Brussels, 17 May 2024

COST 044/24

DECISION

Subject: Memorandum of Understanding for the implementation of the COST Action "ISO compatible, efficient and reproducible protocols/equipment for mICro-nanoPLASTIC detection through machine-learning" (ICPLASTIC) CA23131

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action ISO compatible, efficient and reproducible protocols/equipment for mICro-nanoPLASTIC detection through machine-learning approved by the Committee of Senior Officials through written procedure on 17 May 2024.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA23131
ISO COMPATIBLE, EFFICIENT AND REPRODUCIBLE PROTOCOLS/EQUIPMENT FOR MICRO-NANOPLASTIC DETECTION THROUGH MACHINE-LEARNING (ICPLASTIC)

The COST Members through the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action, referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any document amending or replacing them.

The main aim and objective of the Action is to develop a suitable formulation/realisation of efficient/reproducible protocols and equipment for MNP sampling, sample preparation and analysis to support the application of ISO standards and all water quality legislation, and close knowledge gaps in risk analysis/occurrence through their enablement of improved toxicological/environmental studies. This will be achieved through the specific objectives detailed in the Technical Annex.

The present MoU enters into force on the date of the approval of the COST Action by the CSO.

TECHNICAL ANNEX

OVERVIEW

Summary

Within the EC’s initiative of “Measures aiming to reduce the presence in the environment of unintentionally released microplastics from tyres, textiles and plastic pellets” knowledge gaps for micro and nanoplastics (MNPs) in environmental, drinking and bottled water have been acknowledged for correction including: Risks and occurrence; harmonised methods for sampling, processing, data analysis and reporting. Imminent new ISO standards for the sampling of microplastics in water and the spectroscopic methods for their analysis, and environmental legislation for microplastics in water, that began with the EU’s 'Towards Zero Pollution for Air, Water and Soil' of 2021, were joined in 2022 by a standard for microplastics in drinking water in the state of California.

The 'ISO compatible, efficient and reproducible protocols/equipment for mICro-nanoPLASTIC detection through machine-learning' (ICPLASTIC) Action will create a broad and skilled transdisciplinary network of instrument/equipment makers, their end-users and relevant academics/technologists. It will, through scientific discussion and elaboration, converge on the necessary key parameters (and their value ranges) for user and design specifications of protocols and equipment that can support the aforementioned standards and legislation, and produce a risk analysis.

ICPLASTIC’s impacts will benefit the scientific community, economy and all European citizens: (1) Marketed equipment for MNP sampling, sample preparation and analysis, compatible with ISO standards and the ICPLASTIC risk analysis; (2) Environmental, drinking and bottled water legislation introduced, compatible with ISO, the ICPLASTIC risk analysis and the aforementioned equipment; (3) Dissemination of information from non-ITCs to ITCs, and from senior to junior researchers, for regional MNP monitoring and legislation, and career development.

Areas of Expertise Relevant for the Action	**Keywords**
● Environmental engineering: Water management and technology ● Nano-technology: Optics, non-linear optics for nano-technology applications ● Chemical sciences: Spectroscopic and spectrometric techniques ● Chemical engineering: Characterization methods of materials ● Chemical sciences: Electrochemistry, electrodialysis, microfluidics, sensors	● Microplastics ● ISO ● Machine learning ● envrionmental, drinking and bottled water ● analytical techniques

Specific Objectives

To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

<u>Research Coordination</u>

● Determination and sharing of best practice and protocols for monitoring plan, sampling and sample preparation methods for environmental, drinking and bottled water

● Coordinating inter-laboratory studies and joint projects involving European and International researchers on the development of efficient and reproducible protocols and equipment for the sampling, sample preparation and analysis of MNPs through the use of ML, microfluidics and filtration

● ML algorithms and tools to interpret the big and complex data produced by advanced instruments for quantifying MNPs

● Determination of particle mass, shape and size distribution ranges, and chemicals to undertake toxicological studies.

● Determination of the risk analysis based on the revised particle mass, shape and size distribution ranges, and chemicals from the toxicological studies.

● Determination of end user and design specifications for MNP characterisation equipment based on the ICPLASTIC risk analysis and ISO standards.

● Collection and organization of relevant research results, and wide dissemination of research achievements and the Action's activities.

● Funnelling 1: Determination by Core Group of equipment manufacturers and end users of narrower aspects to focus on in all WGs from M13.

● Funnelling 2: Determination by Core Group of equipment manufacturers and end users of narrower aspects to focus on in all WGs from M25.

● Funnelling 3: Determination by Core Group of equipment manufacturers and end users of narrower aspects to focus on in all WGs from M37.

Capacity Building

● Training of European stakeholders to lead a homogeneous approach to MNP monitoring, sampling, sample preparation and analysis.

● Training of European public and private stakeholders to establish a shared pathway for the use of ML in MNP sampling, sample preparation and analysis.

● Increasing the capacity for MNP monitoring, and the awareness of the need to do so, both in non-ITCs, but particularly in ITCs, by fostering the knowledge exchange and the development of a joint research agenda with regards to optimising sampling, sample preparation and analysis protocols and equipment for MNPs.

● Connecting and strengthening collaborations among outstanding European and international scientists and experts to create a consortium with the transversal competences necessary to undertake a transdisciplinary research agenda within the field of MNP analysis.

● Involve newly established research groups and teams from countries with less capacity, whilst assuring gender balance and the enabling of a uniform access to scientific and technological knowledge to enhance knowledge sharing.

● Supporting YRIs, underrepresented genders and researchers from ITCs by enabling them to take leading roles within the Action and developing transdisciplinary collaborations and working opportunities.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. SOUNDNESS OF THE CHALLENGE

1.1.1. DESCRIPTION OF THE STATE OF THE ART

The term plastic refers to a ubiquitous group of synthetic or semi-synthetic materials whose main ingredient is polymers but may have different additives so as to have certain properties. With their high strength to weight ratio, low-cost, durability, adaptability and perceived bio-inertness or harmlessness, plastics have found a purpose in almost every area of life, from food packaging to production of analytical instruments or thickeners in cosmetics. This demand has led to a production that has grown exponentially since the 20th century, rising from 1.7 million tonnes in 1950 to 359 million metric tonnes of plastic in 2018 [1]. Within its production both thermostability and recyclability properties are monitored for the purposes of its use, however these same attributes also lead to environmental concerns when it is merely discarded instead of being recycled or reused after use.

The 91% [2] which is discarded, in water bodies, natural environments, open landfills or dumps, gradually fragments due to the effect of heat, UV radiation, atmospheric oxidation and mechanical degradation, into tiny particles smaller than 5 mm, known as 'microplastics' (MPs), whose lifetimes, due to the aforementioned properties, can surpass several hundreds of years. The recent worldwide COVID19 emergency worsened the concerns of plastic waste and MP generation due to the massive production of disposable protective equipment such as gloves, masks and diagnostic test kits [3]. Due to the bioavailability of these tiny particles to aquatic animals and their large surface area which facilitates waterborne pollutants to adhere to them, accumulate and act as vectors for their transport, such as Persistent Organic Pollutants (POPs) [5] and pharmaceuticals [6] MP pollution is becoming a major environmental concern, especially for marine life [4]. Furthermore, human exposure to MPs has been associated with numerous adverse results [7] and therefore pose a risk, although largely unknown still [8]. With their origin being important environmentally and toxicologically, they have undergone further classification by many organisations as to be either primary or secondary of origin. Although definitions vary, that of the European Chemicals Agency (ECHA) sees primary MPs as those that are intentionally added as micro beads, microflakes or nurdles to host products such as fertilisers, plant protection products, cosmetics, household and industrial detergents, cleaning products, paints and products used in the oil and gas industry, whilst secondary MPs are those that have been unintentionally generated through wear and tear from larger plastic pieces such as tyres or synthetic fibres [9], or the degradation of discarded plastic.

Finally, plastic particles much smaller than 5mm, either between 1 nm to 100 nm or 1 nm to 1000 nm (there is no universal consensus) have been sub-classified as 'nanoplastics' (NPs), and these can also have been generated through biodegradation by microbial action. Compared to MPs their high surface area leads to an enhanced reactivity, bioavailability and absorption capacity to overcome biological barriers and cause oxidative stress and cell death, and thus probably a more varied and greater toxicity. However, although they therefore probably represent a greater concern for the environment and human health than MPs, little is still known about their actual toxicity and therefore their risk, due to their size making their isolation from the environment, as well as their characterization, challenging.

Water treatment monitoring plays an important role in protecting the public from micro and nanoplastics (MNPs), and functional and reproducible protocols for sampling, sample preparation and analysis are currently being developed for inclusion [10]. However, guidelines for manufacturers to develop effective sampling, sample preparation and analytical equipment and their protocols are still absent, not least because "plastics" include a large number of different classes of polymers and additives with dramatically diverse chemical and physical properties, but also because of the inherent small size of MNPs.

Various state of art analytical techniques are applied to monitor spatial and temporal trends of MNPs, although visual sorting is an accepted approach for larger ones (0.3 to 5 mm). Vibrational spectroscopy (Raman and infrared), mass and elemental spectrometry, chemical and physical characterisation (e.g. specific density, light scattering), and fluorescence emission (imaging of stained particles and spectroscopy), have been introduced to reduce the risk of false positive/negative identification of MNPs.

Fourier Transform Infra-red spectroscopy (FTIR) imaging is a rapid label-free screening technique that detects MPs down to a size of 10-20 µm in reflectance mode [11] and transmission mode [12, 13], whereas the novel laser direct infrared (LDIR) chemical imaging, with tuneable quantum cascade lasers (QCLs) as radiation source and reflectance geometry, is 15x faster [14]. Optical photothermal spectroscopy (OPTIR) [15] uses the photothermal effect induced by tuneable QCLs and detects by a visible probe laser for superior resolution of MPs below 20 µm. Furthermore, the inelastic scattered portion of the visible probe laser can be used to collect simultaneously a Raman spectrum. Raman microscopy is another vibrational spectroscopic technique for label-free identification of MNPs [16] down to ~1 µm with spectral libraries commercially available as well. Surface-enhanced Raman scattering (SERS) overcomes the low limit of detection of Raman spectroscopy, which is a limitation for the detection of a single NP [17].

Thermal desorption pyrolysis gas chromatography mass spectroscopy (Py GC/MS) has been shown to identify and quantify MNPs on a polymer specific mass related trace level [18] whilst elemental spectrometry techniques of inductively coupled plasma-mass spectrometry (ICP-MS) and laser induced breakdown spectroscopy (LIBS) have both been used to successfully identify MPs against a non-plastic background [19, 20]. A simple technique using density gradient solutions has had some success in identifying MPs through measuring their density [21], whilst also in liquid media particle number and size distribution can be determined by static or dynamic light scattering (DLS) as well as nanoparticle tracking analysis (NTA). Measurement of the static scattering intensity [22] at many angles (multi angle light scattering, MALS) allows the calculation of the root mean square radius, also called the radius of gyration R_g, and other geometrical parameters such as form factor and structure factor of particles with radius above 1-2% of incident wavelength.

The dye Nile Red absorbs onto plastic surfaces rendering them fluorescent under blue light irradiation making this a rapid screening technique for MP detection and quantification, and its solvatochromic nature also offers the possibility of plastic categorization based on surface polarity characteristics of identified particles [23]. Other dyes, such as 4-dimethylamino-4'-nitrostilbene (DANS) exhibit emission profiles specific to the polymer's polarity, thus allowing for a more specific analysis of fluorescence images [24]. The use of fluorescence microscopy is still under investigation for a cost-effective high-throughput analysis platform for many routine applications. More recently fluorescence spectroscopy has been successfully used to identify MPs below 2 µm in inline experiments [25].

The analytical methods described above yield a huge amount of data, e.g. in terms of hyperspectral images and pyrograms, which must be interpreted to arrive at the amount, mass and type of MNPs. Interpretation is complicated due to interfering non-plastic materials, that cannot be completely removed in the sample preparation process following sampling, and the large variants of plastics and their additives, which may even be found within the same material. Machine learning (ML) is therefore sometimes used to interpret data as well as previously preselect potential plastic particles out of large sample set for analysis [26].

Within sampling of drinking water and beverages for MNP analysis the volume of bulk samples for tap water can vary from 0.25 litres to several 100 or 1000 litres whereas for bottled drinking water they have been mostly chosen arbitrarily, varying between 0.25 and 1L [27, 28]. However, sample sizes can be a determining factor in the accuracy of results as MPs generally occur in moderate concentrations in drinking water (10^{-3} - 10^{3}/litre) due to the sampling period, hence a standardized volume of samples with adequate replicates must be taken to ensure result reproducibility.

Within sample preparation various MNP extraction techniques are used [29], with the most common being density separation followed by organic matter digestion or vice versa, although there is no standard and comparable methodology for either. Thereafter, asymmetric flow field-flow fractionation (AF4) has been used to separate MNPs by size and an AF4-like setup can be miniaturized by microfluidic technology, which could allow the decrease of sample volume [30]. In general, although little microfluidic technology has been applied to MNP preconcentration and size separation, passive size sorting, via micro-reservoirs ahead of micro-filters, has been implemented to separate standard plastic particles of different sizes for fast imaging and optical spectroscopy detection [31]. During sample preparation, quality assurance and quality control (QA/QC) are becoming more and more common as these are key for precise and comparable results, and to implement them, different certified reference materials will be needed to measure recovery, and a series of blanks need to be measured to determine background contamination and limit detection/quantification of different MPs. Due to these complex matters, sampling and sample preparation methods should be validated for different matrices to ensure compliance with high QA/QC standards.

Toxicity assessment of MNPs for humans and other animals, plants and microbes [32] requires an innovative framework of research inputs for conclusive evidence on plastic toxicity, furthermore there is a lack of information on the possible adverse effects on human health of MNPs in food and the scientific evidence that exists is of variable quality. The variation in fate, physicochemical properties of the directly and indirectly (via food chain) ingested particles (e.g. size, length, shape, polymer type and surface chemistry), and biological activity of MNPs can lead to different potential hazardous effects, and particle size in particular (especially for NP) plays a decisive role in imparting toxicity to humans or animals and environmental health. *The lack of analytical tools and techniques that are sufficiently accurate to detect and estimate divergent MNPs within environmental samples is therefore a barrier to advances in toxicological studies.* Another source of concern is the toxicity of chemical additives and/or adsorbed chemicals that have a potential harmful effect as in this case MNPs can serve as a vector between the environment and humans or animals. More research in hazard identification and characterisation, and developments in the field of human exposure to MNPs are needed for a comprehensive assessment of the risk of MNPs on human health. *Having appropriate good quality data on particle toxicology for both MPs and NPs is the key to also inform exposure assessment activities* [33, 34].

In addition to ***first issue*** of the *aforementioned limitations within individual sampling, sample preparation and analysis protocols and equipment*, a ***second issue*** is that the protocols themselves are so diverse that the *lack of standardisation/harmonisation* leads to results obtained by different laboratories being often incomparable. Recent attempts to address this include three rounds of a European interlaboratory study initiative [35], a global comparative study [36] and a comparison of the reproducibility of vibrational spectroscopic-based approaches [37], and a potential solution could be an advanced experimental design through the *smart combination of modalities* selected by chemometrics [38]. **In summary, these two issues have resulted in qualitative and quantitative characterisation limitations for MNPs, and thus precise measurements for occurrence in the environment or within toxicological studies, and therefore the *knowledge gaps* in occurrence, toxicity and risk of MNPs.**

Recently various *independent initiatives,* not least H2020 MONPLAS [39], and the CORNET project “microplastic@food” [40], have been funded to address mostly the ***first issue,*** whilst other projects are *independently* tackling mostly the ***second issue*** of harmonisation/standardisation of methods and reference materials and the ***knowledge gaps*** such as H2020 EUROqCHARM [35], 21GRD07 PlasticTrace [41], VAMAS TWA45 [42] and the CUSP Cluster of five H2020 projects on MNPs [43]. The COST ACTION PRIORITY [44] also focusses mostly on the ***second issue*** and the ***knowledge gaps***, and also just partially on the ***first issue***.

1.1.2. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

Within the EC’s action of “Measures aiming to reduce the presence in the environment of unintentionally released microplastics from tyres, textiles and plastic pellets” [45] ***knowledge gaps*** for MPs in the environment, food and drinking water have been acknowledged for correction: “3. Knowledge gaps. Risks and occurrence of microplastics in the environment, drinking water and foods still need to be explored. Methods for sampling, processing, data analysis and reporting are ***not sufficiently harmonised***. Most recently, under the (2020) recast Drinking Water Directive [46], the Commission was tasked with ***developing a harmonised method*** to measure microplastics in drinking water in the next 3 years. Under Horizon 2020, a coordination and support action on ***harmonising procedures*** for plastics pollution monitoring and assessment was launched” – (2020) EUROqCHARM [35]. Progress since then has meant that ISO standards are due to come into existence in 2024 (ISO/TC 147/SC 2/JWG 1, Joint ISO/TC 147/SC 2 – ISO/TC 61/SC 14 WG: Plastics (including microplastics) in waters and related matrices) with regards to the sampling of microplastics in water and the spectroscopic (and thermo-analytical) methods for their analysis [10]. Furthermore, environmental legislation for MPs in water, that began with the EU Action Plan: ‘Towards Zero Pollution for Air, Water and Soil’ of 2021 targeting a reduction in plastic litter at sea by 50% and microplastic release into the environment by 30% by the year 2030 [47], was joined in early 2022 by a 0% content standard of MPs in drinking water from the state of California [48]. They are sure to be soon joined by others, indeed the United Nations is currently in discussions with regards to a plastics treaty for signature in 2025 for the reduction in use and impact of plastic, including its production [49].

However, none of the aforementioned independent initiatives in 1.1.1, even PRIORITY, take into

consideration the imminent ISO standards and link to existing and future potential legislation. ICPLASTIC will do so whilst also effectively integrating those initiatives through addressing both issues and the knowledge gaps as well.

Thus, ICPLASTIC will uniquely meet the <u>timely challenge</u> of urgently developing a suitable formulation and realisation of efficient and reproducible protocols and equipment for sampling, sample preparation and analysis of MNPs to both support the application of the imminent ISO standard and current/forthcoming water quality legislation, as well as to close knowledge gaps in risk analysis and occurrence through their enablement of improved toxicological and environmental studies.

1.2. PROGRESS BEYOND THE STATE-OF-THE-ART

1.2.1. APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE OF THE ART

The aforementioned *protocols and equipment* can only be realised, and thus the *timely challenge* met, through urgent *extensive networking* of equipment manufacturers (Raman, FTIR, PY-GC-MS, Microscopy, LIBS, QCL IR imaging...), their end-users (drinking and bottled water companies, NGOs, meteorological institutes and environmental monitors) and relevant academics/technologists (in MNPs/analytical techniques/ML/toxicologists/microfluidics/filtration) in such a way that all relevant technical barriers can be rapidly overcome.

The ICPLASTIC Action is *unique*, and thus *innovative*, in both establishing such a broad and highly skilled transdisciplinary *network* and through the necessary scientific discussion, planning and implementation taking place via a '*funnel approach*', where the use of feedback from ***studies*** will progressively narrow its scope to rapidly converge on the required key parameters and their range of values for both user and design specifications and thus realisation of the aforementioned *protocols and equipment.* In doing so much of the equipment will go beyond the state of art, and its use in toxicological ***studies*** with a subsequent risk analysis being performed, will enable beyond the state of art advances in those areas too.

To do so the Action will fundamentally focus on the determination of suitable particle mass, shape and distribution *ranges and chemicals* from various ***studies***, whilst ensuring that they remain coherent with parameters in sampling, preparation, analysis and risk analysis of plans and programmes external to ICPLASTIC. These ***studies*** include: the optimisation of methods and equipment for sampling, sample preparation and analysis - with ***their implementation of ML into algorithms and the use of state of art microfluidics and filtration techniques being key*** for what is often time limited work; toxicology of MNPs; a risk analysis made from the resulting toxicological data. The interdependency of those *ranges and chemical identity* are such that not only will they be influenced by feedback from those ***studies*** but that they will also 'feed in' to those ***studies*** as initial study parameters. Emerging AI techniques (e.g. Segment Anything Model from Meta AI) as well as established ML tools will be applied to optimize the sampling, sample preparation and analysis processes, to adapt to changing environmental conditions and improve accuracy. It will enable greater automation and integration of sampling, analysis, and reporting processes to streamline the entire workflow, making it more accessible and cost-effective, both in time and money, for researchers, regulatory agencies, and citizen scientists.

Fundamental to technical advances (knowledge creation) in the above ***studies*** will be the inter-laboratory studies and collaborations organised by Working Group (WG) leaders, as well as open dissemination and discussion of best practices and experience (knowledge sharing) between stakeholders at training events and conferences/workshops. The latter are essential for the establishment of reliable protocols for representative sampling, adapted for different matrices (such as environmental, drinking, and bottled water) and analytical methods. *The support of COST instruments in these activities are essential, particularly the grants for Virtual Mobility (VM) and Short-Term Scientific Missions (STSM) to widen the output from the inter-laboratory studies and collaborations*.

As a consequence of meeting the ***<u>timely challenge</u>*** ICPLASTIC will have gone beyond the current state of art by ***formulating and realising efficient and reproducible protocols and equipment for sampling, sample preparation and analysis of MNPs that will both support the application of the forthcoming ISO standard and water quality legislation as well be used to close knowledge gaps in risk analysis and occurrence through their enablement of improved toxicological and***

environmental studies. Ideally, these would provide *automated harmonized methods able to analyse numerous particles per sample in 2-3 hours for reliable/comparable results.*

Finally, it should be noted that as the equipment and their protocols will be compatible both with the forthcoming ISO standards and the ICPLASTIC risk analysis, it will have significant market value. Furthermore, given that ***ICPLASTIC also includes various influential members of the ISO standard committee and/or NGO policy supporters*** for MNP legislation, new environmental, drinking and bottled water legislation is expected to result from a roadmap (deliverable 20). Moreover, the above will only be possible through dissemination of technical information from non-Inclusiveness Target Countries (non-ITCs) to ITCs and from senior to junior researchers resulting in corresponding regional development in MNP monitoring and legislation, and career development. A strong team from the Core Group will support Young Researchers and Innovators (YRI) and ensure Equality, Diversity and Integrity (EDI). The scientific community, economy and all European citizens will thus benefit from ICPLASTIC outcomes, and subsequent sections will detail the impacts and the objectives to realise them.

1.2.2. OBJECTIVES

Through ICPLASTIC, European and non-European (global proposers) research groups working on MNPs will create one transnational team, thus supporting the sharing of the know-how and the discussion on future challenges in the field of MNP characterisation and legislation. All the following listed specific objectives cannot be achieved without international coordination:

1.2.2.1. Research Coordination Objectives

1. Determination and sharing of best practice and protocols for monitoring plan, sampling and sample preparation methods for environmental, drinking and bottled water
2. Coordinating inter-laboratory studies and joint projects involving European and International researchers on the development of efficient and reproducible protocols and equipment for the sampling, sample preparation and analysis of MNPs through the use of ML, microfluidics and filtration
3. ML algorithms and tools to interpret the big and complex data produced by advanced instruments for quantifying MNPs
4. Determination of particle mass, shape and size distribution ranges, and chemicals to undertake toxicological studies
5. Determination of the risk analysis based on the revised particle mass, shape and size distribution ranges, and chemicals from the toxicological studies.
6. Determination of end user and design specifications for MNP characterisation equipment based on the ICPLASTIC risk analysis and ISO standards.
7. Collection and organization of relevant research results, and wide dissemination of research achievements and the Action's activities
8. Funnelling 1: Determination by Core Group of equipment manufacturers and end users of narrower aspects to focus on in all WGs from M13
9. Funnelling 2: Determination by Core Group of equipment manufacturers and end users of narrower aspects to focus on in all WGs from M25
10. Funnelling 3: Determination by Core Group of equipment manufacturers and end users of narrower aspects to focus on in all WGs from M37

1.2.2.2. Capacity-building Objectives

1. Training of European stakeholders to lead a homogeneous approach to MNP monitoring, sampling, sample preparation and analysis.
2. Training of European public and private stakeholders to establish a shared pathway for the use of ML in MNP sampling, sample preparation and analysis
3. Increasing the capacity for MNP monitoring, and the awareness of the need to do so, both in non-ITCs, but particularly in ITCs, by fostering the knowledge exchange and the development of a joint research agenda with regards to optimising sampling, sample preparation and analysis protocols and equipment for MNPs.
4. Connecting and strengthening collaborations among outstanding European and international scientists and experts to create a consortium with the transversal competences necessary to undertake a transdisciplinary research agenda within the field of MNP analysis
5. Involve newly established research groups and teams from countries with less capacity, whilst assuring gender balance and the enabling of a uniform access to scientific and technological knowledge to enhance knowledge sharing.

6. Supporting YRIs, underrepresented genders and researchers from ITCs by enabling them to take leading roles within the Action and developing transdisciplinary collaborations and working opportunities.

2. NETWORKING EXCELLENCE

2.1. ADDED VALUE OF NETWORKING IN S&T EXCELLENCE

2.1.1. ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

As seen in sections 1.1.1 and 1.1.2, several *independent* initiatives have begun at the European and international level to tackle on an *individual* basis both ***issues*** and the closure of the various ***knowledge gaps*** including EC initiatives, EC directives, ISO standard developments, and various research projects, *in support of current legislation and to enable future legislation*. However, *no initiative currently exists that can bridge all these other initiatives with an appropriate and necessary focus and inclusion of necessary novel technologies* so that a ***suitable formulation and realisation of efficient and reproducible protocols and equipment for sampling, sample preparation and analysis of MNPs can be rapidly developed to support the application of the forthcoming ISO standard and water quality legislation, as well to close the knowledge gaps for risk analysis and occurrence through their enablement of improved toxicological studies and field studies.***

Many of the secondary proposers in ICPLASTIC are part of these *independent* initiatives, other networks of interest and/or are to be signatories by 2025 of the currently debated UN instrument on plastic pollution with its ban on intentionally added microplastics to products [49]. **ICPLASTIC,** a network that is necessarily European and International due to the depth and breadth of expertise required to rapidly solve the *timely challenge*, **will thus benefit from the *experience, knowledge, know-how and connection to key stakeholders* of the established networks to fulfil its objectives.** It will do so by building bridges between them to share best practice for sampling and sample preparation and coordinate inter-laboratory studies and joint projects on the development of efficient and reproducible protocols and equipment for the sampling, sample preparation and analysis of MNPs. The integration of participants from the existing networks will allow for rapid exchange of the state of the art and best practice across working groups (WGs) and identification of which experts are best placed to tackle which technical work, either individually or as a group and generally allow the consortium to 'hit the ground running'.

WG meetings, VMs, STSMs, training schools, and open access publications, will facilitate the development of necessary new knowledge and its implementation to solve the *timely challenge, and* given the wide-ranging expertise of ICPLASTIC's members all participating countries will take advantage of the knowledge and experience of the ICPLASTIC network as a whole. Finally, the open, bottom-up and inclusive character of COST Actions allows for the necessary wide participation of academics, industries, and metrology institutes in a way that it will be both effective and enhance the capacities for achievement in European research and innovation.

2.2. ADDED VALUE OF NETWORKING IN IMPACT

2.2.1. SECURING THE CRITICAL MASS, EXPERTISE AND GEOGRAPHICAL BALANCE WITHIN THE COST MEMBERS AND BEYOND

Of the 75 proposers in the ICPLASTIC network their institutions are broken down thus: just 54.7% are Higher Education & Associated Organisations whilst 26.7% are from the Business enterprise sector, with the remaining coming from Government/Intergovernmental Organisations except Higher Education (17.3%), and Private Non-Profit without market revenues, NGO (1.3%). Of those 41 participating from Higher Education & Associated Organisations their types are research oriented (26) and education oriented (15), covering 17 different scientific fields: Other engineering and technologies (4), Biological sciences (4), Chemical sciences (4), Environmental engineering (7), Physical Sciences (3), Materials engineering (3), Mechanical engineering (1), Health Sciences (3), Chemical engineering (1), Earth and related Environmental sciences (1), Environmental biotechnology (2), Interdisciplinary (2), Agriculture, Forestry, and Fisheries (1), Medical Engineering (1), Computer and Information Sciences (1), Electrical engineering, electronic engineering, Information engineering (1), Nano-technology (1). Of the 16 large companies and 4 SMEs involved, 16 are involved in different markets: manufacturing (6) and Professional, Scientific and Technical Activities (10). The 13 proposers from Government/Intergovernmental Organisations except Higher Education represent Local Government

(9), Central and Federal Government Organizations (3) and the EU (1). There is one Private Non-Profit without market revenues, NGO – International/European Trade or Professional Association proposer.

The proposer's core expertise is wide ranging: Chemical sciences (25.3%), Environmental engineering (18.7%), Physical Sciences (12%), Materials engineering (10.7%), Biological sciences (9.3%), Other (22.5%) and Unspecified (1.3%). The network is thus multi-disciplinary, moreover 32% are YRIs and 48% are female. It also has a wide geographical distribution of Affiliations from 21 COST Member countries (52.4% being ITCs): Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Latvia, Montenegro, Poland, Portugal, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom. All the participating countries have a stake in the Action, either as COST Member countries that have well established laboratories which will aim to improve their cross-national and international collaborations, or as others that will want to improve their scientific and technological knowledge through training and secondments to those well-established laboratories. The wide-ranging geographical distribution and the expertise of the participants, their diverse backgrounds and leading balance of young to experienced scientists, and female to male will mean that the network will benefit from the most appropriate solutions for all the multifaceted objectives targeted.

The timely challenge set within ICPLASTIC requires the development of *efficient and reproducible protocols and equipment for sampling, sample preparation and analysis* of MNPs, which is a rapidly emerging but very challenging research area, that requires a genuine transdisciplinary approach to achieve its varied objectives, and this will be met in this action through a critical mass of competences and expertise from academia, industries, public and private organizations. Moreover, the majority of the proposers are involved in MNP characterisation, and many of them lead international activities and so all consortium members, both new and experienced will be made aware of the state or art in relevant and synergistic developments. Furthermore, the COST action will canvass ITCs with less organised MNP research networks to help YRIs develop their careers and in doing so also increase the capacity for MNP monitoring and awareness of the need to do so in those ITCs. Finally, the competitiveness of both EU companies and industries will be boosted by this COST Action, as it will result in novel technological solutions leading to highly marketable products such as MNP sampling equipment, filtration equipment and characterisation tools.

2.2.2. INVOLVEMENT OF STAKEHOLDERS

The essential stakeholders of the Action are already members including academics/technologists, equipment manufacturers and end users (drinking and bottled water companies, NGOs and environmental monitors), although every quarter, in accordance with clearly defined criteria by the MC additional internal stakeholders will be invited to join. Furthermore, certain entities will be invited to join as external stakeholders at appropriate times, not least regulation/legislation bodies to facilitate a roadmap for MNP legislation (deliverable 20). As the wide-ranging expertise of the stakeholders, and the collaboration between them, are necessary for the successful realisation of all objectives, and thus the achievement of the *timely challenge,* an efficient process for information flow will be prioritised through the use of email, cloud storage of project files, and a dedicated website and social media for update and feedback (including to external stakeholders). WG leaders will initially address the needs of each specific target or activity alone, prior to creating dedicated work teams of all relevant stakeholders, with members having vested interest in the project their continuous participation will require little encouragement. VMs and STSMs will enable participation for those who only lack the necessary skills or know-how through formal or hands-on training, particularly for the YRIs, and both academic and industrial participants are equipped and motivated to do so. This should lead to new project ideas and leaders, especially from ITC members who will also be able to raise awareness and capacity for MNP monitoring in their countries which is often of a low profile.

3. IMPACT

3.1. IMPACT TO SCIENCE, SOCIETY AND COMPETITIVENESS, AND POTENTIAL FOR INNOVATION/BREAK-THROUGHS

3.1.1. SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

Given the experience, depth and size of the consortium across the whole value chain the expected close transdisciplinary networking within the Action will enable the ICPLASTIC objectives to be achieved.

Several of those will depend on scientific and technological breakthroughs within sampling, sample preparation (including through the use of filtration and microfluidics) and analytical methods, especially through the innovative use of ML to decrease the time and cost from sampling to reliable and comparable analytical data. Furthermore, those breakthroughs themselves will lead to others in toxicological studies and thus risk analyses for MNP ingestion. As a consequence of achieving those objectives the following impacts are pro-actively targeted as the scope of the Action permits:

I. **Equipment for MNP sampling, sample preparation and analysis marketed that are compatible with ISO standards and ICPLASTIC risk analysis [Science/Technology, economy/competitiveness impact in short term perspective]** - 43% of ICPLASTIC members are either equipment manufacturers or end users of the equipment, and will be well aware of the ISO standards and ICPLASTIC risk analysis (deliverable 13) and so both the ICPLASTIC resultant protocols and equipment, whose designs are in deliverable 14, will reach the market.

II. **Environmental, drinking and bottled water legislation for MNP content introduced that is compatible with ISO standards, ICPLASTIC risk analysis and the aforementioned ICPLASTIC resultant equipment [Society, Economy/competitiveness impact in long term perspective]** – Many of the ICPLASTIC participants are either members of the ISO standard committee and/or NGO policy supporters for MNP legislation and with the availability of ICPLASTIC resultant monitoring equipment to the market (from designs in deliverable 14) and awareness of the ICPLASTIC risk analysis (deliverable 13) it is expected that new legislation will follow from the project through successful dissemination of a roadmap (deliverable 20) based on these deliverables.

III. **Dissemination of information from non-ITCs to ITCs and from senior to junior researchers resulting in corresponding regional development for MNP monitoring and legislation and career development [Science and Society in short term perspective]** – Members from ITCs and junior researchers have very prominent roles within the project and through appropriate dissemination mechanisms, knowledge exchange will take place and collaborations made and strengthened. Furthermore, newly established research groups and teams from countries with less capacity will be actively involved throughout.

These three impacts from the Action will have a huge socio-economic impact as the use of the first two and the engagement of researchers and regions from the third should lead in the long term to a worldwide reduction of MNP pollution in environmental, drinking and bottled water and thus less risk to all flora and fauna.

3.2. MEASURES TO MAXIMISE IMPACT

3.2.1. KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

Given that ICPLASTIC already includes 44 institutions and 75 proposers working on MNP issues from across multiple disciplines, both within Europe and beyond (9 institutions are global companies), it is projected to form a worldwide community *unique* in being able to support researchers in all relevant scientific areas, industry, regulators/legislators, and society in the challenges of MNP detection and legislation.

Being a COST Action provides the necessary support for the maintenance of such a network as well as enables the sharing of information, experience and ideas, and the development of know-how and careers so that the unprecedented collection of know-how and capability available within will be fully leveraged in pursuits of the challenge it has set itself. Knowledge creation will also be assisted through ICPLASTIC being structured in appropriate WGs and activities that promote the input from proposers for problem-solving and support critical thinking and innovation necessary to realise the objectives.

End products of the inter-laboratory tests will be: identification of where ML and microfluidics/filtration can optimise sampling, sample preparation and analysis, determination of particle mass, shape and size distribution ranges and chemicals; toxicological studies, risk analysis and end user and design specifications for MNP characterisation equipment development. *Experimental results will be disseminated to all stakeholders in open access peer reviewed international journals and/or presented to European and international conferences, and all data uploaded to a findable/searchable Open Database which will be used by participants to share data during the project.* At the end of the four years a handbook will be prepared that details the scientific and technological advances achieved, defining the new state of art and containing suggestions for future research ('ground zero' for future research activities). Prior to this, a progress report summarising network achievements will be prepared every year by the Action Chair, supported by Action participants, that will serve as an evaluation of project progress.

An annual “Impact Areas and Exploitation Plan” will summarize problems, needs and feedback from all stakeholders, outlining a strategic plan for the use of ICPLASTIC generated IP that will include liaising with other initiatives, projects and/or organisations to maximize impact, especially for the three targeted impacts. In general, the exploitation of results within ICPLASTIC will help ensure that knowledge generated is applied in a timely manner to increase national, transnational, and international exchange, funding opportunities, commercialisation of products, the development of new legislation and the revision of certain standards related to MNPs.

The training of YRIs, as well as others such as technicians, will formally take place at training schools organized and hosted by the institutions, with take up maximised through advertising by all participants. A Webinar Series targeting a wider audience still will also be organized whose lectures will be recorded and freely hosted on the ICPLASTIC website and will include subjects that emphasise good practice guidance and equipment in sampling, sample preparation and analysis of MNPs for occurrence, toxicology and risk analysis studies. Career development of YRIs will also take place through having been assigned prominent roles where aforementioned dissemination mechanisms will enable knowledge exchange and collaborations will be made and strengthened.

3.2.2. PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

All three impacts targeted by ICPLASTIC rely directly, or indirectly, on the interest and support of the general public and given that much of it is already aware of MNP pollution and its potential risk to all life as an emerging issue of global concern, the goals and results of the project will be communicated effectively to it for their influence to be leveraged in helping enable the realisation of those impacts:

(1) Grant award bodies and Boards of Directors of companies are much more likely to support calls for funding the development of new equipment if they are influenced by public interest in that equipment due to their importance in the fight against MNP pollution and its potential toxic effects, alongside the forthcoming ISO standards and ICPLASTIC risk analysis, being conveyed to them by ICPLASTIC through appropriate public engagement activities.

(2) Policy makers (regulators/legislators), to whom the various members of the ISO standard committee in ICPLASTIC are well connected and will be invited to join as external stakeholders, will be heavily influenced into developing appropriate environmental, drinking and bottled water legislation for MNP limits by the whole value chain from scientists to the general public. It is the general public and relevant NGOs by whom legislators will most be influenced to introduce such measures once ICPLASTIC generates the risk analysis and specifications for appropriate monitoring equipment to go with the ISO standards and therefore, they will also be strategically targeted through various dissemination activities.

(3) Much of the general public across Europe are keen to see a ‘levelling up’ of the scientific and technological capabilities across much of its regions and also of a shift in the demographics of scientific and technological engagement from the more senior researchers to younger, less conservative, forward thinking and socially conscious researchers. Therefore, the majority of public engagement will be led by young researchers from ITCs in order to gain public profile and thus political for their growth and development.

In general, the Action members will organize and actively participate in conferences, workshops, tradeshows and training courses, in collaboration with regional, national, EU framework projects and initiatives (clustering activities). Dissemination activities will include raising awareness of MNPs, ICPLASTIC and its objectives and targeted impacts; training; capacity building; technology transfer, communication of risk analysis and characterisation equipment specifications to the relevant stakeholders for exploitation, and, last but not least, citizen involvement. The public will be specifically engaged through activities to encourage greater gender parity along those studying and working in STEM subjects, with school outreach specifically targeted. *Dissemination activity planning will be continuously updated by means of a Core Group* and an elected *Science Communication Coordinator* (SCC) that will plan, manage, and monitor the dissemination (and exploitation) activities to verify that they are timely and of value. The Core Group will also ensure that all activities follow the principles of responsible research and innovation (RRI) and will disseminate its observance to all stakeholders.

Dissemination activities will target a wide variety of external stakeholders, using various delivery tools to maximize their efficacy, and delivery methods matched to the targeted stakeholder, and will include face-to-face meetings, workshops, training events and schools, preparation and distribution of hard copy and virtual documentation, presentations at scientific meetings, articles and reports in both the scientific and popular press, special events at industry gatherings, WG special symposia, press releases, and social media/website. Stakeholders will be surveyed before and after the activities to evaluate their needs and the efficacy of the activities.

A dedicated website connected to a repository, to be maintained beyond the Action's lifetime, will provide an overview of ICPLASTIC and its evolution, including copies of the Layman's report for each WG. The website will also host copies of the electronic annual newsletters that will be issued to disseminate the activities and main results to *registered* external stakeholders, whilst the landing page will feature a summary of the project and embedded social media (X, Facebook, Instagram and LinkedIn). The website and social media will be set up and managed by someone selected by the MC. Publicity material with the unique graphic identity of ICPLASTIC will be created and updated every year for distribution at public events.

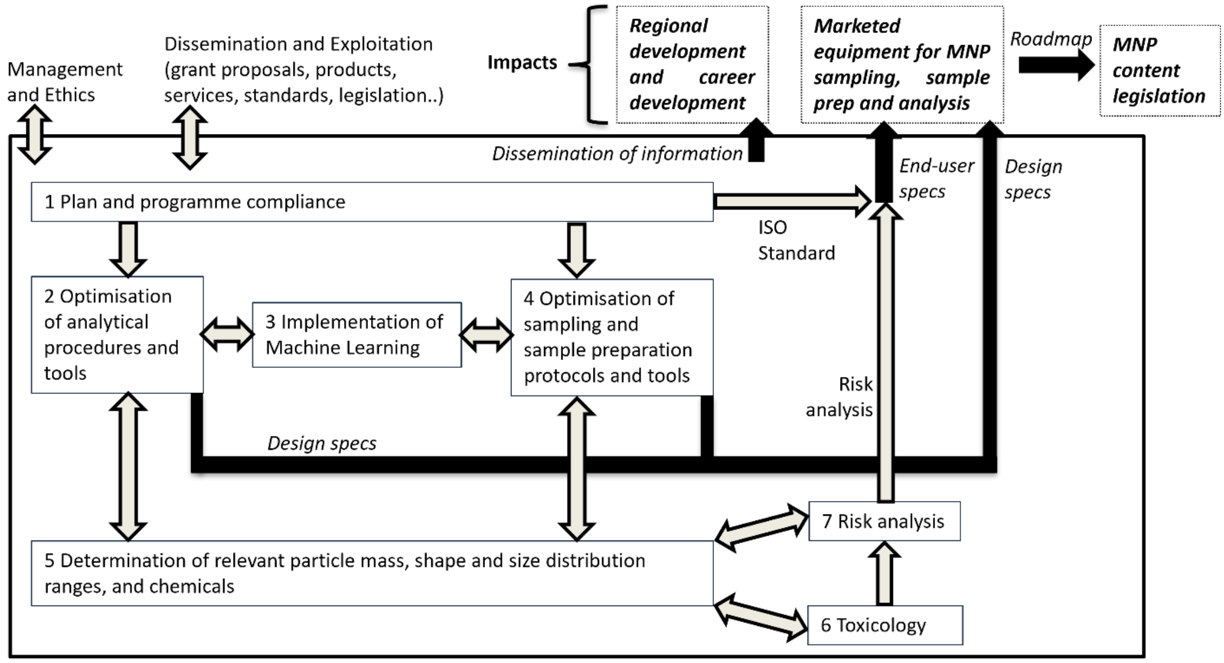
As ICPLASTIC's title suggests, "ISO compatible, efficient and reproducible protocols/equipment for mICro-nanoPLASTIC detection through machine-learning", the principal impact that it targets is that of directly commercialisable technology and therefore 43% of its institutions are private companies, that can either commercialise parts or all of the technology to be realised or have vested interest in their direct use as end-users. Intellectual Property Rights (IPR) will therefore be considered with clear and indisputable agreements signed at the project onset to ensure that everyone has their IP identified, both pre-project and during the project, whilst productive and trustworthy dialogue among the participants can also take place to allow for the emergence of novel concepts, methodologies, procedures, and technological solutions. The agreements will also detail how joint IPR will be divided, how others can take an option to exploit IP that is not of interest to its developer and also how IP will be vetted prior to dissemination in case it is exploitable. Other exploitation strategies targeted include potential revisions to ISO standards based on the resultant measurement technology and risk analysis to be performed, new legislation for permissible MNPs and concentrations in environmental, drinking and bottled water and new grant proposals as a result of new ideas and/or collaborations.

4. IMPLEMENTATION

4.1. COHERENCE AND EFFECTIVENESS OF THE WORK PLAN

4.1.1. DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

ICPLASTIC will be organised in seven specific, but highly interconnected, WGs each with their own clear objectives and activities as seen in the Pert diagram below.



ICPLASTIC Pert Diagram for Working Groups

Each WG will prepare relevant training in order to create a network of experts and the results within each will be disseminated through meetings, workshops, reports, and papers within journals and at conferences. A Core Group will support/coordinate sharing of coherent knowledge between WGs.

WG1 - Plan and programme compliance

WG Objectives:

- To have a global vision of MNP related existing/upcoming EU R&D programmes, scientific activities through publications, standardisation/harmonisation activities and potential/draft legislations for MNP monitoring in food (drinking and bottled water) and environmental water (river and wastewater) matrices that cover sampling, sample preparation, analysis equipment or technologies, reference materials, interlaboratory testing, toxicological studies and risk assessment.
- To provide guidance and ensure coherence of ICPLASTIC streams with these programmes.
- Create a network of informed and trained scientific experts.

WG Activities (Task 5):

- Literature review and survey of existing and upcoming programmes and legislations related to MNP analysis in food and environment on a global scale, regularly communicated to WGs.
- Bimonthly meetings with WGs to provide detailed guidance, to discuss and to share best practices with WGs for sampling, sample preparation, analytical procedures, toxicological studies and risk assessment with respect to existing and upcoming standards and regulations (e.g. ISO etc).
- Proposals to standardisation bodies (e.g. ISO) and legislators based on discussions within WGs.

WG2 - Optimisation of analytical procedures and tools

WG Objectives: To optimize and harmonize MNP analytical equipment and protocols so that, either individually, or combined, when in conjunction with optimised sampling and sample preparation equipment and protocols (WG4), via WG5, end user and design specifications are compatible with the ICPLASTIC risk analysis and the ISO standards when determining number, mass, shape, size distribution ranges and chemical identity of MNPs. In doing so it will attempt to elucidate: Which parameter and output data are needed for which purpose and how can they be obtained in a robust and reproducible way?

WG Activities (Tasks 6, 7): A large parameter space will be assessed to address tasks such as harmonization, reproducibility, common operating procedures and selection of optimum combinations of methods for MNP analysis given that they probe different properties and so can be complementary (*smart combination of modalities*, 1.1.1). In doing so the results from ML (WG3) and sampling and sample preparation optimisations (WG4) will be included via WG5, whilst maintaining Plan and programme compliance (WG1), as well as parameter refinements from toxicological studies and risk analysis via WG5, in order to define end user and design specifications for MNP analytical protocols and tools compatible with the risk analysis (WG7) and ISO standards. Planned activities:

- Identify analytical parameters and data output types that are robustly reproducible across labs.
- Suggest common and harmonized protocols for the above identified parameters and data types.
- Define relevant end user and design specifications for MNP analytical protocols and tools.

WG3 – Implementation of Machine Learning

WG Objectives: To identify where ML can be implemented in WGs 2 and 4 to decrease the time and cost to obtain reliable and comparable MNP analytical data through optimising:

- potentially sampling and sample preparation
- particle selection for analysis by micro-spectroscopy techniques
- interpretation of multi- or hyperspectral imaging data from micro-spectroscopy techniques
- interpretation of pyrograms from thermal desorption pyrolysis.

WG Activities (Task 8): Currently, it is mostly just FTIR that incorporates ML to automate MP analysis from environmental samples. Therefore, quarterly round table discussions will be held with all participants to discuss/share best practice and technical developments/trends, to explore how, whilst maintaining Plan and programme compliance (WG1), ML can be implemented in sampling, sample preparation, and analysis (FTIR, Raman, fluorescence, pyrolysis, etc) for environmental, drinking and bottled water, to automate and speed up the collection of harmonized MNP data. Thus, the following will be investigated:

- Road map towards improved ML algorithms and tools for interpretation of instrument output data, e.g., Raman, FTIR, fluorescence, pyrolysis.
- Road map towards validating these algorithms and tools on environmental data, here among addressing the ground truth issue for method validation.
- The limitations of different ML models and the applicability of different techniques, e.g. for analysing particles (size, shape) and for sampling (sample matrix).
- The number of data needed per sample, polymer type and size to reduce the false negatives and false positives (to produce robust and high-quality data) when analysing MNP with ML.

WG4: Optimisation of sampling and sample preparation protocols and tools

WG Objectives: To optimize and harmonize MNP sampling and sample preparation equipment and protocols so that, when in conjunction with their analytical analogues from WG2, end user and design specifications are compatible with the ICPLASTIC risk analysis and the ISO standards when determining number, mass, shape, size distribution ranges and chemical identity of MNPs.

WG Activities (Tasks 9, 10):

- Research, discuss and share best practice for MNP representative sampling and sample preparation equipment and protocols (e.g. sources of contamination and how to avoid contamination), and their parameters (e.g. minimum number of samples, sample volume, frequency, appropriate flacons, and logistic specifics), for polymer identification in environmental (ground, river), drinking and bottled water. In doing so compare how the same sampling techniques can affect results from different laboratories.
- Study the possibilities of environmentally friendly sampling and extraction techniques.
- Study where microfluidics and filtration techniques can optimise equipment and protocols.
- Inclusion of results from optimisations in analytical procedures and tools (WG2), via WG5, and ML (WG3), whilst maintaining Plan and programme compliance (WG1), as well as parameter refinements from toxicological studies and risk analysis via WG5, in order to define end user and design specifications for MNP sampling and sample preparation protocols and tools compatible with the risk analysis (WG7) and ISO standards.

WG5: Determination of relevant particle mass, shape and size distribution ranges, and chemicals

WG Objectives: To act as a data hub to ensure that data on relevant particle mass, shape and size distribution ranges, and chemical identity, originating from each of the WGs 2, 4, 6 and 7 are communicated to each other to adjust their scope as necessary.

WG Activities (Task 11):

- Communicate relevant (from a technological perspective) particle mass, shape and size distribution ranges, and chemical identities, from WG2 to WG4, and vice versa.
- Communicate to WG6 relevant (from a technological perspective) particle mass, shape and size distribution ranges, and chemical identities from WG2 and WG4 for quantification and characterisation of MNPs in complex matrices to a smaller size than hitherto realised.
- Communicate to WG7 the relevant (from a toxicological perspective) particle mass, shape and size distribution ranges, and chemical identities from WG6 for performing a comprehensive risk analysis.
- Communicate to WGs 2 and 4 the relevant (from a toxicological and risk perspective) particle mass, shape and size distribution ranges, and chemical identities from WG6 and WG7 for final optimisation of protocols and equipment end user and design specifications to be compatible with the ICPLASTIC risk analysis and the ISO standards.

WG6 – Toxicology

WG Objectives: Take into consideration the ever-evolving relevant particle mass, shape and size distribution ranges, and chemicals from WG5 to perform toxicological studies with their results fed back into WG5 and for a risk analysis to be done in WG7.

COST EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

WG Activities (Task 12):

- Data regarding relevant MNP mass, shape and size distribution ranges, and chemical types (from WG5) will be used as the basis for toxicology studies.
- A review of toxic properties of relevant MNP will be performed by research groups based on: Scientific literature; Implemented project; On-going projects; Binding legislation. It will be implemented in close collaboration with WG5 and WG7 to avoid unnecessary information collection, aiming only at relevant MNP and considering human risk assessment.

WG7 - Risk analysis

WG Objectives: A risk analysis of relevant MNPs will be performed from WG6 results to further optimise end user and design specifications for MNP sampling, sample preparation protocols and equipment in WG2 and WG4 and formulate a roadmap for new MNP legislation (deliverable 20) that will include the application for a COST Innovators Grant.

WG Activities (Task 13): A risk analysis will be performed, to fill gaps in previous knowledge, with the best possible model for MNPs of interest to human health, based on the toxicological data (WG6) and ever-evolving relevant particle mass, shape and size distribution ranges, and chemical identities (WG5) that are in part determined themselves from limits in optimized sampling and sample preparation (WG4) and analytical methods (WG2), whilst also considering the available data on health statistics. In doing so it will determine the ability of MNPs to be taken up in the gut and cause any harm to human health and will consider susceptible human populations and life stages relevant to exposure considerations.

WGs and research groups meet every 2 months. Running across these WGs is the ICPLASTIC 'Funnelling process' where in order to stay sufficiently focussed with the finite resources available to complete all objectives and have a realistic chance of achieving all impacts, every 12 months the equipment manufacturers and end-users will agree to sequentially converge on a narrower group of aspects to be studied.

4.1.2. DESCRIPTION OF DELIVERABLES AND TIMEFRAME

Milestones (across all WGs):

1. WGs setup (M1)
2. Core Group meetings (M12, M24, M36)
3. MC meeting once a year (M1, M13, M25, M37, M48)
4. Mid-term review six months after each MC meeting (M7, M19, M31, M43).

Deliverables (C - Critical. K - Knowledge creation):

1. 1st Annual report of individual Working Groups (WGs) Activities. (M12)
2. 2nd Annual report of individual Working Groups (WGs) Activities. (M24)
3. 3rd Annual report of individual Working Groups (WGs) Activities. (M36)
4. 4th Annual report of individual Working Groups (WGs) Activities. (M48)
5. WG1 Plan and programme compliance report on initial relevant plans and programmes for parameters and ranges of interest for MNP to be used across ICPLASTIC. (M3)
6. (CK) WG5 report on particle mass, shape and size distribution ranges, and chemicals to undertake optimal toxicological studies. (M24)
7. (C) First specification of reduced set of aspects for ICPLASTIC to focus on from M13 during 'Funnelling' (M12)
8. Second specification of reduced set of aspects for ICPLASTIC to focus on from M25 during 'Funnelling' (M24)
9. Third specification of reduced set of aspects for ICPLASTIC to focus on from M37 during 'Funnelling' (M36)
10. (K) WG3 report on ML to be implemented. (M12)
11. (CK) WG6 report on toxicological studies, including particle mass, shape and size distribution ranges, and chemicals, to undertake risk analysis study on MNPs to humans. (M33)
12. (CK) WG4 report on optimised sampling and sample preparation methods and tools. (M42)
13. (CK) WG7 report on MNP risk analysis. (M45)
14. WG2 report on end user and design specifications for MNP characterisation equipment based on the ICPLASTIC risk analysis and ISO standards. (M48)
15. (C) Report on the progress made in ITC research groups, and by YRI and underrepresented

genders during ICPLASTIC. (M48)

16. Report on the involvement of all stakeholders, including private and public laboratories, equipment manufacturers, drinking and bottled water companies, NGOs, metrological institutes, environmental monitors and legislators/regulators. (M48)
17. Advances of the Action handbook prepared. (M48)
18. Final Impact Areas and Exploitation Plan presented. (M48)
19. Layperson's report of WG activities and the know-how shared among the experts. (M48)
20. Roadmap for legislation of MNPs in environmental and drinking water/beverages. (M48)

4.1.3. RISK ANALYSIS AND CONTINGENCY PLANS

The success of ICPLASTIC depends on participants' contributions, their availability, effectiveness and efficiency in developing, coordinating and carrying out the activities. The foreseen risks are listed below and the estimated level is given in brackets followed by contingency plans.

1) Mitigation measures to prevent the spread of COVID-19 affecting experts' mobility and thus presential activities strongly affected. (**High**) - Organization of virtual conferences, webinars, e-learning classes, and online meetings.
2) Unsustainable management and coordination costs due to high participation from the large numbers of members. (**High**) – Meetings limited to one per year and all others held online. More participants assigned per task and local activities to replace network activities (training, seminar, etc.). Support from companies and public agencies sought.
3) Disengagement of some countries due to lack of funds. (**Medium-High**) - Organization of network activities at venues in those countries.
4) Geopolitical tensions regarding the Ukraine and/or Israeli/Palestinian conflict affect experts' mobility and thus presential activities strongly affected. (**Medium-High**) - Organization of virtual conferences, webinar, e-learning classes, and online meetings.
5) Low levels of activities, or delays to activities, of WGs outside of scheduled events. (**Medium**) - Clear agenda of meeting, milestones and deliverables shared with all the MC members and WG leaders. Regular check of activity progress and effective monitoring mechanisms, compilation of regular reports (progress made, description of issues, action plan to counteract the issues). Fostering online tools, assigning precise and specific tasks, increasing communication between WGs leaders, rotation of the coordinators, transfer of tasks to motivated newcomers, newsletters, etc.
6) Low participation in interlaboratory studies. (**Medium**) - Evaluation of the risk starting the studies, research groups will conduct their own studies independently for later discussion.
7) Long meetings and not delivering anticipated breakthroughs when several experts deal with large data sets. (**Medium**) - Organization of parallel sessions, dedicated courses and training. Provision of online platforms in multiple domains such as investigation case, joint team, analysis of work files, etc. upon agreed sub-network (invited members) with password, etc.
8) Expensive WG meeting/dissemination. (**Low)** – Attendees to have multi-task roles with interventions as teachers, speakers, learner; search for local and/or industrial sponsorship, minimal fee for attendees as a last resort.
9) Legal and financial risks. (**Low**) - Agreements defined that feature potential IP issues.
10) Conflicts between members. (**Very Low)** - Conflict-resolving mechanism to balance needs.
11) Low participation of members. (**Very Low)** - Most experts participating in ICPLASTIC are scientists working on or with equipment for the sampling, sample preparation and analysis of MNPs, or have a vested interest in their successful development, whose breakdown is well represented by WGs. All the proposers are interested in the successful development of this Action, being advantageous for their field of interest and/or research.

4.1.4. GANTT DIAGRAM

#	Task description	Task responsable	Project Months (Y1)				Project Months (Y2)				Project Months (Y3)				Project Months (Y4)			
			3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48
1	Action management by MC	MC	#		#		#		#		#		#		#		#	#
2	WG coordination and development of joint activities	WG leaders	#			*				*				*				*
3	Involvement of stakeholders	WG leaders																*
4	State of art definition	WG leaders																
5	Observing coherence of strategy with exisiting plans and programmes	WG1 leader	*															
6	Identification and implementation of where sampling and sample preparation optimisation (WG4), and implementation of ML (WG3), can optimise analytical procedures and tools	WG2 leader																
7	Determination end user and design specifications for MNP characterisation protocols and equipment upon consideration of a risk analysis (WG7) and ISO standards.	WG2 leader																*
8	Identification of where machine learning (ML) can be implemented in WGs 2 and 4 for optimisation	WG3 leader				*												
9	Identification and sharing of the best practices and key parameters for MNP sampling and sample preparation	WG4 leader																
10	Identification and implementation of where microfluidics and filtration techniques can be applied, and ML implemented, for optimising MNP sampling and sample preparation	WG4 leader														*		
11	Determination of relevant particle mass, shape and size distribution ranges, and chemicals for toxicology, risk analysis and end user specifications	WG5 leader								*								
12	Toxicological studies	WG6 leader											*					
13	Risk analysis	WG7 leader															*	
14	Scheduling and implementation of dissemination and exploitation activities	MC and SCC																****
15	Meetings of equipment manufacturers and end-user Core Group for 'funelling' at M12, M24 and M36: sequential convergence on a narrower group of aspects to be studied by the Action	Core Group				#*				#*				#*				
16	Schedule of STMSs and VMs	MC																
17	Promotion of the involvement of ITCs, YRIs and underepresented genders.	MC																*

Legend:

* - Deliverable
\# - Milestone
MC - Management Committee
SCC – Science Communication Coordinator
WG - Working group

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