TOWARDS MICROPLASTIC MONITORING AND EVIDENCE-BASED POLICY MEASURES IN VIETNAM

Training Needs Assessment Report (TNA)

By

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IGES Institute for Global Environmental Strategies

CCET IGES Centre Collaborating with UNEP on Environmental Technologies

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

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ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
CCET	IGES Centre Collaborating with UNEP on Environmental Technologies
HCMUT	Ho Chi Minh City University of Technology
IGES	Institute for Global Environmental Strategies
IRD	Institut de Recherche pour le Développement, France
MONRE	Ministry of Natural Resources and Environment
NIFS	National Institute of Fundamental Studies
PCP	Personal Care Products
SIIT	Sirindhorn International Institute of Technology
TNA	Training Need Assessment
TOR	Terms of Reference
VISI	Vietnam Institute of Seas and Islands
VNU-HCM	Vietnam National University Ho Chi Minh City
WWTP	Wastewater Treatment Plant

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EXECUTIVE SUMMARY

Concern over microplastic pollution in the environment is growing worldwide. The body of related global research continues to rise, along with the diversity in methodologies, results and equipment. Building a picture of the state of facilities and research capacities, as well as differences in analysis protocols is important, especially for developing countries, where the extent of research on microplastic pollution is much less compared to developed countries. This study, therefore, aims to assess the training and facilities needs for microplastics research in Vietnam. A questionnaire was designed to clarify the overall state of knowledge concerning the study of microplastic pollution carried out at universities, institutes and private companies in Vietnam. After four months of online surveys, the collected data on the analysis of microplastics in water/wastewater, sediment, biota, and sludge, availability of equipment, and human resources from different organizations were synthesized. As a result, it was found that researching microplastics in Vietnam is not very popular, and mainly takes place in leading institutes and universities in big cities. However, these organizations utilized different protocols in sampling, digestion, observation and chemical composition tests, followed by the publishing of non-comparative data. Moreover, the ability to publish research results in peer-reviewed international and national journals was limited. In the future, standardizing and specifying microplastic sampling, extraction and identification methods for each environmental compartment would help expand the scope of comparative studies in Vietnam. Further, investment in facilities and training on microplastic research to propose consistent protocols for microplastic sampling and analysis to strengthen Vietnamese institutes, laboratories, and universities also need to be considered.

1. INTRODUCTION

1.1 Background

Plastics are used in a very wide range of applications, including packaging, building and construction, transportation, medicine and health, sports and leisure, electronics, agriculture, design and manufacturing. Due also to their low production costs, plastics have enabled technological advances, design solutions, eco-performance enhancements, monetary savings, and thus became a key component of daily life. Global plastic production continues to rise, from 1.7 million tons in 1950 to 368 million tons in 2019 (Plastics Europe, 2020) and is estimated to quadruple by 2050 (Bourguignon, 2017). As a result of poor waste management and low recycling rates, the production and consumption of plastic products has for decades led to significant volumes of plastic wastes which have ended up in continental environments and marine ecosystems worldwide (Geyer et al., 2017). The fate of plastic debris, from larger-sized macroplastic to smaller-sized microplastic and nano-plastic in aquatic systems has become a major worldwide environmental concern in terms of adverse consequences to aquatic life and human health.

Microplastics, i.e., plastic items in the size range of 1 µm to 5 mm, are ubiquitous in the environment with various shapes, e.g., microbeads, pellets, fibers, fragments, films, foams (Bikker et al., 2020; Fu et al., 2020; Harris, 2020; Mao et al., 2021; Napper et al., 2021), and various polymer types, e.g. PE, PP, PET, Polyester, and PS (Hidalgo-Ruz et al., 2012; Van Cauwenberghe et al., 2015a; Pitt et al., 2018). The primary microplastics are plastic pellets, which are spherically shaped particles a few millimeters in size and used as the input material in the plastic industry, and microbeads, which are millimeter-sized spherical particles added to personal care products such as toothpaste and face cleansers (Auta et al 2017; Cole et al 2011; Costa et al 2010). These primary microplastics can be discharged directly to the environment following their use and released into wastewaters. Secondary microplastics originate from the fragmentation of larger plastic items due to the effects of weathering agents such as ultraviolet radiation, or mechanical, chemical and biological degradation processes; from the degradation and wear and tear of synthetic textile and garment products, especially during the processing and washing steps, which are then released into the environment from both domestic and industrial (treated and untreated) wastewaters (Bui et al., 2020); (Auta et al., 2017); (Duis and Coors, 2016); and from the tire erosion process (Luo et al., 2021). Therefore, secondary microplastics can take the form of fragments, films, foams, or fibers. The transport of microplastics via waterways especially rivers (Lu et al., 2021) and air (Dris et al., 2016) results in their entry into a terrestrial environment where they accumulate in soil (Kim et al., 2021), flora (Leifheit, 2021) and fauna (Rezania et al., 2018). Microplastics in freshwater and marine environments remain in suspension or accumulate in sediment, and finally can enter the human body (Prata et al., 2020) via drinking water (Oßmann, 2021), foods (Zhang et al., 2020; Kwon et al., 2020). They can also enter through normal breathing (Gasperi et al., 2018). During their transfer, microplastics can both act as vectors of persistent organic pollutants (Rochman et al., 2013), potentially toxic metals (Ashton et al., 2010; Igalavithana et al., 2022), pathogens (Naik et al., 2019), as well as sink for toxic inorganic and organic chemicals and additives (Naik et al., 2019; Paluselli & Kim, 2020). The toxicological effects of microplastics on aquatic organisms are observed on three levels: individual, cellular, and molecular (Browne et al., 2015).

Asia, especially Southeast Asia, is considered a hotspot for plastic pollution and a large emitter of plastic waste to the oceans (Jambeck et al., 2015). High variability of microplastic abundances in freshwater and sediment has been observed here (f Ngoc et al 2022). China has been the most studied country to date, representing 70% of both overall locations and living species studied, while no data was found to be available for

35 of the 49 countries in Asia, located mainly in the north-central and western regions.

Among the 15 countries studied, surface water was the most investigated compartment (62 studies), followed by sediment (41 studies) and biota (15 studies). Rivers were the most studied systems, compared to lakes, reservoirs, and dams, with the Yangtze River and Poyang Lake being the most studied freshwater bodies in Asia (Ngoc et al., 2022). To guide future research and to improve microplastic pollution management for the sustainable development of highly populated regions such as Asia, in this study the authors recommend standardizing methods for microplastic sampling, sample treatment, and laboratory analysis. Also emphasis on microplastic assessment and flux estimation, is required. They also underscore the importance of research, in terms of its ability to provide a scientific basis for establishing policies and regulatory tools at regional, national, and international scales, such as for imposing bans on the use of single-use plastics or for their replacement (Ngoc et al., 2022). To derive such kind of evidence-based-policy measures, the microplastic-related data set generation becomes critical.

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 being findable, accessible, interoperable, and reusable (FAIR) is essential for making policy and mitigation strategies (Jenkins et al., 2022).

Vietnam, with a population of 97,582,700 inhabitants in 2020 (GSO, 2021), shifted from a centrally planned to a market economy which transformed the country from one of the poorest in the world into a lower middle-income country. Now it is one of the most dynamic emerging countries in the East Asia region. Between 2012 and 2017, its plastic industry expanded at an average annual rate of 11.6%, outpacing the global plastic industry's rate of 3.9% (VPA, 2019). Over 80% of this plastic production, including consumer products, packaging, textile and garment industries, are localized in the South of Vietnam, near Ho Chi Minh City – the economic capital of the country and Binh Duong province. The poor domestic and industrial wastewater treatments (only 13 % of domestic wastewaters, 16% of small and medium sized enterprises industrial wastewaters and 88% of large-sized enterprises industrial wastewaters are treated (MONRE, 2018). Large amount of untreated wastewater resulted in very high concentrations of plastics evidenced for the first time in a Vietnamese aquatic environment – the Saigon River (Lahens et al., 2018). These initial observations, coupled with the prominence of fishing as a primary industry (i.e. with a coastline of 3,620 km) motivated Vietnamese scientists to conduct research on microplastic distribution, sources and fate in Vietnamese aquatic environments (Kieu Le et al., 2022). In the meantime, weaknesses in solid waste management have led to Vietnam being one of the main contributors to plastic waste ending up in oceans (Jambeck et al., 2015). In this context, the nation has made strong political commitments and taken action to manage and reduce its plastic waste, including ocean plastic waste. Resolution No. 36-NQ / TW of October 22, 2018, of the Eighth Conference of the Party Central Committee XII on the strategy for sustainable development of Vietnam's marine economy to 2030 with a vision to 2045, set the goal of "Preventing, controlling, and significantly reducing pollution of the marine environment; becoming a regional leader in minimizing ocean plastic waste". The Government issued Resolution No. 01/NQ-CP of January 1, 2019 on the main tasks and solutions to implement the Socio-Economic Development Plan and State Budget estimate in 2019, with the mission of reducing plastic waste and strengthening international cooperation to solve the problem of plastic waste in the ocean. Following this Resolution, the Ministry of Natural Resources and Environment has presided over and coordinated with ministries, departments, localities, agencies, organizations, experts, scientists, and international partners concerning the drafting of the Prime Minister's Decision on the issuance of the National Action Plan for Management of Marine Plastic Litter by 2030 (Decision No. 1746/ QD-TTg, 2019).

To tackle this issue, scientists and policy-makers need to collaborate by providing new knowledge on the sources, fate and impacts of microplastics for guiding in making legal framework based on scientific evidence. In this context, the scientific community has raised the need to standardize the methods and protocols used for conducting microplastic assessment in the environment, which involved, creating an inventory of the state of the art in order to address recommendations on standardization and future training and needs assessment.

1.2 Objectives and scopes

The main objective of this report is to carry out a training and facility needs assessment to support monitoring and scientific evidence-based policy development for microplastic-related pollution in Vietnam. To assess the needs, an online questionnaire was developed to identify precisely the current protocols and equipment used for sampling, analysing and observing microplastics in various matrices. This questionnaire was sent to Vietnamese research groups (institute and university-based) conducting microplastic assessments in the environment.

2. METHODOLOGY

2.1. Research approach

This study was based on the results obtained from the survey on the current status of microplastic research at different research groups in universities, institutes and companies. To address the research objectives, the following tasks were conducted:

1. Design of the survey
2. Data collection
3. Data synthesis and analysis
4. Data validation

2.2. Design of the survey

- The survey was designed to clarify the overall state of knowledge on the study of microplastic contamination that has been carried out at universities, institutes and private companies. The survey clarified the protocols used for analyzing microplastics in water/wastewater, sediment, biota, and sludge, availability of equipment, and human resources. To design the questionnaire survey, a literature review of existing publications on microplastic analysis was carried out. Based on this review, 68 questions in seven sections were devised to gather information:

1. Section A: Organization information (9 questions)
2. Section B: Present status of microplastic research at the organization (4 questions)
3. Section C: Microplastic sampling of water, wastewater, sediment, biota and sludge (8 questions)
4. Section D: Laboratory analysis of water and wastewater samples (6 questions)
5. Section E: Laboratory analysis of sediment, biota, and sludge samples (6 questions)
6. Section F: Microplastic observation (9 questions)
7. Section G: Determination of the polymer types of microplastics (4 questions)

Sections A and B were aimed at collecting general information on the organizations and their microplastics-related research activities. Concerning microplastic research, Sections C to G targeted collecting data relating to microplastic sampling and laboratory analysis protocols, microplastic observation, and determination of the polymer types of microplastics. These sections also collected data on human resources and available facilities for microplastic research. The survey was written in Vietnamese and uploaded to the online Survey Monkey application with 46 questions as shown in Appendix.

2.3. Data collection

The online survey used in this study was conducted over four months in 2022, from February to May. To collect the data, a link to the online survey was sent directly to the colleagues in relevant organizations of our professional network via email together with the request to share the questionnaire with other relevant teams in their organization and professional networks that we could not communicate with. The results were collected automatically by the Survey Monkey application and downloaded every month until the end of May 2022.

2.4. Data analysis

The data collected through the questionnaire survey were compiled and analyzed using Microsoft Excel. Data were synthesized and divided into four aspects:

- Background of the responding organizations;
- Performance of microplastic research with consideration of the basic steps: sampling, laboratory analysis, microplastic observation, and determination of the polymer types of microplastics;
- Capacity to carry out research on microplastics of the research organizations in Vietnam;
- Analysis of the training and facility needs.

2.5. Data validation

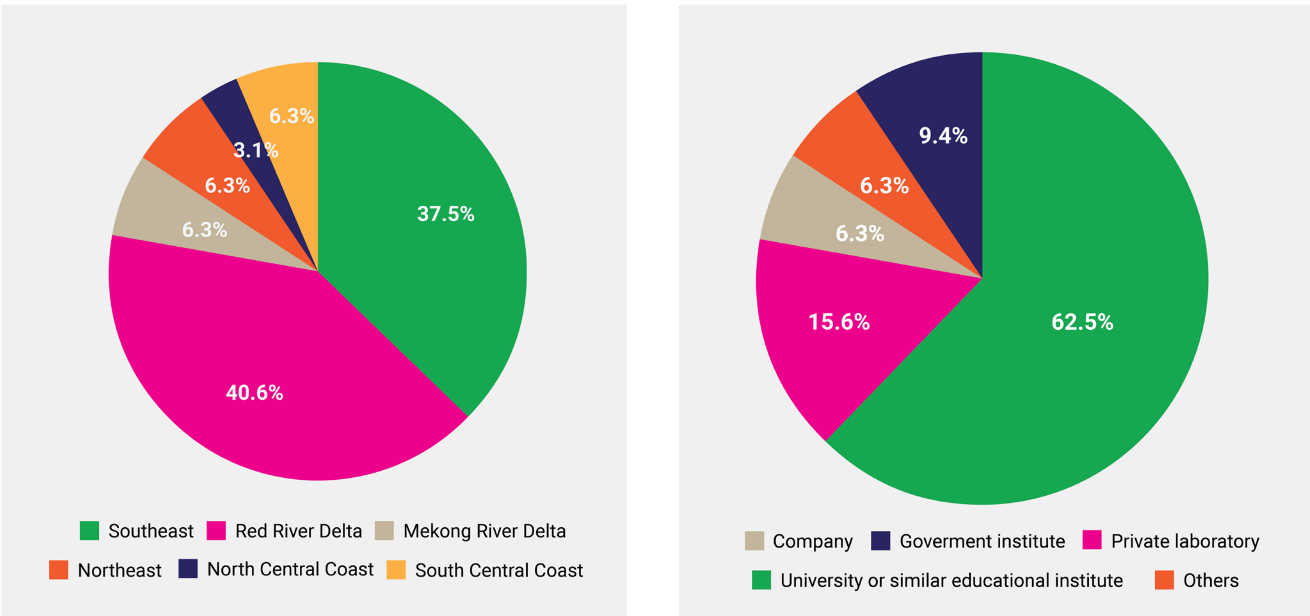
During the data analysis, the respondents were contacted for any information that was omitted orinsufficient, for clarification. This step was carried out to rule out any misunderstandings in comprehending the questionnaire survey.

3. RESULTS ANALYSIS AND DISCUSSIONS

3.1. Organization background

In total, 32 organizations responded to the survey which were grouped into the geographical regions of Vietnam. This revealed that organizations responded in all the regions with most distributed in the Red River Delta, and the Southeast, corresponding to 40.6% and 37.5% of the answered organizations, respectively (fig. 3.1a), followed by the Mekong River Delta, Northeast and South-central coast with 6.3% each. The North Central Coast region had the least respondents. Concerning the organization types (fig. 3.1b), 62.5% consisted of universities or similar educational institutes, followed by private laboratories (15.6%), government institutes (9.4%), companies (6.3%), and other organizations (6.3%).

Figure 3.1. Synthesis data on a) region and b) type of responding organization

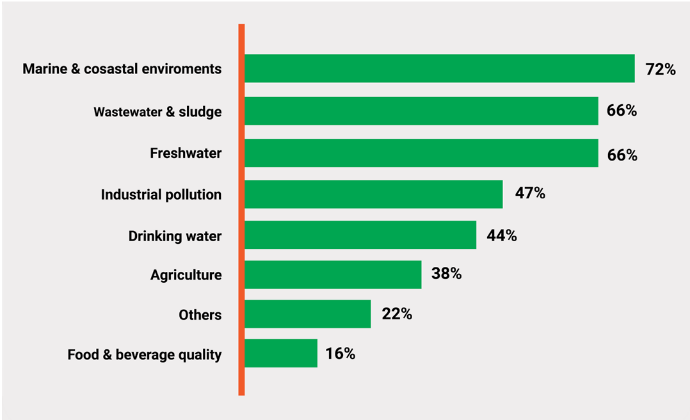


a) b)

The respondent/organizations focused mainly on marine and coastal environments, freshwater, wastewater and sludge for 72%, 66%, and 66% of the organizations, respectively (fig. 3.2a). Industrial pollution, drinking water, and agriculture follow with lower rates of 47%, 44%, and 38%, respectively. Food and beverage quality and other work scopes receive the least attention. The research activities of these organizations involve environmental monitoring (88%), quality assurance (34%), and policy-making (25%), as shown in fig. 3.2b. The laboratories awarded VILAS, VIMCERTS, and ISO/IEC 17025 accreditation accounted for 23%, 20%, and 17%, respectively (fig. 3.2c).

Concerning the experience in microplastic research of the organizations, nearly two-thirds had carried out research in the field of microplastics (fig. 3.3a). These organizations focus on marine water, freshwater, and sediment accounting for 78%, 70%, and 70%, respectively (fig. 3.3b). About half of these organizations conduct research in biota and wastewater. The research on microplastic in food, atmospheric fallout and soil receives the least attention among all of the research compartments.

Figure 3.2. Synthesis data on a) work scope, b) laboratory activities, and c) laboratory certificates



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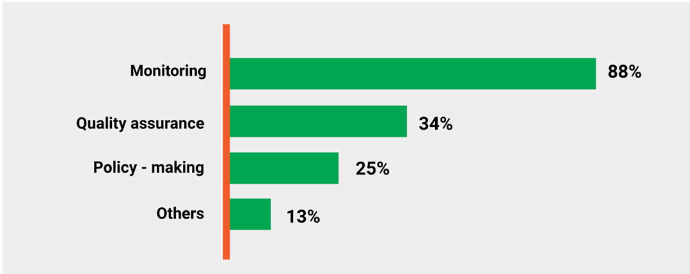

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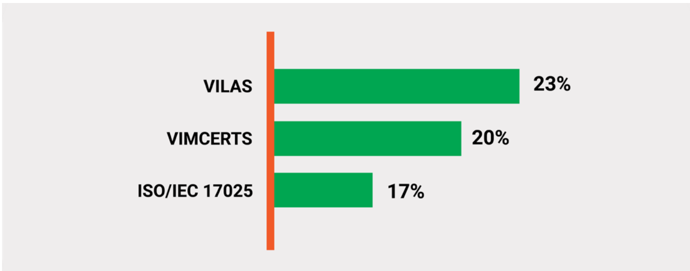

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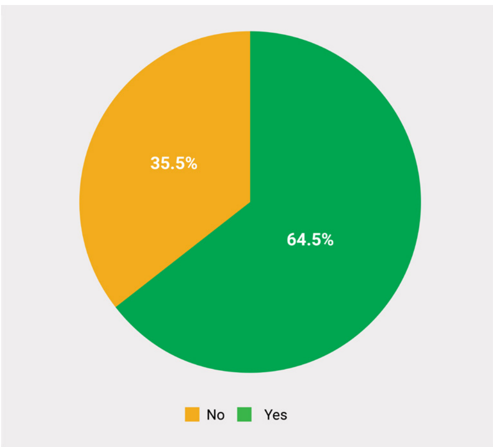
Figure 3.3. Synthesis data on a) the status of conducting/not conducting research in microplastics, and b) microplastic-related research compartments



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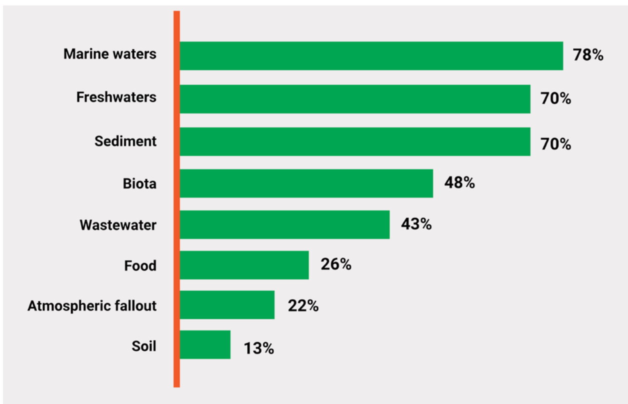
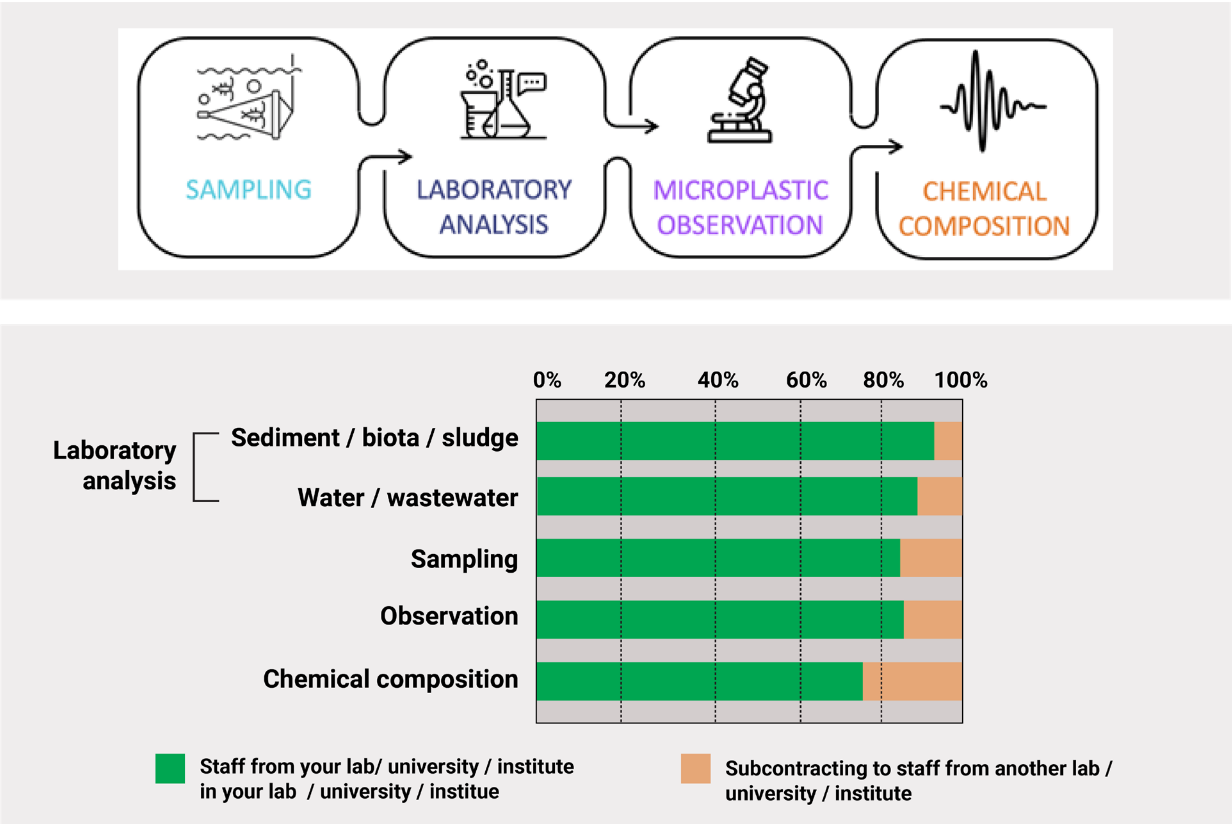


b)

3.2. Performance of microplastic research

A research in microplastic abundance in the environment includes four fundamental tasks: sampling, laboratory analysis, microplastic observation, and determination of the polymer types of microplastics (fig. 3.4a). The survey results revealed that from 75% to more than 90% of the organizations conducted these tasks themselves, i.e., by their staff (fig. 3.4b). This section details how each task is conducted with consideration for the technical aspects as well as the equipment utilized at each organization.

Figure 3.4. Fundamental tasks in research of microplastic abundance in the environment and, b) synthesis data on staff conducting each task in research on microplastics



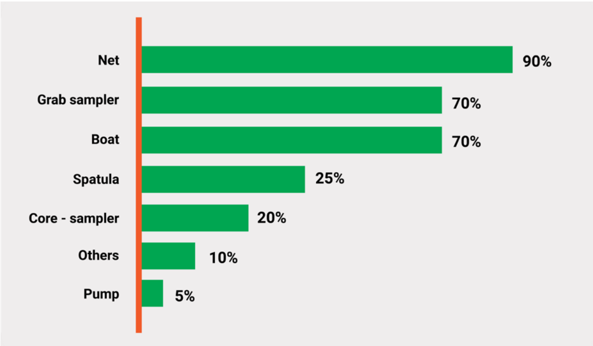
3.2.1. Microplastic sampling

For microplastic sampling in water and sediment, different sampling methods were utilized by the organizations. For water, nets were used more than pumps (90% and 5%, respectively, fig. 3.5a). Specifically, manta nets, neuston nets, or plankton nets with mesh sizes ranging from 25 to 300 μm are used for water sampling. A flowmeter was also attached to the net for measuring water volume. Sampling duration varied from two minutes to two hours depending on the environment. organizations have rented boats for such sampling. For sediment, samples were collected mainly by a grab sampler (70%). Spatula and core samplers were less common for sampling sediment (at 25% and 20%, respectively).

Among the equipment, nets and grab sampler are available in the organizations (fig. 3.5b). In general, boats were used in the microplastic sampling (70%); however, almost all organizations have rented boats for such sampling.

Concerning the sampling depth, different depths were selected in both water and sediment sampling. For water, the collection of samples from the water surface was the most common option (67%, fig. 3.6a). For sediment, samples were collected mainly at depths of 0 – 5 and 0 –10 cm (48 % and 43%, respectively, fig. 3.6b).

Figure 3.5. a) Equipment utilized in microplastic sampling
b) Ownership status of equipment at the responding organizations



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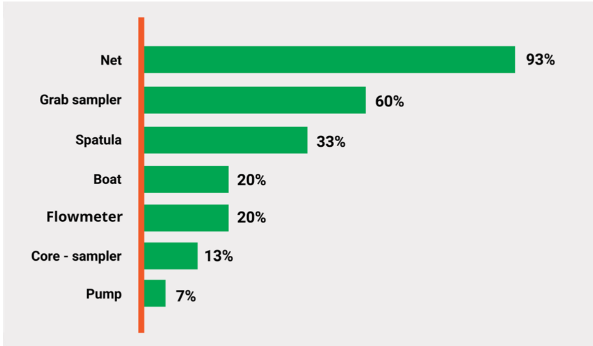
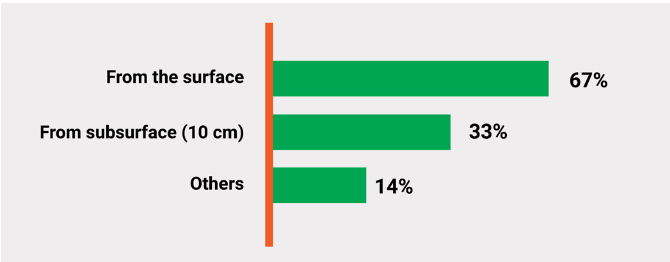


b)

Figure 3.6. Microplastic sampling depth in a) water b) sediment



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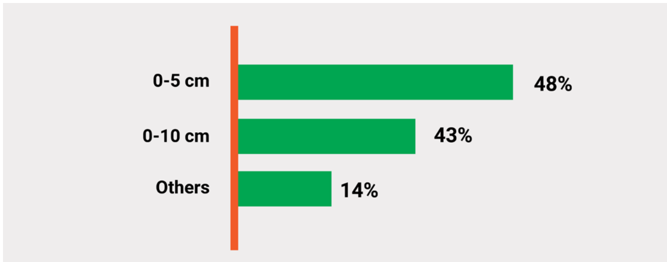
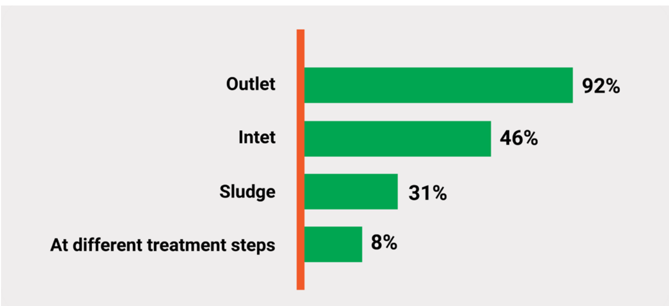


b)

For microplastic sampling in wastewater treatment plants (WWTPs), different sampling strategies were used. Most organizations collected samples at the outlet (92%, fig. 3.7a). Inlet samples were also taken into account for 46% of the organizations, and sampling in different treatment steps was conducted by at least (8%). Sludge samples also received much consideration in microplastic research (31%).

In agriculture and food, microplastics collected in agricultural land contributed the highest rate (88%). Microplastics collected in fertilizer and anaerobic digestate as well as other WWTPs sludge disposal into agricultural land were lower (fig. 3.7b). All collected samples were stored along with information of the time, location, weather, etc., before pretreatment and laboratory analysis (fig. 3.8).

Figure 3.7. Sampling location in WWTPs; b) research compartments in agriculture and food



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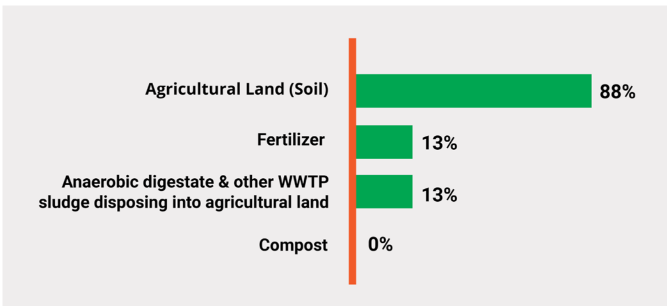

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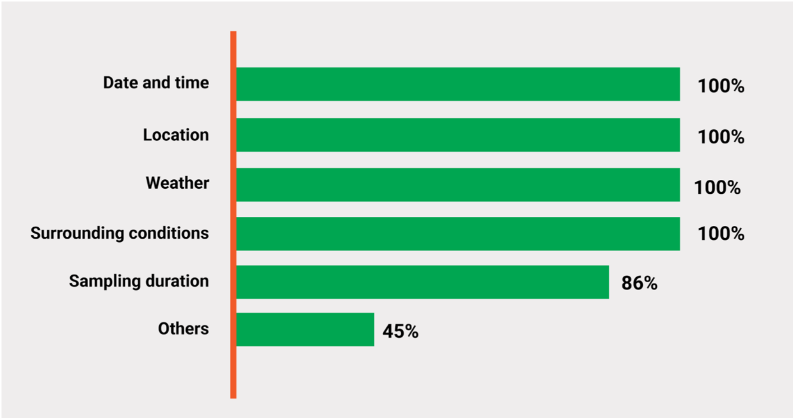
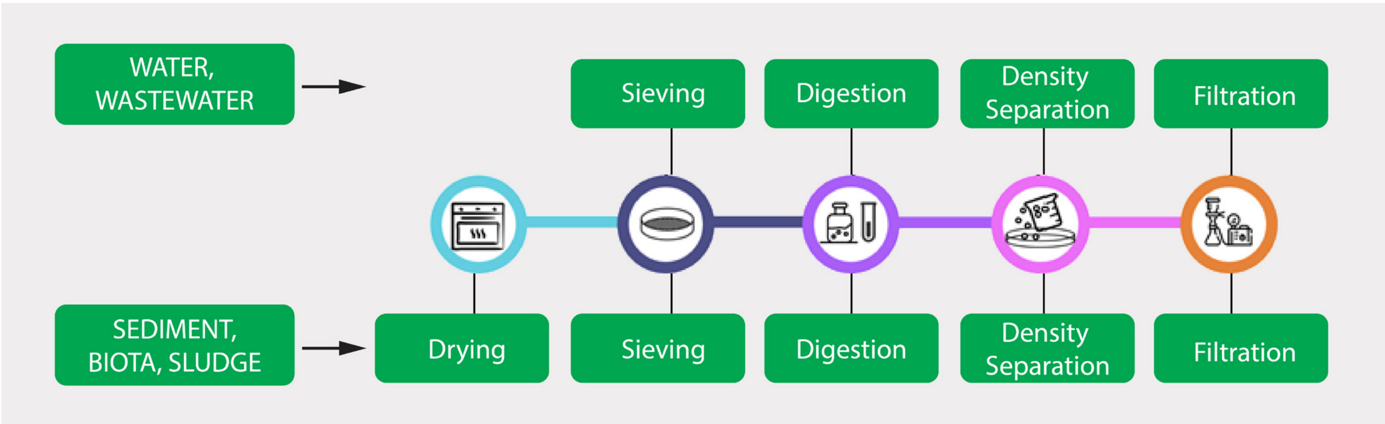
Figure 3.8. Important information recorded on sampling sheet



3.2.2. Laboratory analysis

Laboratory analysis of microplastic samples included several fundamental aspects, i.e., sieving, digestion, density separation, and filtration (fig. 3.9). For sediment, sludge and biota samples, drying was also sometimes included.

Figure 3.9. Main steps in laboratory analysis of samples in microplastic research



For water and wastewater samples, the survey results in fig. 3.10a show that most organizations conduct sieving (94%), digestion (95%), density separation (89%), and filtration (94%). For sediment, biota, and sludge samples, the percentage of organizations conducting the fundamental steps varied: 88% (filtration), 80% (density separation), 80% (digestion), 78% (sieving), and 73% (drying).

Figure 3.10. Performance status of fundamental steps in laboratory analysis of microplastics in a) water and wastewater samples and b) sediment, biota, and sludge

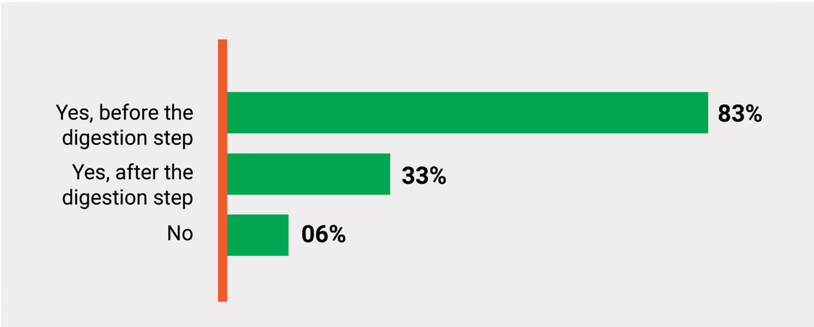
a) b)

The detailed results for each analysis step, types of chemical, dose, temperature, and digestion duration used for analyzing microplastic from each environmental media at different laboratories are presented in the subsections below.

a) Water and Wastewater Samples

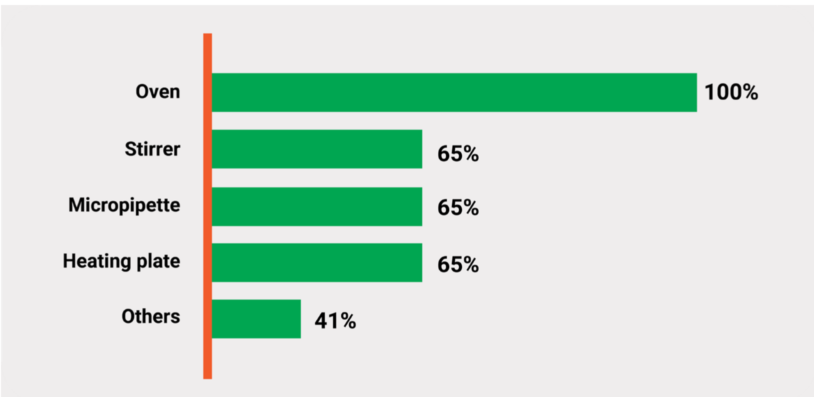
Sieving steps can be conducted before or after the digestion of samples, accounting for 83% and 33%, respectively (fig. 3.11). Sieves with a mesh size of 250 and 300 µm were commonly used after the digestion step. Only two organizations provided information on sieve mesh size used before the digestion step, for which 1 mm mesh size sieves were generally used.

Figure 3.11. Status of conducting sieving step in laboratory analysis of microplastics in water and wastewater samples



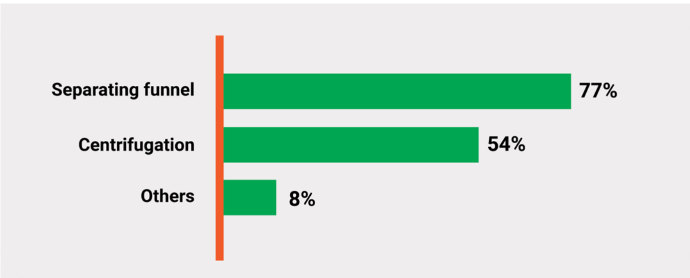
For the sample digestion, the types of used chemicals, dose, temperature and digestion time varied greatly among the organizations, of which three organizations followed the laboratory analysis protocol proposed by Strady et al. (2021). The most common equipment used in this step was ovens (100%, fig. 3.12). Heating plates, stirrers, and micropipettes were also important equipment for the digestion of samples (65%). The other necessary equipment in some organizations were lab scales, manifolds, centrifuge machine, heating-plate with magnetic stirrers, fume hoods, and furnaces. The glassware used during the digestion step included glass bottles, beakers, and cylinders.

Figure 3.12. Synthesis data on the equipment used in sample digestion



Concerning the isolation of microplastics from the samples, the density separation step was conducted with a separating funnel (by 77%) or centrifugation (by 54%). The glassware used in this step were beakers, glass bowls, and glass rods. The separation media used varied from lower-density solution types (however the density is greater than the water) such as NaCl (1.18 g cm^{-3}), to higher density types such as $ZnCl_2$ (1.64 g cm^{-3}). A low percentage of organizations chose to reuse the density separation solution (28.6%, fig. 3.13b); however, no information on the reuse frequency was provided. In addition, instead of density separation, picking up microplastics was also chosen as the step to collect microplastics from the samples.

Figure 3.13. Synthesis data on a) density separation equipment and b) reuse of density separation solution



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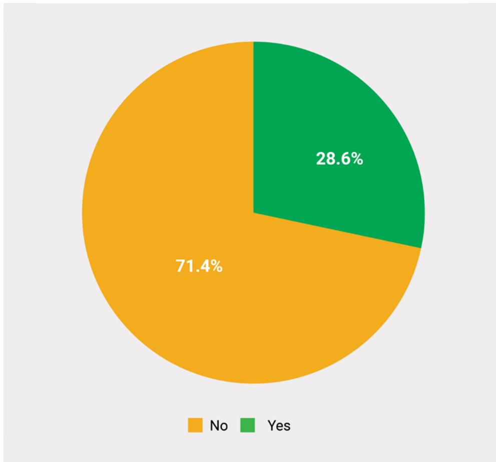
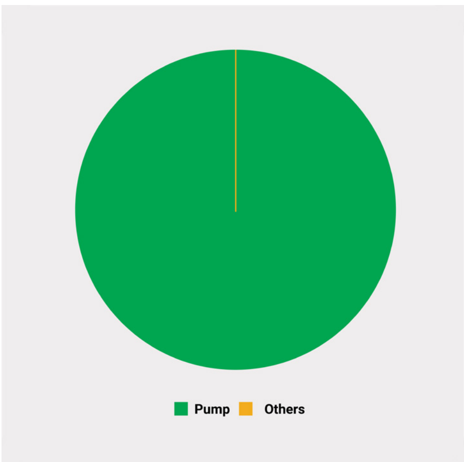


b)

The supernatants collected from the density separation were filtrated through filter paper by using a vacuum pump (100%, fig. 3.14a). Whatman glass microfiber filter papers (1.5 µm pore size, 47 mm Ø) were the most popular type of filter paper. Regarding storage, filters containing microplastics were kept in Petri dishes (94%, fig. 3.14b). A small number of organizations picked up microplastics from the filters and stored them in small glassware bottles (6%).

Figure 3.14. Synthesis data on a) filtration equipment and b) storage of microplastics



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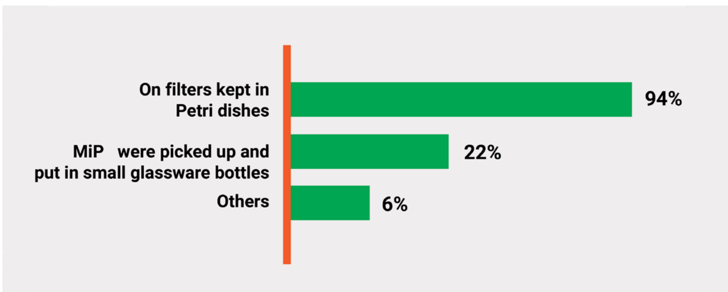
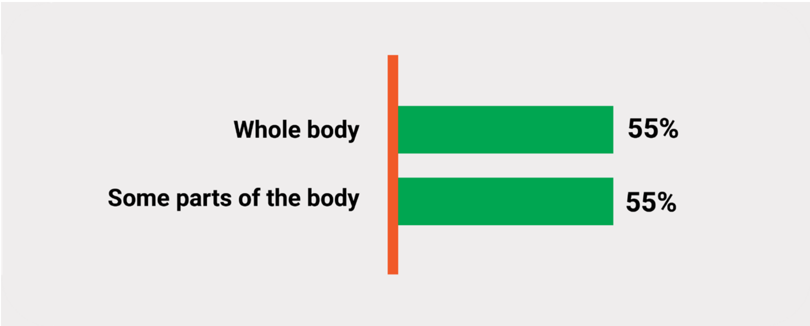


b)

b) Sediment, Biota, and Sludge Samples

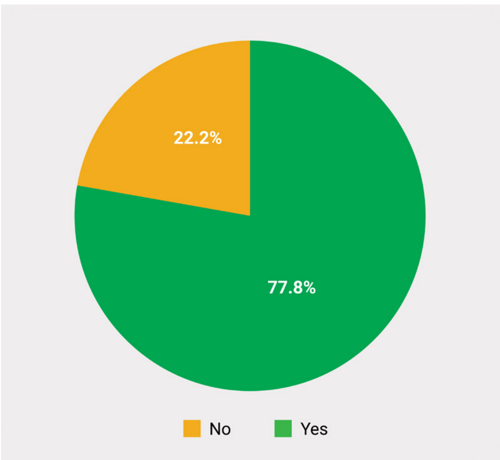
For biota samples, the laboratory analysis could be carried out on the whole sample body (55%, fig. 3.15) or on some parts of the organisms (55%, fig. 3.15). For the sediment and sludge samples, a drying step could be performed before digestion, with temperatures and drying times ranging from 35 – 105°C over 3-48 hrs or until achieving the constant weight.

Figure 3.15. Analysis of biota samples: whole body and part of the body

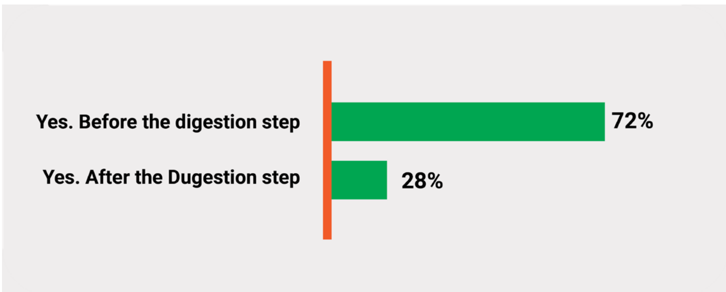


For the sieving step, there were almost four fifths of the organizations carrying out sieving step (fig. 3.16a). About 72% and 28% of the organizations carried this out before and after sample digestion, respectively (fig. 3.16b). Among them, only one organization conducted sieving both before and after digestion. The mesh sizes of the sieves used were 50, 100, and 250 µm. In some cases, a full set of sieves with mesh sizes 53, 105, 300, 500, 1,000 and 5,000 µm were utilized.

Figure 3.16. Synthesis data on a) rates of conducting or not the sieving step in laboratory analysis of sediment and sludge samples, and b) when to conduct sieving step



a)



b)

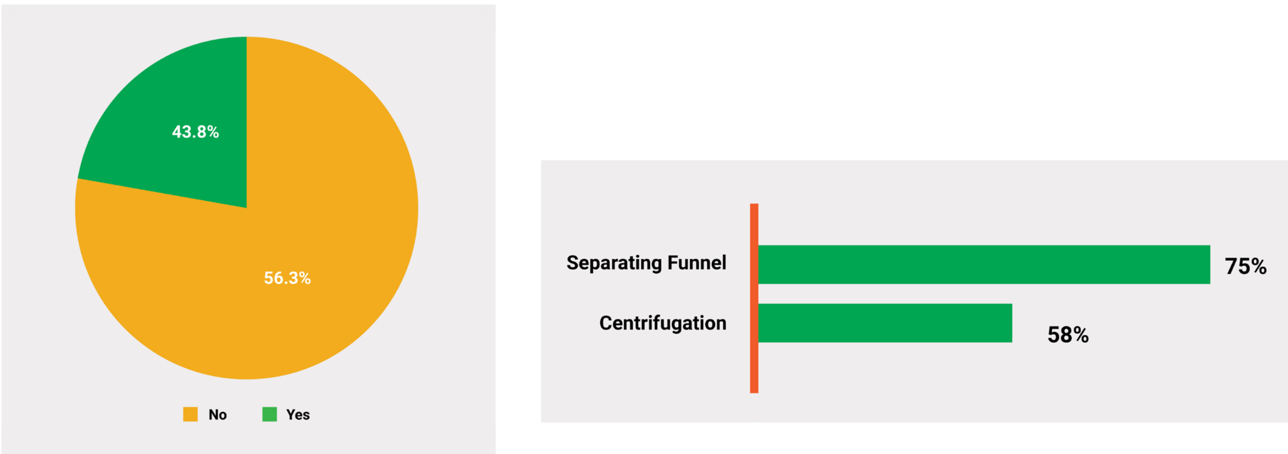
In the digestion step, different reagents were used at different doses and temperatures. KOH and H_2O_2 were the most commonly used and samples were heated at 40 – 60°C over 1 – 3 days or until samples were completely digested. The equipment used in the digestion step included ovens (88%), stirrers (76%), micropipettes (71%), and other equipment (29%) such as laboratory scales, centrifuges, and hot plate with magnetic stirrers, fume hoods, and furnaces (fig. 3.17). The glassware used during the digestion step included glass bottles, beakers, and cylinders.

Figure 3.17. Equipment used in the digestion of samples

In the density separation step, separating funnels and centrifugation were used in 75% and 58% of the organizations, respectively (fig 3.18). NaCl and $ZnCl_2$ solutions were the most common reagents used in this step. Density separation solutions were reused up to 2-5 cycles by 44% of the organizations (fig. 3.18b).

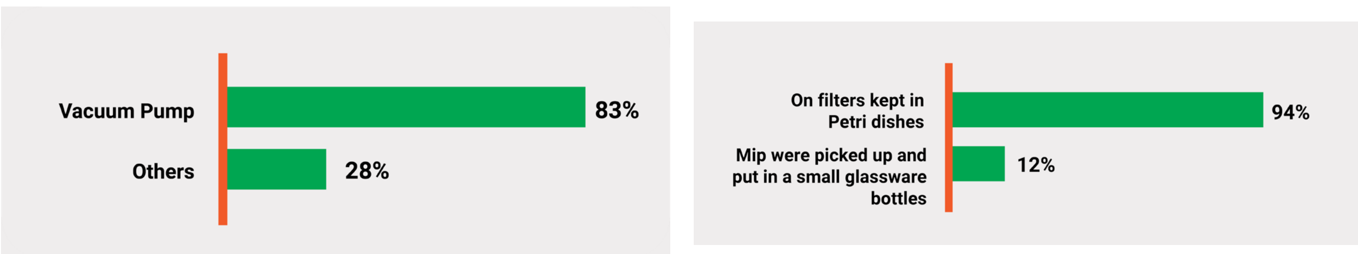
For the filtration step, most of the organizations used a vacuum pump (83%, fig. 3.19a), and the other remaining organizations used a funnel and cylinder (28%). Filters were kept in the Petri dishes (94%, fig. 3.19b). Some organizations picked up microplastics and stored them in small vials.

Figure 3.18. Synthesis data on a) equipment utilized in density separation and b) status of reuse/not reuse of density separation solution



a) b)

Figure 3.19. Synthesis data on a) equipment used in filtration step and b) storage of microplastics



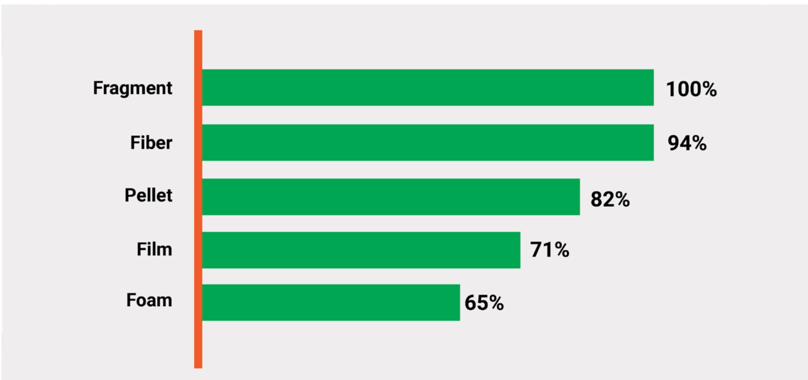
a) b)

3.2.3. Observation of microplastics

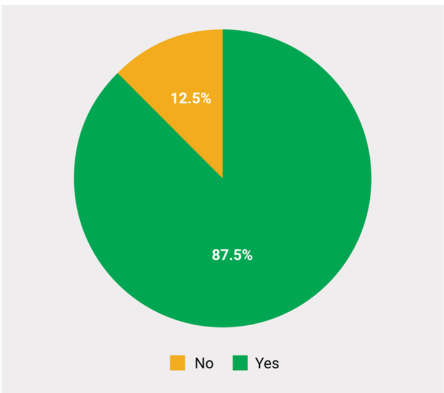
Different types of equipment were used to observe microplastics on filters, including the Leica, Spotlight 200i, common camera, classic magnifying glass, etc. The observation size range varied among the organizations and was mostly from 300 µm. Some organizations observed microplastics from 50 µm or 100 µm. Microplastics were grouped into different shape categories such as fragments, fibers, pellets, films, and foams at 100%, 94%, 82%, 71%, and 65% of the organizations, respectively (fig. 3.20a).

Concerning the measurement of the size of microplastics, 87.5 %, 56.3%, and 81.3% of the organizations measure the length of fibers, the diameter of fibers, and the area of fragments, respectively (fig. 3.20b-d). Recording of microplastic colours was also conducted at 87% of the organization (fig. 3.21a). The colour palette varied among the organizations with the main colours being purple, transparent, pink, brown, yellow, green, grey, white, black, blue and red (fig. 3.21b). Yellow, green, white, blue, and red were among the most observed colours of microplastics.

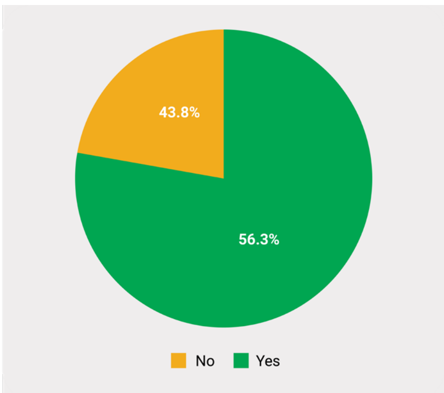
Figure 3.20. Microplastic observation: a) rates of shape categories recorded and rates on measurement/not measurement of b) length of fibers, c) diameter of fibers, and d) area of fragments



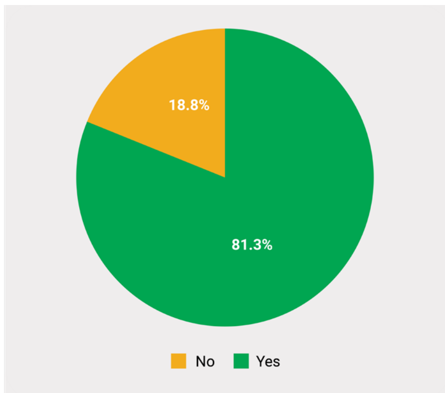
a)



b)

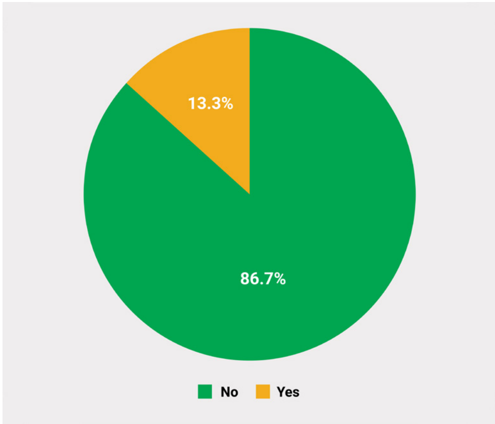


c)

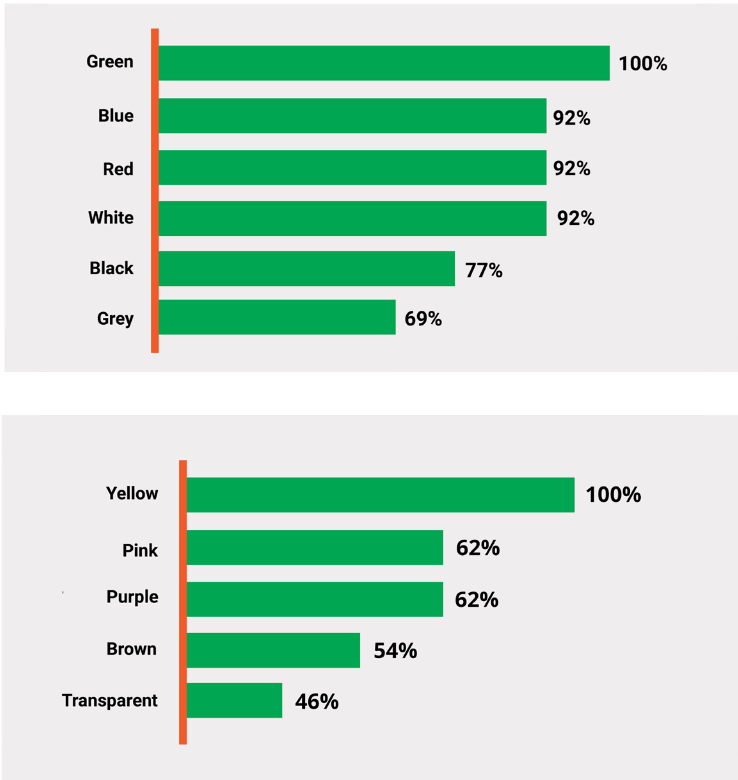


d)

Figure 3.21. Synthesis data on a) status of recording/not recording colours of microplastics and b) main colours of microplastics recorded in the observation step

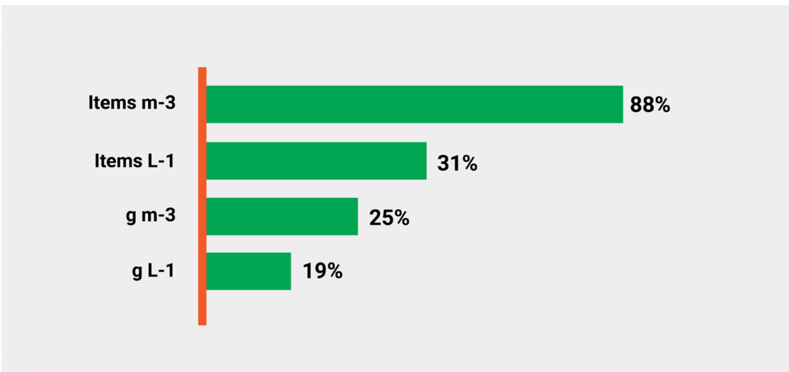


a)

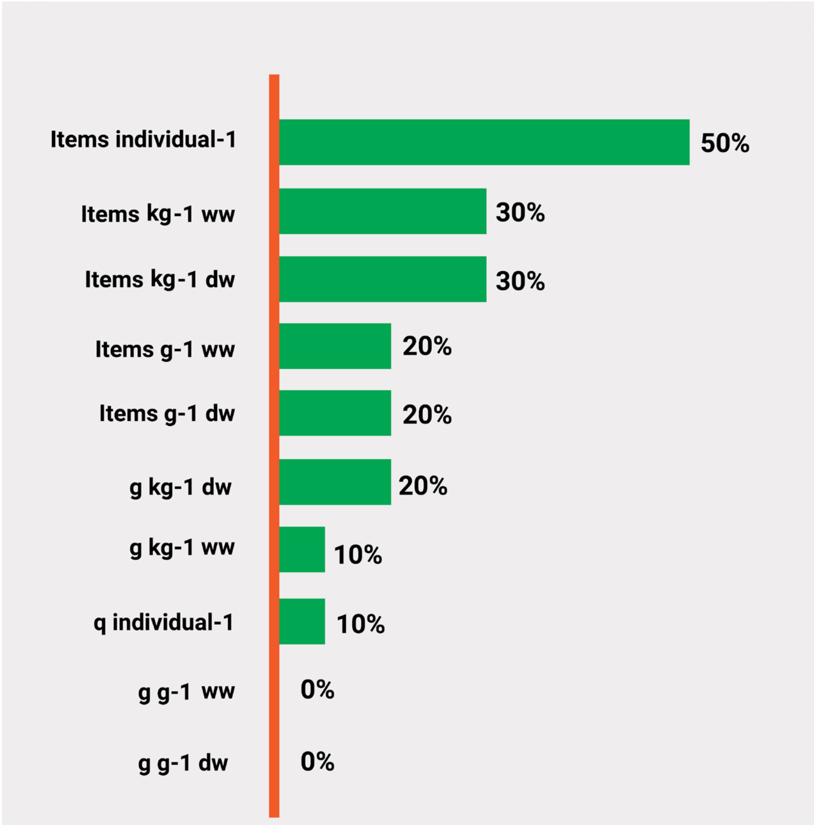


b)

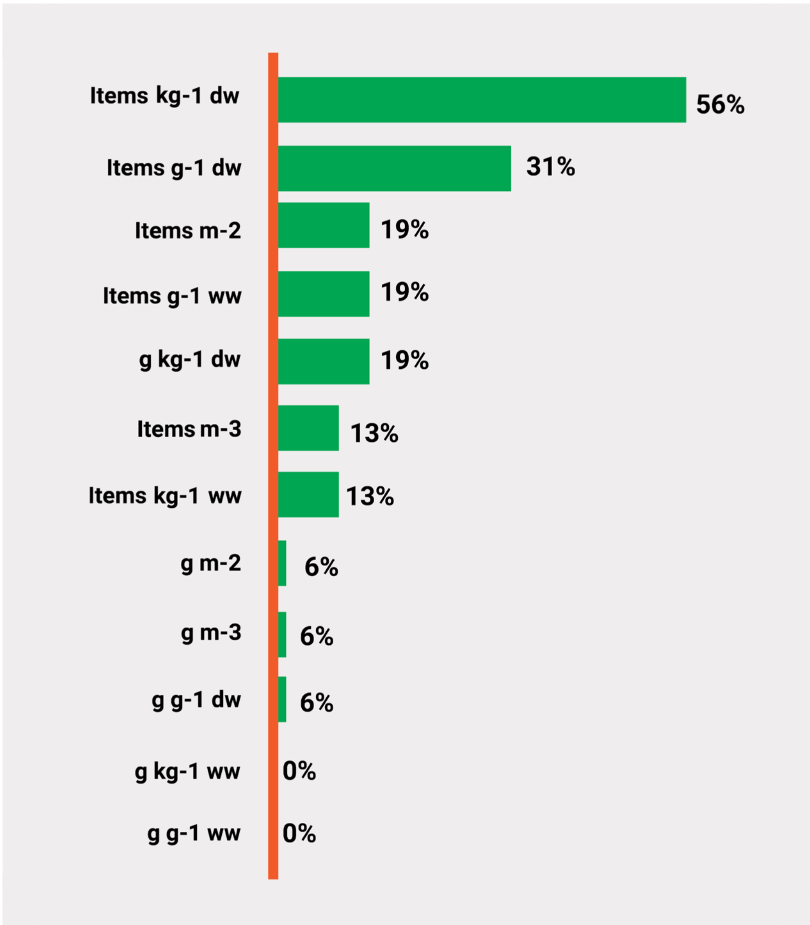
Figure 3.22. Types of units used in expressing microplastic abundance in a) water and wastewater, b) biota, and c) sediment and sludge



a)


Items individual-1
50%
Items kg-1 ww
30%
Items kg-1 dw
30%
Items g-1 ww
20%
Items g-1 dw
20%
g kg-1 dw
20%
g kg-1 ww
10%
q individual-1
10%
g g-1 ww
0%
g g-1 dw
0%

b)


Items kg-1 dw
56%
Items g-1 dw
31%
Items m-2
19%
Items g-1 ww
19%
g kg-1 dw
19%
Items m-3
13%
Items kg-1 ww
13%
g m-2
6%
g m-3
6%
g g-1 dw
6%
g kg-1 ww
0%
g g-1 ww
0%

c)

The units used to demonstrate the abundance of microplastics in water/wastewater, sediment, biota, and sludge are important factors to be considered. For water, among 16 answers, 88% of institutions were using the unit of items m^{-3}. As other units, items L^{-1}, g m^{-3} and g L^{-1} were used at lower rates of 31%, 25% and 19%, respectively (fig. 3.22a).

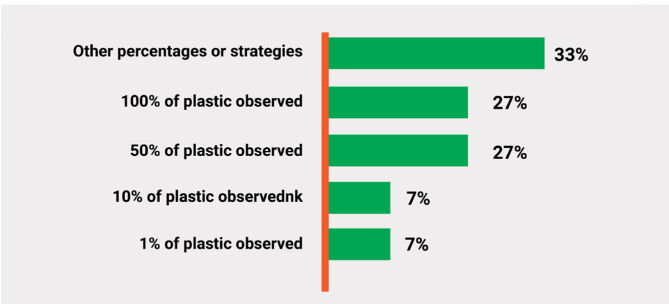
More types of units were used for demonstrating microplastic abundance in sediment/sludge (fig. 3.22b) and biota (fig. 3.22c). Among them, items $individual^{-1}$ and items g^{-1} dw were the most common units used for biota and sediment samples, at 50% and 56% of institutions, respectively.

3.2.4. Determination of chemical composition of microplastics

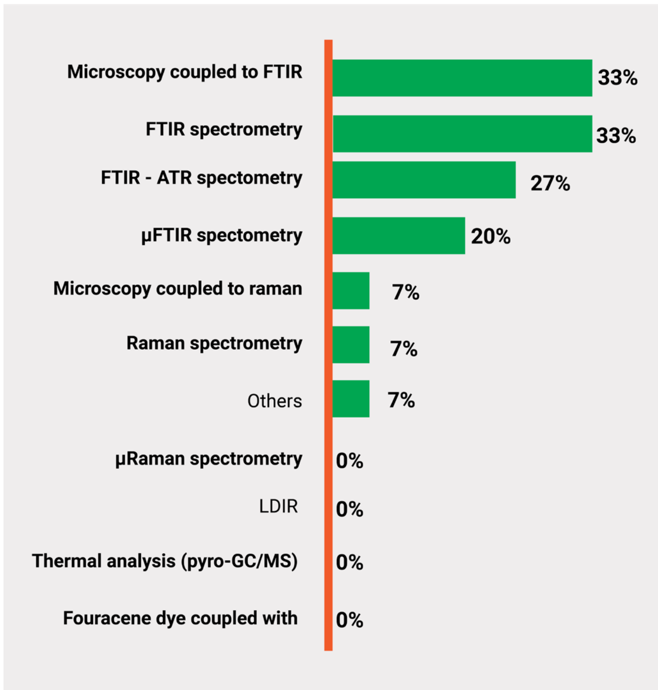
The percentage of particles tested using the chemical composition test varied across organizations. Among 15 answers, only 8 laboratories (54%) analyzed 50% and 100% of particles in their samples. The other organizations only conduct the test of polymer types for 10%, or even 1% of total suspected microplastics (fig. 3.23a).

The technique and equipment used to determine the polymer types of microplastic varied among the organizations. The most common technique and equipment used for this test included microscopy coupled with FTIR (33%), FTIR spectrometry (33%), FTIR-ATR spectrometry (27%), and μFTIR spectrometry (20%) as presented in fig. 3.23b.

Figure 3.23. Determination of the chemical composition of microplastics:
a) percentage of tested particles and b) techniques and instruments



a)



b)

3.2.5. Discussion

The survey results demonstrate a level of inconsistency in the analysis of microplastics across all compartments in all aspects of research in microplastics, i.e., sampling (equipment and duration), fundamental laboratory steps (mesh size of sieves, chemicals and dose, temperature and duration), microplastic observation (criteria, observation size range, demonstration units), and test of chemical composition of microplastics (technique and equipment,

It should be noted that utilization of a consistent protocol for microplastic research is of key importance to providing a comparable database throughout the country and for contributing to future actions in promulgating national standards to assess the microplastic abundance and reducing microplastic pollution in the environment. Accordingly, studies that lead to feasible and reliable protocols for sampling and analysis of microplastics

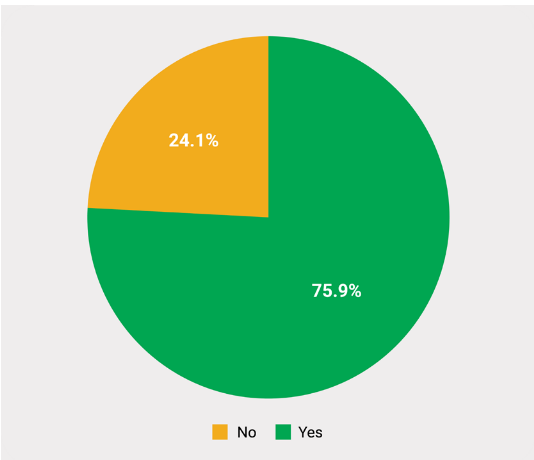
3.3. Capacity of organizations in microplastic research

In this study, organizational capacity was approached from two important aspects: i) the ability of the organization/institute to conduct research in microplastics by itself, and ii) the ability to publish the research results in qualified peer-reviewed journals. There were 65% of the organizations carrying out microplastic research (fig. 3.3a), mostly come from leading universities and institutes in Vietnam. In particular, 8 out of 20 organizations, i.e, 40%, have acted as a partner of the COMPOSE project (Creating an Observatory for Measuring Plastic Occurrences in Society and Environment, 2019 – 2021), which was aimed at creating a research network of laboratories and researchers to carry out research in microplastic pollution. Local environmental departments, smaller universities, companies and private laboratories mostly comprised the group of organizations that have not carried out much research on this topic.

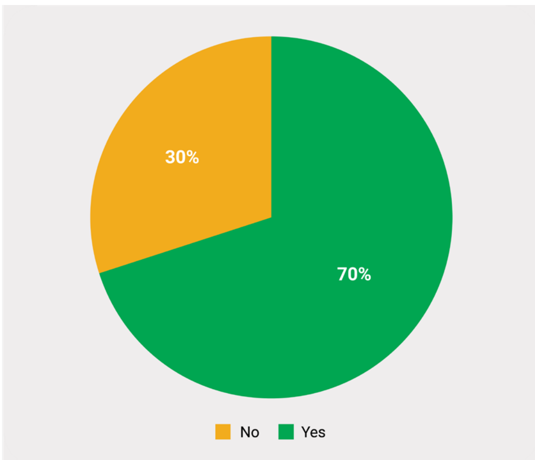
The percentage of organizations capable of carrying out research in microplastics is presumed to be much lower if the survey had been extended to include broader types of organizations.

Concerning the ability to publish research results among the organizations that have conducted research in microplastics, the rates for publishing/not publishing peer-reviewed international papers were 24%/76% (fig. 3.24a). The rates for national papers were 30%/70% (fig. 3.24b). This low publishing rate demonstrates that most organizations lacked the capacity in microplastic research.

Figure 3.24. Status of publishing/not publishing research results in
a) peer-reviewed international papers and b) peer-reviewed national papers



a)

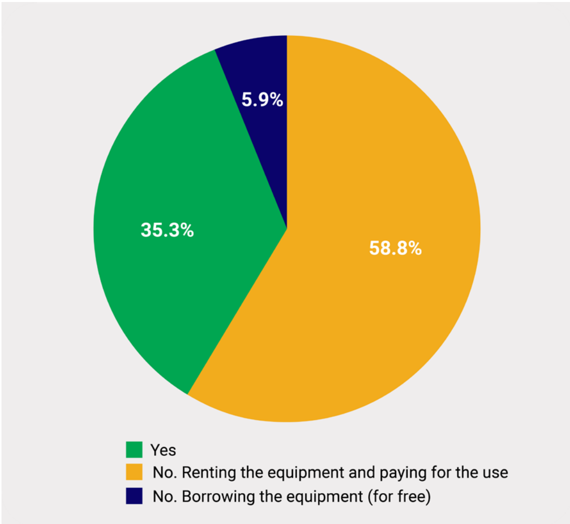


b)

3.4. Training and facility needs

Figure 3.25 presents the status of the availability of equipment for testing the polymer types of microplastics of different organizations in Vietnam. Among 15 answers, only 35% of the organizations owned the equipment for testing the microplastic polymer types. The remaining organizations rented or borrowed equipment. Most of the organizations that could analyze the polymer types of microplastics were found in large cities of Vietnam, such as Ha Noi, HCMC, and Da Nang city.

Figure 3.25. Status of owning/not owning equipment for polymer types testing of microplastics



Due to the lack of μFTIR spectrometry and μRaman spectrometry equipment (fig. 3.23b), any research on microplastics will face the following issues:

- The imprecision in measuring small-sized microplastics by a stereoscope. Thus, most organizations did not observe all microplastics from 1 to 5,000 μm and usually set the minimum observation size at 100 μm, 300 μm, or even 500 μm. It should be noted that to date many studies demonstrate a predominance of small-sized microplastics in different environmental compartments (Strady et al., 2020; Lahens et al., 2018). The meta-analysis provides evidence that there are more than tenfold magnitude differences in microplastic concentration when the analytical ranges are focused on larger microplastics (typically larger than 100 μm; analysed using equipment such as FTIR-ATR) compared to the smaller ranged microplastics (analysed using μFTIR spectrometry and μRaman spectrometry) (Abeynayaka et al., 2022).
- If other techniques such as FTIR-ATR are used instead, the percentage of identifying microplastic particles is usually low due to the disadvantage in picking up the small particles from the filters and transferring them to the FTIR-ATR equipment. Accordingly, the origins of microplastics in the environment cannot be known, despite such key knowledge being crucial to policymakers in designing action plans aimed at dealing with the issue of microplastic contamination.

Moving forward, based on the lack of capacity to research microplastics as discussed in Section 3.3 combined with the unavailability of equipment, preparing the facilities and human resources needed to strengthen the capacity of Vietnam's organizations to conduct research in microplastics is, therefore, an important task.

4. CONCLUSIONS AND RECOMMENDATIONS

This report provides in-depth knowledge on the state of the art of research on the assessment of microplastic contamination carried out at different universities, institutes, and companies in Vietnam. Based on this, the training and facility needs assessment to support monitoring as well as scientific evidence-based-policy development on microplastic-related pollution was addressed. At present, the methods used in microplastic analysis in Vietnam are not standardized and different organizations use different protocols in their sampling, laboratory analysis, microplastic observation, and chemical composition tests. This means research results published by different groups of researchers cannot be compared (in other words the data is not FAIR). Microplastic research mainly takes place in leading universities and institutes in large cities such as Ha Noi, Ho Chi Minh, and Da Nang city. However, the capacity for publishing research results in international and national journals by these organizations was comparatively low. The unavailability of necessary equipment is another constrain that needs to be addressed. To effectively implement the national action plan aimed at reducing contamination of microplastics in Vietnam's aquatic environments, addressing the capacity of research groups across universities, institutes, and companies to assess the level of microplastic contamination is an urgent need. This could be achieved by:

- Standardizing the full set of protocols for sampling and analyzing microplastics in the different compartments: water, sediment, biota, etc. Such protocols should be based on scientific knowledge and state-of-practice in microplastic research in Vietnam.
- Provision of support finding and laboratory equipment for universities and institutes in the regions that lack strong research groups, such as the Mekong River Delta, the northeast, north-central coast, and south-central coast.
- Organizing training programs to strengthen the ability of staff from various laboratories in these universities and institutes to be able to conduct the required research and publish the scientific results linked therewith- such training programs include the following:

    1. Fundamentals of the plastic and microplastic pollution issue
    2. Microplastic sampling and analysis including i) lessons on worldwide and Vietnamese protocols with emphasis on the strengths and weaknesses of each protocol and ii) field and laboratory practice on microplastic sampling and analysis
    3. Determination of the polymer types of microplastics: theory and practice
    4. Writing for scientific publication

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Appendix : Content of the questionnaire

Purpose of this Questionnaire

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. 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.

It is not necessarily the answering organization currently engaged in microplastic-related activities. The survey is intended to assess the present situation 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.

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A. Organization Background

1. Organization Name: ………………………………………………………………………………………………………

2. Adress: ……….

3. Province:
   - ☐ Southeast
   - ☐ Red River Delta
   - ☐ Mekong River Delta
   - ☐ Northeast Northwest
   - ☐ North Central Coast
   - ☐ South Central Coast
   - ☐ Central Highlands

4. Name of the person filling: ………………………………………………………………………………………

5. Emal: ……

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 government sector). Please select one or more relevant answers.
   - ☐ Drinking water (public water supply)
   - ☐ Freshwater (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 policymaking? (Please answer especially if you are a government sector). Please select one or more relevant answers.
   - ☐ Quality assurance
   - ☐ Monitoring
   - ☐ Policymaking
   - ☐ Other (please describe) ……………………………………………………………….

B. Research Activities

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

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.

   ………

C. 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

D. 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 time
       - ☐ 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

E. 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 time
       - ☐ 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

F. 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?
   - ☐ Fiber/filament
   - ☐ Fragment
   - ☐ Pellet
   - ☐ Film
   - ☐ Foam

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

6. Are you measuring the diameter of fiber?
   - ☐ 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}

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

G. 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)

We would like to thank you for your support.
Please provide us the protocols that you are using and any documents or information which may support us.

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