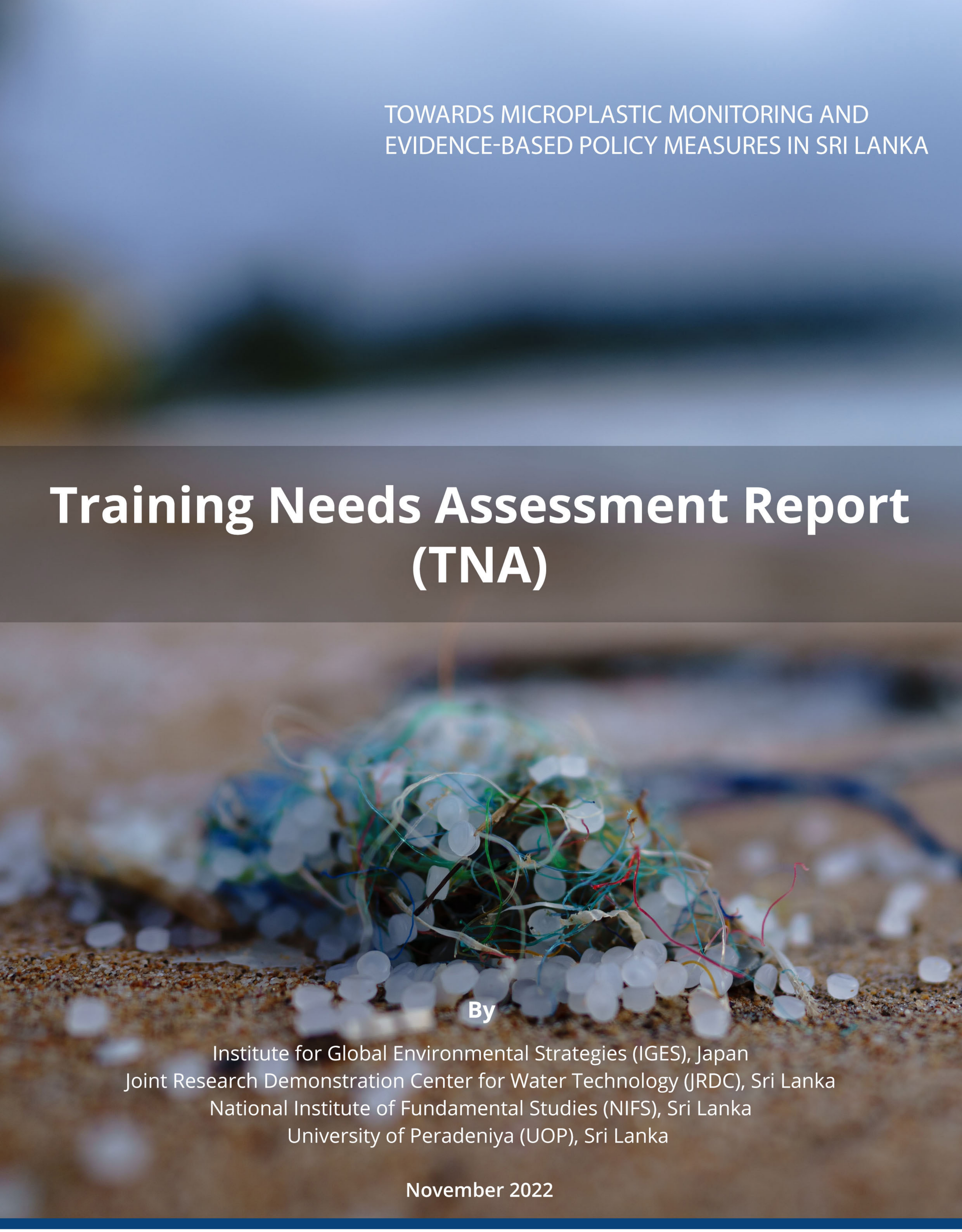

TOWARDS MICROPLASTIC MONITORING AND EVIDENCE-BASED POLICY MEASURES IN SRI LANKA

Training Needs Assessment Report (TNA)

By

Institute for Global Environmental Strategies (IGES), Japan
Joint Research Demonstration Center for Water Technology (JRDC), Sri Lanka
National Institute of Fundamental Studies (NIFS), Sri Lanka
University of Peradeniya (UOP), Sri Lanka

November 2022

Training Needs Assessment Report (TNA):
Towards Microplastic Monitoring and Evidence-Based Policy Measures in Sri Lanka

Authors

IGES Centre Collaborating with UNEP on Environmental Technologies (CCET), Institute for Global Environmental Strategies (IGES), Japan
Amila Abeynayaka
Premakumara Jagath Dikella Gamaralalage

Joint Research Demonstration Center for Water Technology (JRDC), Sri Lanka
Madhubashini Makehelwala (Principal Investigator)
Sujithra Kaushalya Weragoda

National Institute of Fundamental Studies (NIFS), Sri Lanka
Lakmal Jayarathne

University of Peradeniya (UOP), Sri Lanka
Mallika Pinnawala
Avanthi Deshani Igalavithana
Chamil Perera

Contributors

Anurudda Karunarathna, Saman Dharmakeerthi - University of Peradeniya (UOP), Sri Lanka.
Miki Inoue - Institute for Global Environmental Strategies (IGES), Japan.

Reviewers

Win Cowger, - Moore Institute for Plastic Pollution Research, USA
Motomichi Oono, Naoko Yoshizato, and Ayako Inoue, - IDEA Consultants Inc., Japan
Thuy-Chung Kieu-Le, - Ho Chi Minh University of Technology (HCMUT), Vietnam
Thomas Maes, - GRID-Arendal, Norway
Rohan Weerasooriya, - National Institute of Fundamental Studies (NIFS), Sri Lanka

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ABBREVIATIONS

CCET	IGES Centre Collaborating with UNEP on Environmental Technologies
EU	European Union
FGD	Focus Group Discussion
IGES	Institute for Global Environmental Strategies
JRDC	Joint Research and Demonstration Center for Water Technology
KII	Key Informant Interview
MOWS	Ministry of Water Supply
NIFS	National Institute of Fundamental Studies, Sri Lanka
NWSDB	National Waste Supply and Drainage Board, Sri Lanka
TNA	Training Need Assessment
UOP	University of Peradeniya, Sri Lanka
WHO	World Health Organization
WSP	Water Safety Plans
WWTP	Wastewater Treatment Plants

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EXECUTIVE SUMMARY

The Joint Research and Demonstration Center for Water Technology (JRDC) under the Ministry of Water Supply (MOWS), Sri Lanka and the IGES Centre Collaborating with UNEP on Environmental Technologies (CCET), and the National Institute of Fundamental Studies, Sri Lanka (NIFS), University of Peradeniya, Sri Lanka (UoP) compiled a survey report, "Training Needs Assessment (TNA): Towards Microplastics Monitoring and Evidence-Based Policy Measures". The report assesses the level of public awareness on microplastic pollution and related hazards as well as the current status of microplastic monitoring facilities available in Sri Lanka's state and private sector institutes, with an emphasis on the public water supply chain and identifying microplastic point sources upstream to ensure safe drinking water. The survey results of this work provide the essential first step in formulating mitigation programs to prevent aquatic microplastic pollution and build human capacity in Sri Lanka. The TNA report comprises four broad themes, namely, (1) Status of public awareness on microplastics, (2) Engagement level assessment on sampling, analysis, and research publications related to microplastics, (3) Capacity and gap assessment for determining the degree of microplastic pollution, and (4) Recommendations for achieving the required monitoring activities of microplastics. The survey results of the TNA include a nationwide data assessment.

This TNA project was governed by the principles of participatory qualitative assessments and followed the established steps, involving the identification of problems and assessment of design needs, collection and analysis of information, compilation of a preliminary report reviewed by national, regional and international peers, and data validation via random stakeholder consultations and expert reviews. Information compilation and analysis followed a five-step process and the existing situation was evaluated against the desired situation.

The cumulative training gap identification outcomes were presented at the national workshop for validation and later revised accordingly. These were presented to the thematic experts, from whom the views and recommendations solicited were incorporated into the identified training needs. The key training and facility needs identified through this TNA are, a) Gaps in awareness on microplastic-related pollution and impacts, which may lead to insufficient engagement of the potential stakeholders identified in monitoring and policymaking; b) Addressing such awareness gaps through engaging stakeholders in awareness programs; c) Institutionalization of any program outcomes developed; d) Development of organizational scope-related skills through training programs; and e) Development of facilities and formation of organized intra- and inter-organizational systems to conduct the monitoring programs.

As a result of this TNA, the final training needs identified were categorized as knowledge, attitudes, and skills and used as the basis for the module development of each theme. The expressed opinions and information collected during the TNA did not, in their entirety, end up as training needs; instead, some were retained for incorporation into recommendations for the planned future project implementation.

1. INTRODUCTION

1.1. Plastic pollution and microplastics

Plastic has become one of the materials we use to maintain convenient and comfortable lifestyles. Its low cost, convenience, and durability have led to strong demand as well as an exclusively large range of uses (Ryan, 2015). Historically, the annual global production of plastics rose from 2 million tons in 1950 to 381 million tons in 2015 (Geyer et al., 2017) and reached a remarkably high level with the COVID-19 pandemic (Adyel, 2020). Adding to this demand are growing trends in takeaway food culture, e-commerce and the 'sachet economy'. However, despite rising awareness of the environmental consequences of plastic pollution from the scientific community, in the absence of any strict regulations, irrational consumption and littering continue to rise, resulting in severe damage to global aquatic ecosystems (Alegado et al., 2021).

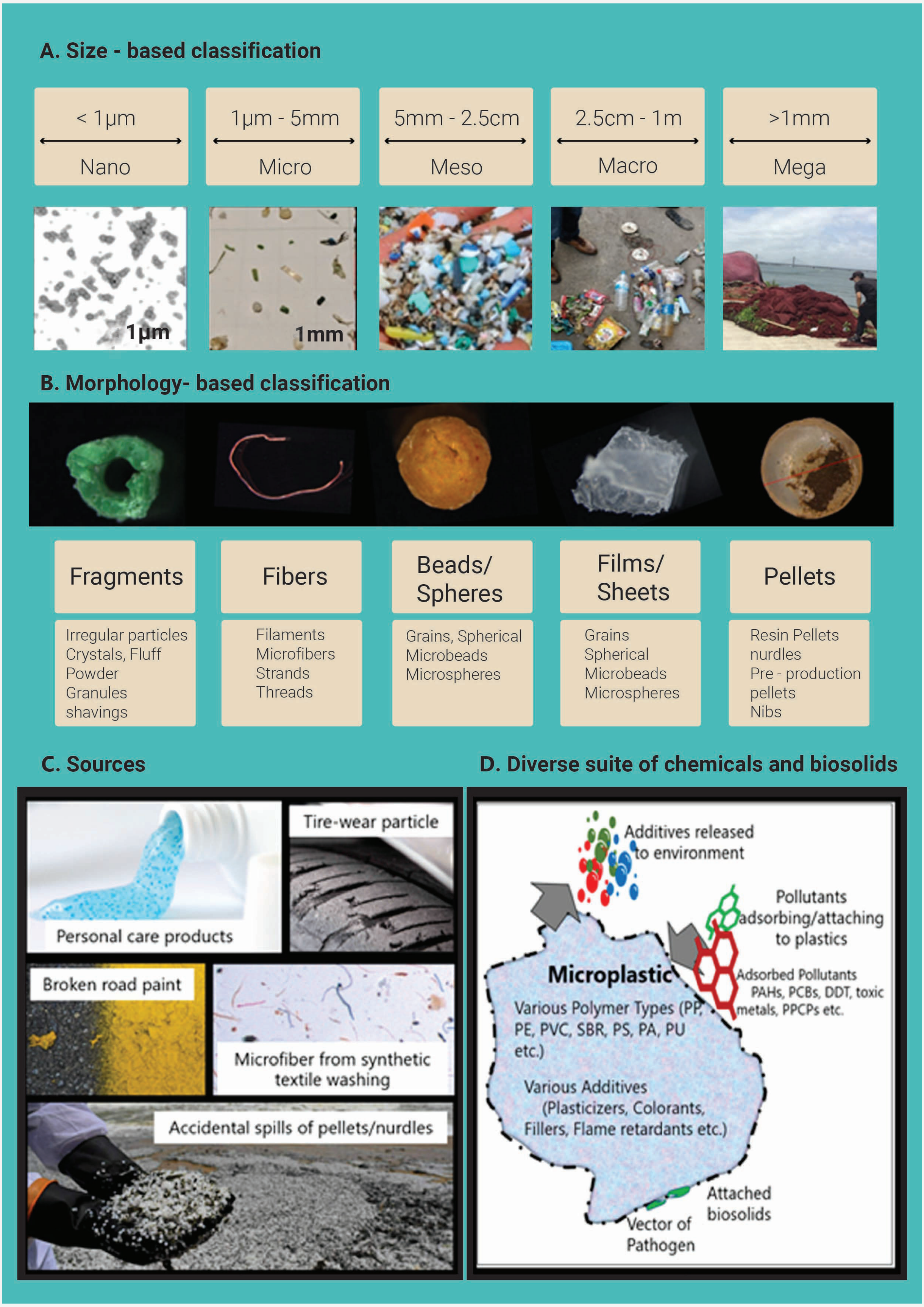
Based on size, plastics are categorized into megaplastics (>1 m), macroplastics (1 m–25 mm), mesoplastics (25–5 mm), microplastics (5 mm–1 μm), and nanoplastics (<1 μm) (fig. 1a) (Cozzolino et al., 2020; Hartmann et al., 2019). Microplastics are divided into primary and secondary categories based on their origin. Primary microplastics enter the environment directly as microplastics, and secondary microplastics result from the breakdown of larger plastics in the environment (Rogers, 2022).

The primary microplastics include tire-wear particles, fragmented road markings, synthetic textile microfibers from washing, micro-beads from personal care products, and accidental pellet releases (such as the M/V X-Press Pearl Nurdle Spill in 2021] (de Vos et al., 2022), and secondary microplastics such as decomposed plastic litter of less than 5 mm size (fig. 1b and 1c). Environmental degradation of plastic is governed by a synergic effect of photo- and thermo-oxidative degradation, abrasion, and biological action (Chamas et al., 2020; Thompson et al., 2009).

Microplastics released from sources (fig. 1c) often flow directly or indirectly into surrounding aquatic environments (e.g., rivers, lakes, estuaries) and eventually enter the ocean (Lebreton et al., 2017). Further, due to their long lifespans, microplastics entering one environmental compartment may transfer to another, thus becoming ubiquitous and remaining in the environment for extended periods while degrading into smaller and smaller particles and ultimately entering the food chain and humans (Woods et al., 2021; Abeynayaka et al., 2019) (fig. 1).

Microplastics found in the environment are a diverse range of contaminants (Rochman et al., 2019), with a variety of additives and polymers shapes and sizes with sorbed and inherent toxic chemicals (Campanale et al., 2020; Koelmans et al., 2016), elements (Igalavithana et al., 2022; Akhbarizadeh et al., 2018), and microorganisms including pathogens (Oberbeckmann et al., 2018; McCormick et al., 2014). Hence, a comprehensive understanding of microplastic toxicity on ecosystems and human health impacts is a complex process involving diverse research fields (Cowger et al., 2020). Further, evidence gathering requires multi-disciplinary expertise such as in plastic and related chemical toxicology, fate analysis, and plastic degradation; hence, addressing microplastic's environmental and human health impacts requires open collaboration between diverse sectors (Coffin et al., 2021).

Figure 1. Characteristics for categorizing plastic debris: a) size-based classification, b) morphology-based classification of microplastics; c) microplastic sources; d) diverse suite of chemicals and biosolids.



Source: a), b), and d): [Abeynayaka et al., 2022]; c): [Ryberg et al, 2018]

The adverse effects of plastic litter in ecosystems have been widely discussed in the literature (Bellasi et al., 2020; Horton et al., 2018). Plastic contaminants in freshwater sources threaten ecosystems and pose a potential health hazard to humans (Jemec et al., 2016; Redondo-Hasselerharm et al., 2018; Su et al., 2018). The reported evidence indicates that upon human exposure (Cox et al., 2019; Ageel et al., 2022) to microplastics, they can travel through the digestive tract and into organs. Further, recently microplastics were discovered in human blood samples (Leslie et al., 2022) They can also carry a diverse range of toxic chemicals, elements, and pathogens, which may cause cancer, neurological and immune system damage, and other effects if the particles themself are toxic or absorb toxic substances (Arkin et al., 2019; Smith et al., 2018; Ragusa et al., 2021). Table 1 summarizes the potential human health effects due to exposure to microplastics and associated chemicals.

Table 1: Potential human health effects due to exposure to plastic-associated chemicals

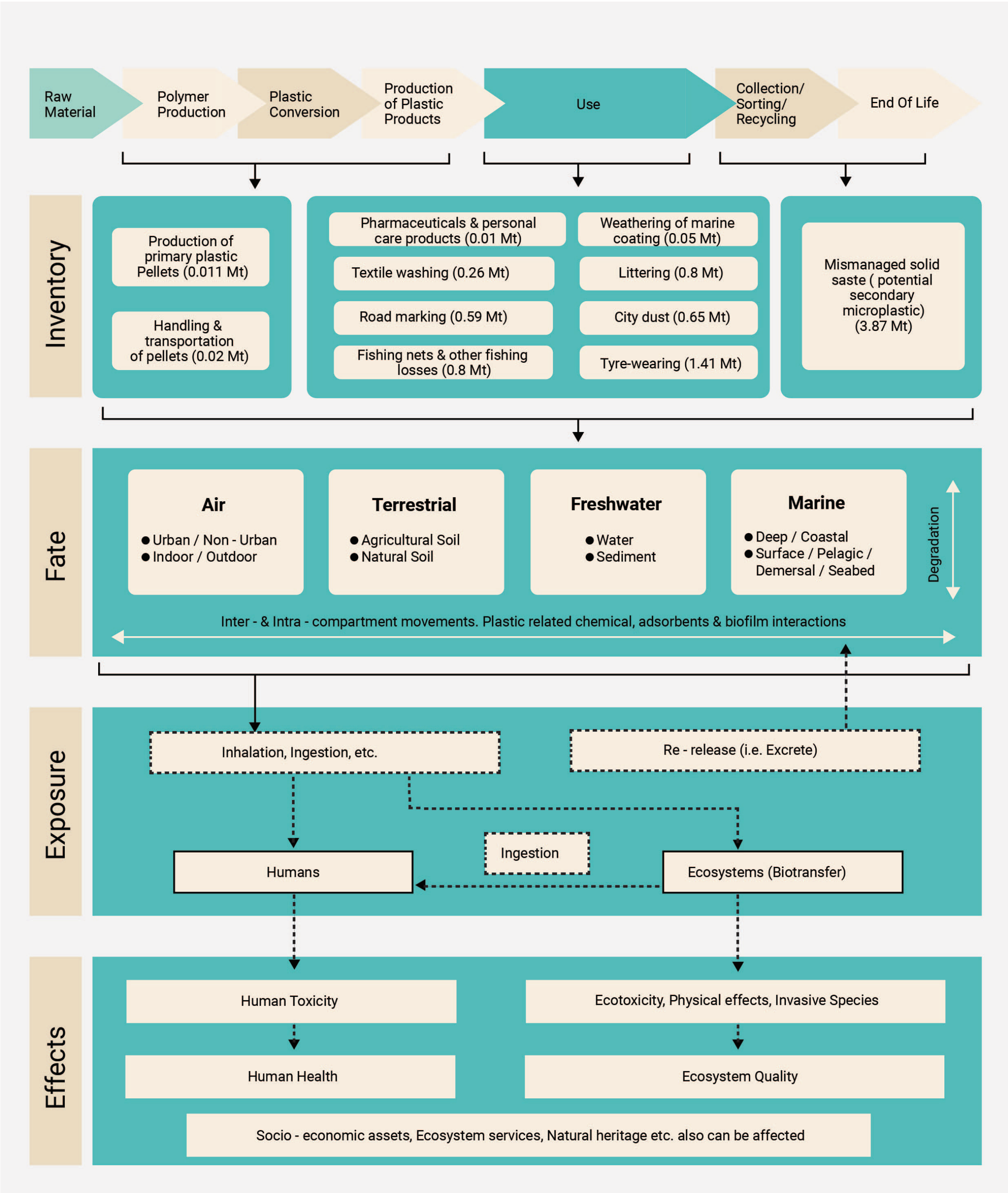
Affected organs or potential health issues	Potential human health impacts
Brain/Nervous system	Neuro-developmental disorders (Attention deficit hyperactivity disorder: ADHD) Autism, Neurobehavioral, IQ, Cognition
Thyroid	Hormonal (Thyroid disease, Thyroid cancer)
Reproductive system	Polycystic ovarian syndrome, Endometriosis, Male subfertility, Reduced sperm quality, Delayed time to pregnancy, Abnormal PAP smears, Pregnancy-induced hypertension, and/or pre-eclamicroplasticsia
Respiratory system	Asthma
Heart	Cardiovascular disease
Metabolic diseases	Type 2 diabetes, childhood obesity; increased waist circumference; serum lipid levels, e.g. total cholesterol and LDL cholesterol
Antibody responses	Decreased antibody response to vaccines
Pregnancy outcomes – offspring	Period of gestational; birth weight; delayed puberty; genital structure (anogenital distance); and pubertal onset.

Source: Nikiema et al., 2020

Figure 2 summarizes microplastic's sources, fate, exposure, and effects. Microplastics originate from sources (see fig. 1c) such as microbeads contained in personal care products, plastic microfibers derived from washing and drying of synthetic textiles, fragmented tire-wear particles and road marking paints, accidental spills of pellets, and fragmentation of larger plastics used for activities such as food packaging, drink bottles, industrial materials, household goods, synthetic fiber, and many others (Hann et al., 2018; Lim, 2021; Sundt et al., 2014). Such sources can vary from one geographical region to another. For example, in Japan artificial turf and capsules of plastic-coated fertilizer are reported widely (Abeynayaka et al., 2020; Katsumi et al., 2020), which are associated with the prevalence of artificial fields and the consumption of plastic-coated fertilizer, respectively. Throughout the globe, municipal wastewater treatment plants (MWWTPs) are also found to be a significant source of microplastics (Leslie et al., 2017; Miller et al., 2017), which is associated with domestic wastewater containing the remains of washed textiles and personal care products.

As mentioned above, once plastic enters the environment it can move to other systems or transfer between them (Fig. 2), after which degradation breaks it down into smaller and smaller particles. Due to the long half-life of plastics, estimated at hundreds to thousands of years (Barnes et al., 2009), complete breakdown and removal of microplastics from a system requires long timespans. Regarding exposure pathways for humans and ecosystems, human pathways are highly associated with inhalation (Ageel et al., 2022; Borthakur et al., 2022), ingestion through drinking water (Cox et al.,2019; WHO, 2019), food web-associated ingestion (Setälä et al., 2014; Carbery et al., 2018; Wang et al.,2019), directly contaminated food-related ingestion, with plastics reaching the intestine (Prata et al., 2020).

Figure 2. Source, fate, exposure and effects of microplastics



Source: Modified from Ryberg et al, 2018 and Woods et al., 2021

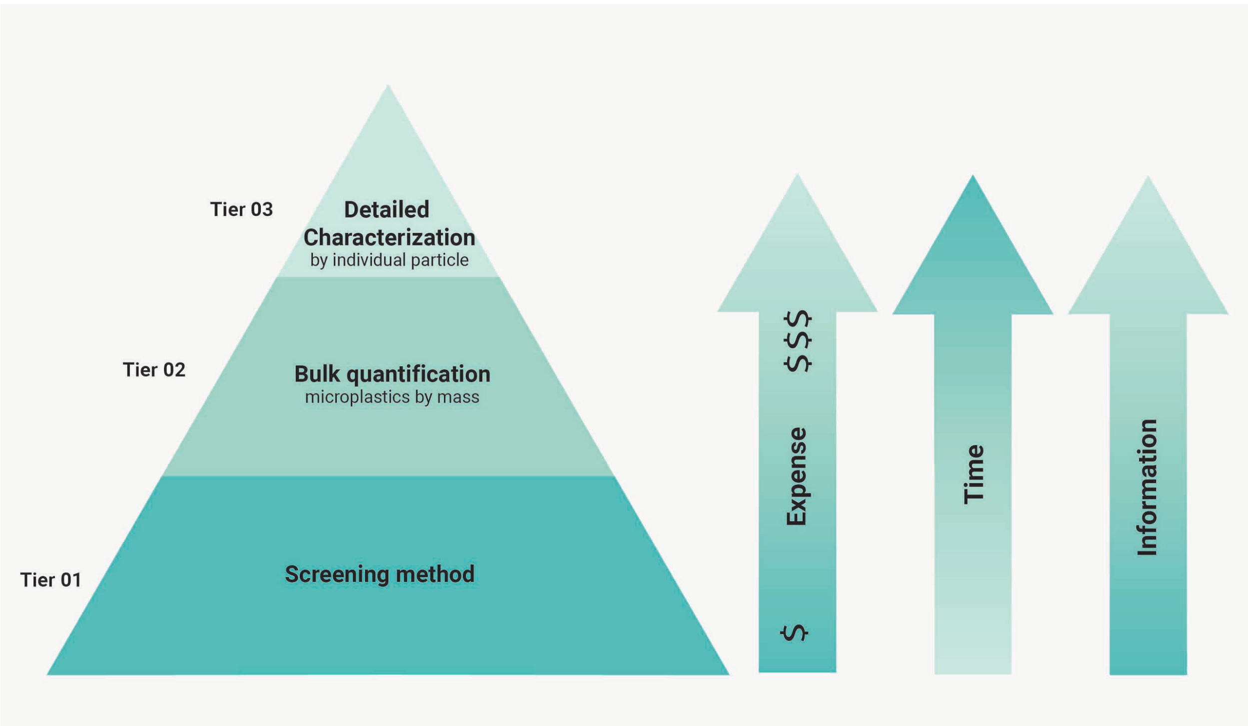
1.2. Microplastic data and evidence-based policy

While the academia keeps revealing new evidence on the occurrence, fate, exposure and effects of microplastics, international functions such as UNEA 5.2 and G20, and regional economic and political unions such as the European Union (EU) and the Association of Southeast Asian Nations (ASEAN), and national governments of mainly developed countries have also begun to address the issue by implementing various measures such as policies and management strategies (Kadarudin et al., 2020; Kentin and Kaarto, 2018; GRID-Arendal, 2021a; GRID-Arendal, 2021b).

Along with the increasing recognition of microplastic pollution and its effects at global, regional and national levels, sources of funding for priority research on microplastics are also increasing (Jenkins et al., 2022). While funding will certainly generate data, however, ensuring such data are findable, accessible, interoperable, and reusable (FAIR) is essential to informing policy and mitigation strategies (Jenkins et al., 2022). Hence generation of FAIR data is essential for optimizing the impacts of funds and generating information for evidence-based policymaking.

Monitoring assists the generation of scientific evidence to support evidence-based policymaking implementation related to decision-making. Figure 3 illustrates the potential tiered monitoring systems for microplastics proposed by the California water board (Coffin et al., 2021).

Figure 3. Potential tiered microplastic monitoring process



Source: Coffin et al., 2021

Monitoring and regulation of microplastics are currently underway in certain areas of the world, such as the EU and North America. The EU has been working on the "Upcoming initiative on microplastics," initiated in 2019 (EU, 2022), and the US State of California initiated such a process several years ago starting with the California senate bill on statewide Microplastics strategy in 2018, as shown in Box 1 (Coffin et al, 2021) below:

Box 1

- California Senate Bill 1263 (2018): Statewide Microplastics Strategy
- July 2020: Define Microplastics
- July 2021: Standard methods, four years of testing; Health-based guidance level; Accredit laboratories
- 2022: Initiate statewide Microplastics strategy within 4 years
- 2026: Deadline to achieve the following tasks:
  1. Develop a risk assessment framework
  2. Develop standard methods
  3. Establish baseline occurrence data
  4. Investigate sources and pathways
  5. Recommend source reduction strategies

1.3. Methods and facilities

A diverse range of methods are used in microplastic sampling and analysis, involving different matrices. Sampling and analysis have been conducted and advanced over the past decade, and various organizations have put forward several efforts to standardise methods and protocols (MOE-J, 2020) and researchers (Primpke et al., 2020; Cowger et al., 2020).

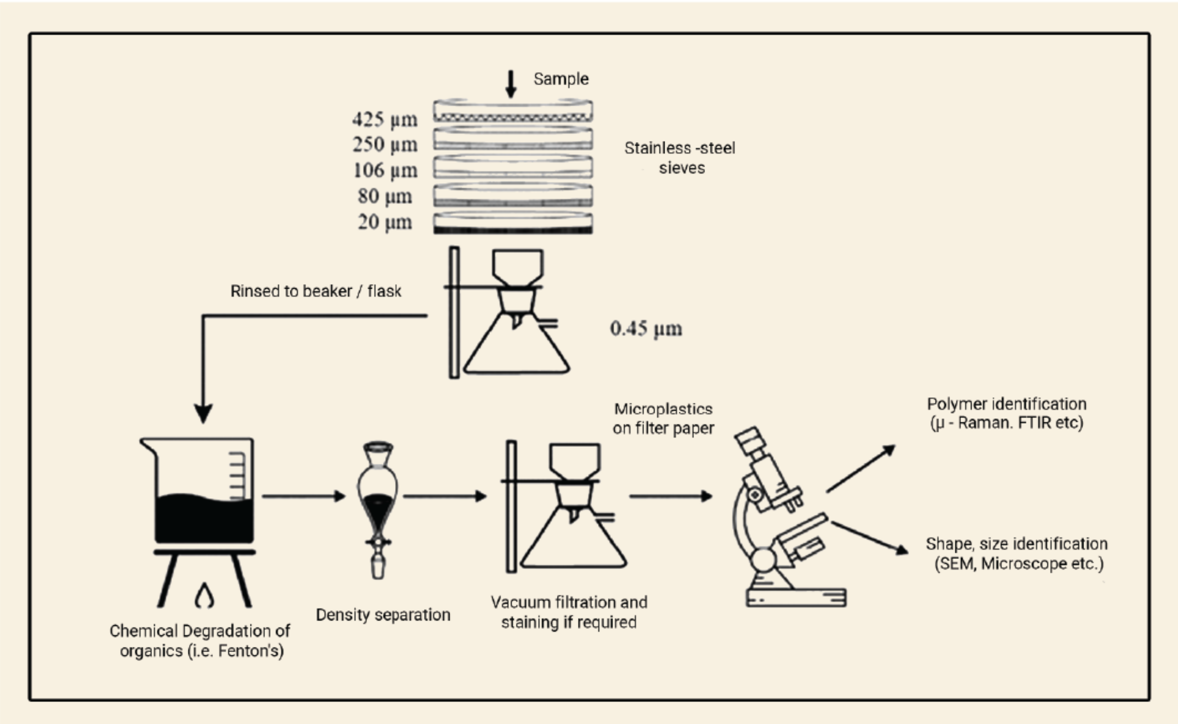
Figure 4 provides some commonly used microplastic sampling methods for surface water and WWTP water. Other methods include sampling microplastics from WWTP sludge (Lars et al., 2019), soils (Scheurer et al., 2018; Palansooriya et al., 2022), sediment (Maes et al., 2017a), and drinking water (De Frond et al., 2022; Pivokonsky, eta l., 2018; Novotna et al., 2019).

Figure 4. Basic microplastic sampling methods used in surface water and Wastewater Treatment Plants (WWTPs)

Source: Modified from Abeynayaka et al., 2022

After sampling, sample purification must be performed to separate microplastics from other solid constituents such as organic matter, sand particles, etc. Figure 5 illustrates a typical sample purification and analysis process (Ben-David et al., 2021). Rochman et al. (2019), in their review of the physical and chemical properties of microplastics, summarized them into physical properties such as mass, shape, and color, and chemical properties including polymer-type, additives and adsorbed chemicals. Attached biological constituents such as biofilms, pathogens, and antigens are also important properties to consider (Oberbeckmann et al., 2018).

Figure 5. Typical microplastic purification and analysis process flow



Source: Modified from Ben-Davis et al., 2021

Table 2 summarizes the salient features of analytical equipment used in microplastic-related research. Researchers often use µRaman and µFTIR-based analytical methods for polymer identification. For polymer identification with microscope-based methods, fluorescence staining (such as Nile Red) has often been conducted (Erni-Cassola et al., 2017; Maes et al., 2017b). Apart from the polymer identification, parameters such as the detectable size range, affordability, and the time taken for analysis are important considerations regarding equipment usage, as is the detection limit and aim of the study. Detection limits depend not only on the equipment but also on the analytical skills of the operators. Research related to the smaller ranges of microplastics (1−100 µm) is hindered by the unavailability of analytical equipment and a robust method (Abeynayaka et al., 2022).

Table 2: Features of commonly used microplastic analytical equipment

Features	***µ-Raman***	***µFT-IR***	***ATR-FT-IR***	***Microscope-based***	***SEM***	***Pyrolysis GC-MS***
Possible equipment price range*	3		2	1	5	3
	Prices vary from 20,000 to 1 million USD. Ranking is on a scale from 1 to 5 based on relative price (1 = cheapest equipment).					
Type of polymer	Yes				No	Yes
Detectable additives	Pigments	Not				Yes
Particle surface chemical	Yes	No	Yes	No		
State of degradation	Surface oxidation	No	Surface oxidation	No		
Suitable sampling sites	Wastewater, water environment, drinking water		Wastewater, water for larger microplastics	Waste-water, water environment	Nanoplastics and small microplastics with known polymers	Wastewater, water environment
Dimension of specimen mass	ng-µg		µg-mg	ng-µg	ng	mg
Number of measurable particles per sample	10^2-10^5		One at a time	Microscopic visibility	Visibility	Depends on sample mass
Preparation and measuring time	Hours to days		Minutes	Hours		Minutes to hours
Detection level	>5 µm		>80 µm	>5 µm	>1 nm	Depends on sample mass
Example reference*	Wolff et al., 2019	Mintenig et al., 2017	Simon et al., 2018	Sierra et al., 2020	Nguyen et al., 2021	Hermabessiere et al., 2018

*Prices of equipment were obtained through personal communication with leading manufacturers (as of 2021) and information on manufacturer homepages. References are given for further reading as case studies of equipment usage. Tabulated information does not necessarily represent the example reference content. For drinking water microplastic observation, it is recommended to use micro-level equipment considering the smaller-sized microplastics. Another challenge is the analysis of plastic-related chemicals, such as toxic metal analysis. The microplastic associated organic pollutant assessment methods are in developing (Yukioka et al, 2021 Järlskog et al., 2021).

Common metal analysis methods such as ICP-MS (inductively coupled plasma mass spectroscopy) require sample weights of several grams. However, the weight of the microplastic fragment is less than a milligram (mg), which limits the analysis of toxic metals in microplastics. However, toxic metal analysis using larger-sized microplastics based on x-ray fluorescence spectroscopy is showing promise (Turner, 2017; Abeynayaka et al., 2021). While the selection of analytical equipment depends on various factors, the research objectives need to be in line with the available facilities in order to provide meaningful outcomes.

1.4. Sri Lanka: the way forward on microplastic monitoring and evidence-based policymaking

Plastic pollution has been widely reported in Sri Lanka (Geyer et al., 2017: NAPPWM, 2021), and microplastics in coastal environments has been reported on also (Sevwandi Dharmadasa et al., 2021; Athawuda et al., 2020; Bimali Koongolla et al., 2018). The country's national action plan on plastic waste management (NAPPWM) recognizes that microplastic-related pollution is a serious domestic concern (NAPPWM, 2021). To initiate appropriate and effective countermeasures to control the impacts of microplastics on life and the environment in Sri Lanka, increased awareness of microplastics and their impacts at various levels (e.g., by policymakers, industry, and the general public), as well as identifying and addressing knowledge gaps related to continuous monitoring and scientific evidence-based policy measures are necessary.

For the Sri Lankan context, achieving the five tasks outlined in box 1 are essential; i.e., passing related bills, defining microplastics, determining methods, initiating a statewide strategy and setting deadlines for determining the related framework and methods, baseline data, sources and pathways and recommended reduction strategies. However, certain areas require capacity building to achieve these tasks. One important task is to educate society on the potential negative impacts of microplastics on life and the environment (findings of this study). Hence, urgent awareness and training programs on the adverse impacts of microplastics and assessment methods for different social levels of Sri Lanka are essential.

Therefore, this TNA was conducted to study the present state of knowledge among the potential stakeholders on microplastics monitoring and policymaking. Furthermore, the status of current capacities (knowledge and facilities) and the required training to improve existing capacities of Sri Lanka were assessed. The gap between the present status and the desired level of knowledge (i.e., related to the prevailing issues) was identified, then segmented and translated into training needs.

2. AIMS, OBJECTIVES, AND SCOPE

This study was formulated based on global findings on the extent of microplastics in the environment, with a special focus on the potential monitoring of food and water. The main focus of this study was to ascertain the level of understanding regarding how microplastics were currently investigated and to develop a curriculum to assist microplastic monitoring in Sri Lanka. Moreover, putting into practice actions linked with the study outcomes will ultimately contribute to achieving the implementation of regional and global commitments, including the Honolulu Strategy, a framework for comprehensive and global collaborative efforts in reducing the ecological, human health, and economic impacts of marine debris worldwide and the UNEA 5.2, ending plastic pollution: towards international leagaly binding instrument. This framework is organized by a set of global goals and strategies, regardless of specific conditions or challenges. Further, the intended activities will contribute to achieving the sustainable development goals (SDGs) of GOAL 6: clean water and sanitation, GOAL 14: life below water, GOAL 2: Zero Hunger, GOAL 3: Good Health and Well-being, and GOAL 4: Quality Education.

2.1. Aims

To minimize the potential health effects of microplastics and plastic-related chemicals by assessing their fate in the environmental systems, enable the development of rigorous awareness programs for pollution prevention, and support the evidence-based policy-making process with scientific information.

2.2. Objectives

1. To assess the know-how related to microplastics spread and mitigation measures adapted to the overall environment;

2. To determine the current status of microplastics pollution research in national institutes;

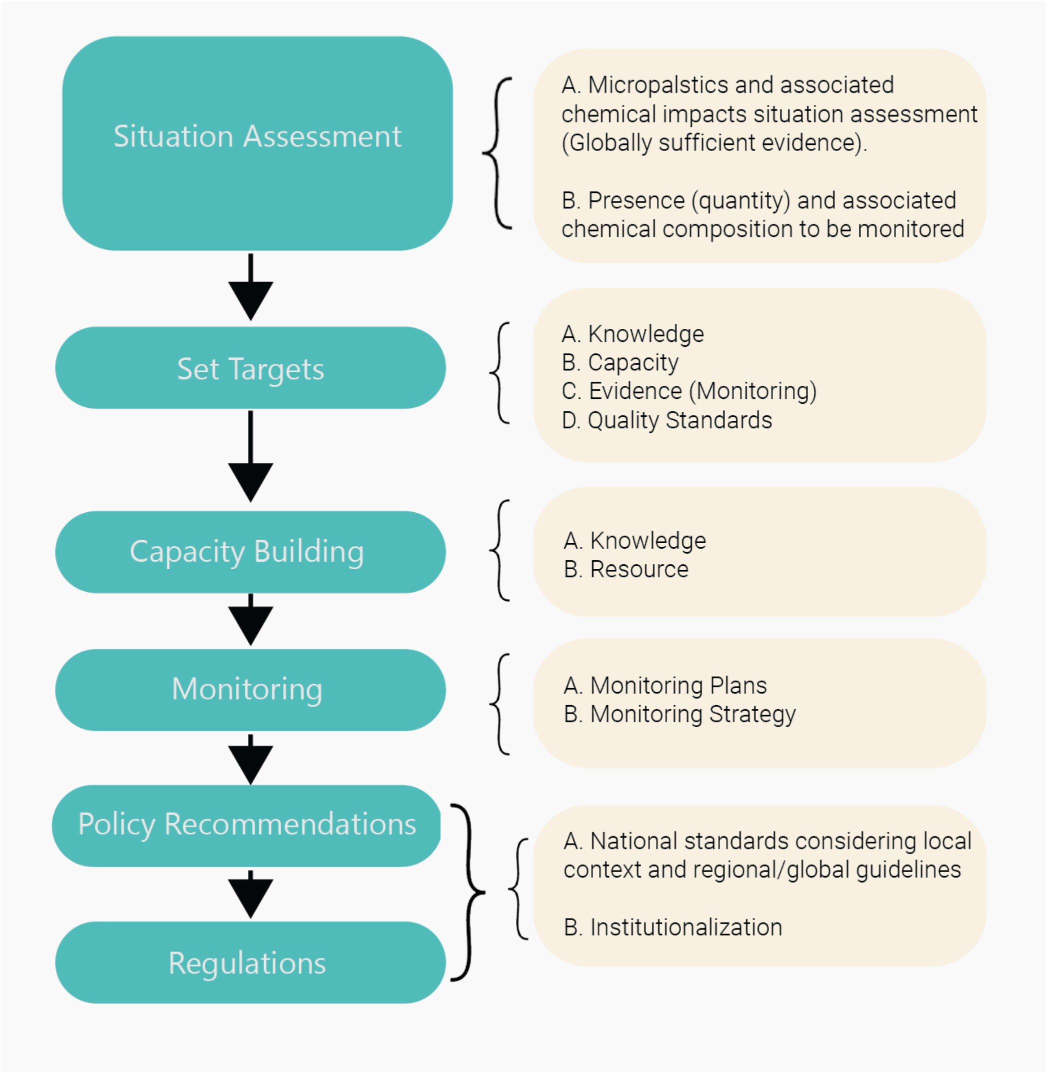
3. To assess the available facilities for microplastics pollution monitoring;

4. To develop a curriculum on the origin, fate, and mitigation of microplastics in the environment, based on addressing knowledge gaps at the fundamental and professional levels; and

5. To assess the need for a centralized microplastics monitoring facility related to water, under the purview of the Ministry of Water Supply.

The steps for achieving the overall objectives of the capacity building for microplastic monitoring and evidence-based policymaking are given in box 2.

Box 2



2.3. Scope

The project's scope is based on objective data analysis through a questionnaire survey compiled by the Social Science Group. The data were collected from environmental professionals throughout Sri Lanka representing all nine provinces, focusing on the water sector. The survey results provided information and data on the current status of microplastics pollution, awareness status, professional databases, available facilities for microplastics research and monitoring, etc., which will be used in designing a training curriculum on microplastics pollution aimed at national and local policy-makers, practitioners and research communities involved in the water supply sector. Further, awareness-building for the general public will also be targeted through mobilizing program stakeholders. The technical needs of microplastics inventorying and monitoring facilities among Sri Lankan institutes were also examined. The curriculum is standardized to meet world norms through quality control and assurance programs. Avenues will be sought to integrate the critical training modules into the secondary and tertiary curricula in Sri Lanka.

3. METHODOLOGY

3.1. Research approach

The data required for this study were obtained mainly through a structured questionnaire (see Annexure 1). Quantitative information was collected from different focus groups and other general stakeholders. The following steps were followed in carrying out this study:

1. Detailed literature survey of indexed journals and internationally published reports
2. Determining and designing the survey for data collection
3. Collecting empirical knowledge through questionnaires, field visits, workshops, and expert opinion [Key Informant Interview (KII) and Focus Group Discussion (FGD)]
4. Producing a preliminary report
5. Validation of information via stakeholder consultations and inputs from the subject experts (national, regional, and international)

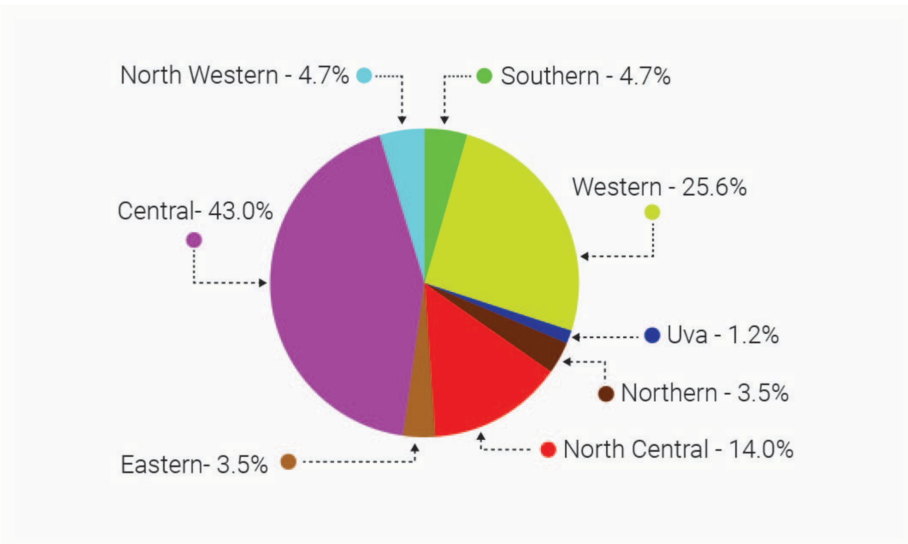
A working group including thematic leaders, consultants, and local and international experts was formed to initiate and conduct the TNA preparations. The questionnaire was then drafted incorporating inputs from the thematic experts before being finalized.

3.2. The research context and sample

This TNA study set out to collect information covering all Sri Lankan provinces. Thus, the questionnaire was shared through the various stakeholder groups in the country as follows using a Google Forms questionnaire from February to March, 2022.

The survey was technically conducted in two layers/ tiers of stakeholders: (1) General respondents including graduate students in the environmental field and ordinary citizens, and (2) Stakeholders involved in microplastics monitoring and/or microplastics users (mandatory institutions, affiliated institutions, and the relevant stakeholders, academics). Finally, at the national/international level, several subject experts, policymakers, administrators, and academics were individually consulted to triangulate the data and key findings to obtain in-depth knowledge. The geographical distribution of the questionnaire respondents is given in fig. 6. Map of the provinces of Sri Lanka is given in Annexure 2.

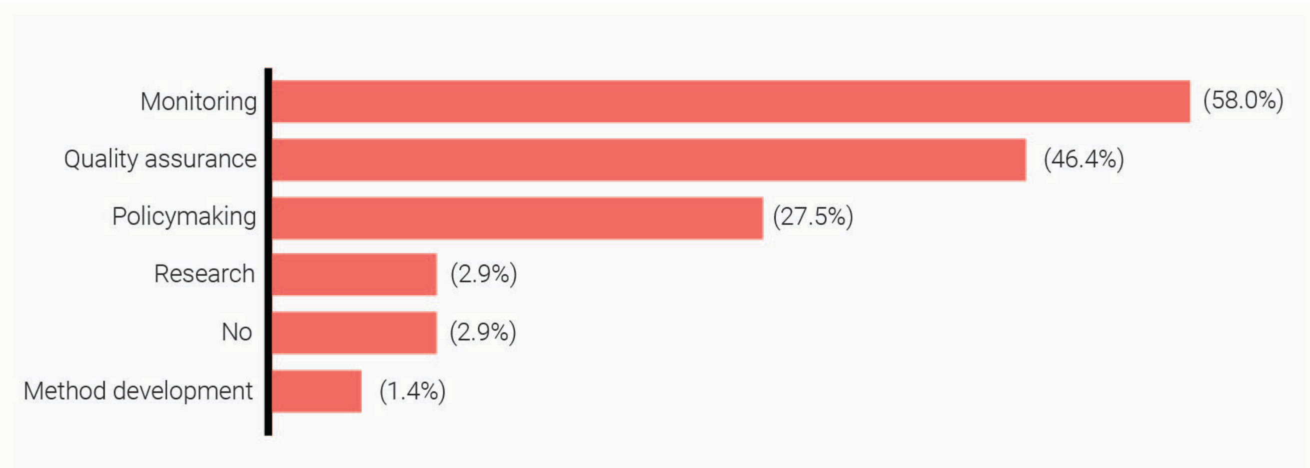
Figure 6. Geographical distribution of questionnaire respondents



Source: Survey data, February–March, 2022

The respondents (n = 83) considered in the study were from the thematic areas as shown in fig. 7 (quality assurance, monitoring, policy-making, methods development, and research). Among those targeted were the monitoring and quality assurance organizations and policy-making organizations needed to achieve the project's ultimate objectives, carry out the microplastics-related pollution monitoring, and inform on the scientific evidence-based policy-making process.

Figure 7. Organizational roles of the respondents



Source: Survey data, February–March 2022

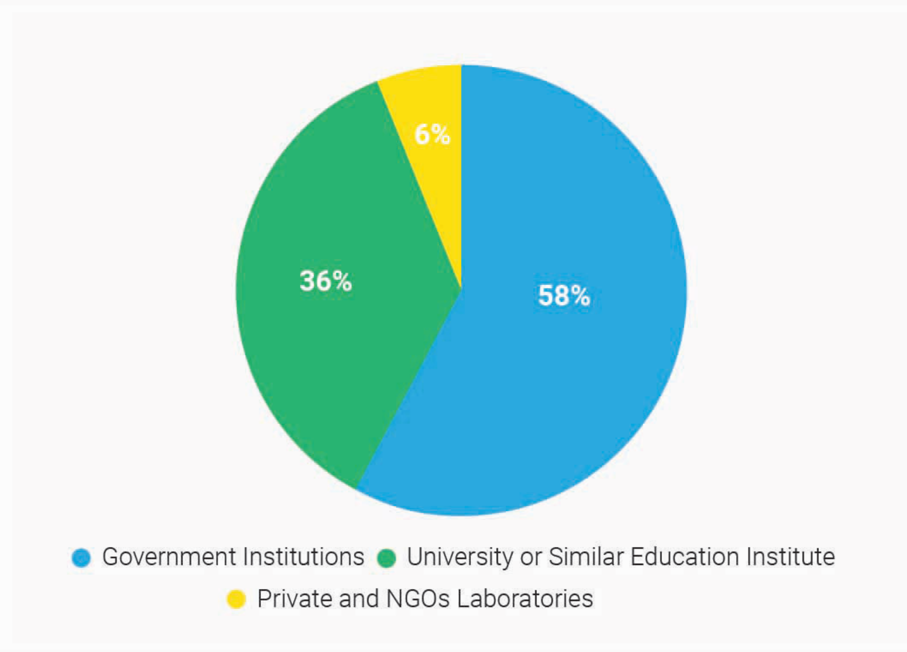
Based on the data analysis, the scope of respondents' areas of work was divided into six main categories, which are water (drinking water, freshwater, wastewater, and sludge), agriculture (soil, fertilizer,irrigation), marine and coastal environments, academic research, cosmetics (industrial pollution) and food and beverage quality.

3.3. Method of data collection

Questionnaire surveys were conducted online through a Google form, Consultative Workshops, FGDs, and KIIs, desk surveys, and discussions with experts in the field were used as information collection techniques.

Data collection mainly involved quantitative data, with a small amount of qualitative data. The working group managed the field-level coordination in close collaboration with the relevant institute's contact personnel. The following figure (fig. 8) shows the institutions (government institutions, universities or similar educational institutions, and private and NGO laboratories) that responded.

Figure 8. Respondent institutions



Source: Survey data, February–March, 2022

3.4. Data analysis

The data collected through the google form based questionnaire survey were analyzed using Microsoft Excel, and statistical software, IBM SPSS Statistic Data Editor.

3.5. Limitations of the study and overcoming the limitations

Limitations are part of any research and can be divided broadly into two categories: methodological limitations and data limitations, as follows:

1. Limits are determined by whether stakeholders had access to the Internet
2. Limits are determined by whether the accessible group of stakeholders was literate in Google forms
3. Limits imposed by existing facts and data on microplastic monitoring
4. Limits imposed by the quantitative data received through the questionnaire survey

Due to the prevailing Covid-19 situation in the country, the main data collection technique was limited only to the online survey (Google forms questionnaire). Thus, this TNA report is mainly based on quantitative data rather than qualitative data. However, to overcome these limitations or challenges, various literature was referred to in the writing stage, subject matter experts were consulted, and several field visits were conducted to obtain more knowledge on a practical basis. The field visits were made at faciltieis suchs as drinking water, wastewater, sludege treatment and the quiestionnaire respondents institutions to interview and obaserve the situation.

4. INFORMATION ANALYSIS

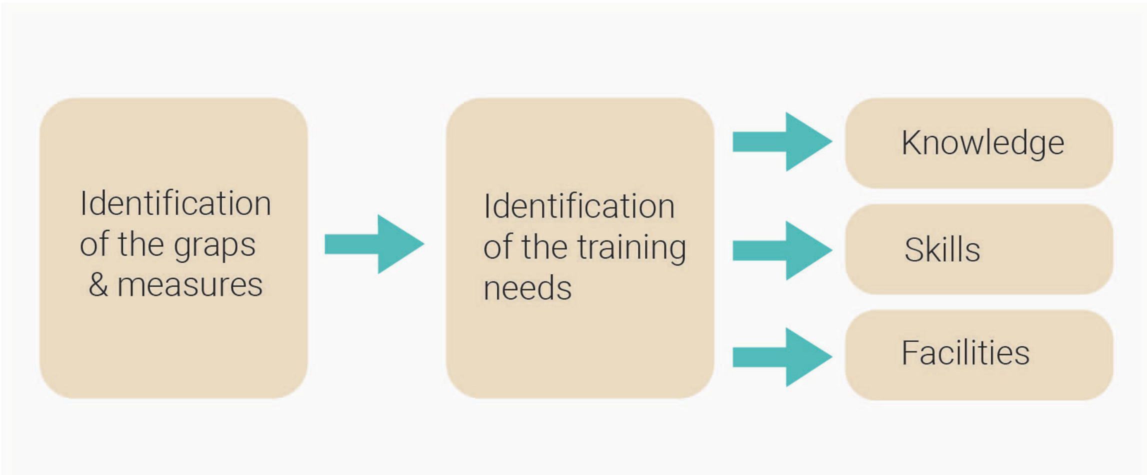
4.1. Compilation

Information compilation involved the initial separation of information from general and technical respondents and subsequently proceeded as per the respective themes In the final stage, the collected information was compiled separately, theme-wise, for analysis.

4.2. Analysis

Information analysis consists of 3 steps, as illustrated in the following flow chart (fig. 9):

Figure 9. Process of information analysis



The above steps comprise:

1. Reviewing the compiled information according to the theme and extracting key facts
2. Identifying the gaps and adequate measures
3. Identifying the cumulative training needs, in terms of knowledge, facilities, and skills. In the analysis process, the existing situation was judged against the desired situation.

4.3. National validation

The cumulative training gaps identified outputs were presented to the national validation reviewers for validation and incorporated into the identified training gaps. The cumulative identified training needs were then updated after that.

4.4. Expert interviews and field visits

The training gaps and needs identified in the field were presented to the thematic experts and their views and recommendations were gathered for incorporation into the identified training needs. Field visits and FGDs were conducted to observe and verify the information (fig. 10, 11).

Figure 10. Discussions with experts in the field

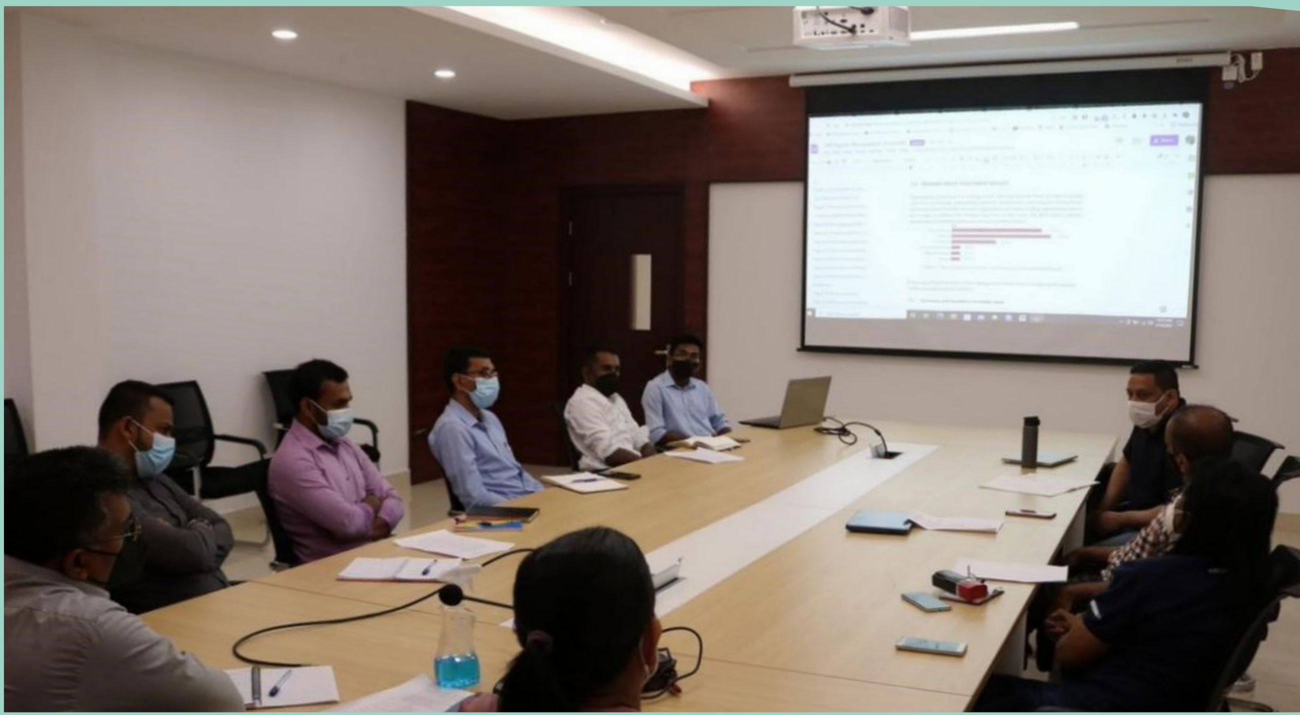


Figure 11. Field photos:a) Water treatment plant intake, b) wastewater treatment plant, wastewater treatment plant strainers retain sludge with visible meso- and large-sized microplastics, and d) sludge drying facility

Source: Field visit, March 2022

The field visits were conducted to observe the ongoing typical water treatment processes, the wastewater treatment processes, waste disposal sites and wastewater treatment plant sludge and disposal. Observations were recorded and the information was confirmed and verified through discussions with relevant officers.

5. SURVEY RESULTS OF TRAINING NEEDS ASSESSMENT

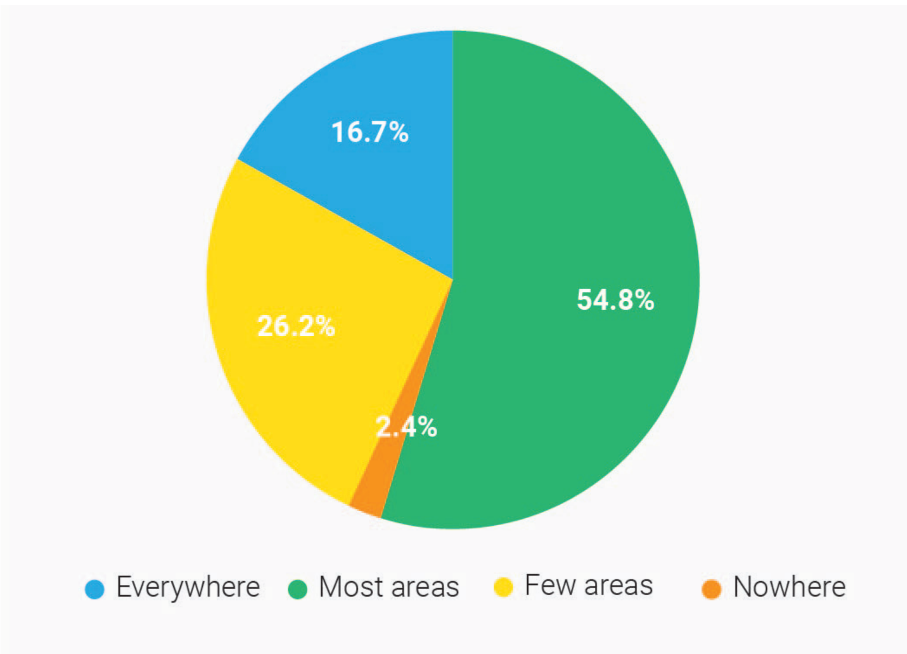
The survey findings were two-fold, i.e., covering general/social and technical aspects. Consequently, the survey results were analyzed to identify the general knowledge gaps, the technical skills/knowledge, and facilities for monitoring microplastics.

5.1. General/Social

5.1.1. Awareness of plastics (Opinions on plastic pollution and microplastics)

Based on the information obtained from the questionnaire survey, the participants' awareness of plastic and microplastic pollution, and the potential impacts of microplastics were assessed. According to the views expressed by the respondents, plastic pollution is present in the natural environment of Sri Lanka and the majority of the respondents (55%) mentioned that plastic pollution can be seen in most environments (fig. 12).

Figure 12. Presence of plastic in the natural environment



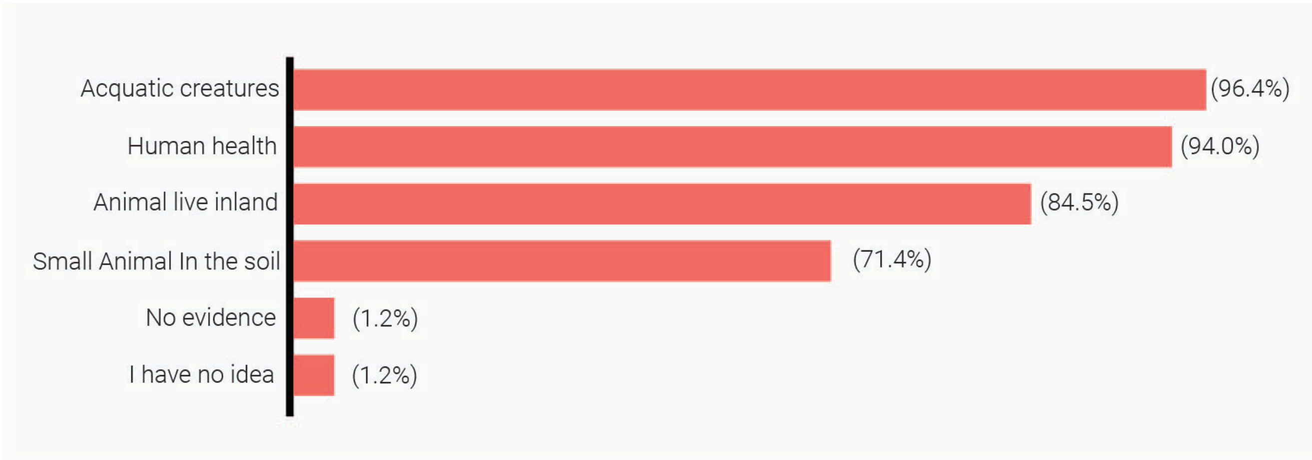
Source: Survey data, February–March 2022

Figure 12 implies that a considerable portion (26.2% + 2.4%) of the stakeholders have low awareness of plastic pollution in the surrounding environment. Consequently, a lack of awareness can lead to a lack of attention to plastic pollution and microplastics among the potential stakeholder communities, which can have consequences regarding their engagement in microplastics monitoring and policymaking processes.

The study findings (fig. 13) revealed that basic awareness of the environmental impacts of microplastics within the target population was considerably higher. Awareness of impacts on human health and aquatic creatures was comparatively higher. However, some of those who acknowledged there are impacts on aquatic creatures and humans still believe there are no impacts on animals living inland and small creatures living in the soil.

Such thinking could be associated with concerns on microplastics that were initially raised related to marine environments which then involved human health concerns afterward. Thus awareness of the impacts on terrestrial animals and small creatures in the soil needs to be improved since microplastic contamination associated with WWTP's sludge applications on agricultural land and their impacts are important factors in Sri Lanka.

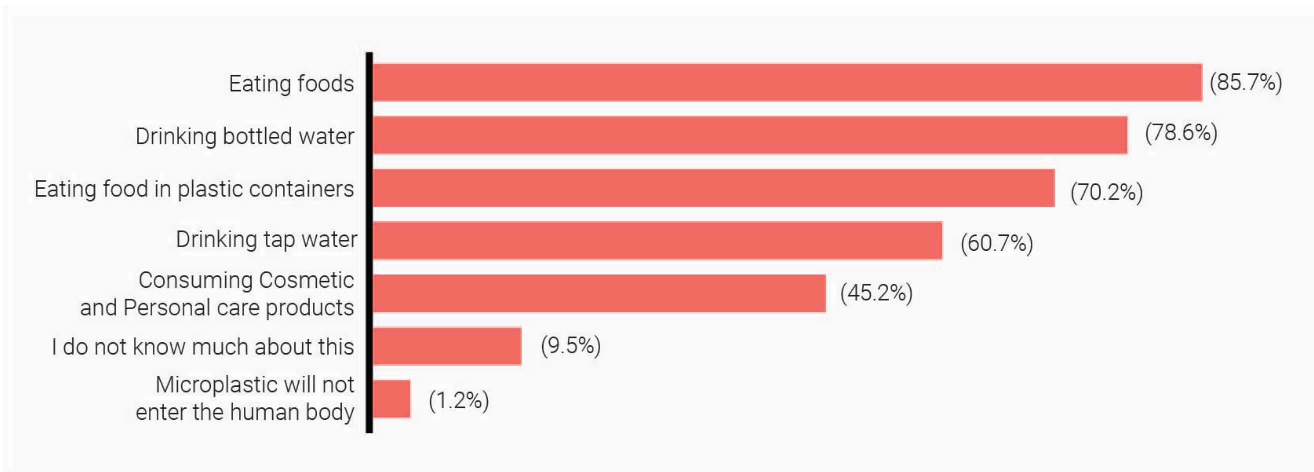
Figure 13. Basic awareness of the impacts of microplastics related to pollution



Source: Survey data, February–March 2022

The basic awareness of human exposure to microplastics through food consumption is higher (fig. 14). However, tap water consumption was not recognized as a potential exposure path by more than 40% of the respondents.While the reasons are not definite, this could be due to a lack of awareness of reports on microplastics in tapwater in other parts of the world. This would appear to relate to a gap in accessing scientific literature.

Figure 14. Basic awareness of human exposure to microplastics



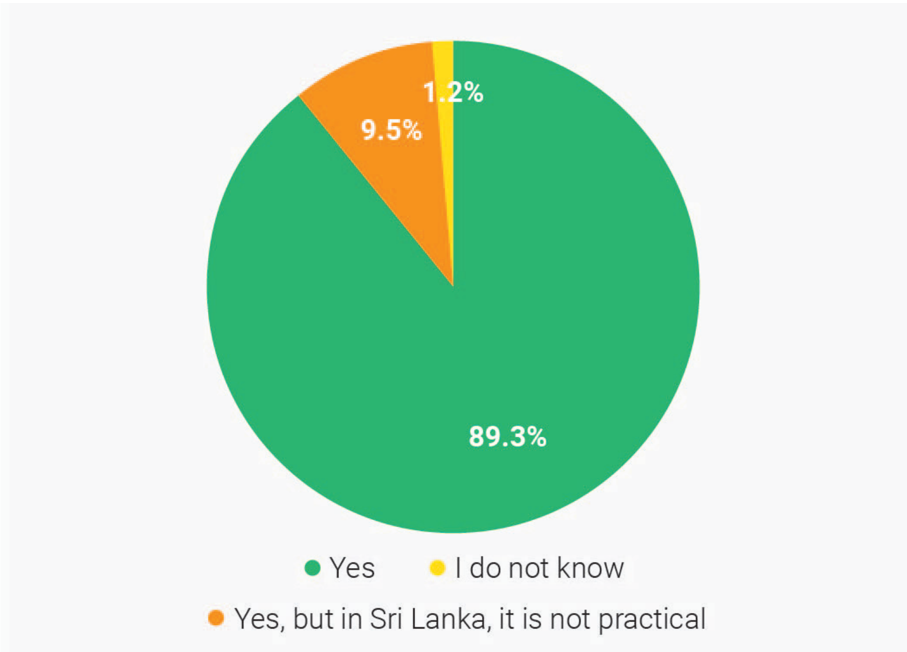
Source: Survey data, February-March, 2022

Awareness of the presence of plastic and microplastic pollution and the impacts of microplastics appears to be present in the respondents. However, certain knowledge gaps need to be addressed. Awareness-raising needs to be focused on all levels, starting from the tertiary education systems, technicians, other staff, and policy-makers potentially involved in the monitoring and policy recommending processes.

5.1.2. Attitude of respondents on microplastics monitoring in Sri Lanka

According to the outcomes shown in fig. 15, a high percentage (i.e., 89.3%) of respondents were aware of the fundamentals of microplastic-related pollution. Hence it can be assumed that many stakeholders believe plastics threaten humans and the environment. Based on this argument, the respondents emphasized the importance of monitoring microplastics in Sri Lanka to address human exposure.

Figure 15. Monitoring needs of microplastics in Sri Lanka



Source: Survey data, February–March 2022

Accordingly, it is interesting to note that the majority of respondents were in favor of having a monitoring system for microplastics. This willingness implies a supportive environment for preparing a monitoring mechanism and policy recommendations for microplastic-related pollution mitigation.

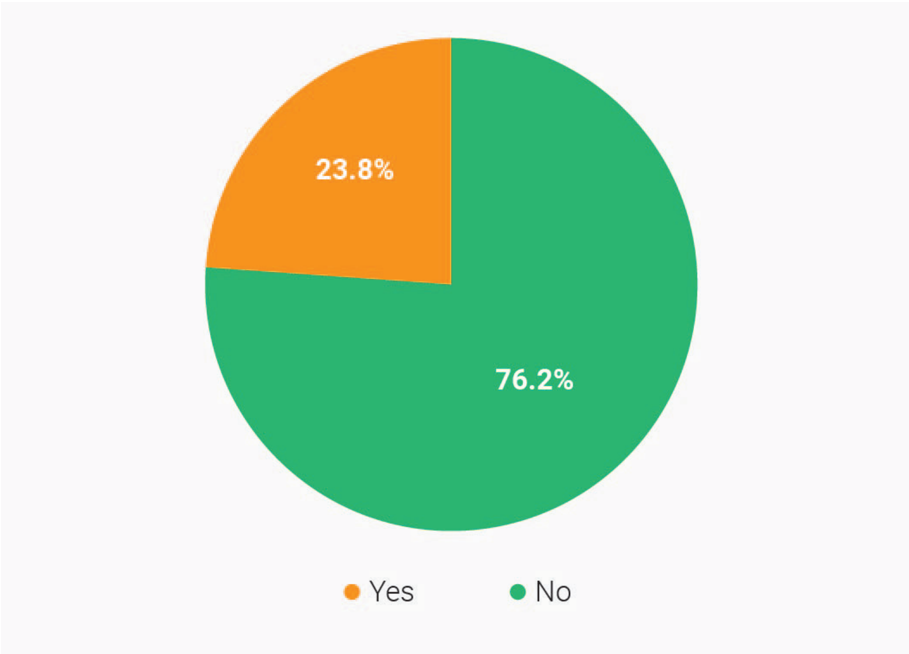
The identified training needs for microplastics monitoring activities to overcome the gaps need to be addressed through a training program, thus such a program needs to be institutionalized. The training modules need to be planned in detail and supporting resources need to be developed.

5.1.3. Microplastics-related activities

5.1.3.1. Microplastics-related activities with in organizations

As shown in fig. 16 organizations (Annexure 3) working in the field of microplastics and microplastics-related pollution were low among all the participants. This could mean that the respondents had low awareness of microplastics because they were not involved in related work.

Figure 16. Organizational work in the field of microplastics in the environment



Source: Survey data, February-March, 2022

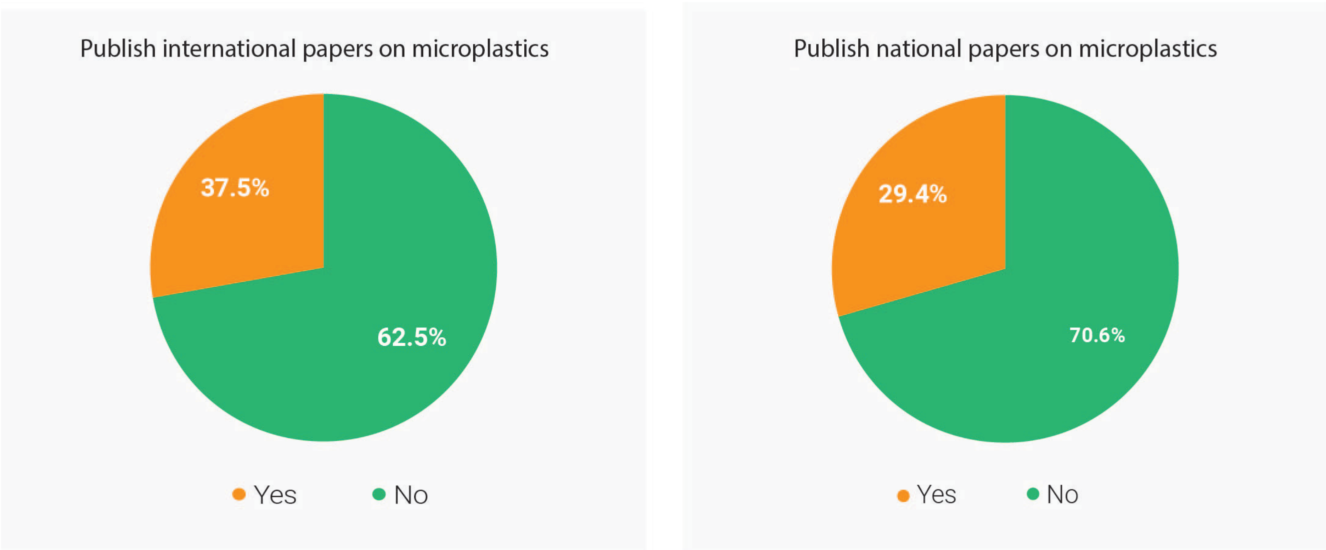
However, the major objectives of analyzing microplastics among the respondents are monitoring, pollution load estimation, research on various aspects, minimizing contamination and raising public awareness, gathering information to support policy decisions and comprehending the gravity of the issue, and identifying harmful microplastics components.

5.1.3.2. Current status of internationally and locally published research papers on microplastics pollution

Based on the current level of awareness of microplastics, disseminating knowledge is vital. According to the study, there are fewer publications conducted in Sri Lanka that are published at global (only 37.5% respondents have published globaly) or local levels (only 29.4% respondents have published globaly). Surprizingly publications by global sources are comparatively higher than local sources, at 37.5 and 29.4% respectively (fig. 17).

The lower number of publications covering environmental fields in Sri Lanka could be associated with several factors, such as a lack of knowledge, lack of funding targeting microplastics, lack of access to analytical equipment, and so on. The comparatively lower number of publications by local sources could be attributed to the lower number of conferences and scientific publications targeting microplastic pollution and factors such as lack of local target audience.

Figure 17. Publications (international and national) related to microplastics-related pollution published by the target population



Source: Survey data, February-March, 2022

On the other hand, this also shows that most of the respondents were unaware of local and international publications related to microplastic pollution, from which it could be inferred that awareness of the authorities and institutions on microplastic pollution and its threats to humans and the environment is low. This therefore needs to be addressed through a newly developed curriculum in the upcoming years.

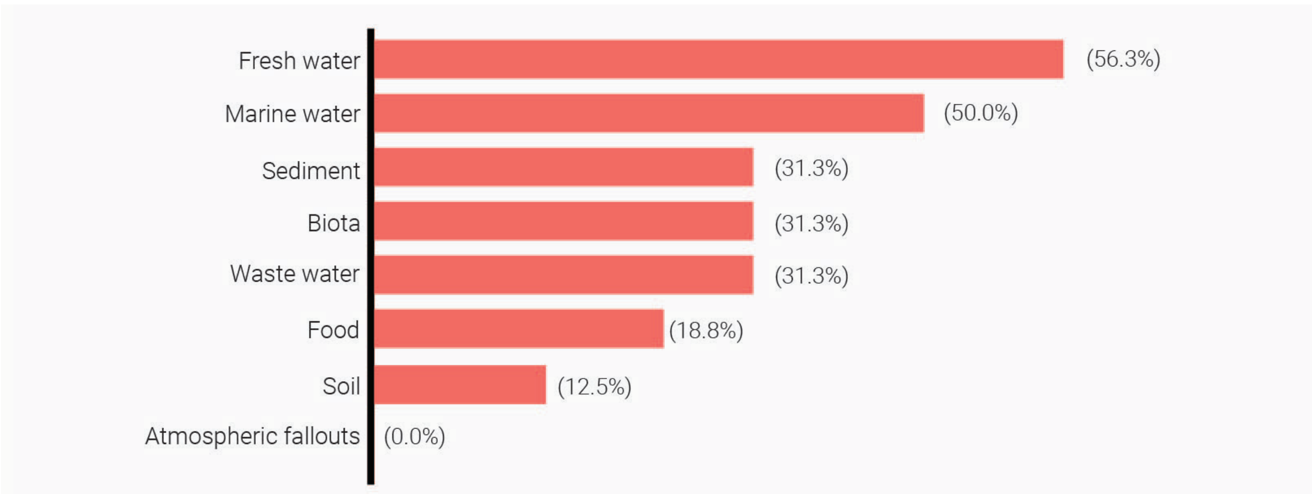
5.1.3.3. Fields of microplastics dealing with measuring or study in Sri Lankan institutions working on water supply, agriculture, waste management, and pollution monitoring

Figure 18 illustrates the fields or areas in which microplastics are measured or studied in Sri Lankan institutions, from which it can be seen that the majority of institutes work in the fields of freshwater and marine water-related environments, as well as wastewater, soil, and food. The study did notapproach potential institutes related to atmospheric pollution (other than universities, and the universities reported negative observations).

Further, according to the expert opinions and the Scopus literature survey, and Google scholar survey, there are no reported publications on atmospheric microplastics in Sri Lanka.

Reports on pollution levels due to microplastics, especially in the aquatic environment, and the potential risks posed to human health through aquatic life exist. Further, it is already well known that plastic contaminants in freshwater threaten ecosystems and are a potential health hazard to humans (table 1). Microplastics can be ingested by plankton at the bottom of the aquatic food chain, which then move up to the next level in the food chain, eventually affecting humans through bodily accumulation (fig. 3). Thus, authorities need to take the necessary actions to eliminate this threat.

Figure 18. Areas of measuring or studying in Sri Lankan institutions



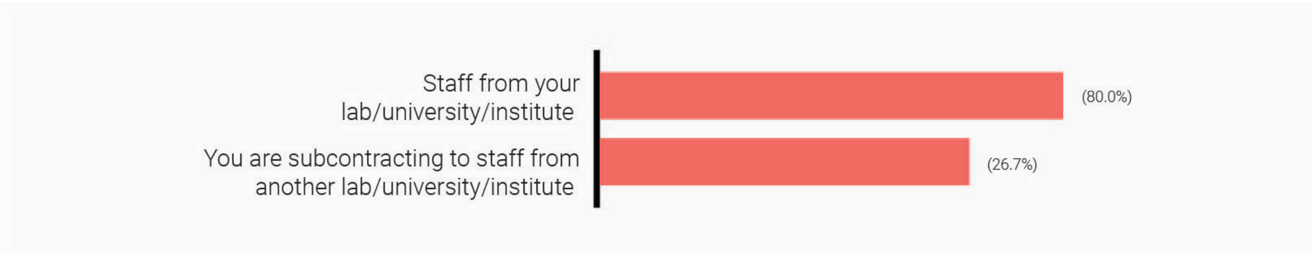
Source: Survey data, February-March, 2022

5.2. Technical

5.2.1. Sampling

At present, sampling is conducted solely through the relevant institutes, and if sampling facilities or instruments are lacking in institutes, they do not consider conducting sampling or analysis. The lack of technical knowledge and resources, especially regarding instruments, are leading factors for the lack of monitoring conducted by such institutes despite monitoring being within their scope (fig. 19). Strengthening the relevant institutes through the provision of sophisticated modern instruments can overcome this issue. Further, proper institutionalization and coordination of the facilities and stakeholders for resource sharing and where/how to access resources is essential. Actions related to monitoring and policy-making need to be coordinated, and needs related to obtaining scientific evidence must be communicated properly to the stakeholders.

Figure 19. Sampling activities

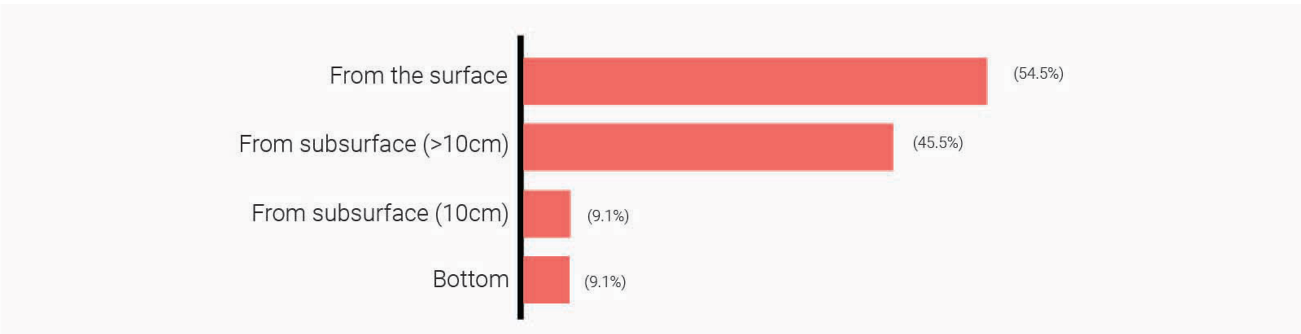


Source: Survey data, February-March, 2022

Sampling methods for water, wastewater, fertilizer, and soil need to be separately addressed for the groups focused on. The related equipment and laboratory facilities need to be developed and effectively used for the training programs that include field exercises. The following three areas, i.e., sampling depth, for water sampling; locations, for wastewater sampling; and locations for agricultural and food-related sampling, should be stressed in the training program.

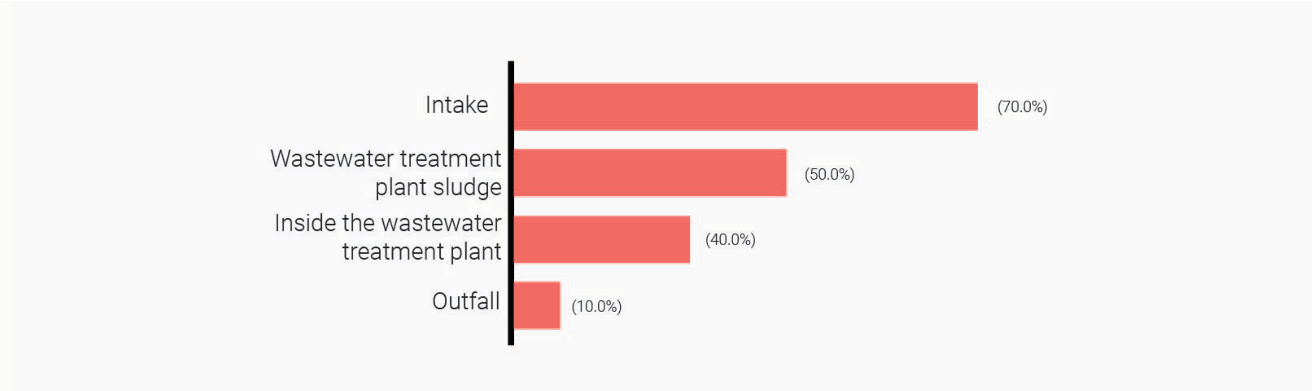
Based on our results, the depths used for water and wastewater sampling mainly focused on intake and wastewater treatment plant sludge. This may have been due to the easy access and lack of other sampling facilities and/or inadequate knowledge and training.

Figure 20. Sampling depth of water sampling



Source: Survey data, February-March, 2022

Figure 21. Locations of wastewater sampling

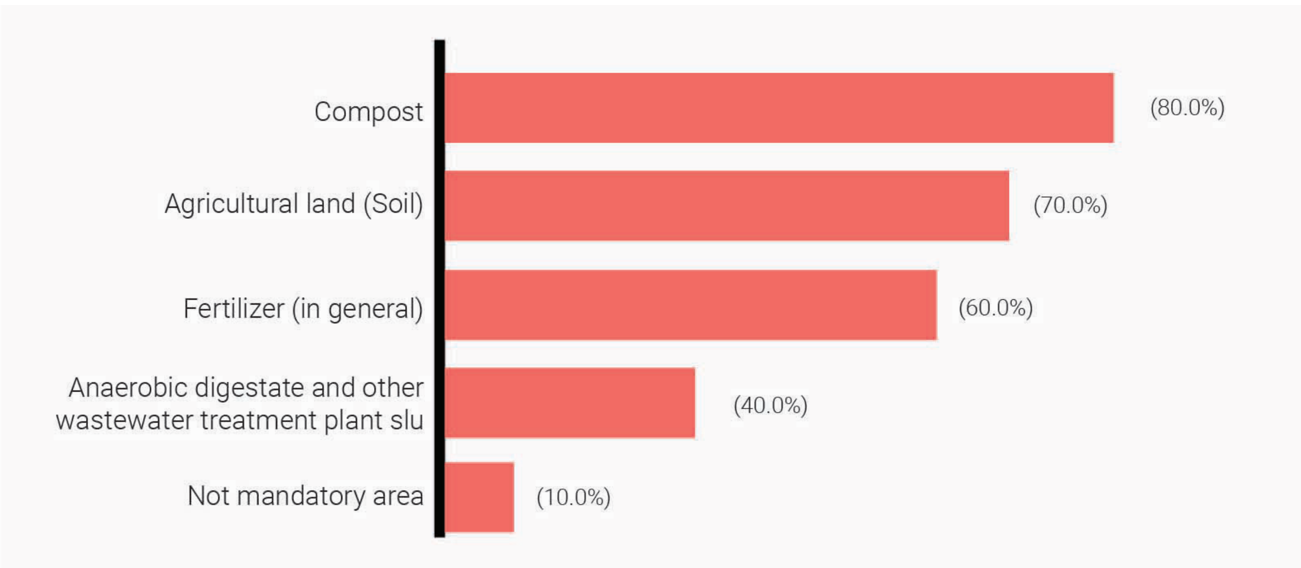


Source: Survey data, February-March, 2022

The sampling locations considered mainly comprised surface and near-surface water. However, little concern was paid to the lower or bottom levels. Concentrations of microplastics, along with precipitation and coagulation with other materials occur at the bottom layers of water bodies, therefore sampling the whole water body is critical to providing an overall picture of the status of microplastic pollution. This can be realized by educating the relevant staff and providing the relevant sophisticated instrument facilities.

Based on the study results, the main focus for agricultural and food-related sampling was on compost materials used in farming. This is mainly due to the thinking that compost, which originated from domestic waste may be contaminated with microplastics.

Figure 22. Locations of agriculture and food-related sampling

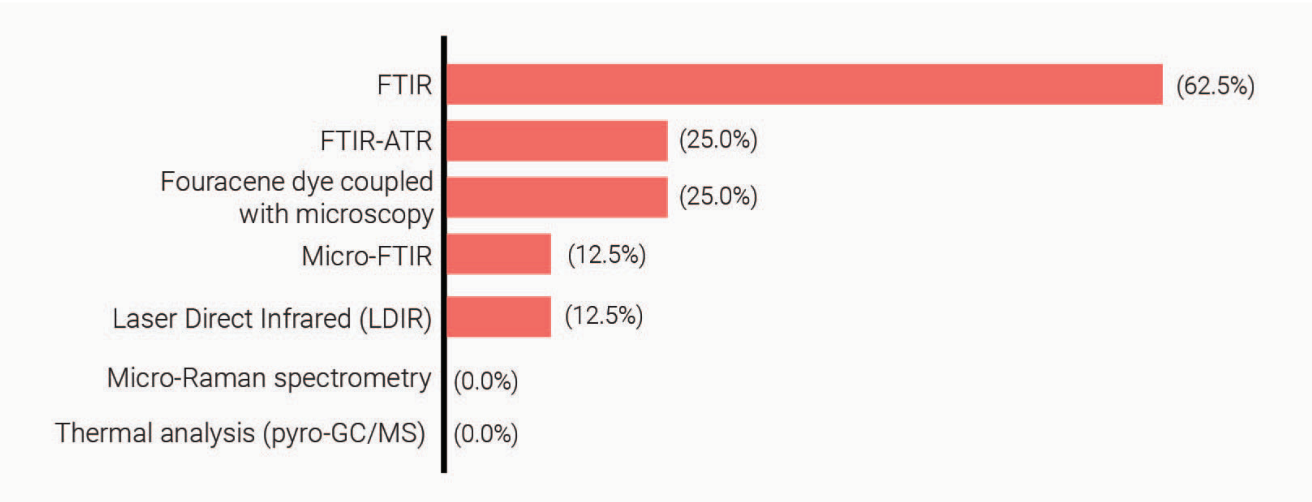


Source: Survey data, February-March, 2022

5.2.2. Laboratory analysis of samples for polymers

Figure 23 shows the equipment used by institutions for monitoring microplastics pollution. Most of the institutions answered that they use FTIR instrument facilities; however, there was no focus on microscopy coupled with Raman spectroscopy (micro-Raman), which is also widely used tools for microplastic detection (specially for small sized microplastics). This may be due to the lack of availability of such instruments in Sri Lanka or lack of knowledge. Currently, monitoring is only focused on the larger microplastics and it appears there are no facilities for detecting microplastics in the smaller ranges (due to the lack of equipment such as micro-FTIR and micro-Raman). Since monitoring of drinking water has been identified as important by the stakeholders, the monitoring process needs to be supplemented with micro-FITR and micro-Raman.

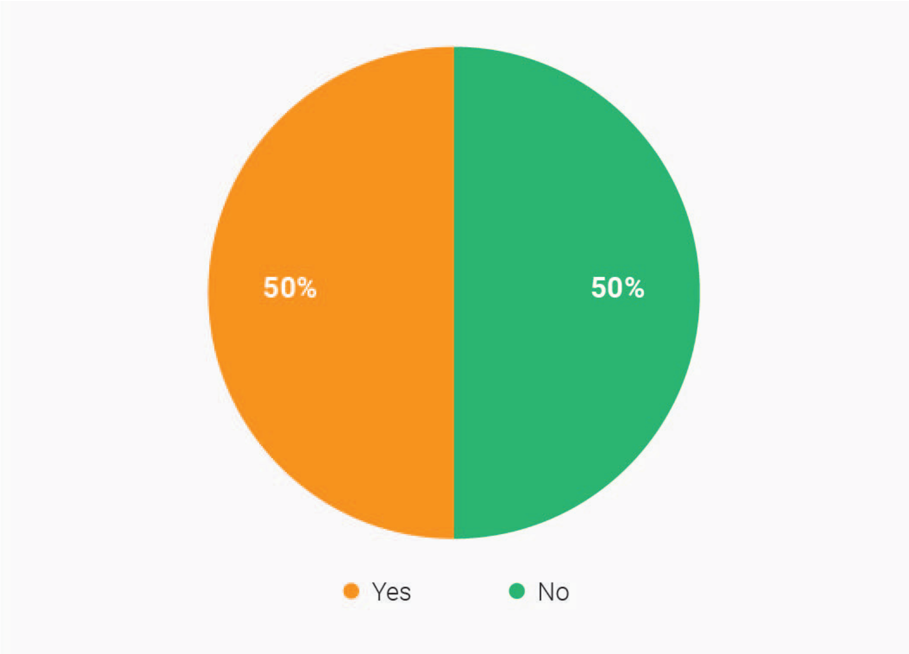
Figure 23. Techniques and Instruments used in Sri Lanka



Source: Survey data, February-March, 2022

The identified key institutes for monitoring microplastics need to be linked with the existing facilities. The following figures (fig. 24, 25) show the extent of ownership of current lab equipment available in the institutes of Sri Lanka, which may point to the importance of increasing the number of facilities available in such labs. In particular, the regional centers will need to develop the skills and provide the facilities to enable continuous monitoring activities. Further, facilities in regional areas also need to be seriously addressed. Due to the lack of such equipment in the relevant sectors and authorities, the institutional research capacity has dropped, thus institutions will need to procure capital if plans to upscale research progress. Similarly, sample pretreatment and transportation need to be addressed during capacity-building activities. Moreover, an operational mechanism with proper coordination needs to be established.

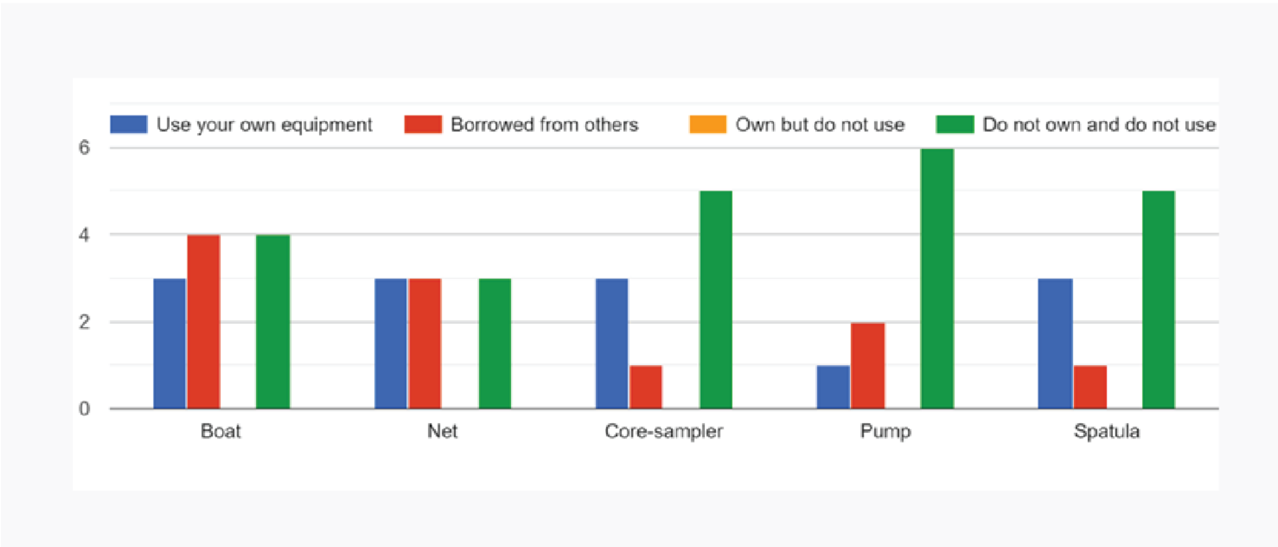
Figure 24. Percentage of labs having their own equipment



Source: Survey data, February-March, 2022

Identification of each institution's role and different sections (such as head office, laboratory, regional office) are important to capacity-building programs, which should be planned and conducted accordingly.

Figure 25. Usage and ownership of equipment



Source: Survey data, February-March, 2022

Analytical methods for water, wastewater, fertilizer, and soil samples need to be separately addressed for the groups focused on. Sampling methods and analysis preparations differ depending on the microplastic source's origin. Thus, this area needs to be addressed appropriately to obtain the best results. As shown in fig. 26, certain steps of the sample analysis have been conducted with support from other organizations, mainly for plastic polymer identification and related activities where polymer identification equipment is needed. The regional areas suffer from limited facilities, thus this also needs to be addressed.

As shown in fig. 27, most respondents report that they do not sieve samples, even before or after the digestion step. For each analysis, standard protocols need to be put in place and followed, and such steps may be not possible without resorting to the education and training of the relevant staff.

Figure 26. Who analyzes the samples

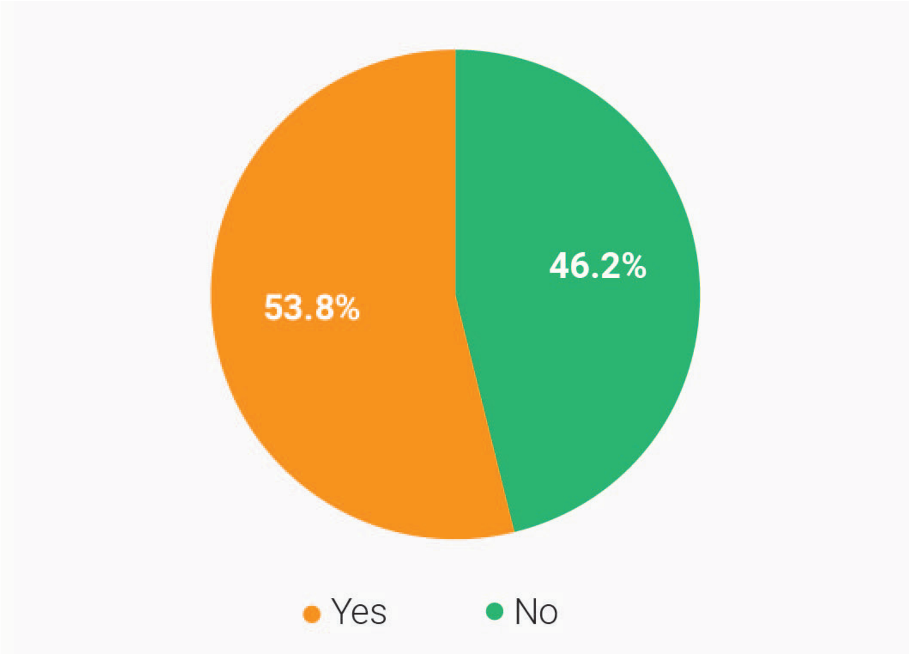
Source: Survey data, February-March, 2022

Figure 27. Sieving of samples

Source: Survey data, February-March, 2022

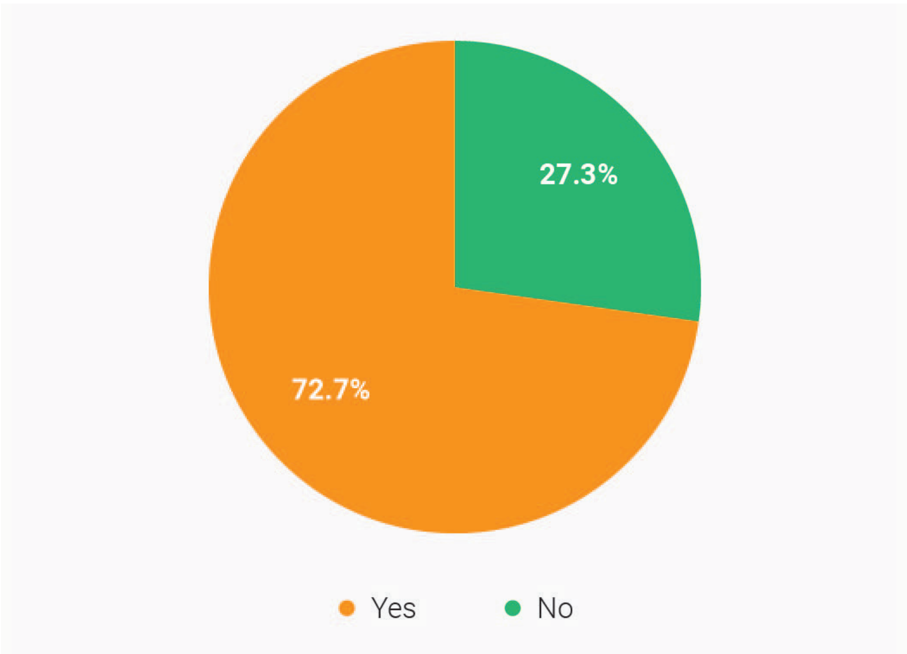
Sample purification often includes density separation for higher density particle separation from microplastics and organic digestion to remove the organics from samples. According to the survey, certain percentages indicate no digestion and/or density separation is conducted. The limited access to chemicals and equipment, and cost-cutting are the common causes behind this. Moreover, the lack of standard protocols for sample purification and data reporting could be other aspects to consider.

Figure 28. Percentage performing digestion of samples



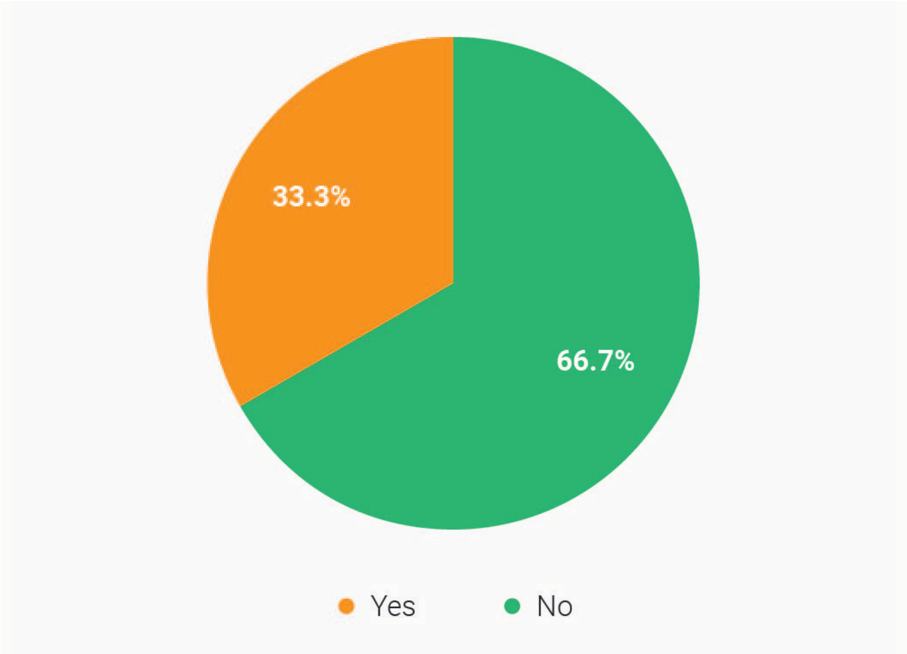
Source: Survey data, February-March, 2022

Figure 29. Percentage performing density separation of samples



Source: Survey data, February-March, 2022

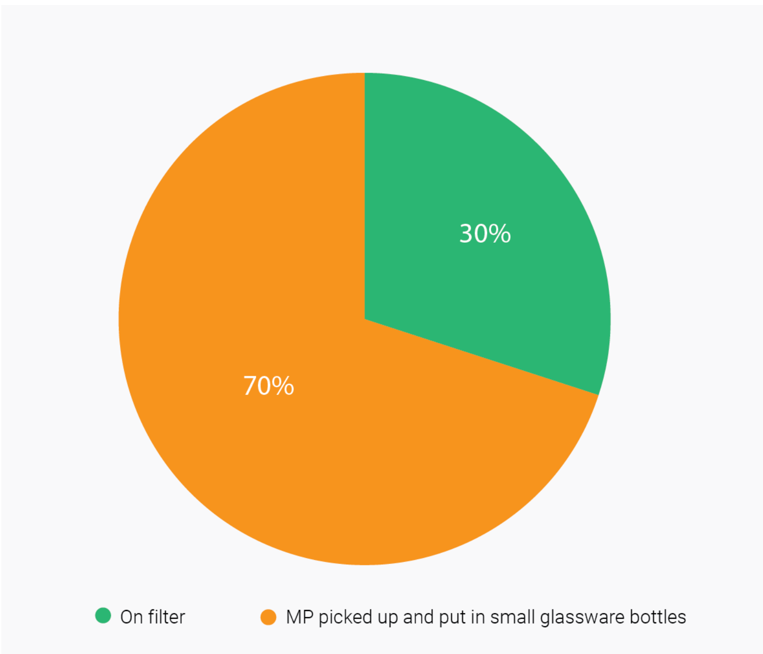
Figure 30. Percentage re-using the density separation solution



Source: Survey data, February-March, 2022

Following the steps mentioned above, respondents analysed the liquid matrix. The samples were then stored in three ways: on filter and microplastic picked up and placed in small glassware bottles. As shown in fig. 31, most respondents (60% of the total) say they keep microplastic samples in small glass bottles.

Figure 31. Percentage performing digestion of samples

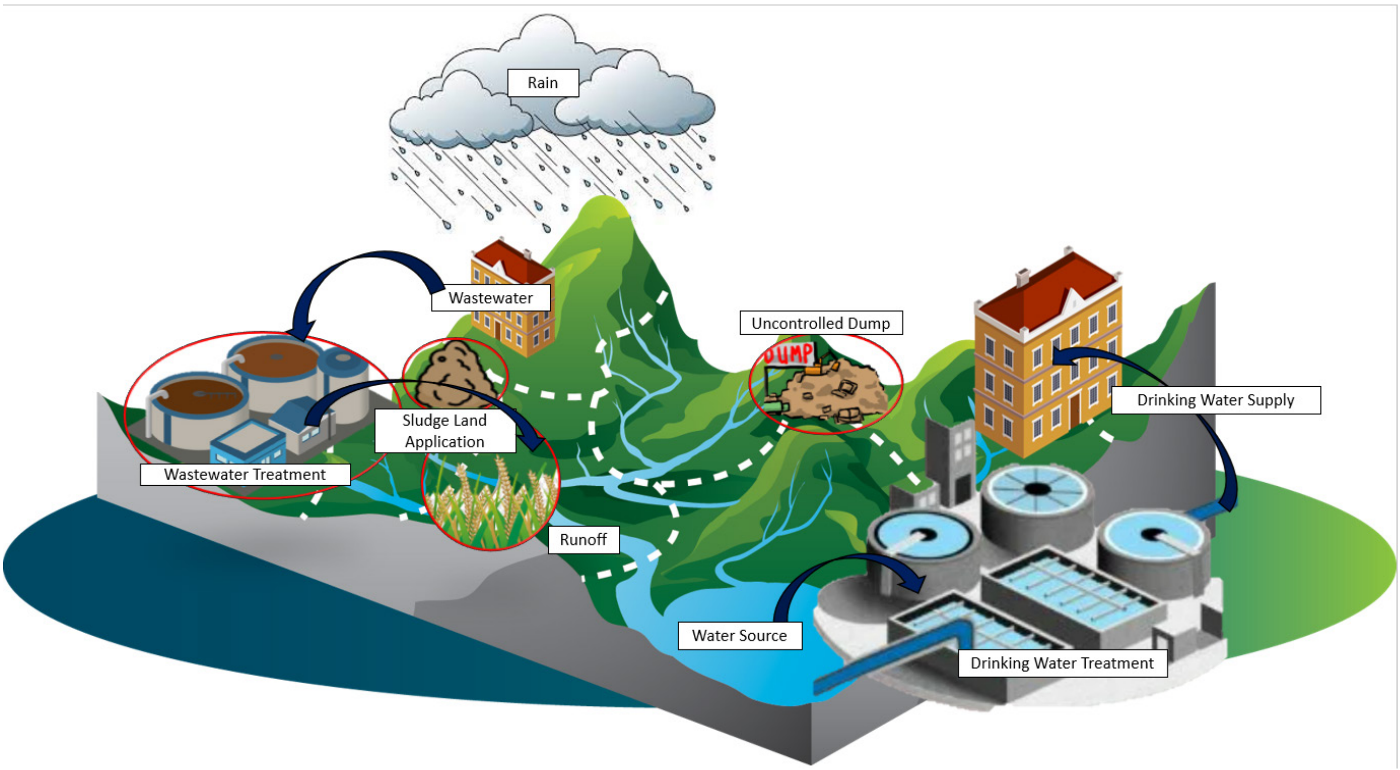


Source: Survey data, February-March, 2022

5.2.3. Field observations

Figure 32 illustrates the observed urban water cycle in Sri Lanka. The KIIs, FG, and field visits revealed that contamination of waste sources is possible with plastics (and microplastics) from waste dumps, etc. Moreover, wastewater treatment plants receive plastics (and microplastics), and the sludge consists of visible potential (since only physical observations were conducted without polymer confirmation) mesoplastics and large-sized microplastics. Further, the presence of microplastics in WWTP sludge is widely documented (Lares et al., 2018; Mohan et al., 2017, Li et al., 2018), hence the present practices of sludge disposal, such as land application, could be a source of microplastics and potentially act as a vector of toxic elements and substances (Igalavithana et al., 2022). Further, the runoff from the WWTP sludge contaminated agricultural land contaminates water resources (Corradini et al., 2019). Therefore, further assessments of the water and wastewater treatment systems and plastic pollution sources affecting drinking water sources and agricultural land need to be carried out. Interdisciplinary coordination and wider awareness of the issues are required to obtain a fuller picture of the situation and engage in action.

Figure 32. Observed common urban water cycle in Sri Lanka



Source: Authors

6. GAPS AND CAPACITIES IDENTIFIED

6.1. Awareness of microplastics

- Many potential stakeholders have low awareness of the presence of plastic pollution in the surrounding environments. Moreover, certain gaps exist in comprehension of the impacts of microplastics.

- Lack of awareness may lead to the lack of attention regarding plastic pollution and microplastics among the potential stakeholder communities, thus potentially hindering their engagement in microplastics monitoring and policymaking processes.

- Most respondents were in favor of having a microplastic monitoring system, which will support preparing a monitoring mechanism and policy recommendations for microplastic-related pollution mitigation.

- Gaps in the comprehension of microplastics identified require addressing through training programs. Such training program needs to be institutionalized, and individual training modules need to be planned in detail, together with the development of supporting resources.

6.2. Knowledge/skills and infrastructure/ facilities for microplastics monitoring

- On an institutional level, the lack of technical knowledge and skills has been identified as one factor behind the lack of monitoring despite monitoring being within a particular organization's scope.

- Current sampling practices depend highly on the available facilities of institutes; if sampling facilities or instruments are absent, sampling and analysis are not considered.

- Proper institutionalization and coordination of facilities and stakeholders for resource sharing and where/how to access resources are essential. Monitoring and policy-making activities need coordination and methods of scientific evidence gathering must be communicated properly to the stakeholders.

- Identify of the role of each institution and different sections within institutions.

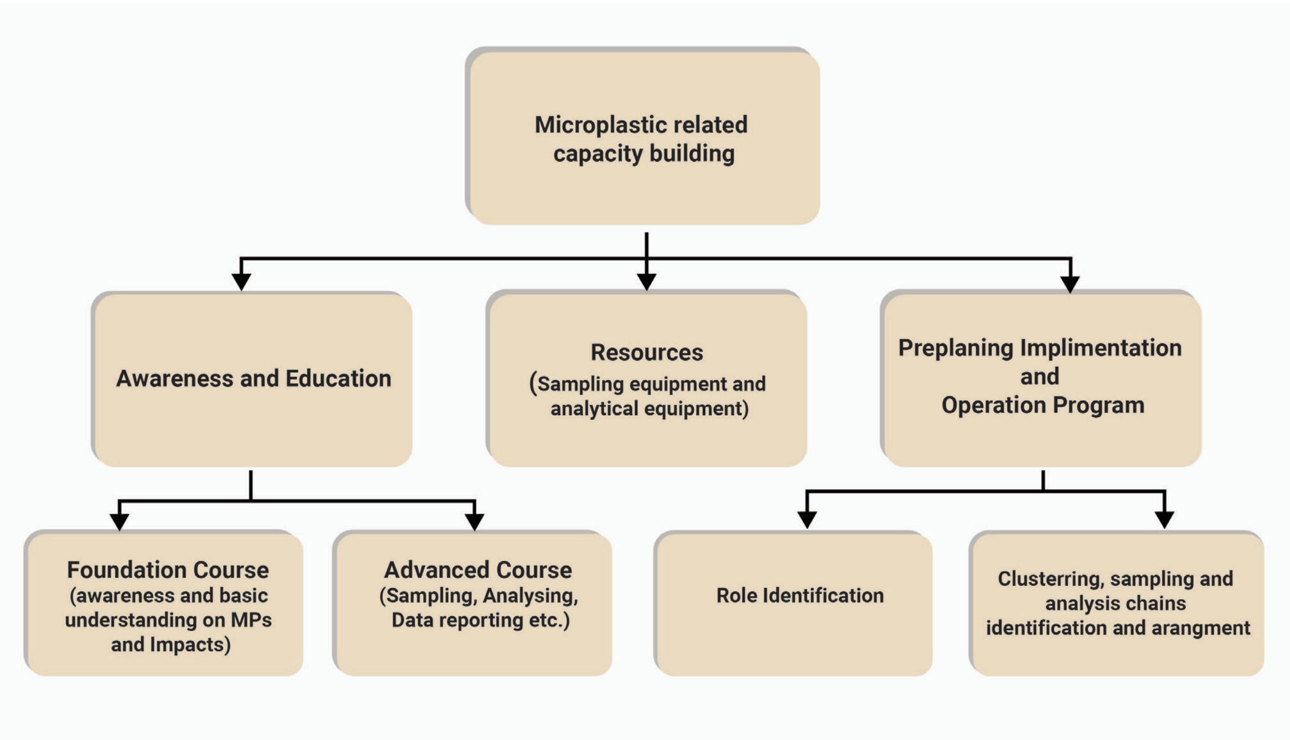
- Lab equipment is available for analysis tasks; however, the scope and channeling of equipment for monitoring programs are currently unclear and thus need to be delineated. MOWS currently lacks micro-Raman/FTIR facilities. While institutional collaboration could resolve this bottleneck during training activities, long-term monitoring programs for drinking water necessitate more concrete provision of facilities.

- Currently, some organizations possess organized laboratory systems, and the national water supply and drainage board has a cluster-based system involving regional and central levels. Capacity-building activities should further strengthen such systems to enable comprehensive island-wide monitoring programs.

7. PROPOSED TRAINING MODULE STRUCTURE

Modules covering basic knowledge on microplastics and targeted training modules on microplastics sampling, analysis, and data reporting need to be developed to achieve the targets. The following diagram illustrates the two-stream conceptual model for capacity building.

Figure 33. Conceptual model for capacity building



7.1. Awareness and Education

7.1.1 Foundation course

Following the above identified needs, a foundation course has been designed to address the gaps in basic understanding of microplastics among policymakers, practitioners, researchers, and academia. This course is limited to the fundamentals and covers the sources of microplastics and their health impacts to enable the required ground-level actions for decision-making to be initiated. The content of the proposed foundation course is given in table 3.

Table 3: Foundation course module

<table>
<tr><th>Module Title</th><th colspan="2">Foundation course on microplastic monitoring and evidence-based policy measures</th></tr>
<tr><td>Duration</td><td colspan="2">One day (355 min. excluding breaks)</td></tr>
<tr><td>Classroom lecture</td><td colspan="2">190 min.</td></tr>
<tr><td>Group exercise and discussion</td><td colspan="2">165 min.</td></tr>
<tr><td>Objectives</td><td colspan="2">To provide a basic understanding of the origin of microplastics, their fate and health impacts, and mitigatory technologies – particularly aimed at policymakers, researchers, laboratory analysts, students, and water practitioners.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="2">On completion of the training, participants will be to:
▪ Explain the origin of microplastics
▪ Recognize the elements, processes, and mechanisms that affect water and soil environments
▪ Explain the health impacts of microplastics
▪ Explain mitigating principles, strategies, and implementation</td></tr>
<tr><td rowspan="6">Outline of Sessions</td><td>1</td><td>Registration and self-introduction of participants</td></tr>
<tr><td>2</td><td>Introduction to the program</td></tr>
<tr><td>3</td><td>Origin of microplastics and adverse health impacts</td></tr>
<tr><td>4</td><td>Recognition of the elements, processes, and mechanisms affecting water and soil environments and mitigatory technologies</td></tr>
<tr><td>5</td><td>Group activities using case studies and group presentations</td></tr>
<tr><td>6</td><td>Discussion, Q&A, Way forward</td></tr>
<tr><td>Recommended Textbooks, Websites, and other resources</td><td colspan="2">1. Wagner, M., & Lambert, S. (2018). Freshwater microplastics: emerging environmental contaminants? (p. 303). Springer Nature.
2. Coffin, S., Wyer, H., & Leapman, J. C. (2021). Addressing the environmental and health impacts of microplastics requires open collaboration between diverse sectors. PLoS Biology, 19(3), e3000932.
3. Galgani, F., Hanke, G., & Maes, T. (2015). Global distribution, composition and abundance of marine litter. In Marine anthropogenic litter (pp. 29-56). Springer, Cham.
4. WHO. Microplastics in drinking-water. Geneva: World Health Organization; 2019. Licence: CC BY-NC-SA 3.0 IGO
5. Igalavithana, A. D., Mahagamage, M. G. Y., Gajanayake, P., Abeynayaka, A., Gamaralalage, P. J. D., Ohgaki, M., ... & Itsubo, N. (2022). Microplastics and Potentially Toxic Elements: Potential Human Exposure Pathways through Agricultural Lands and Policy Based Countermeasures. Microplastics, 1(1), 102-120.
6. EU. Upcoming initiative on microplastics https://ec.europa.eu/environment/topics/plastics/microplastics_en
7. Microplastics Drinking Water | California State Water Resources Control Board https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html</td></tr>
</table>

7.1.2 Advance course: technical staff in the full monitoring chain

Table 4: Advanced course module

Module Title	Advanced course on microplastic monitoring and evidence-based policy measures	
Duration	Four days (1,540 min., excluding breaks)	
Classroom lecture	505 min.	
Group exercise and discussion	1,035 min.	
Objectives	To provide the knowledge needed to understand the origin of micro-plastics, their fate, and health impacts, design experiments, develop analytical methods; conduct detailed investigations for monitoring and mitigatory technologies – aimed particularly at policymakers, researchers, laboratory analysts, students, and water practitioners.	
Learning Outcomes	On completion of the training, participants will be able to: ▪ Describe and trace the origin of microplastics ▪ Recognize the elements, processes, and mechanisms that affect the water and soil environment ▪ Explain and research on the health impacts of microplastics ▪ Describe and implement mitigating principles, strategies, and implementation ▪ Gain hands-on experience in sampling, pre-treatment, analysis, and data reporting ▪ Design and conduct detailed monitoring programs on microplastics	
Outline of Sessions	1	Registration and self-introduction of participants
	2	Introduction to the program
	3	Origin of microplastics and adverse health impacts
	4	Recognizing the elements, processes, and mechanisms that affect the water and soil environment, and mitigatory technologies
	5	Group activities using case studies and group presentations
	6	Field visit (Introduction followed by hands-on experience) 1. Identification of sampling points 2. Sampling methods-Water (depth, bottom), Soil 3. Preservation methods 4. Transportation to laboratory
	7	Laboratory analysis (Introduction followed by hands-on experience) 1. Sample preparation 2. Introduction to analytical instrument operation (micro-Raman and micro-FTIR), troubleshooting 3. Sample measurements, QC, and data analysis
	8	Test report preparation and data reporting
	9	Presentation based on case studies
	10	Identification of policies for microplastics in different countries
	11	Discussion, Q&A, Way forward
Recommended Textbooks, websites and other material	1. Rochman, C.M., Brookson, C., Bikker, J., Djuric, N., Earn, A., Bucci, K., Athey, S., Huntington, A., McIlwraith, H., Munno, K. and De Frond, H., 2019. Rethinking microplastics as a diverse contaminant suite. Environmental toxicology and chemistry, 38(4), pp.703-711. 2. Jenkins, T., Persaud, B.D., Cowger, W., Szigeti, K., Roche, D.G., Clary, E., Slowinski, S., Lei, B., Abeynayaka, A., Nyadjro, E.S. and Maes, T., 2022. Current State of Microplastic Pollution Research Data: Trends in Availability and Sources of Open Data. Frontiers in Environmental Science, p.824.	

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7.2. Resources (sampling equipment and analytical equipment)

Table 5: Analytical equipment

No	Apparatus	Purpose
1	Micro-FTIR/Micro-Raman	Polymer charactetization of microplastics in drinking water and other mediums (small range)
2	FTIR	Polymer charactetization of microplastics
3	STEREO microscope	Size, shape etc. observations

7.2.1. Apparatus and materials for water analysis (saline and freshwater)

Table 6: Apparatus for water analysis

No	Apparatus	Purpose
1	Surface net (0.335 mm)	Collection of microplastic debris (hard plastics, soft plastics/foams, films, line, fibers, sheets) as suspended solids in water
2	Stainless steel sieve (8 in. diameter, 2 in. depth); ➢ 5.6 mm mesh (Number 3.5) ➢ 1 mm mesh (Number 18) ➢ 0.3 mm mesh (Number 50)	➢ Collecting <5 mm size microplastics ➢ Collecting 1–5 mm size microplastics ➢ Collecting 0.3–1 mm size microplastics
3	Customized small sieve (59 mm diameter) fitted into polypropylene Buchner funnel; ➢ 5 mm size nylon mesh ➢ 1 mm size nylon mesh ➢ 0.3 mm size nylon mesh	➢ Collecting <5 mm size microplastics ➢ Collecting 1–5 mm size microplastics ➢ Collecting 0.3–1 mm size microplastics
4	Analytical balance	Weighing samples for gravimetric analysis
5	Drying oven (90°C)	Sample drying
6	Chemical solutions: ➢ 0.05 M Iron Fe(II) solution ➢ 30% Hydrogen peroxide ➢ Sodium chloride	➢ Catalyst for digesting labile organic matter ➢ Oxidizing natural organic matter ➢ Solid materials of microplastic debris float in this solution, giving positive visual inspection under microscope (40X)
7	Laboratory hotplate	Sample heating
8	Density separator (Glass funnel 122 mm diameter fitted with 50 mm segment of latex tubing)	Plastic separation
9	Dissecting microscope (40× magnification)	Microplastic analysis
10	Other accessories; ➢ 500 mL glass beaker ➢ Squirt bottle with distilled water ➢ Metal spatula ➢ Stir bar ➢ Watch glass ➢ Standard metal forceps ➢ Retort stand, O-ring, spring clamp (2 inch), aluminum foil ➢ 4 mL glass vials	➢ Sample transfer ➢ Sample rinsing and removal of residual solids and salts ➢ Sample transfer ➢ Microscopic measurement ➢ Sample stand and sample preparation ➢ Microscopic measurement

7.2.2. Apparatus and materials for beach sand analysis

Table 7: Apparatus for sand sample analysis

No	Apparatus	Purpose
1	Shovel/spade	Collecting microplastic debris (hard plastics, soft plastics/foams, films, line, fibers, sheets) as suspended solids in beach sand
2	Customized small sieves (59 mm diameter) fitted into polypropylene Buchner funnel; ➢ 5 mm size nylon mesh ➢ 1 mm size nylon mesh ➢ 0.3 mm size nylon mesh	➢ Collecting <5 mm size microplastics ➢ Collecting 1–5 mm size microplastics ➢ Collecting 0.3–1 mm size microplastics
3	Analytical balance	Weighing samples for gravimetric analysis
4	Drying oven (90°C)	Sample drying
5	Chemical solutions; ➢ Lithium meta-tungstate solution and Sodium chloride solution ➢ 0.05 M Iron Fe(II) solution ➢ 30% Hydrogen peroxide	➢ Solid materials of microplastic debris float in this solution, enabling positive visual inspection under microscope (40×) ➢ Catalyst for digesting labile organic matter ➢ Oxidizes natural organic matter
6	Laboratory hotplate	Sample heating
7	Density separator (Glass funnel 122 mm diameter fitted with 50 mm segment of latex tubing)	Separating plastics
8	Dissecting microscope (40× magnification)	microplastic analysis
9	Other accessories; ➢ 800 mL and 500 mL glass beakers ➢ Squirt bottle with distilled water ➢ Metal spatula ➢ Stir bar ➢ Watch glass ➢ Standard metal forceps ➢ Retort stand, O-ring, spring clamp (2 inch), aluminum foil ➢ 4 mL glass vials	➢ Sample transfer ➢ Rinsing samples to remove residual solids and salts ➢ Sample transfer ➢ Microscopic measurement ➢ Sample stand and sample preparation ➢ Microscope measurements

7.2.3. Apparatus and materials for bed sediment analysis

Table 8: Apparatus for bed sediment analysis

No	Apparatus	Purpose
1	Corer/grab sampler (Ponar sampler)	Collecting microplastic debris (hard plastics, soft plastics/foams, films, line, fibers, sheets) as suspended solids in bed sediments
2	Customized small sieves (59 mm diameter) fitted into polypropylene Buchner funnel; ➢ 5 mm size nylon mesh ➢ 1 mm size nylon mesh ➢ 0.3 mm size nylon mesh	➢ Collecting <5 mm size microplastics ➢ Collecting 1–5 mm size microplastics ➢ Collecting 0.3–1 mm size microplastics
3	Analytical balance	Weighing samples for gravimetric analysis
4	Drying oven (90°C)	Sample drying
5	Chemical solutions; ➢ Lithium meta-tungstate solution and Sodium chloride solution ➢ 0.05 M Iron Fe(II) solution ➢ 30% Hydrogen peroxide ➢ Potassium meta-phosphate	➢ Solid materials of micropalstic debris float in this solution, enabling positive visual inspection under microscope (40X) ➢ Catalyst for digesting labile organic matter ➢ Oxidizes natural organic matter ➢ Disaggregates dried bed sediment
6	Laboratory hotplate	Sample heating
7	Density separator (Glass funnel 122 mm diameter fitted with 50 mm segment of latex tubing)	Separating plastics
8	Dissecting microscope (40× magnification)	Micropalstic analysis
9	Other accessories; ➢ 800 mL and 500 mL glass beakers ➢ Squirt bottle with distilled water ➢ Metal spatula ➢ Stir bar ➢ Watch glass ➢ Standard metal forceps ➢ Retort stand, O-ring, spring clamp (2 inch), aluminum foil ➢ 4 mL glass vials	➢ Sample transfer ➢ Rinsing samples to remove residual solids and salts ➢ Sample transfer ➢ Microscopic measurement ➢ Sample stand and sample preparation ➢ Microscopic measurement

7.3. Pre-planning, implementation, and operation program

7.3.1. Role identification in a monitoring lab

Table 9: Postions and roles

No	Position	Role
1	Field/Lab assistant	Sampling, preservation, and transport to laboratory
2	Lab technician/Technical Officer	Pre-treatment and sample preparation for analysis
3	Analyst/Chemist/Research Assistant	Sample analysis, QC, and data reporting
4	Senior Chemist/Scientist	Interpretation of data and authorization of lab reports
5	Administrator/Manager	Policymaking for mitigating pollution from microplastics
6	Academia	Develop curricula at various levels to include details on microplastics
7	Researchers	Collaborate with local/international research partners to secure further research funding for related areas and conduct advanced investigations

7.3.2. Clustering

The National Water Supply and Drainage Board, Sri Lanka (NWSDB), the sole government institute responsible for supplying safe piped water in urban and peri-urban areas of Sri Lanka, maintains over 30 laboratories around the country. NWSDB regional laboratories are present almost in every district, with more in areas of higher population density or supply coverage. The main laboratory is located at its head office, in Rathmalana. Over 50 trained, well-qualified chemists perform daily duties related to these laboratories, ensuring water quality is maintained consistently. Further, a recently established advanced laboratory (JRDC) under the Ministry of Water Supply in Peradeniya, provides assistance and coordination for these laboratories in advanced testing. Hence, developing facilities for testing microplastic at the JRDC offers a highly effective and efficient way to commence testing in Sri Lanka's water sector. Expertise developed in this way will gradually filter down to other regional laboratories, thus addressing the testing requirement for all water supply schemes under the NWSDB, which currently number over 340. Hence, clustering laboratories based on provincial boundaries offers the most efficient and productive route to launching the program island-wide.

7.3.3. Sampling and analysis chains identification and arrangement

The training program for sampling, analysis, and data reporting must target the selected institutes during the TNA. The modules need to be planned in detail, with essential/pertinent supporting documents such as reading materials developed for the components given below.

- **Selection of sampling locations and sampling methods for drinking water, environmental water, biota, bed sediment, beach sand, and soil to be guided.**

Sampling locations can be selected according to institutional requirements (such as highly polluted areas) by studying land use maps, surface water bodies near waste dump sites, busy beaches, river salinity gradients, and other surface water bodies. Sample collection for microplastics in water can be performed using a surface net with a 0.335 mm mesh. For beach sand sample collection, a shovel or spade can be used, and for the ocean or river bed sample collection, a corer or grab sampler (Ponar sampler) can be used. Plastics found will likely comprise hard and soft plastics, films, lines, fibers, and sheets shapes.

- **Pretreatment and transportation of samples under the required conditions.**

After water sample collection, nets are rinsed with DI water into glass bottles or beakers for transportation to the lab. Soil samples are collected to zip bags.

- **Selection and development of analytical methods for microplastics in water and soil.**

Further particle size separation of microplastic samples can be performed in labs via wet sieving with appropriate sieves of sizes 5.6 mm, 1 mm, and 0.3 mm. The dried weight of the sieved material is measured (0.3 mm sieve). The labile organic matter is digested by wet peroxide oxidation (30% hydrogen peroxide) (WPO) in the presence of a 0.05 M Fe (II) catalyst. The remaining plastic debris is separated by density separation in 5 M NaCl (aq) (d=1.15 g/mL) or 5.4 M lithium meta-tungstate (d=1.62 g/mL) solution through flotation. Analyzing microplastics in bed sediments involves an initial disaggregation of dried bed sediments by adding 5.5 g/L potassium meta-phosphate.

- **Identification and quantification of plastic polymers, their state, and potential risk.**

Floating plastic debris is collected in the density separator to a 4 mL vial for examination under a dissecting microscope at 40× magnification. Analytical instruments such as micro-FTIR and micro-Raman can be used to determine the chemical morphology of the microplastics collected.

- **Institutionalization of monitoring and policy-making activities.**

NWSDB is highly recognized for its ongoing efforts in applying Water Safety Plans (WSP) throughout the island. Likewise, Sri Lanka has received recognition and support in various forms by the World Health Organization (WHO) to strengthen this process. Hence, the Ministry of Water Supply and Ministry of Health work together under the gazetted ordinance to enable a smooth channel for all policy-making activities, from the grass-roots to decision-making levels. Conversely, decisions can also be implemented back at the ground level, through the well-established WSP implementation mechanism which encounters all possible means of contamination, from catchment to consumer.

- **Methods used in data analysis and reporting with the minimum information**

Data generated at JRDC will be analyzed using standard statistical software to produce monthly reports for the NWSDB head office and ministries through the WSP auditing process, thus ensuring decisions can be made by putting into place adequate control measures at various stages, following the multibarrier approach. This mechanism will be entrusted by WHO through its external formal auditing mechanism, firmly established since its inception three years ago.

- **Use of appropriate data sharing platforms and citizen science data**

The presenters' guide, participants' handbooks and PowerPoint presentations for different sessions arranged as 1-day and 3-day programs for foundation and advanced courses respectively will be developed for the follow-up awareness and training programs.

At present, there is no institutionalized mechanism to gather and report microplastics-related information. Further, no national-level datasets, research publication repositories, or databases focusing on microplastics exist.

Effective data reporting with the minimum information, appropriate units, data-sharing platforms, citizens' science data usage, etc., all need to be addressed through this program. To this end, standard reporting and monitoring systems need to be developed. The following five key strategies for advancing good research data management practices in microplastic research shall be used as a guideline to prepare the institutional and national databases and scientific publications (Jenkins et al., 2022):

1. Use available standards/practices to describe data
2. Share raw data – or as close to raw as possible
3. Use a trusted digital repository
4. Link datasets to publications
5. Plan to share data from the onset of a study

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Conclusions

This work examined the public awareness of microplastics in Sri Lanka, their entry modes to the environment, pollution status, social status, monitoring, and research needs to sustain a healthy environment. Most Sri Lankan communities are unaware of microplastic pollution and its environmental hazards. Microplastics are ubiquitous in the environment and intimately associated with the population's lifestyles, and the threat they represent to wildlife and human life is alarming. However, the detection of microplastics in the environment is a specialized task. Further, no systematic monitoring and regulatory programs exist to assess the current status of microplastic pollution geared to safeguarding the environment. Research publications and other awareness programs on microplastic pollution are sporadic in Sri Lanka. Knowledge of the deleterious effects of microplastics on ecosystems needs to be imparted into curricula at the tertiary education level. The ubiquity of microplastics in the land, and fresh and marine aquatic environments of Sri Lanka represents a serious threat to overall ecosystems and potentially hazardous conditions to the public and wildlife. Some Sri Lankan laboratories are equipped with research-grade Raman and IR measuring sensors for other activities. However, the inadequacy of sample collection and preparation facilities requires serious consideration toward establishing dedicated monitoring facilities for microplastics according to standard laboratory norms. Such facilities can be integrated with global microplastic monitoring programs in later stages.

Based on the above findings, the following can be recommended:

1. Develop an empirical budgeting model based on microplastic imports and distribution into different sectors in Sri Lanka. Theme models can be extended at the life cycle analysis-level of microplastics in the latter stage.
2. Develop awareness programs on the deleterious effects of microplastics on ecosystems. Programs can be designed in two modes: entry and professional awareness. The professionals will act as a nucleus for strengthening future awareness programs.
3. Incorporation of the threat of microplastics into primary-, secondary- and tertiary-level curricula.
4. Develop general public awareness programs utilizing modern technologies and social media.
5. Develop professional training programs for professionals by means of certified courses workshops, etc.
6. Establish a centralized microplastic laboratory facility with dedicated equipment.
7. Establish sample collection and processing centers at the regional level for microplastic monitoring in waters.
8. Establish a network of national institutions to assess the status of microplastics in Sri Lanka optimizing human and other resources.

8.2. Proposed Framework of the Curriculum

Table 10: Summary of the courses

Description	Foundation	Advanced
What	Definition of microplastics (size, origin, etc.); Presence of microplastics in the environment and other systems; Different types of microplastics; Potential impacts of microplastics	Sampling Sample preparation Analytical equipment (FTIR; Microscope, etc.)
Who	All potential stakeholders (targeting monitoring and policy advice); Further, explore engagement with policymakers (ideally, to cover various disciplines across the chain)	Technical staff assumed to be engaged in the monitoring program
How	On-site/hybrid (online/on-site); On demand web (i.e., YouTube videos)	On-site Resource bank (online videos, other resource materials)
Whom	National/Regional/International experts, teaching staff	National/Regional/International experts, teaching staff
Where	JRDC Premises/JRDC website/ IGES-CCET website; Other institutes (TBD)	JRDC Premises; Other institutes (TBD)
Time Duration (hrs)	8	24

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Annexure 1: Questionnaire

Questionnaire Survey on Microplastic-related Pollution and its' impacts on Ecosystems and Human Health in Sri Lanka

Microplastics is the small plastic pieces less than five millimeters (0.2 inches) in length. At present, microplastic-related pollution and its' impacts on ecosystems and potential human health impacts are widely discussed around the world. To take appropriate and effective countermeasures to control the impacts of microplastics, monitoring and scientific evidence-based policy measures are necessary. These require certain facilities such as sampling devices and analytical equipment and skilled technical staff. Therefore this questionnaire survey intends to collect the present situation of various potential stakeholders in government, academia, private and other organizations in the context of microplastic sampling and analysis related facilities and skills and identify the facility and training-related capacity needs, the available resources, and potentials of contributing to future capacity-building activities and national strategic plans of monitoring and science-based policy-making process.

For Inquiries:

- lakmal.ja@nifs.ac.lk Dr. Lakmal Jayarathna, *Research Fellow, National Institute of Science, Kandy, Sri Lanka*
- madhu10w@yahoo.com Dr. Madubashini Makehelwala, *Senior Chemist, China Sri Lanka Research Grant Project, Ministry of Water Supply, Sri Lanka*
- abeynayaka@iges.or.jp Dr.Amila Abeynayaka, *Institute for Global Environmental Strategies, Japan.*
- mallikap@pdn.ac.lk Prof. Mallika Pinnawala, *Department of Sociology, Faculty of Arts, University of Peradeniya, Peradeniya, Sri Lanka.*

Confidentiality of data is guaranteed

A. Organization background

1. Name of the Organization:
   ………

2. Address:
   ……….

3. Province:
   - ☐ Southern
   - ☐ Western
   - ☐ Uwa
   - ☐ Northern
   - ☐ North Central
   - ☐ Eastern
   - ☐ Central
   - ☐ Sabaragamuwa
   - ☐ North Western

4. Name and the Position of the Respondent:
   ………
5. Email:
   ………

6. Phone number: ………………………………………………

7. Your organization is a
   - ☐ Government institute
   - ☐ University or similar educational institute
   - ☐ Private laboratory
   - ☐ Other (please describe) ………………………………………………………….

8. The organization's work scope is on (please answer especially if you are a sector). Please select one or more relevant answers.
   - ☐ Drinking water (public water supply)
   - ☐ Fresh water (river, lake, etc.)
   - ☐ Marine and coastal environments
   - ☐ Wastewater and sludge
   - ☐ Industrial pollution
   - ☐ Agriculture (Soil/Fertilizer/Irrigation water)
   - ☐ Food and beverages quality
   - ☐ Other (please describe) ………………………………………………………….

9. Does your organization involve quality assurance/monitoring or policyma answer especially if you are a government sector). Please select one or m answers.
   - ☐ Quality assurance
   - ☐ Monitoring
   - ☐ Policymaking
   - ☐ Other (please describe) ………………………………………………………….

B. Opinion of Plastic Pollution and Microplastics

1. Do you see plastic pollution in the area where you are living?
   - ☐ Everywhere
   - ☐ Most areas
   - ☐ Few areas
   - ☐ Nowhere

2. Do you think microplastics are a problem for: (tick the boxes you agree with
   - ☐ Aquatic creatures (fish, dolphins, plankton, etc.)
   - ☐ Human health
   - ☐ Animal live inland
   - ☐ Small animals live in the soil
   - ☐ No evidence
   - ☐ I have no idea

3. How can microplastics get into human body (tick the boxes you agree with)?
   - ☐ Eating foods (eating contaminated fish, etc.)
   - ☐ Drinking tap water
   - ☐ Eating food in plastic containers
   - ☐ Drinking bottled water
   - ☐ Cosmetic and Personal care products
   - ☐ Other way (please specify) ……………………….
   - ☐ I do not know much about this
   - ☐ Microplastic will not enter the human body

4. Do you think microplastics in the environment need to be monitored?
   - ☐ Yes
   - ☐ No
   - ☐ Yes, but in Sri Lanka, it is not practical
   - ☐ I do not know

   If yes why ....
   If not why ....

5. If you mentioned YES to question 6, where do we need to monitor microplastics (tick the boxes you agree with)?
   - ☐ Water environments (rivers, ocean, etc.)
   - ☐ Drinking water (Tap water)
   - ☐ Bottled water
   - ☐ Wastewater and wastewater sludge
   - ☐ Compost and other fertilizer
   - ☐ Agricultural soil
   - ☐ Other (please write ....)

6. State your opinion about microplastics (tick the boxes you agree with)?
   - ☐ To get rid of microplastics, we should immediately ban all plastics
   - ☐ Replace all the plastic products with bioplastics, this will solve the issue
   - ☐ Monitoring of microplastics in water, fertilizer, etc. to collect information, and then implement policy measures.
   - ☐ I do not agree with any of the above.

   If you are not agreed give reasons
   ....

C. Research activities

1. Does your organization already work on the topic of microplastic in the environment?
   - ☐ Yes since which year (.........................)
   - ☐ No

   If yes, what are the objectives of analyzing microplastics?
   ....
   ....
   ....

2. In which compartment are you measuring/studying microplastics
   - ☐ Freshwaters (river, lake, etc.)
   - ☐ Marine waters
   - ☐ Sediment
   - ☐ Biota (fish, plants, etc.,)
   - ☐ Wastewater
   - ☐ Soil
   - ☐ Atmospheric fallouts
   - ☐ Food

3. Did your lab publish international papers on microplastics?
   - ☐ Yes.
   - ☐ No

   If yes, please provide a few references.

   ....

   ....

4. Did your lab publish national papers on microplastics? Please provide references
   - ☐ Yes.
   - ☐ No

   If yes, please provide a few references.

   ....

   ....

5. Did your lab provide reports to government bodies and/or private organization and/or other organization on microplastics in different compartments?
   - ☐ Yes.
   - ☐ No

   If yes what are those organizations?

   ....

   ....

   ....

D. Sampling

1. Who is performing the sampling?
   - ☐ Staff from your lab/university/institute
   - ☐ You are subcontracting to staff from another lab/university/institute

   (If you subcontract, please provide the institute name:

   ....

2. What kind of equipment are you using? Please specify the reference for each
   - ☐ Boat
     Does your lab own this equipment? ☐ Yes; ☐ No
   - ☐ Net (type and mesh size: ....)
     Does your lab own this equipment? ☐ Yes; ☐ No
   - ☐ Core-sampler
     Does your lab own this equipment? ☐ Yes; ☐ No
   - ☐ Pump
     Does your lab own this equipment? ☐ Yes; ☐ No
   - ☐ Spatula
     Does your lab own this equipment? ☐ Yes; ☐ No
   - ☐ Others:
     Does your lab own this equipment? ☐ Yes; ☐ No

3. For water sampling, what is the sampling depth?
   - ☐ From the surface
   - ☐ From subsurface (10cm)
   - ☐ Other depth:

4. For water sampling, how long is the sampling duration? ………min …………hours

5. For sediment sampling, what is the sampling depth?
   - ☐ 0-5cm
   - ☐ 0-10 cm
   - ☐ Others:

6. For wastewater treatment plants, which kind of sampling locations?
   - ☐ Intake
   - ☐ Inside the wastewater treatment plant
   - ☐ Wastewater treatment plant sludge
   - ☐ Other (please specify ……………………….).

7. For agriculture and food-related sampling, which kind of locations are you focussing on?
   - ☐ Fertilizer (in general)
   - ☐ Compost
   - ☐ Anaerobic digestate and other wastewater treatment plant sludge disposing into agricultural land
   - ☐ Agricultural land (Soil)
   - ☐ Other (please specify ……………………….).

8. What kind of information are you writing in your notebook during sampling?
   - ☐ Date and time
   - ☐ Location
   - ☐ Sampling duration
   - ☐ Sampling condition
   - ☐ Weather
   - ☐ Other information

E. Laboratory analysis for liquid matrix

1. Who is performing the laboratory analysis?
   - ☐ Staff from your lab/university/institute
   - ☐ You are subcontracting to staff from another lab/university/institute

2. Sieving step: Are you sieving the sample?
   - ☐ Before the digestion step
     - Which equipment and glassware are you using?
   - ☐ After the digestion step
     - Which equipment and glassware are you using?
   - ☐ No

3. Digestion step: Are you performing digestion of your sample?
   - ☐ No
   - ☐ Yes:
     - Which reagents are you using?
     - Which glassware are you using?
     - Which equipment are you using?
       - ☐ Heating plate
       - ☐ Stirrer
       - ☐ Micropipette
       - ☐ Others
     - Duration and temperature:
4. Density separation step: Are you performing a density separation of your sample?
   - ☐ No
   - ☐ Yes:
     - Which salt and reagents are you using?
     - Which glassware are you using?
     - Which equipment are you using?
       - ☐ Separating funnel
       - ☐ Centrifugation
       - ☐ Others
     - Are you re-using the density separation solution?
       - ☐ Yes: how many times
       - ☐ No

5. Filtration step: Are you performing a filtration of your sample?
   - ☐ No. How do you separate the microplastic from the sample?
   - ☐ Yes:
     - Which glassware are you using?
     - Which equipment are you using?
       - ☐ Pump
       - ☐ Others
     - Which filters are you using?

6. Storage of sample. How do you keep the analysed sample?
   - ☐ On filter
   - ☐ MiP picked up and put in small glassware bottles
   - ☐ Others

F. Laboratory analysis for solid matrix (sediment, biota)

1. Who is performing the laboratory analysis?
   - ☐ Staff from your lab/university/institute
   - ☐ You are subcontracting to staff from another lab/university/institute

2. Sieving step: Are you sieving the sample?
   - ☐ Before the digestion step
     - Which equipment and glassware are you using?
   - ☐ After the digestion step
     - Which equipment and glassware are you using?
   - ☐ No

3. Digestion step: Are you performing digestion of your sample?
   - ☐ No
   - ☐ Yes:
     - Which reagents are you using?
     - Which glassware are you using?
     - Which equipment are you using?
       - ☐ Heating plate
       - ☐ Stirrer
       - ☐ Micropipette
       - ☐ Others
     - Duration and temperature:
4. Density separation step: Are you performing a density separation of your sample?
   - ☐ No
   - ☐ Yes:
     - Which salt and reagents are you using?
     - Which glassware are you using?
     - Which equipment are you using?
       - ☐ Separating funnel
       - ☐ Centrifugation
       - ☐ Others
     - Are you re-using the density separation solution?
       - ☐ Yes: how many times
       - ☐ No
5. Filtration step: Are you performing a filtration of your sample?
   - ☐ No. How do you separate the microplastic from the sample?
   - ☐ Yes:
     - Which glassware are you using?
     - Which equipment are you using?
       - ☐ Pump
       - ☐ Others
     - Which filters are you using?
6. Storage of sample. How do you keep the analysed sample?
   - ☐ On filter
   - ☐ MiP picked up and put in a small glassware bottles
   - ☐ Others

G. Observation of microplastic

1. Who is performing the observation?
   - ☐ Staff from your lab/university/institute in your lab/university/institute
   - ☐ Staff from your lab/university/institute in another lab/university/institute
   - ☐ You are subcontracting to staff from another lab/university/institute
2. Which equipment are you using to observe? Please provide details

   ……………………………………………………………

3. What is your observation size range?

....

4. Which shape category are you using?
   - ☐ Fibber/Filament
   - ☐ Fragment
   - ☐ Pellet
   - ☐ Film
   - ☐ Foam

5. Are you measuring the length of fibber?
   - ☐ Yes
   - ☐ No

6. Are you measuring the diameter of fibber?
   - ☐ Yes
   - ☐ No

7. Are you measuring the area of other shapes?
   - ☐ Yes
   - ☐ No

8. Are you recording the color? Which color category are you using?
   - ☐ No
   - ☐ Yes:

     ☐ Red; ☐ Blue; ☐ Black; ☐ White; ☐ Grey; ☐Green; ☐ Yellow; ☐ others: ....

9. Which units are you using to present the data

   Water: ☐ item m^{-3}
   - ☐ item L^{-1}
   - ☐ g m^{-3}
   - ☐ g L^{-1}

   Sediment:
   - ☐ item m^{-2}
   - ☐ item m^{-3}
   - ☐ item kg^{-1}
   - ☐ item g^{-1}
   - ☐ g m^{-2}
   - ☐ g m^{-3}
   - ☐ g kg^{-1}
   - ☐ g g^{-1}
   - ☐ item kg^{-1}

   Biota:
   - ☐ item g^{-1}
   - ☐ item $individual^{-1}$
   - ☐ g kg^{-1}
   - ☐ g g^{-1}
   - ☐ g $individual^{-1}$

H. Nature of microplastic

1. Who is performing the analysis and determination of plastic polymers?
   - ☐ Staff from your lab/university/institute in **your lab**/university/institute
   - ☐ Staff from your lab/university/institute in **another lab**/university/institute
   - ☐ You are subcontracting to staff from another lab/university/institute

2. Are you performing it for
   - ☐ 100% of plastic observed
   - ☐ 50% of plastic observed
   - ☐ 10% of plastic observed
   - ☐ 1% of plastic observed
   - ☐ Other percentage or strategy?

3. Which technique and instrument are you using?
   - ☐ Microscopy coupled to FTIR
   - ☐ Microscopy coupled to Raman
   - ☐ FTIR spectrometry
   - ☐ FTIR-ATR spectrometry
   - ☐ µFTIR spectrometry
   - ☐ Raman spectrometry
   - ☐ µRaman spectrometry
   - ☐ LDIR
   - ☐ Thermal analysis (pyro-GC/MS)
   - ☐ Fouracene dye coupled with microscopy
   - ☐ Other (please specify ……………………..).

4. Does your lab own this equipment?
   - ☐ Yes
   - ☐ No:
     - ☐ You are renting it and paying for the use
     - ☐ You are borrowing it (for free)

Any other information that you need to share with us

……

……

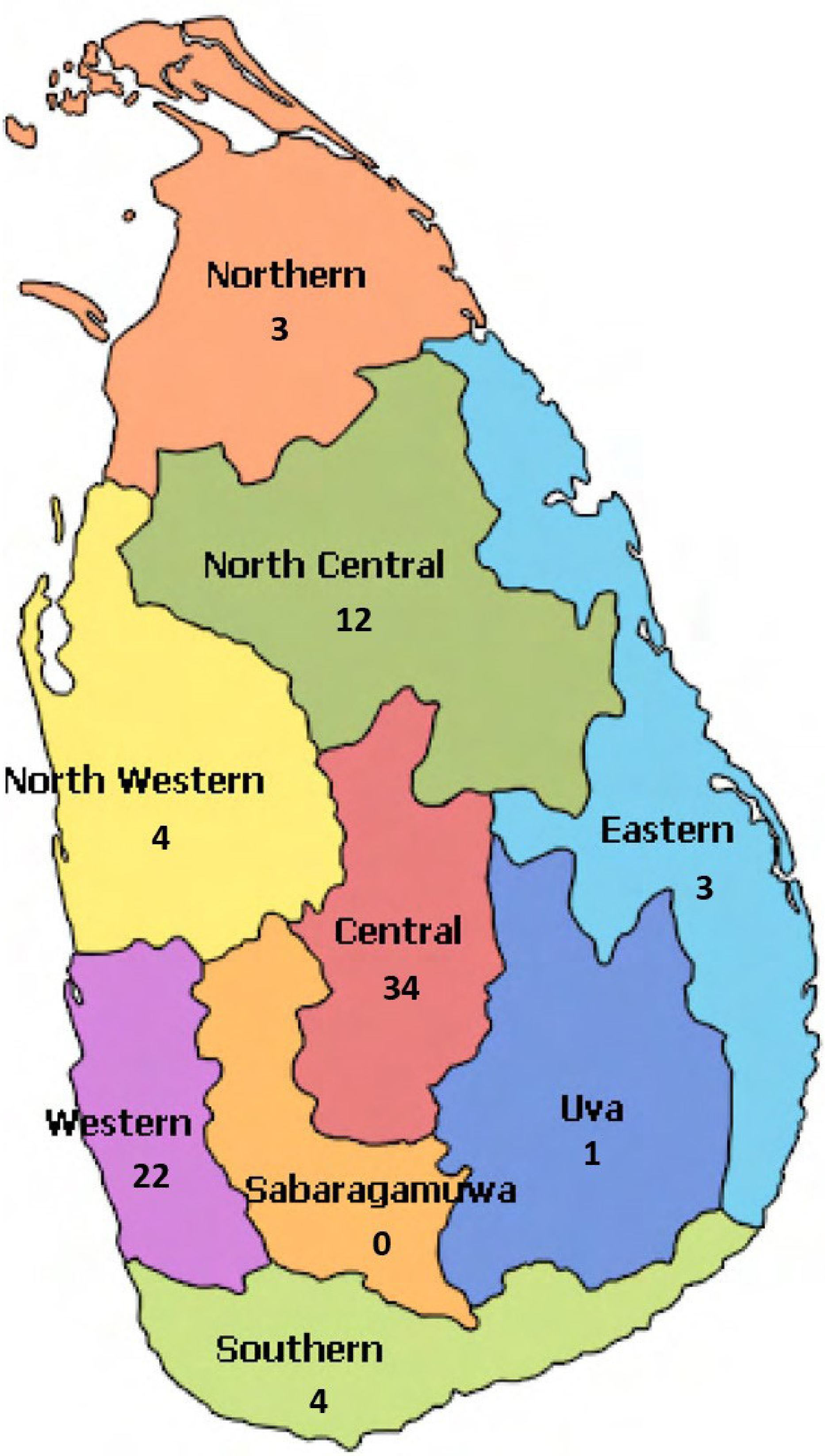
……

……

Thank you for your time!

Annexure 2: Map of the research area

(Based on the provinces in Sri Lanka)



Annexure 3: Working Group

Institute for Global Environmental Strategies (IGES)

Dr. Premakumara D. G. J. (International Consultant)
Dr. (Eng.) Abeynayaka A. (International Consultant)

Joint Research Demonstration Center for Water Technology (JRDC)

Dr. (Eng.)Weragoda S. K. (Water supply and wastewater treatment expert)
Dr. Makehelwala S. A. M. (Seniour Chemist)

National Institute of Fundamental Studies, Sri Lanka (NIFS)

Prof. Weerasooriya R. (Water and Analytical methods expert)
Dr. Jayarathne L. (Analytical equipment expert)

University of Peradeniya, Sri Lanka (UOP)

Prof. Pinnawala M. R (Socialogy Expert)
Prof. Dharmakeerthi R. S. (Soil and fertilizer expert)
Dr. Karunarathna A. (Agricultural engineering and solidwaste management expert)
Dr. Igalavithana A. D. (Soil microplastic and toxic element expert)
Mr. Perera R. P. C. H. (Resaearch Assistant)

Institute for Global Environmental Strategies (IGES), Japan
Joint Research Demonstration Center for Water Technology (JRDC), Sri Lanka
National Institute of Fundamental Studies (NIFS), Sri Lanka
University of Peradeniya (UOP), Sri Lanka