

The seminar was jointly organized by the Norwegian Environment Agency and the Norwegian Institute of Public Health (NIPH). The seminar was held on the 20th of January 2026 from 9.00 to 16.00. More than 90 people participated in person, 15 people attended online and two international speakers participated.

Participation in the seminar was by invitation only and Norwegian agencies, ministries, directorates and research institutes were invited.

Oslo, August 2026

Hubert Dirven, Gro Dehli Andersen and Dorte Herzke

TABLE OF CONTENTS

KEY MESSAGES

This report summarizes a national seminar organized by the Norwegian Environment Agency and the Norwegian Institute of Public Health on plastics and human health, bringing together invited researchers and health and environmental authorities working on plastic-related issues related to human health.

Key findings and knowledge gaps identified during the seminar are:

- Micro- and nanoplastic particles are widespread in the Norwegian environment, and humans are continuously exposed through air, food, water and everyday products.
- Major knowledge gaps remain regarding exposure levels, health effects, and how to measure micro- and nanoplastic particles reliably. This limits current risk assessment and the ability to set safe levels.
- There is increasing evidence from laboratory studies that micro- and nanoplastics can affect cells, but it is still unclear whether current exposure levels cause harm to human health.
- Plastics contain a very large number of chemicals, many of which are insufficiently studied. People are exposed to complex mixtures of these chemicals, and some have been linked to health effects, particularly during early life stages.
- There is an urgent need for coordinated, long-term research and collaboration across research areas on possible health effects, improved monitoring of exposure in the population, and better harmonized analytical methods and protocols to strengthen the scientific basis for risk assessment and regulation.
- Reducing exposure to plastic particles and hazardous chemicals, improving transparency about chemicals in plastics, and developing safer and more sustainable materials are important steps to protect human health in the future.

Executive summary

The seminar "Micro- and Nanoplastics from a Human Health Perspective" was aimed at summarizing the existing knowledge on micro- and nanoplastics (MNP) exposure, plastic-related chemicals, health impacts and analytical challenges for relevant authorities and to identify knowledge gaps and research needs. The workshop was jointly organized by the Norwegian Environment Agency (NEA) and the Norwegian Institute of Public Health (NIPH).

The seminar, which brought together presentations on the current state of research from Norwegian and international research institutions, panel discussions with governmental bodies, and active audience engagement, provided a shared overview of existing knowledge and highlighted key considerations for how Norway can strengthen research and regulatory efforts to better protect human populations from potential adverse health effects of MNPs and plastic-associated chemicals.

MNP exposure

Human exposure to MNPs can occur through multiple sources. MNPs are found in air, water, soil, fauna and flora throughout Norway, as presented in this seminar. Speakers identified agriculture as a key source of MNPs in food systems, while car tires contribute most to MNPs in urban environments. Biologically, it is plausible that the smallest particles (smaller than 1 to 2 µm), often referred to as nanoplastics, can cross biological barriers in the human body. Based on numerous recent reports, there is consensus in the scientific community that nanoplastics are present in the human body, while there are uncertainties on the amounts and their fate within our bodies.

Analyses of MNPs in human samples

Measuring MNPs of a size range smaller than 1 µm in human tissues is challenging due to limitations of available analytical instrumentation and contamination of samples during collection and processing. In addition, interferences caused by organic residues after incomplete sample preparation can give an overestimation of the amount of plastics in biological tissues. On the other hand, loss of MNPs during sample preparation is difficult to monitor, due to the lack of suitable reference samples, potentially causing underestimation. To address these challenges, strict protocols need to be applied to ensure robust and sensitive data reporting. A combination of high-end analytical methods for the detection of MNPs in biological tissues, and particularly human samples, is needed according to international expert groups. Progress in developing new sensitive methods, harmonized analytical protocols and standardization applicable in human samples is an ongoing process with international efforts.

Human health impacts of MNPs

Evidence is emerging that MNPs cause cellular effects such as oxidative stress, inflammation, impacts on membrane integrity and intercellular communication when tested *in vitro.* In most of these studies, relatively high doses of MNPs were used. An increasing number of scientific papers lists adverse health outcomes that may be associated with MNP exposures, but causal relationships are far from being demonstrated. At this point in time, we do not have enough data linking exposure of MNPs to potential health effects in humans. The presence of plastics in the human body is not automatically a hazard to human health.

Hazard assessment of MNPs

Currently we are still in the phase of hazard identification. Studies to benchmark the hazards of MNPs towards the hazards of other already better-studied particles should assist in the hazard assessment (e.g. inorganic nanoparticles, asbestos). To advance hazard assessment of MNPs, nanoplastics with varied polymers, shapes, composition, and surface chemistry are essential for toxicological testing and biomonitoring. A thorough characterization of the MNPs intended for toxicological testing is needed while effective cellular exposure must be demonstrated. Given continuous human exposure to MNPs, more knowledge of the health effects associated with chronic exposure is needed to support hazard and risk assessment. This requires well-designed and well-conducted experimental and epidemiological studies.

Chemicals in plastics

Based on the PlastChem report and its updated version, more than 16,000 chemicals may be present in plastics, including additives, monomers, and non-intentionally added substances. Hazard data is lacking for these chemicals, and information on human exposure is limited. Humans are continuously exposed to complex mixtures of plastic-associated chemicals through food, drinking water, air and dust, building materials, and everyday consumer products. While some migration and biomonitoring data exist, large knowledge gaps remain for most substances.

Human biomonitoring studies in Norway, including the Environmental Biobank (a sub-study of the Norwegian Mother, Father and Child Cohort Study, MoBa), show widespread human exposure to plastic chemicals such as phthalates, bisphenols, PFAS, and flame retardants in children and adolescents. Importantly, many chemicals lack defined safety thresholds and hazard data, and current assessments do not adequately address mixture effects. If these samples can also be used for the biomonitoring of MNPs is highly uncertain due to the lack of appropriate protocols in place during sampling collection.

Epidemiological findings from the MoBa-based NeuroTox-study indicate that prenatal exposure to plastic-related chemicals is associated with adverse neurodevelopmental outcomes such as ADHD, autism, and lowered cognitive function in children. More broadly, these chemicals have been linked to reproductive, metabolic, and cardiovascular disorders, as well as certain cancers, with fetal development appearing particularly sensitive. For most of these health effect associations, we lack a mechanistic understanding.

Large knowledge gaps persist regarding the persistence, bioaccumulation, mobility, and toxicity of many substances associated with plastics. Ongoing research initiatives, such as the PARC PlasticLeach project, aim to address some of these gaps by identifying and characterizing hazardous chemicals that leach from plastic products and by generating data to support regulatory action. In parallel, continued development of resources such as the PlastChem database is improving transparency on chemical use, occurrence, and possible hazards, thereby supporting prioritization in both research and policy development.

Key priorities and outlook

Overall, there is a clear and urgent need for holistic research on MNPs and plastic-associated chemicals and human health, including toxicological testing, improved biomonitoring, improved exposure characterization, and assessment of mixture effects. In addition, sound regulatory action to limit MNP exposure, phasing out chemicals of concern, increasing transparency on chemical composition of plastics, the development of safer and more sustainable plastic materials is needed to reduce potential risks to human health.

During the seminar, it was recognized that possible health effects of plastics are complex cross-sectorial topics, and interlinked collaboration across universities, research institutes, authorities, municipalities and industry is needed. Several ideas for the way ahead were discussed: 1) A follow-up seminar was suggested, including participation from municipalities, NGOs and industry for knowledge dissemination, exchange of insights, and identifying solutions to limit human exposure. 2) Establishing a national research center on plastics and human health combining many research fields by expanded biomonitoring, improved chemical characterization and well-designed experimental and epidemiological studies. Both MNP and chemicals in plastics are in scope of the proposed center.

HOVEDBUDSKAP

Denne rapporten oppsummerer et nasjonalt seminar om plast og menneskers helse, arrangert i fellesskap av Miljødirektoratet og Folkehelseinstituttet. Seminaret samlet forskere, helsemyndigheter og miljømyndigheter for å dele kunnskap, identifisere kunnskapshull og diskutere framtidige prioriteringer innen forskning og forvaltning.

Følgende hovedbudskap kom fram under seminaret:

- Mikro- og nanoplastpartikler finnes i luft, vann, jord, mat og i menneskekroppen. Samtidig er det fortsatt betydelig usikkerhet knyttet til nivåene av eksponering hos mennesker, hva som skjer med partiklene i kroppen, og hvilke helseeffekter de kan ha.
- Det er store kunnskapshull knyttet til hvordan nivåer av mikro- og nanoplast i prøver fra mennesker kan måles og rapporteres på en pålitelig måte. Disse begrensningene gjør det vanskelig å gjennomføre risikovurderinger og etablere helsebaserte grense- eller veiledningsverdier.
- Forskning viser at mikro- og nanoplast kan påvirke celler og biologiske prosesser i laboratoriestudier. Det finnes imidlertid foreløpig ikke tilstrekkelig kunnskap til å fastslå om eksponering for mikro- og nanoplast gir negative helseeffekter hos mennesker.
- Plast inneholder også tusenvis av kjemikalier. Mange av disse stoffene er påvist hos mennesker, og flere er knyttet til helseutfall som påvirkning av barns utvikling, reproduktiv helse, stoffskifte og hjerte- og karhelse. For de fleste plastrelaterte kjemikaliene er det fortsatt betydelige kunnskapshull når det gjelder eksponering og mulige helsefarer.
- Seminaret viste et tydelig behov for mer forskning på både mikro- og nanoplast og plastrelaterte kjemikalier. Bedre human biomonitorering, økt kunnskap om helseeffekter av langtidseksponering og utvikling av robuste og harmoniserte analysemetoder er nødvendig for å styrke risikovurderinger av menneskers helse.
- Mulige helseeffekter av plast representerer en kompleks og tverrsektoriell utfordring. For å styrke kunnskapsgrunnlaget og støtte framtidige tiltak og reguleringer er det behov for langsiktig samarbeid mellom forsknings-institusjoner, myndigheter, kommuner og næringsliv.

SAMMENDRAG

Seminaret «Mikro- og nanoplast fra et menneskehelseperspektiv» hadde som formål å oppsummere eksisterende kunnskap om mikro- og nanoplast (MNP)-eksponering, plastrelaterte kjemikalier, helseeffekter og analytiske utfordringer for relevante myndigheter, samt å identifisere kunnskapshull og forskningsbehov. Seminaret ble arrangert i samarbeid mellom Miljødirektoratet og Folkehelseinstituttet (FHI).

Seminaret samlet presentasjoner om dagens kunnskapsstatus fra norske og internasjonale forskningsinstitusjoner, paneldiskusjoner med myndigheter og et aktivt engasjement fra deltagerne. Dette ga en oversikt over eksisterende kunnskap og fremhevet viktige hensyn for Norge i det videre arbeidet med å styrke forskning og reguleringsarbeid for bedre å beskytte befolkningen mot mulige negative helseeffekter av MNP og plastrelaterte kjemikalier.

MNP-EKSPONERING

Menneskelig eksponering for MNP kan skje gjennom flere kilder. Som presentert i seminaret finnes MNP i luft, vann, jord, fauna og flora. Foredragsholderne identifiserte landbruk som en nøkkelkilde til MNP i matsystemer, mens bildekk bidrar mest til MNP i urbane miljøer. Biologisk sett er det sannsynlig at særlig partikler mindre enn 1 til 2 µm, såkalte nanoplastpartikler, kan krysse biologiske barrierer i menneskekroppen. Basert på oppdatert kunnskap er det enighet i det vitenskapelige miljøet om at nanoplast finnes i menneskekroppen, samtidig som det er usikkerhet rundt mengdene og deres skjebne i kroppen vår.

ANALYSE AV MNP I PRØVER FRA MENNESKER

Måling av MNP mindre enn 1 µm i menneskelige prøver er utfordrende på grunn av begrensninger i tilgjengelig analytisk instrumentering og forurensning av prøver under innsamling og prosessering. I tillegg kan interferens forårsaket av organiske rester etter ufullstendig prøveopparbeidelse gi en overestimering av mengden plast i biologisk vev. På den andre siden er tap av MNP under prøveforberedelse vanskelig å overvåke, på grunn av mangel på egnede referanseprøver, noe som kan føre til undervurdering av mengden plast i biologiske vev. For å møte disse utfordringene må strenge protokoller benyttes for å sikre robuste og sensitive analyseresultater. En kombinasjon av slike protokoller og avanserte analytiske metoder for påvisning av MNP i biologisk vev er nødvendig ifølge internasjonale ekspertgrupper. Videreutvikling av nye sensitive metoder, harmoniserte analytiske protokoller og standardisering er en pågående prosess med internasjonalt fokus.

HELSEEFFEKTER AV MNP

Det finnes bevis for at MNP forårsaker cellulære effekter som oksidativt stress, betennelse, påvirkning på membranintegritet og effekter på intercellulær kommunikasjon i *in vitro*-studier. I de fleste av disse studiene ble relativt høye doser MNP brukt. Et økende antall vitenskapelige artikler lister opp mulige negative helseutfall som kan relateres til MNP, men årsakssammenhenger er ikke dokumentert. På nåværende tidspunkt har vi ikke nok data som knytter eksponering av MNP til mulige helseeffekter hos mennesker. At vi finner plast i menneskekroppen betyr ikke automatisk at dette utgjør et helseproblem.

Farevurdering av MNP

For øyeblikket er kunnskapsgrunnlaget fortsatt i en fase preget av fareidentifikasjon. Studier som sammenligner farene ved MNP med farene ved andre allerede bedre studerte partikler kan bidra i dette arbeidet (f.eks. uorganiske nanopartikler, asbest). For å fremme farevurdering av MNP er tilgjengelighet av nanoplast med ulike polymerer, former, sammensetning og overflatekjemi nødvendig for toksikologisk testing og biomonitorering. En grundig karakterisering av MNP som blir brukt i toksikologisk testing er nødvendig, samtidig som celleeksponering må påvises. Siden mennesker er kontinuerlig eksponert for MNP, trengs mer kunnskap om helseeffektene knyttet til kronisk eksponering for å støtte fare- og risikovurdering. Dette krever godt utformede og godt gjennomførte eksperimentelle og epidemiologiske studier.

Kjemikalier i plast

Basert på PlastChem-rapporten kan mer enn 16 000 kjemikalier være til stede i plast, inkludert tilsetningsstoffer, monomerer og ikke-tilsiktede kjemikalier. Det mangler faredata for disse kjemikaliene, og informasjon om menneskelig eksponering er begrenset. Mennesker utsettes kontinuerlig for komplekse blandinger av plastrelaterte kjemikalier gjennom mat, drikkevann, luft, støv, byggematerialer og hverdagsprodukter. Selv om det finnes noe migrerings- og bioovervåkingsdata, gjenstår store kunnskapshull for de fleste stoffene.

Studier av biologisk overvåking av mennesker i Norge, inkludert Miljøbiobanken (en delstudie av Den norske mor, far og barn-undersøkelsen, MoBa), viser en utbredt menneskelig eksponering for kjemikalier som ftalater, bisfenoler, PFAS og flammehemmere hos barn og ungdom. Mange kjemikalier mangler definerte sikkerhetsgrenser og faredata, og dagens vurderinger tar ikke tilstrekkelig hensyn til blandingseffekter.

Epidemiologiske funn fra den MoBa-baserte studien NeuroTox indikerer at prenatal eksponering for plastrelaterte kjemikalier er assosiert med nevroutviklingsutfall som ADHD og autisme, samt redusert kognitiv funksjon hos barn. Mer generelt har disse kjemikaliene blitt knyttet til reproduktive, metabolske og hjerte- og karsykdommer, samt visse kreftformer, hvor fosterutviklingen virker spesielt sensitiv. For de fleste av disse sammenhengene med helseeffekter mangler det en mekanistisk forståelse.

Store kunnskapshull eksisterer når det gjelder persistens, bioakkumulering, mobilitet og toksisitet for mange kjemikalier assosiert med plast. Pågående forskningsinitiativer, som PARC PlasticLeach-prosjektet, har som mål å tette noen av disse hullene ved å identifisere og karakterisere farlige kjemikalier som lekker fra plastprodukter, og ved å fremstille data som støtter regulatoriske tiltak. Parallell utvikling av verktøy som PlastChem-databasen øker åpenheten rundt kjemikaliebruk, forekomst og mulige farer, og støtter dermed prioritering både i forskning og håndtering.

Prioriteringer og utsikter

Alt i alt er det et klart og akutt behov for helhetlig forskning på MNP og plastrelaterte kjemikalier, inkludert toksikologisk testing, biomonitorering, bedre eksponeringskarakterisering og vurdering av mulige blandingseffekter. I tillegg er det behov for regulatorisk handling for å begrense eksponeringen for MNP, fase ut bekymringsfulle kjemikalier, økt åpenhet om plastens kjemiske sammensetning, og utvikling av tryggere og mer bærekraftige plastmaterialer for å redusere potensielle helserisikoer.

Under seminaret ble det fremhevet at mulige helseeffekter av plast er et tverrsektorielt tema, og at samarbeid mellom universiteter, forskningsinstitutter, kommuner, myndigheter og industri er nødvendig. Flere ideer for mulige veier videre ble diskutert. Et av forslagene var å arrangere et oppfølgingsseminar, som også inkluderer representanter fra kommuner, ikke-statlige organisasjoner (NGO-er) og industrien, for videre utveksling av kunnskap og innsikt samt å identifisere løsninger for å begrense menneskelig eksponering. Et annet forslag som ble diskutert på seminaret var opprettelse av et nasjonalt forskningssenter for plast (MNP of kjemikalier i plast) og menneskers helse som et mulig verktøy for å sikre bredt samarbeid og koordinering. Å møte de komplekse utfordringene knyttet til MNP krever langsiktig forskning som kombinerer mange forskningsfelt, derunder forbedret biomonitorering, kjemisk karakterisering og faredata, samt gjennomføre godt utformede eksperimentelle og epidemiologiske studier.

Presentation

1 Micro- og nanoplastics: Priorities for the Norwegian Environment Agency

Anne Christine Parborg, Norwegian Environment Agency

Pollution (including plastics and chemicals) is one of several policy areas prioritized by the Agency.

With respect to plastic pollution, the Norwegian Environment Agency (NEA) works towards the four national goals: pollution shall not harm human health or the environment, the amount of waste generated shall be reduced, material recycling shall be increased, and the use and emissions of chemicals on the priority list shall be phased out. The NEA addresses microplastics using a range of policy instruments, including the Norwegian Plastics Strategy. Knowledge-based management, the precautionary principle, and the “polluter pays” principle are the guiding principles of this strategy.

In addition, Norway has an action plan for a non-toxic environment, which identifies the detection and regulation of hazardous chemicals in plastics as a priority for the NEA.

Human health falls within the NEA’s remit, as REACH, CLP, and the Pollution Control Act (Forurensningsloven) regulate both health and environmental issues. The NEA is responsible for several of these regulations, as well as for the regulation of products such as toys and cleaning products. Furthermore, the NEA has an advisory role towards national actors, is involved in the development of regulations, carries out inspections, and has a coordinating role across different government sectors. The NEA also participates in international regulatory processes, including negotiations for a global plastics treaty and regulatory work related to water, waste, REACH, CLP, and other frameworks.

In its efforts to address plastic pollution, the NEA prioritizes improved coordination among national actors, better knowledge of sources of exposure and exposure pathways, increased understanding of effects on human health and the environment, and enhanced knowledge of the role of hazardous chemicals in plastic pollution.

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Presentation

2 Micro- og nanoplastics: What the Norwegian Institute of Public Health needs to know

Hubert Dirven, NIPH

The Norwegian Institute of Public Health (NIPH) provides knowledge-based advice on the effects of environmental factors on human health. NIPH has the largest human toxicology group in Norway and provide advice on health effects of chemicals to national governmental actors (Norwegian Environment Agency, the Norwegian Food Safety Authority, the Norwegian Directorate of Health) and international organizations like ECHA, EFSA, OECD and WHO.

Possible health effects from plastics are linked to the particle component of micro- and nanoplastics (MNP), chemicals leaching from plastics, microbes that use the MNPs as vectors or chemicals adsorbed to particles.

MNPs are mainly formed by degradation of plastics in the environment. Exposure to MNPs is primarily happening by oral ingestion and inhalation, but in medical settings administration of MNPs directly in the blood system is likely.

To perform a risk assessment for MNPs, both data on exposure and health hazards are needed. Currently we lack data on both exposure and hazards.

At NIPH several research projects on MNPs and chemicals leaching from plastics are ongoing. We need more studies with MNPs that are representative of the particles that we are exposed to in real-life to perform hazard identification and hazard characterization studies. Also, more data on human exposure is needed to perform a knowledge-based risk assessment.

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Presentation

3 New EFSA mandate on micro/nanoplastics as contaminants

Elena Rovesti, European Food Safety Authority (EFSA)

EFSA has had the topic of microplastics on their radar since 2016, published several publications and organized a Scientific Colloquium.

In 2025, EFSA received a new mandate from the European Parliament/European Commission to deliver a scientific opinion based on an extensive literature review covering the following topics:

- Human exposure pathways and bioaccumulation within a One Health context.
- Toxicological human health effects (Hazard identification and characterization).
- Advances in analytical methodologies for quantification of micro- and nanoplastics in food.
- Micro- and nanoplastics as vectors for chemical contaminants and human foodborne microbiological hazards in food.
- An update of the dietary exposure and risk assessment of micro- and nanoplastics, including an overview of the available occurrence data.

EFSA will build on data and evidence gaps previously identified by EFSA. The One Health approach entails that EFSA will work with ECHA, JRC and other EU agencies and member states to develop a scientific opinion. The deadline is 31st of December 2027.

Keynote lecture

4 WHY IS IT SO DIFFICULT TO MEASURE EXPOSURE TO MICRO- AND NANOPLASTICS.

DORTE HERZKE, NIPH

Precise and sensitive analytical methods are critical to enable effective research into the potential toxicity of plastic particles in the body and their contribution to adverse health effects (Thomas et al., 2026).

To estimate the internal exposure to MNPs, a set of analytical techniques are available, all characterized by benefits and drawbacks, requiring careful selection prior to use to allow for the most appropriate results. In general, we distinguish between two major classes of techniques: one resulting in data on particle size, shape, number and chemical composition and the other in mass-based concentrations and chemical composition of the plastics present. Detecting trace levels of ubiquitous and diverse types of plastic particles present challenges, including the risk of sample contamination, and the need for efficient, yet selective matrix removal, which are both essential for subsequent analysis. A further challenge is the difficulty of identifying and reliably quantifying these particles in complex biological media. With the focus on human exposure and biological processes transporting MNPs throughout the body, analytical methods also need to be able to identify and quantify particle sizes below the critical size of 1 µm. This requirement is today only fulfilled by a limited number of techniques based either on imaging and vibrational methods or thermic methods, pyrolyzing MNPs under controlled conditions prior analyses using gas chromatography and mass spectrometry.

While imaging techniques are time-consuming, often requiring several days of sample processing, thermic methods are much faster but destructive and lose the information on particle number and size. All approaches struggle with the presence of biological tissue residues, requiring thorough sample preparation prior to measurement without damaging or losing the MNPs present while simultaneously preventing contamination by sample handling. To counterbalance the benefits and drawbacks of both approaches, a combined use of both technique types in subsets of samples in addition to robust and harmonized quality control and quality assurance protocols is recommended.

Recent concerns about the quality of human exposure to MNPs must be taken seriously, while we also need to inform the public and regulators about the uncertainties present in a young field of science. As part of the process, early results have always been continuously questioned and tested, resulting in improved methodologies and adjusted experimental designs. This process requires open communication of methodological challenges and quality of the data as well as the ability to learn and follow up on recommendations for improvement. This is a time consuming but necessary process, typical in analytical chemistry, based on broad collaboration and knowledge exchange rather than competition.

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Presentation

5 SOURCES FOR MICRO- AND NANOPLASTICS IN HUMANS

BERIT GRANUM, NIPH

Skin, lungs and the intestines play a role in the uptake of both chemicals and particles. The skin is an effective barrier to prevent uptake of chemicals and particles, unless the skin is damaged.

Uptake of particles by inhalation depends on the size of the particles. Only small particles (0.1-1 µm) can reach the alveoli where transfer over the lung membrane is possible.

The intestines in humans have a large surface (30 m^2) and different types of cells can transfer particles from the lumen to the tissue. M cells and enterocytes can transfer particles by endocytosis (100 nm to several µm), migratory macrophages or dendritic cells transfer particles larger than 500 nm, and paracellular membrane transport is possible for small particles (less than 10 nm). If the epithelial membrane in the intestines is damaged, like in disease situations, large particles (more than 200 nm) can also pass the barrier.

After uptake, particles can be distributed to several organs and excretion is most likely by feces and urine.

Tires, paint, food and drinks, clothes, artificial football fields, cosmetics and many others are sources of MNP. Particles can be introduced during the processing of food and drinks or from the packaging materials. In many animal and plant products MNP are detected. Food and drinks are therefore considered as the most important exposure sources for MNPs.

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Presentation

6 Micro- and Nanoplastics in Soil and Plants

Rachel Hurley, NIVA

Dr. Hurley presented the results of the EU project Plastic in Agricultural Production: Impacts, Lifecycles, and LONg-term Sustainability (PAPILLONS), aiming at increasing our knowledge on sources, behavior and long-term ecological and socioeconomic impacts of micro- and nanoplastics (MNPs) from agricultural plastic in European soils. A European spatial survey found that agricultural plastics contributed between 18-40% of microplastics (MP) in the fields investigated.

Atmospheric deposition was an important contribution to soil MP levels. Plant-based MP uptake is expected to be minimal while nanoplastics (NP) are challenging to track, given their small size and a lack of analytical methods for their detection in plant samples. Experimental exposure resulted in detection of NP in roots at all concentrations, while in the shoots NPs were only observed at high concentration exposure in lettuce and barley (15, 150, 1500 µg/L).

Experiments showed MNPs can cause negative effects on plants at environmentally relevant concentrations. Effects on germination were found while growth stress indicators and stress responses were consistently upregulated, especially by biodegradable plastics.

In summary, MP are present in European agricultural soils at high concentrations with Norwegian concentrations being generally lower than other countries. No singular dominant source could be identified, hampering the regulation. NP uptake is observed in plants – but most particles remain in soils. However, MNPs have effects on plants, and this occurs at concentration levels observed in Europe today. An important risk pathway is likely by indirect effects that impact agricultural ecosystems: MNP alter habitats by being present physically in the soil.

Presentation

7 Micro and nanoplastic in the air

Natascha Schmidt, NILU

Atmospheric micro- and nanoplastics (MNPs) are still understudied with little understood sources, transport pathways and role in human exposure to MNPs. As part of the recent national microplastic (MP) monitoring projects by the Norwegian Environment Agency (MIKRONOR1-3), atmospheric MP have been measured at both remote air quality stations as well as urban sites such as Oslo. Tire Wear Particles (TWPs) were identified as major part of air pollution and often dominated 'microplastic' composition in urban air samples. To follow up on these findings, Statens vegvesen commissioned NILU to carry out a pilot study investigating PM_{10} TWP emissions on a heavily used main road (E18 at Hjortnes) and an urban park (Sofienbergparken, same station also used in MIKRONOR projects). Large volume samplers were used for 5 sampling periods at both sites in October 2025, and additional 5 timepoints for Hjortnes in November 2025. Both common PM_{10} and TWP PM_{10} were measured in parallel. TWP chemicals as 6PPD and its degradation product 6PPDQ and others were also screened for in the collected filters.

TWPs were detected in all samples both from urban background and curbside site during October and November 2025 in Oslo, with higher levels at the traffic-intense site. TWP are consistently a measurable part of urban PM_{10} with TWP amounts representing up to 28.5% of PM_{10} (mean 10.6%). The TWP chemical 6PPDQ was the majorly detected TWP-related chemical. Environmental parameters such as temperature and precipitation might influence temporal variability in airborne TWP concentrations. PM_{10}, TWP PM_{10} and 6PPDQ PM_{10} exhibit similar temporal variations. Calculated daily airborne intake of TWP (8.8 µg/day) represents a high-exposure scenario (4 h outdoor time per day in urban settings) but might be realistic for certain population groups (e.g. street construction/repair workers, bicyclists). Results indicate further a very high short-term temporal variability in TWP and 6PPDQ concentrations, pointing to variable sources and transport fates within the observed timeframes. Comprehensive spatio-temporal studies are needed to improve our understanding of human exposure to tyre-related airborne pollution.

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Keynote lecture

8 Plastic chemicals and health

Martin Wagner, NTNU

The PlastChem report states that 16,325 chemicals might be present in plastic and that no data on hazardous properties are available for 10,726 of these chemicals. All chemicals that can be present in plastic materials and products are included in this number.

With respect to human exposure, for 2,368 chemicals data on migration is available, and 63% are detected and 7% are ambiguous. For the 1,406 chemicals that are present in food contact materials, 10% are detected in human biomonitoring studies, 3% are not detected and no data on 87% of the chemicals is available regarding exposure.

Figure 1 Current knowledge on chemicals present in plastic materials and products (PlastChem report)

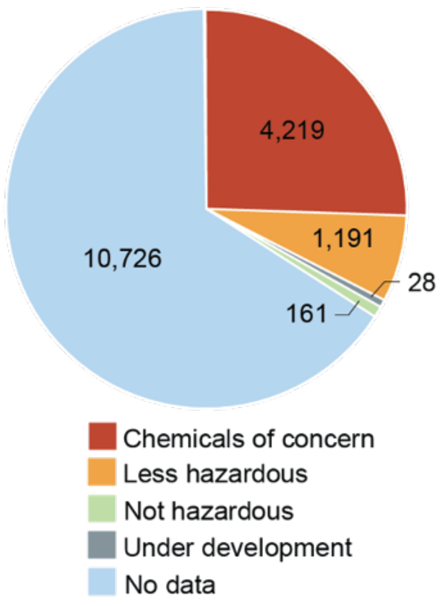

Figure 1. Current knowledge on chemicals present in plastic materials and products. Source: PlastChem Report

These data indicate a large knowledge gap regarding exposure and hazardous effects of chemicals present in plastics. Chemicals in plastics have been in epidemiological studies associated with adverse health outcomes like reproductive disorders, metabolic disorders, cardiovascular disease, congenital malformations and certain types of cancer. An example of regulatory challenges of chemicals in plastic is Bisphenol A (BPA). BPA was first synthetized in 1891. In 1936 estrogenic effects were described. BPA was introduced in the production of polycarbonate in 1958. In 2002 a WHO EDC report confirmed BPA as an endocrine disrupting chemical, but first in 2011 EU introduced a ban on the use of BPA in baby bottles and a ban in food contact materials was introduced in 2024, despite more than 46,138 papers being published between 1990 and 2024 on BPA.

Regarding the topic of chemicals used in plastics the following improvements were suggested:

- a faster removal of chemicals of concern from plastics
- improved transparency on the 16,325 chemicals in plastics including data on chemical composition, concentrations used and tonnages produced
- development of simpler and safer plastics

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Presentation

9 Epidemiological studies on chemicals from plastics on child and adolescent health

Gro Dehli Andersen, NIPH

Humans are exposed daily to complex mixtures of substances through food, air, consumer products, and indoor environments. Pregnant women and developing children are particularly vulnerable, as many chemicals cross the placenta and interfere with critical stages of fetal development, potentially leading to long-term and irreversible effects on endocrine, immune, metabolic, and neurological systems.

The Norwegian Mother, Father and Child Cohort Study (MoBa) provides a unique resource for studying prenatal exposures and later health outcomes, with extensive questionnaire data, biological samples, and genotyping data, as well as linkage to national health registries. The MoBa sub-study, NeuroTox, includes up to 3,500 mother-child pairs and has investigated prenatal, maternal exposure to plastic-associated chemicals (PFAS, phthalates, organophosphate esters) in relation to child neurodevelopment. Results suggest associations between certain exposures and increased probability of ADHD and/or autism, and lowered cognitive function, with some evidence of mixture effects and interactions with factors like sex, socioeconomic status, and mediation by maternal thyroid function.

The ongoing MoBa-PlastChem project (2023–2028) builds on and expands the NeuroTox study, by further examining how prenatal exposure to plastic-associated chemicals influences reproductive and brain development, following participants from early childhood into young adulthood.

In conclusion, there is a clear and urgent need for substantially more research on plastic-related chemicals and their health impacts, including biomonitoring in the Norwegian population and improved assessment of emerging and replacement chemicals, to better understand and manage potential health risks.

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Presentation

10 Plastic-related chemical exposure in Norwegian children and adolescents

Line Småstuen Haug, NIPH

Human biomonitoring data from Norwegian children and adolescents show widespread exposure to a broad range of environmental and plastic-related chemicals. Results from the Miljøbiobanken study, a sub-study of the Norwegian Mother, Father and Child Cohort Study (MoBa), demonstrate that many substances, including phthalates, bisphenols, PFAS, flame retardants, pesticides, and metals, are detected in a large proportion of samples. Several chemicals, such as phthalates and BPA, were found in nearly all participants, highlighting continuous and ubiquitous exposure from everyday sources. Exposure levels varied by age, sex, and geography, with higher concentrations often observed in younger children and some regional differences across Norway.

Comparisons with international data indicate that Norwegian levels are generally in a similar range to other countries. However, for some substances, a proportion of individuals exceeded established tolerable intake levels (e.g. BPA and PFAS), suggesting potential health concerns. At the same time, knowledge gaps remain substantial, as safe exposure thresholds are lacking for many chemicals and may change as new evidence emerges.

The findings underline that children are exposed to complex mixtures of chemicals rather than individual chemicals, complicating risk assessment. While regulatory measures and individual actions can help reduce exposure, continued and expanded biomonitoring is essential. There is a clear need for more representative population data, repeated measurements over time, and inclusion of a wider range of chemicals to better understand exposure patterns and potential health risks in the Norwegian population.

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Presentation

11 Hazard identification and characterization of leachable chemicals from plastic products: the PARC PlasticLeach project

IGOR SNAPKOW, NIPH

Many chemicals are used in plastics, and we lack hazard data on Persistence, Bioaccumulation, Mobility and Toxicology (PBMT) characteristics on many of these chemicals. Within the Partnership for the Assessment of Risk from Chemicals (PARC), a large European project with 200 partners in all European countries, NIPH is leading the PlasticLeach project. Sixteen research institutes and universities in 9 countries participate in the project. Both human health and ecotoxicity endpoints are being studied.

The following steps will be used:

- Selection of different types of plastics and products.
- Preparing methanol extracts from these products.
- Toxicity testing of the leachates in selected bioassays and subsequent chemical identification of chemicals present in the leachates.
- Testing of individual chemicals.
- For chemicals with hazardous properties: propose regulatory action.

Products that will be studied include baby bottles, cupcake forms, rubber granulates, athletic clothing and cigarette filters. Currently the first two leachates are distributed to the labs participating in the project, and testing will start.

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Presentation

12 Updating the PlastChem database

Laura Monclús, NGI

The PlastChem database is a rapidly developing resource designed to map and organize the extensive chemical complexity associated with plastics. Since its initial release in 2023, the database has gained substantial scientific and public interest, with tens of thousands of accesses and downloads, and a peer-reviewed publication in *Nature*. It compiles information on plastic-associated chemicals, including their uses, occurrence in materials, and potential hazards, providing a structured foundation for research and regulatory prioritization.

Ongoing updates towards version 1.1 focus on expanding and refining the evidence base. This includes the addition of new data on chemical presence in plastics, human exposure, and production volumes, as well as a comprehensive update of hazard information. The database integrates detailed classifications from multiple international regulatory and scientific sources (e.g., ECHA, REACH, US EPA, IARC), improving transparency and enabling users to trace hazard assessments back to original sources.

A key aim of the update is to strengthen the prioritization of chemicals of concern by providing more granular and harmonized hazard data. This enhances the ability to identify substances of high concern and supports risk assessment, research, and policy development. Overall, PlastChem represents an important step toward systematically understanding and managing the large number of chemicals associated with plastics.

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Keynote lecture

13 The POLYRISK risk assessment framework for micro- and nanoparticles and its application in selected case studies

Andrea Haase, German Federal Institute for Risk Assessment, BfR, Germany

Dr. Haase presented the general risk assessment paradigm: substance identity, hazard identification, hazard characterization, exposure assessment and risk characterization (is there a risk, for whom, how large the risk is). On the hazard assessment side, different types of hazards might be relevant for MNPs and should be considered: chemical hazards, general particle hazards, morphology-triggered hazards and microbiological hazards.

Within the EU project POLYRISK, a generic Risk Assessment Framework (RAF) was developed based on state-of-the-art approaches in risk assessment, identification of suitable concepts (including polymers of low concern, poorly soluble low toxicity particles and fiber pathogenicity paradigm) and screening of the literature. The developed framework is a modular framework. It combines several Integrated Approaches to Testing and Assessment (IATA), uses New Approach Methodologies (NAMs) and provides guidance on suitable methods to cover physicochemical properties, exposure and hazard assessment.

The initial framework (Vogel et al., 2024) concerns the inhalation route. It starts with basic physicochemical characterization (step 1), followed by assessing the potential for inhalative exposure (step 2), and includes several modules for toxicological assessment (step 3). The framework provides specific guidance for each step and suggests for instance characterization methods based on existing OECD test guidelines. The first step is to understand if the particles considered would meet the criteria for MNPs. In the second step, an assessment is made if the MNP can reach the distal lungs and if the MNP is likely to be persistent in the lung lining and lysosomal fluid. In step 3 toxicological properties are assessed to identify if the particle could be grouped as Poorly Soluble Low Toxicity (PSLT) particles or if the MNP would need to be considered as critical fibers (resembling asbestos fibers). This assessment is based on several screening assays including cytotoxicity, reactivity/oxidative stress, (pro-)inflammatory potential and genotoxicity. The framework also foresees case-by-case assessments for MNPs which cannot be grouped as critical polymeric fibers or PSLT polymer particles. For a detailed case-by-case evaluation POLYRISK considered in particular immunotoxicity and developed a specific IATA for this. The POLYRISK consortium established two types of case studies to demonstrate the practical applicability of the risk assessment framework: laboratory-based studies and real-world scenarios. Overall, the framework was applicable for both types of case studies. The experimental findings supported the classification of most of the POLYRISK MNPs as PSLT polymer particles. However, a few showed some activity in immune-related assays. Overall, more research is needed to better define the thresholds for “no/low toxicity”.

The oral risk assessment framework (Vogel et al., 2026) follows a similar approach and describes a modular framework that combines several IATAs with a comparable overall structure as the inhalation framework. It has three main steps: i) basic physicochemical characterization of testing materials, ii) intestinal crossing, iii) hazard assessment testing. Each step is supported by scientifically sound methods. The focus is on assessments of whether the MNP can cross the intestinal barrier, if in vitro digestion influences the physicochemical properties of the MNP and if the MNP can induce oxidative stress, cytotoxicity or (pro)-inflammatory potential or may impact the gastrointestinal barrier integrity. The POLYRISK framework for inhalation and oral exposure can easily be combined into one showing the route forward to ultimately tackle human health risk assessment of MNPs.

The following knowledge gaps were identified regarding the presented RAF: reproducibility and relevance of existing test methods need to be improved, reference materials for analytics and development of representative test materials for toxicity studies are needed. Benchmarking with other types of particles for comparison are needed. This requires collaboration among all stakeholders.

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Presentation

14 HEALTH EFFECTS OF MICRO- AND NANOPLASTICS

HUBERT DIRVEN, NIPH

In a WHO report from 2022 a group of experts concluded that micro- and nanoplastics (MNPs) can cause effects in the intestine (changes in the microbiome and effects of the barrier function) and liver (hepatitis and steatoses). They also concluded that many studies have methodological weaknesses and that no conclusions can be drawn about exposure and health effects of MNPs.

The challenge is that there are many different MNPs possible that vary in size, surface area, shape, pristine vs. weathered, polymer materials and added chemicals and to manufacture these materials as nanoplastics is challenging.

There are many review papers that link MNPs to all kinds of possible health effects but data to support the proposed effects are lacking. Three human studies that received a lot of attention in the last years were discussed and for at least two studies of these studies there is a debate among scientists whether the methods to quantify plastics in the tissues are not prone to contamination with plastics or interference from lipids.

From *in vitro* studies there is data that MNPs cause oxidative stress which can result in genotoxicity, inflammation, changes in membrane permeability, mitochondrial dysfunction, changes in intracellular communication and other effects.

To improve risk assessment of MNPs we need to standardize the methods to produce nanoplastics as test material in toxicological studies and as analytical standards. Methods to improve exposure assessments are needed. Probably we need animal studies and human studies to study the effects of more chronic exposure. We also need more data on the fate of MNPs after uptake in the body.

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Presentation

15 Micro and Nanoplastics and human health: what do we do at NIPH?

Igor Snapkow, NIPH

NIPH is following closely the literature on MNPs and assessing the relevance for human risk assessment. We get a lot of questions from journalists who are interested in our assessments of the findings published. NIPH is actively participating in meetings during, for example the Arendals week, national congresses and national meetings to present the existing state-of-the-art knowledge on this topic and our assessment of relevance for human health.

Research done at NIPH is funded by external sources, so we are depending on what kind of calls are published and if we get our proposals accepted. Most of the research is funded by the EU since NFR has no relevant human toxicology calls.

Figure 2 Research projects on plastic at NIPH

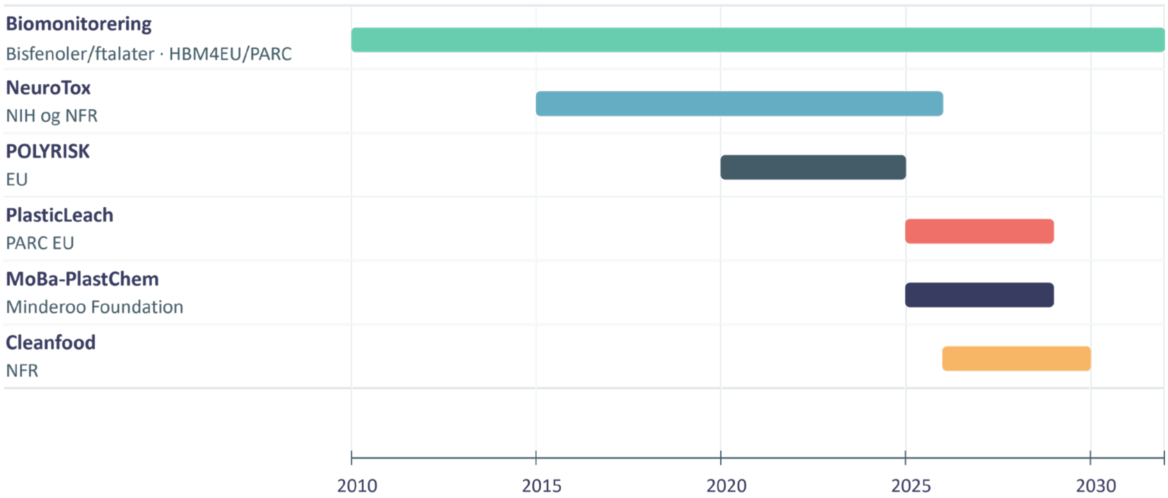

Figure 2 Ongoing research projects around MNPs and chemicals in plastics at NIPH. Source: NIPH

Panel debate

16 MAIN POINTS FROM THE PANEL DEBATE

MODERATED BY JOHAN ØVREVIK, NIPH

Organizations that participated in the panel debate were the Norwegian Environment Agency, Norwegian Food Safety Authority, Norwegian Labour Inspection Authority, Norwegian Research Council, Norwegian Public Roads Administration and the Norwegian Institute of Public Health.

The knowledge needed for regulation needs to be based on the best available science. Methods that are used must be standardized and generally accepted. The Norwegian Pollution Control Act (Forurensingsloven) can potentially be used to regulate release of MNPs and therefore contribute to reducing exposure to humans and the environment. Knowledge of MNP levels in European water bodies will increase in the coming years, due to the inclusion of microplastics on the EU Water Framework Directive watch list, which requires EU/EEA countries to monitor their presence.

MNPs in food can be regulated as environmental contaminants or by using the food contact materials regulations. Thresholds for MNPs cannot be set without knowledge on concentrations in food and knowledge on health effects. If the precautionary principle is used, we risk that a lot of the food must be discarded as food waste due to microbial contamination.

Airborne MNPs are an important exposure source for occupational and urban settings. More data on actual MNP exposure levels at workplaces is needed. It should be explored if existing guidelines for nanomaterials can be used. More knowledge on exposure and health effects of nanoplastics is needed to set threshold levels. For some chemicals used in plastics, we already have threshold levels.

Manufacturers can be obliged to label their products for potential release of MNPs.

Protective action is also possible without threshold values. There is no official safe level for microplastics established by the European Chemicals Agency (ECHA) or the European Food Safety Authority (EFSA). In ECHA's background document for the restriction on intentionally added microplastics it is stated that **microplastics are treated as substances of concern** because of their persistence, insolubility, progressive accumulation, it is not scientifically possible to derive a safe environmental threshold. This means that any uncontrolled release into the environment carries a potential risk. Instead of relying on a safe limit, the EU approaches this via the precautionary principle, implementing a relatively widespread ban on intentionally added microplastics under the REACH regulation.

With respect to human exposure, it is important to know what the **main sources of exposure** are. Is it mostly food? Is it already in the food, or is it introduced during processing? If we can regulate emissions of MNPs from industry, we still have a lot of plastics in the environment, which will only very slowly degrade. In a globalized world, with long transport of pollution, global solutions are to be preferred. **The Global Plastics Treaty would be an important cornerstone in this regard.**

A cross-sectoral approach is needed so one can create synergies and priorities across different sectors. Research funding for thematic centers was mentioned by some panelists. For instance, four departments supported a research program on food, environment, climate and public health.

The Research Council of Norway receives funding from the departments, and the departments together decide what kind of research topics will be funded.

For nanomaterials a national strategy was developed by authorities, The National Institute of Occupational Health (STAMI) and the departments. **A long-term focus and work program across sectors could also be needed for MNPs.**

17 PLASTICS AND HUMAN HEALTH- MOVING FORWARD

The seminar, which presented the current state of research from Norwegian and international research institutions, provided an overview of existing knowledge and highlighted key considerations for how Norway can strengthen research and regulatory efforts to better protect humans from potential adverse health effects of MNPs and plastic-associated chemicals.

MNPs consist of different polymer compositions, sizes, shapes, chemical compositions and surface properties. Future studies should cover the totality of this complex chemical and physical space to study the full depth of their hazardous properties. Knowledge gaps in the hazard assessment of MNPs for human health were identified. Especially data on health effects of chronic exposure to nanoplastics are needed.

All plastics are also a source of chemicals. Some of these, like the phthalates and bisphenols are known, but the universe of intentionally and unintentionally added chemicals to plastics is much larger. Since many chemicals identified in the PlastChem report are not covered by REACH, there is a need to collect more hazard data related to Persistence, Bioaccumulation, Mobility and Toxicity (PBMT) on these chemicals, and to identify causal relationships for possible health effects, including mixture effects.

Epidemiological studies in Norway, for example MoBa, and in Europe represent a globally unique resource and should be leveraged and further expanded to investigate health outcomes associated with plastic-associated chemicals and their mixtures. These cohorts should also, in the future, incorporate measurements of MNPs, particularly to capture exposures during vulnerable life stages such as pregnancy.

As a next step, the plastic chemicals of concern should be included in large biomonitoring studies to improve our understanding of human exposure and establish causal relationships to health outcomes. Some speakers and panelists recommended to initiate regular biomonitoring studies, of the Norwegian population, building upon existing but fragmented and non-representative activities. It is important to assess today’s exposure levels, and to be able to assess changes in exposure to chemicals and MNPs over time, and link exposure data to information on habits and health outcomes.

Many of these key considerations cannot be addressed by individual research groups or institutions alone, but require timely, well-coordinated collaborative efforts that are difficult to achieve within highly competitive national research programs. Since plastic is a complex, cross-sectoral topic, national coordination is needed. Long-term, coordinated of research efforts are needed in Norway, building on the country’s commitment to the ongoing plastic treaty negotiations and due to the presence of internationally recognized research groups on MNPs, plastic-associated chemicals, and human health research.

A national research Centre on Plastics and Human Health was suggested by some panelists as a potential vehicle to ensure broad collaboration and coordination with the goal of accelerating and connecting research outcomes. Similar research centers were established by Norway for other urgent research needs in the past (e.g. for climate change: FRAM Centre, Nansen Centre, the recently funded Research centers for sustainable area and nature use). All centers act as a unifying force for national research and provide long-term research activity in collaboration with users from the industrial sector, the public sector and other societal actors, funded by multiple ministries over a longer timeframe and support strong collaboration across universities, research institutes, municipalities, and industry.

The most pressing knowledge gaps should be identified, prioritized and followed up by a plan on how to close these gaps. It is important that a discussion across sectors is initiated and promoted, and where possible synergies with other programs should be sought, for example with the Momentum initiative in the Netherlands and the CUSP Research Roadmap.

Existing legal frameworks, which often are developed at the European level, must be developed to encompass MNPs to enable more targeted and efficient regulatory outcomes. Any regulation must be based on well-accepted and reproducible methods and, where possible, threshold values. In the absence of these, it was discussed that other ways to regulate MNPs should also be considered, learning from other harmful particles such as inorganic nanoparticles and asbestos.

In the meantime, applying the precautionary principle could help limit the generation of additional MNPs from discarded plastics in the environment. This includes promoting the development of materials that reduce MNP formation and contain fewer hazardous chemicals, alongside a broader shift toward reducing the use of non-essential plastic products.

This report is meant to ensure a widespread dissemination of knowledge arising from this seminar and will contribute to broader involvement and discussions on insights and solutions to limit human exposure and therefore prevent potentially adverse health effects of MNPs.

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MOMENTUM SOLUTIONS ROADMAP 2.0 Aiming to minimize the human health impact of exposure to micro- and nanoplastics.
https://momentummicroplastics.nl/wpcontent/uploads/sites/740/2025/11/Momentum2.0_Roadmap_final.pdf

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