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ORIGINAL ARTICLE

Microplastics Characterization by Raman Spectroscopy in The Sediments of Kongsfjorden, Svalbard, Arctic

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ABSTRACT

In our ocean, plastic is the most prevalent type of marine debris found. Plastic debris can come in all sizes, but those less than five millimetres in length are called microplastics. When ingested by marine life, microplastics have both toxic and mechanical effects, leading to issues including reduced food intake, suffocation, behavioural changes, and genetic alteration. In addition to entering the food chain through seafood, these have been found in various human organs and even in the placenta of newborn babies. This study reports the size and polymer type distribution in the sediments of the Kongsfjorden, Arctic Ocean. Microplastics were extracted from twelve sediments of the Arctic Ocean, and qualitative determinations of polymer type and size distribution were highlighted. In addition to this, the ecological risk was highlighted using pollution indices such as the pollution load index (PLI), polymer hazard index (PHI), and potential ecological risk index (PERI), which revealed the pollution proximity of the study area as a reference line for future research.
Keywords: *Microplastics, Characterization, Raman Spectroscopy, Sediments, Kongsfjorden, Svalbard, Arctic*

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INTRODUCTION

Raman spectroscopy is considered to be effective in small-sized microplastic analysis [23, 25, 30, 32, 33, 39]. Microplastics plastic debris smaller than 5 mm, have raised widespread concern in society and the scientific community [34] but the lower size limit has not yet been accurately defined [9]. Environmental samples studies have shown that the abundance of microplastics is high [4, 15, 32, 36, 39] and are easily ingested by organisms [5, 29] which have significant toxic effects [13, 33]. Microplastic research in environmental samples has a great need to pay attention to the smaller particle sizes and accurate polymer type identification [9, 10, 20].

An estimate showed currently more than 5 trillion plastic particles floating in the Ocean, totalling circa 270,000 tonnes [11]. Degradation of each plastic particle fragments into ever smaller pieces, the total number of particles gallops upwards and so do the risks they pose to animal and human life [2, 37, 16, 22, 28]. Sediment serves as the ultimate sink of these microplastics. The study of microplastics in the Ocean sediments is important. So the present study highlights the microplastic polymer type and size distribution in the sediments of Kongsfjorden, an Arctic fjord, Svalbard. In the Arctic Ocean, we got some reports of microplastics. Microplastics from the deep-sea sediments in the Arctic were studied and their finding is scarce [3]. La Daana et.al. [17] presented preliminary information regarding microplastics in surficial sediments of the Arctic Central Basin (ACB). The first record of microplastic contamination in the surface sediment was presented from the northern Bering and Chukchi Seas [21]. González- Pleiter et.al. [12] investigated the presence of microplastics in the sediments adhered to rocks of an Arctic freshwater lake at Ny-Ålesund (Svalbard Archipelago, 78°N; 11°E). Analysis of microplastics in the Arctic sediment from Hudson Bay to north Baffin Bay was done by Huntington et.al. [14]. The occurrence of microplastics in the sediments of Kongsfjorden, an Arctic fjord in the Svalbard archipelago revealed the presence of microplastics in this sediment [26]. The first Canadian Arctic-wide study of anthropogenic particles (APs, >125 µm), including microplastics, in marine sediments from 14 sites was reported [1]. Choudhary et.al. [6] investigated the surface sediment of the Krossfjord Kongsfjord system to assess the distribution of microplastics. The abundance of microplastic was high in the fjord, indicating the influence of anthropogenic activity. In our study microplastics were extracted from twelve sediments of Kongsfjorden, an Svalbard, Arctic and qualitative determination along with size distribution was performed. This result gives detailed polymer type distribution in each station and the ecological risk of these polymers in the study area. Thus the study provides the compositional differences of different microplastics in the Kongsfjorden Svalbard, Arctic area which in turn provide a baseline for future research.

MATERIAL AND METHODS

The location map of the sampling sites is provided in Figure 1 and its geographical coordinates are given in Table 1. Surface sediment samples were collected from each station during the summer season in May-June 2019. Three lakes and nine stations along the Kongsfjorden glacial fjord were selected for the study. For the fjord sampling, a Van Veen grab (KC Denmark A/S) was deployed from a research boat (*M.S. Teisten*). In the case of lake sampling, the sediment samples were collected using a grab sampler (3.14 L, KC Demark A/S). The samples were collected, labelled, and transferred to -20º C at the earliest and were cold shipped to our laboratory for further analysis.

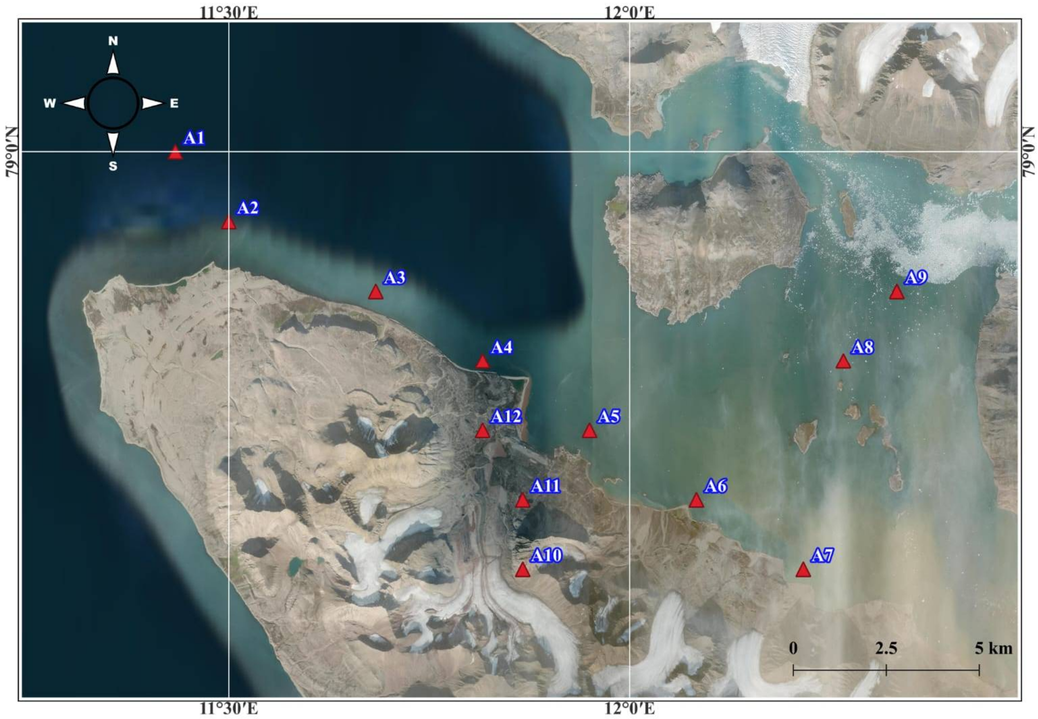

Figure 1: Location map of sampling sites in Kongsfjorden and lakes

Table1: Geographical coordinates of sampling locations

Station	Latitude	Longitude
A1	79°00'683N	11°26'269E
A2	78°59'589N	11°30'456E
A3	78°58'310N	11°41'822E
A4	78°57'534N	11°49'529E
A5	78°56'358N	11°57'910E
A6	78°55'351N	12°05'861E
A7	78°54'216N	12°13'796E
A8	78°57'379N	12°16'839E
A9	78°58'216N	12°20'190E
A10	78°54'9490N	11°52'5078E
A11	78°55'4640N	11°52'6209E
A12	78°56'4431N	11°49'4595E

Extraction of microplastics in the sediment samples was done as per the National Oceanic and Atmospheric Administration (NOAA) protocol [19]. The samples were subjected to wet peroxide oxidation with 30% hydrogen peroxide was then subjected to density separation using $ZnCl_2$ (density = 1.6 g/cm^3) [8, 38] to separate microplastics through floatation. The supernatant was then filtered using Whatman GF/A filter paper (47 mm). Filters were oven-dried (60^{0}C) and identification was done using a custom-built Raman Spectrometer [35]. The images were captured in a 10x microscope objective. The software used for capturing and size measurement of the images was NIS Elements D 3.2. To evaluate the potential risks of microplastics in surface sediments, we have considered the concentration of the chemical composition of microplastics. The pollution load index (PLI) and pollution hazard index (PHI) of polymer type [27] were calculated to understand the pollution status of microplastics. The chemical toxicity of different polymer types of microplastics is considered to evaluate their ecological harm by polymer hazard assessment [18]. The potential ecological risk index (PERI) is also used to assess the degree of contamination of microplastics in the sediments [24].

RESULTS AND DISCUSSIONS

Microplastics from the deep-sea sediments in the Arctic were studied and their finding is scarce. Bergmann et al. 2017 reported almost 80 % of the microplastics were ≤ 25 μm. The microplastic quantities are amongst the highest recorded from benthic sediments, which corroborates the deep sea as a major sink for microplastics and the presence of accumulation in this remote part is via the Thermohaline Circulation. In the present study abundance of microplastics and pigment distribution in the Arctic Ocean, along the Kongsfjorden glacial fjord twelve stations (A1, A2, A3, A4, A5, A6, A7 and A8, A9, A10, A11, A12). This investigation resulted in the identification of different size distributions of microplastics and qualitative determination of microplastics with the use of Raman spectroscopy. Results highlighted the detailed polymer type distribution and size variation in the study area. Ecological risks of the polymer type of microplastics were analysed using Pollution Load Indices (PLI), Polymer Hazard Indices (PHI) and Potential ecological risk indices (PERI).

The Raman spectra of 3 particles were recorded from the sample collected from site A1. Among these particles, one particle was identified as Polyethylene terephthalate, two particles were classified as anthropogenic particles that exhibited the spectrum of blue dyes; copper phthalocyanine and indigo blue. The Raman spectra of some microplastics recorded from site A1 are shown in Figure 2.

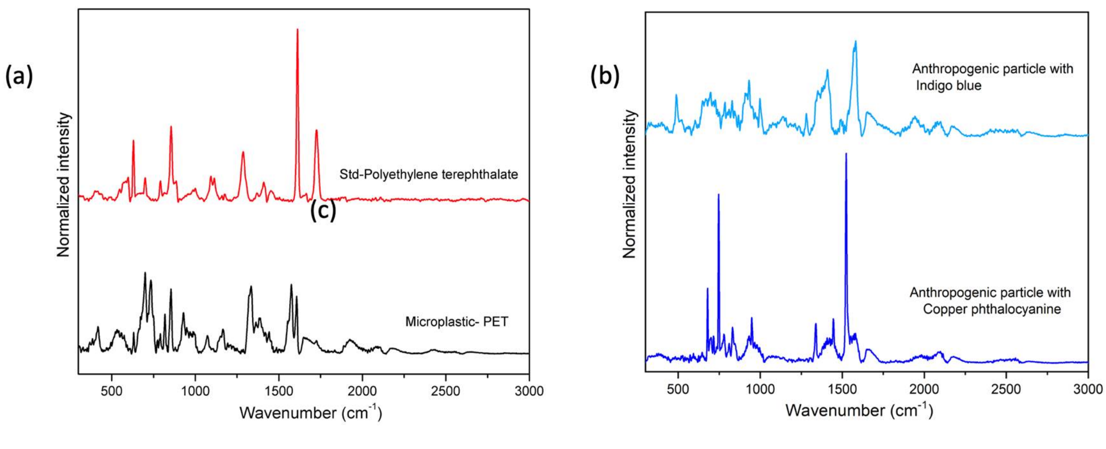

Figure 2: Raman spectra of identified microplastics (a) PET (b) Anthropogenic particle with Pigment (site A1)

The bar diagrams of different types of polymers and sizes of microplastics found in site A1 are given in Figure 3.

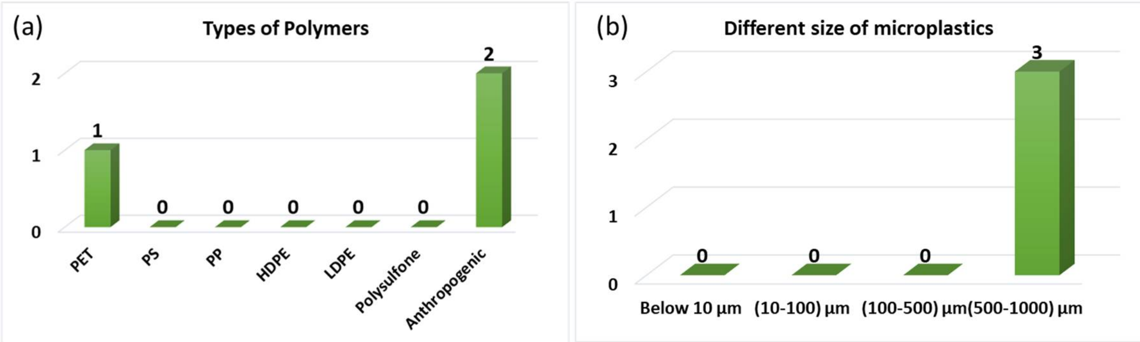

Figure 3: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (site A1)

The microscopic images of microplastics collected from the Arctic Ocean (Site- A1) are shown in Figure 4.

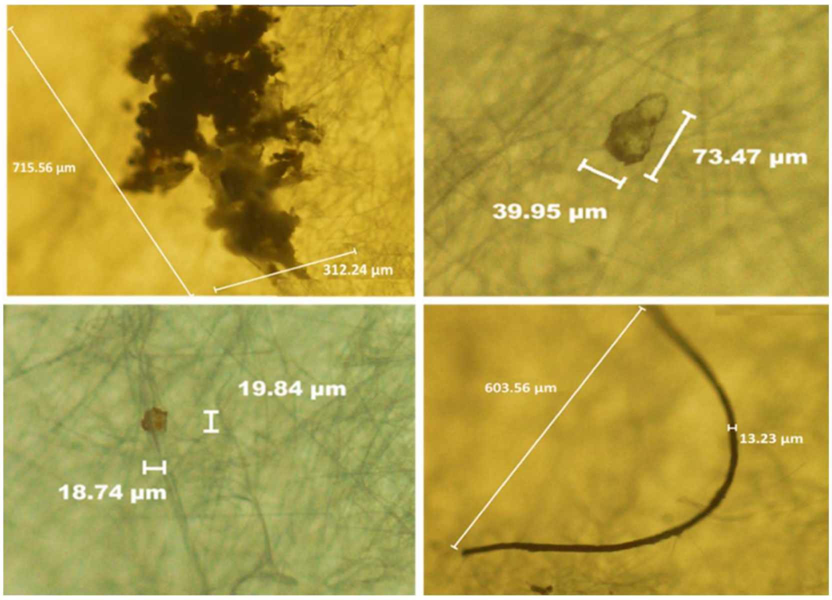

Figure 4: Microscopic images of microplastics from site A1

The Raman spectra of 7 particles were recorded from the sample collected from site A2. Among these particles, one particle was identified as Polystyrene and four were identified as polyethene terephthalate. Two particles were classified as anthropogenic particles that exhibited the spectrum of blue dye copper phthalocyanine. The Raman spectra of some microplastics recorded from site A2 are shown in Figure 5.

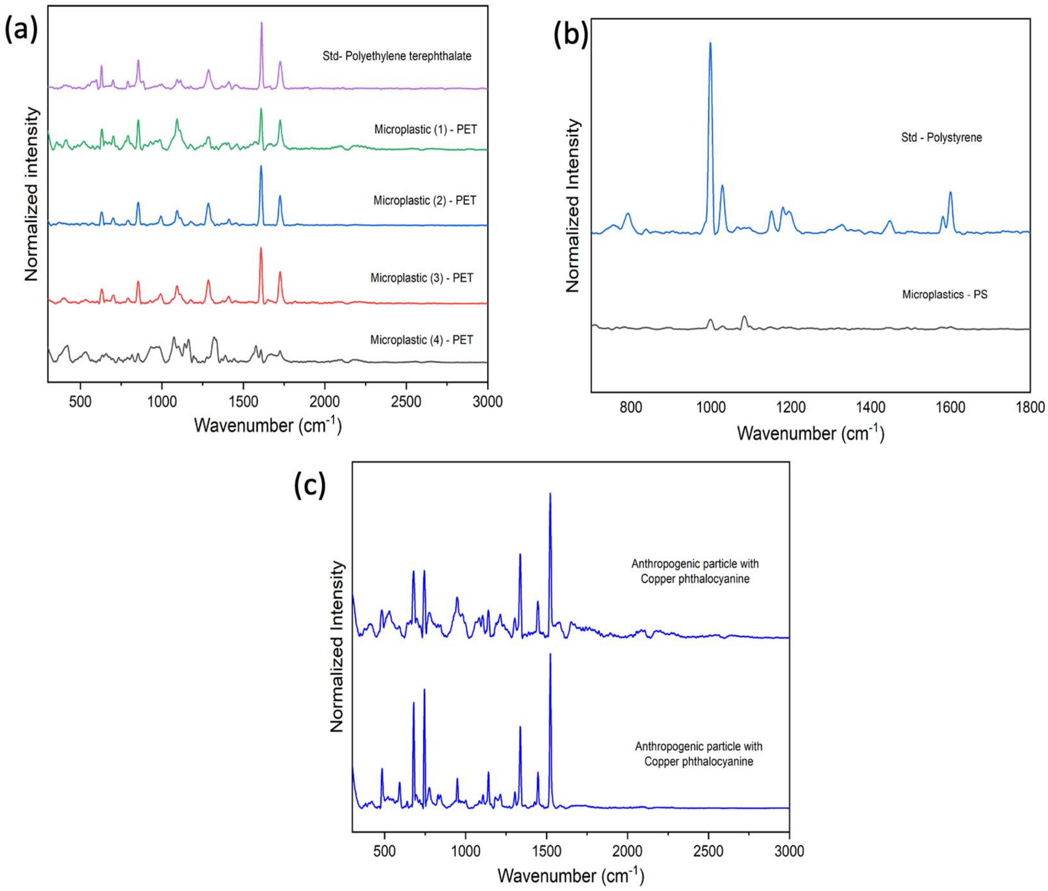

Figure 5: Raman spectra of identified plastics (a) PET (b) PS and (c) Anthropogenic particle with pigment (site A2)

The bar diagrams of different types of polymers and sizes of microplastics found in site A2 are given in Figure 6.

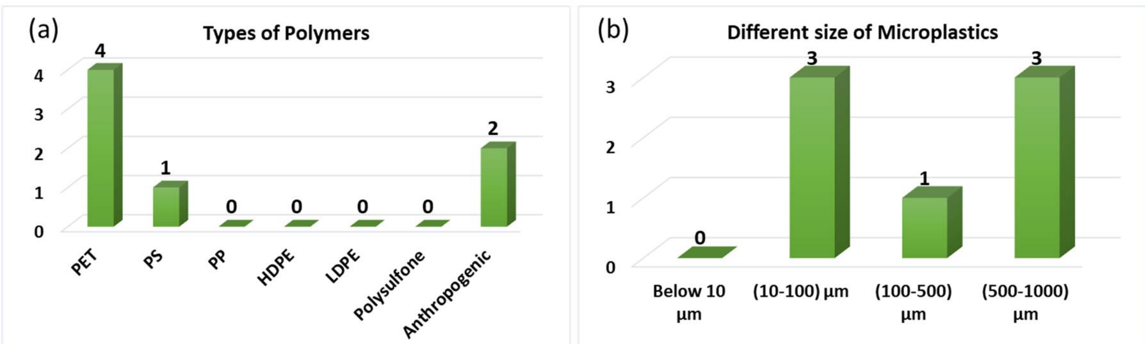

Figure 6: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (site A2).

The microscopic images of microplastics collected from the Arctic Ocean (Site- A2) are shown in Figure 7.

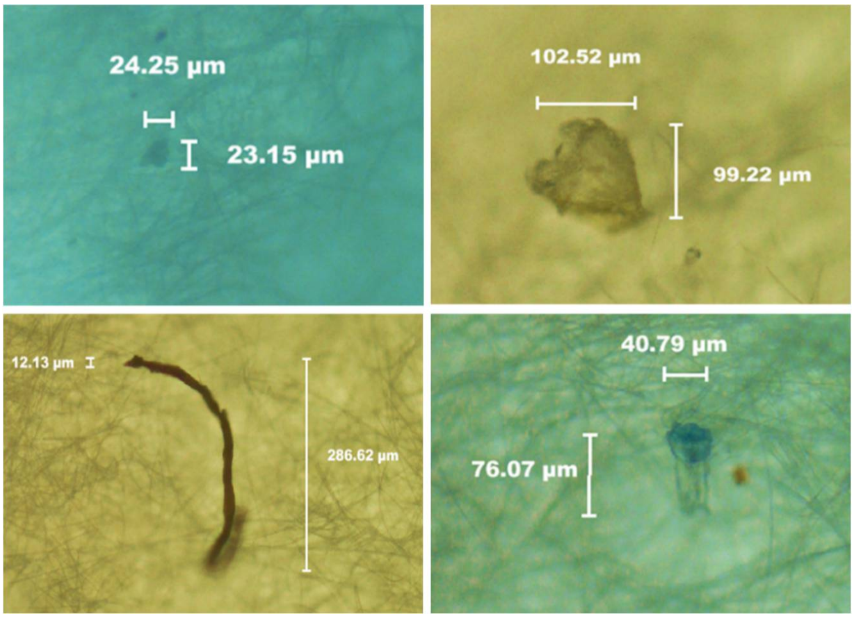

Figure 7: Microscopic images of microplastics from site A2

The Raman spectra of 18 particles were recorded from the sample collected from site A3. Among these particles, one particle was identified as Polystyrene, one identified as Polypropylene and one was identified as Low-density polyethene. 13 particles were identified as polysulfone that exhibited the spectrum of blue dye copper phthalocyanine. 2 particles were identified as anthropogenic particles showing the spectrum of pigments. The Raman spectra of some microplastics recorded from site A3 are shown in Figure 8.

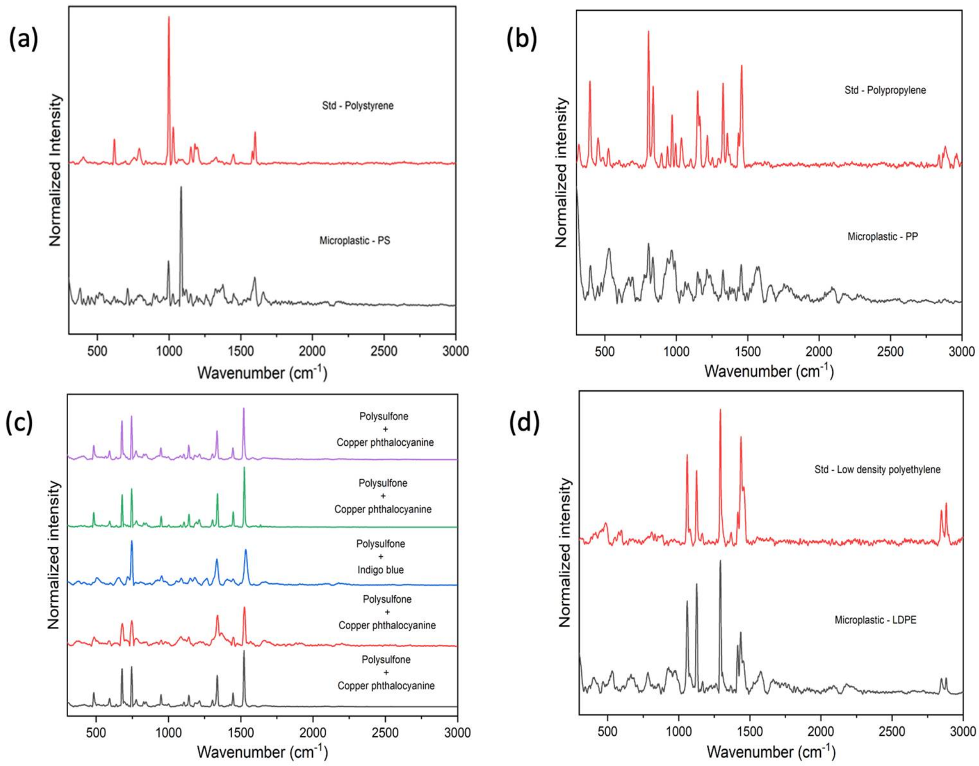

Figure 8: Raman spectra of identified plastics (a) PS (b) PP (c) Polysulfone and pigment and (d) LDPE (site A3)

The bar diagrams of different types of polymers and sizes of microplastics found in site A3 are given in Figure 9.

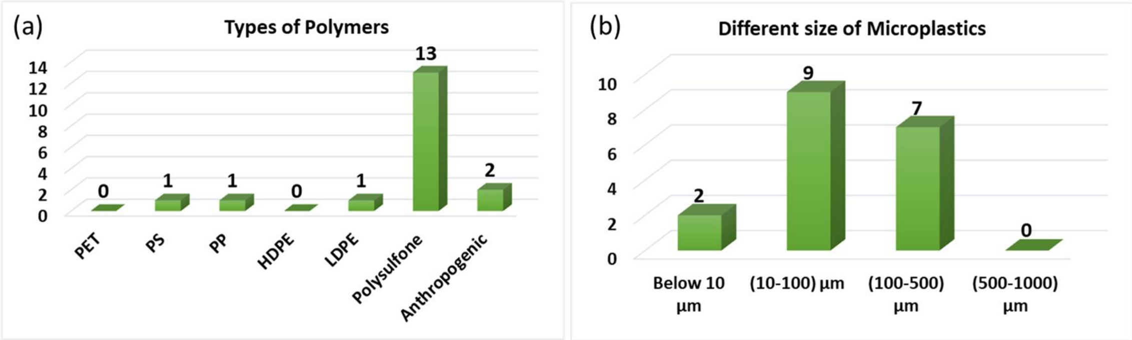

Figure 9: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (site A3)

The microscopic images of microplastics collected from the Arctic Ocean (Site- A3) are shown in Figure 10.

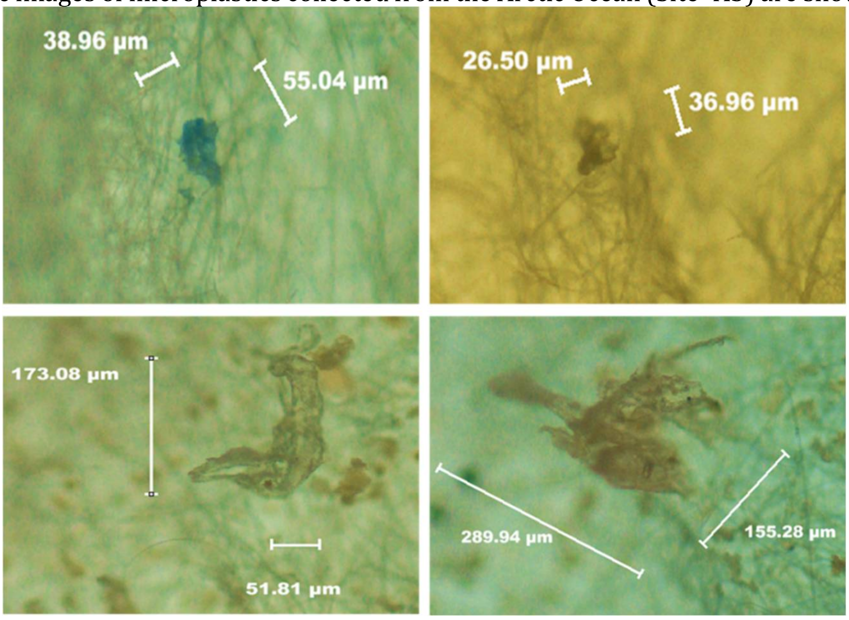

Figure 10: Microscopic images of microplastics from site A3

The Raman spectra of 39 particles were recorded from the sample collected from site A4. Among these particles, 6 particles were identified as PET, 2 particles were identified as PS, 9 were identified as PP, 3 were identified as HDPE, 9 were identified as LDPE, 2 were identified as polysulfone,8 particles were identified as anthropogenic particles that exhibited the spectrum of blue dye copper phthalocyanine or red pigment. The Raman spectra of some microplastics recorded from site A4 are shown in Figure 11.

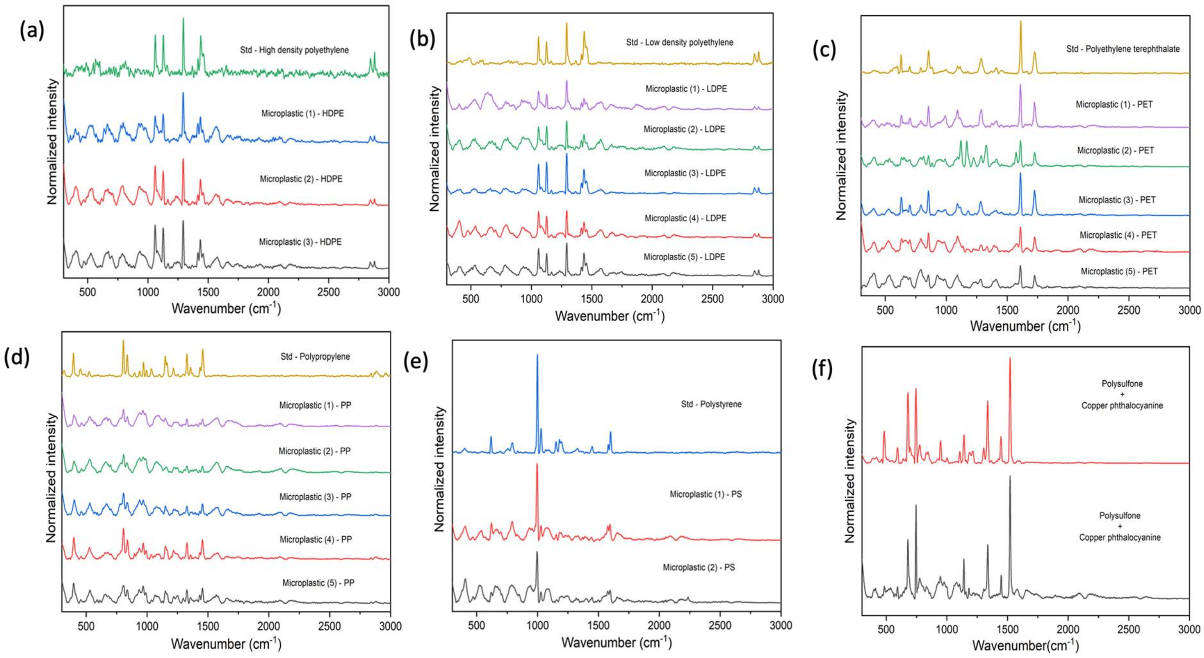

Figure 11: Raman spectra of identified plastics (a) HDPE (b) LDPE (c) PET (d) PP (e) PS and (f) Polysulfone and pigment (site A4)

The bar diagrams of different types of polymers and sizes of microplastics found in site A4 are given in Figure 12.

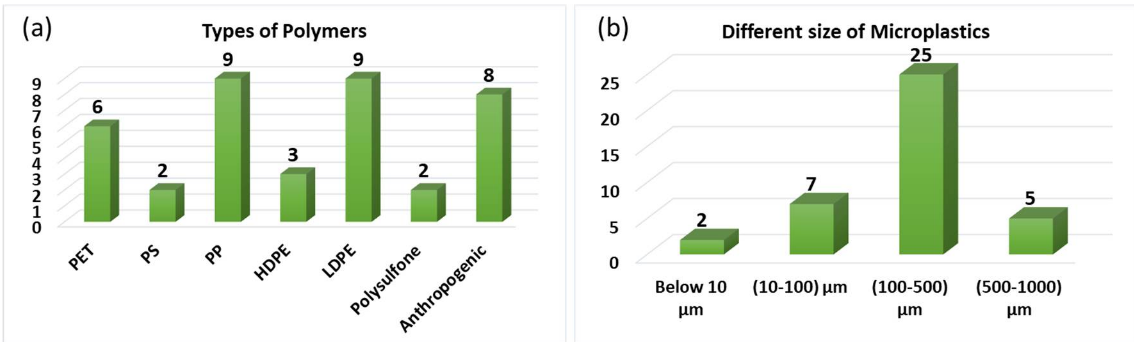

Figure 12: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics(site A4)

The microscopic images of microplastics collected from the Arctic Ocean (Site- A4) are shown in Figure 13.

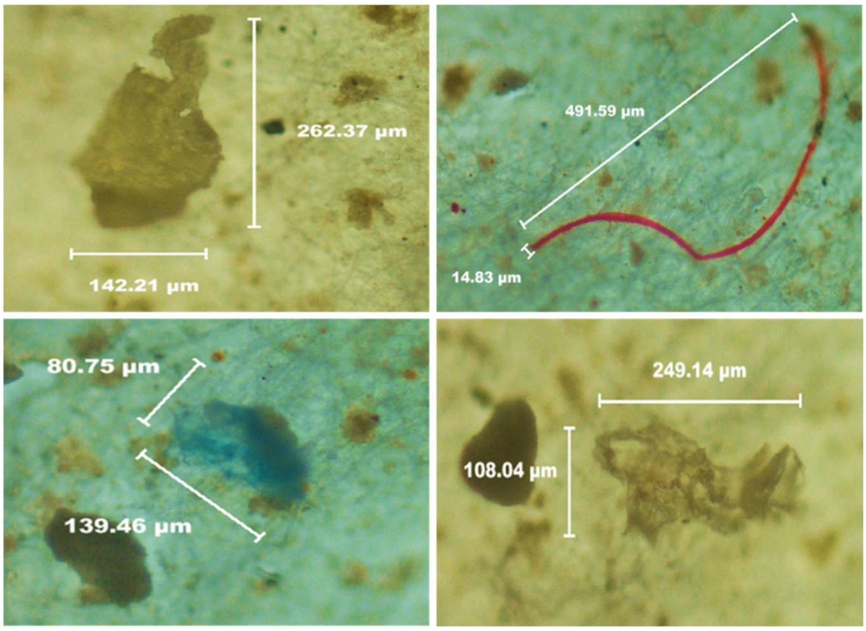

Figure 13: Microscopic images of microplastics from site A4

The Raman spectra of 34 particles were recorded from the sample collected from site A5. Among these particles, 2 particles were identified as PET, 5 particles were identified as PS, 10 were identified as PP, 2 were identified as HDPE, and 7 were identified as LDPE. 8 particles were identified as anthropogenic particles that exhibited the spectrum of blue dye copper phthalocyanine and red pigment. The Raman spectra of some microplastics recorded from site A5 are shown in Figure 14.

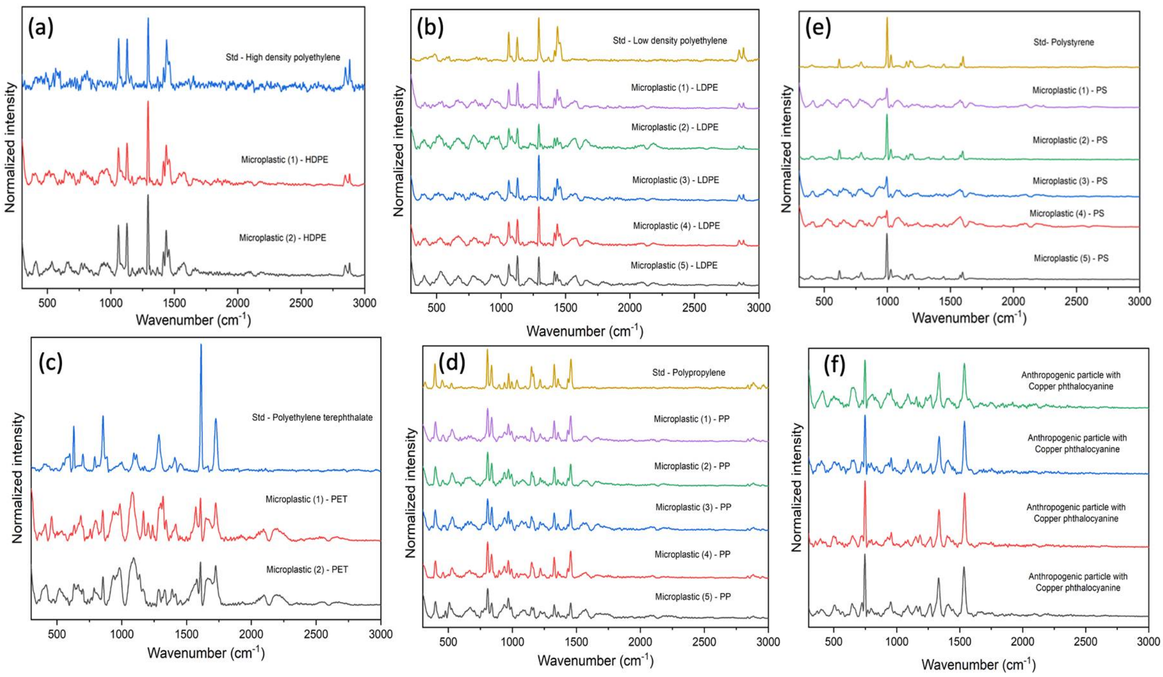

Figure 14: Raman spectra of identified plastics (a) HDPE(b) LDPE (c) PET (d) PP (e) PS (f) Anthropogenic particle with pigment (site A5)

The bar diagrams of different types of polymers and sizes of microplastics found in site A5 are given in Figure 15.

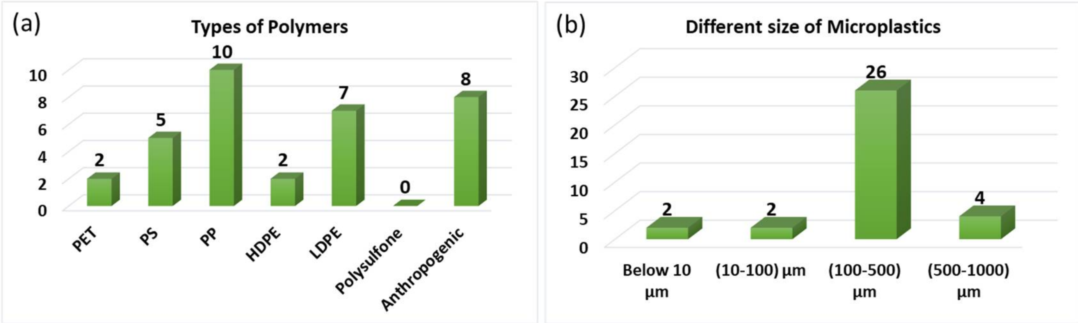

Figure 15: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (site A5)

The microscopic images of microplastics collected from the Arctic Ocean (Site- A5) are shown in Figure 16.

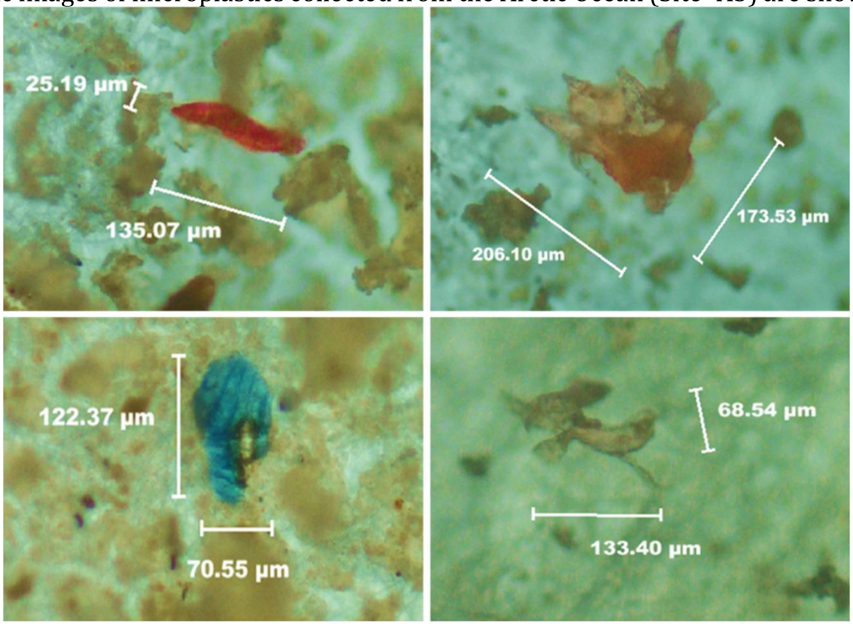

Figure 16: Microscopic images of microplastics from site A5

The Raman spectra of 16 particles were recorded from the sample collected from site A6. Among these particles, 1 particle was identified as PET, 1 particle was identified as PS, 1 was identified as PP,1 particle as polysulfone and 4 were identified as LDPE. 8 particles were identified as anthropogenic particles that exhibited the spectrum of blue dye copper phthalocyanine and red pigment. The Raman spectra of some microplastics recorded from site A6 are shown in Figure 17.

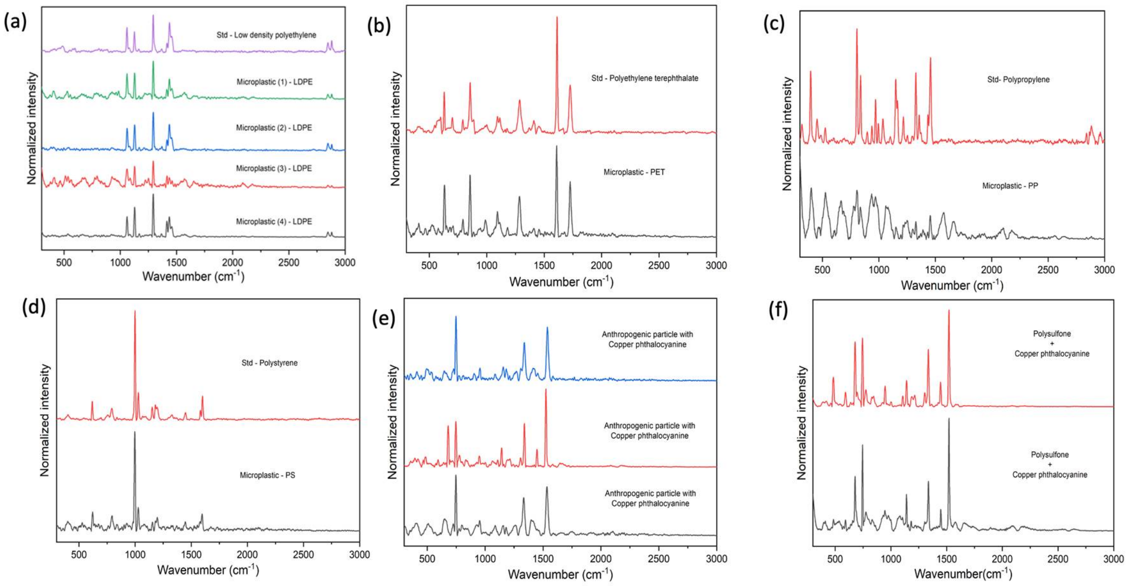

Figure 17: Raman spectra of identified plastics (a) LDPE (b) PET (c) PP (d) PS (e) Anthropogenic particle with pigment and (f) polysulfone (site A6)

The bar diagrams of different types of polymers and sizes of microplastics found in site A6 are given in Figure 18.

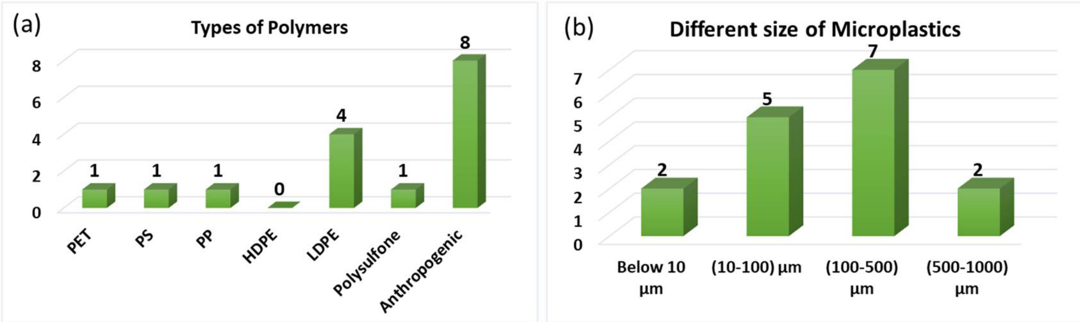

Figure 18: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (site A6)

The microscopic images of microplastics collected from the Arctic Ocean (Site- A6) are shown in Figure 19.

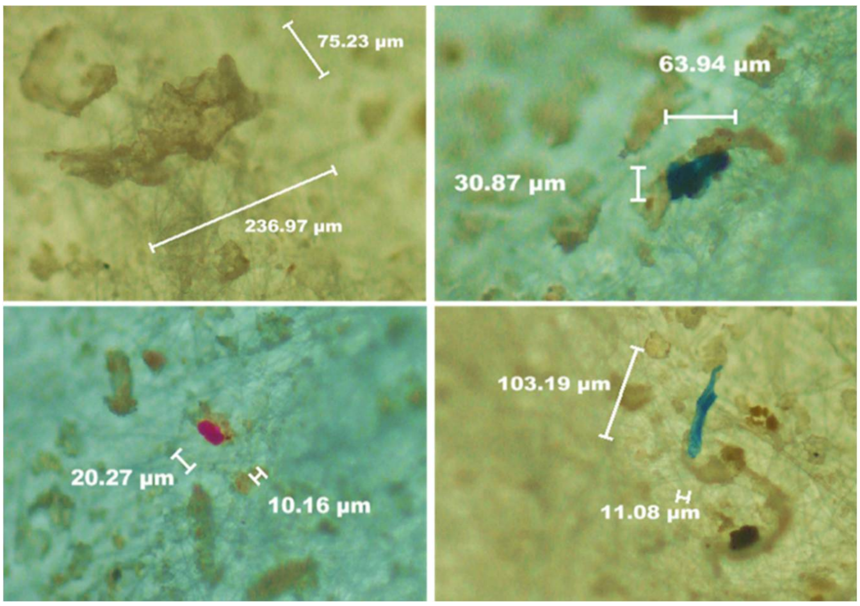

Figure 19: Microscopic images of microplastics from site A6

The Raman spectra of 19 particles were recorded from the sample collected from site A7. Among these particles, 5 particles were identified as PET, 1 particle was identified as PP, 2 were identified as LDPE and 2 were identified as HDPE. 9 particles were identified as anthropogenic particles that exhibited the spectrum of blue dye copper phthalocyanine and red pigment. The Raman spectra of some microplastics recorded from site A7 are shown in Figure 20.

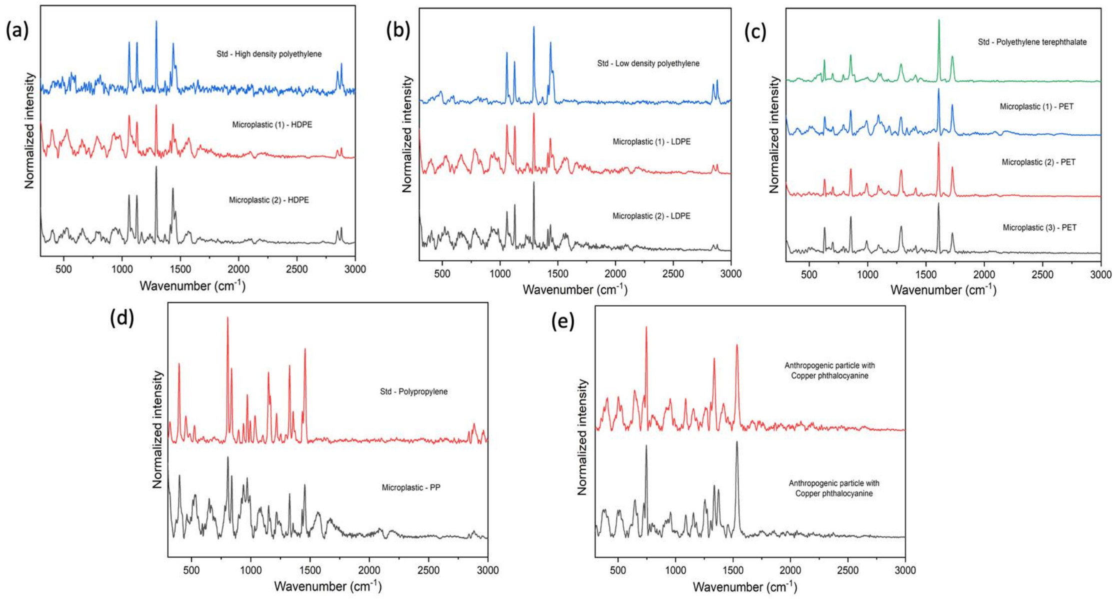

Figure 20: Raman spectra of identified plastics (a) HDPE (b) LDPE (c) PET (d) PP and (e) Anthropogenic particle with pigment(Site- A7)

The bar diagrams of different types of polymers and sizes of microplastics found in site A7 are given in Figure 21.

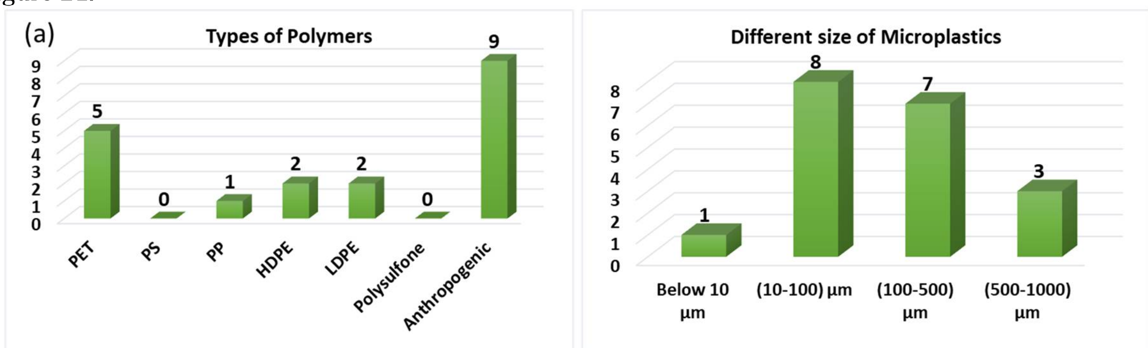

Figure 21: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (Site- A7)

The microscopic images of microplastics collected from the Arctic Ocean (Site- A7) are shown in Figure 22.

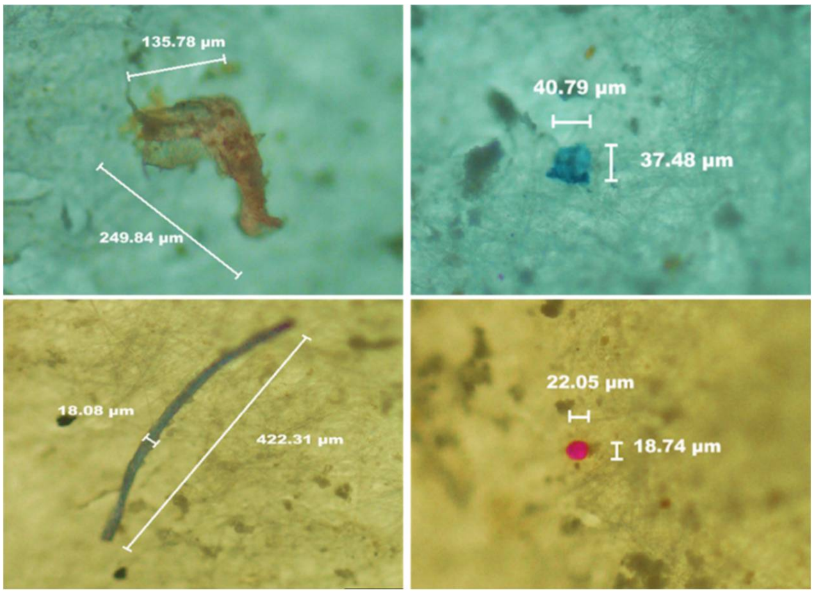

Figure 22: Microscopic images of microplastics from site A7

The Raman spectra of 9 particles were recorded from the sample collected from site A8. Among these particles, 4 particles were identified as PET, and 2 were identified as PP. 3 particles were identified as anthropogenic particles that exhibited the spectrum of blue dye copper phthalocyanine. The Raman spectra of some microplastics recorded from site A8 are shown in Figure 23.

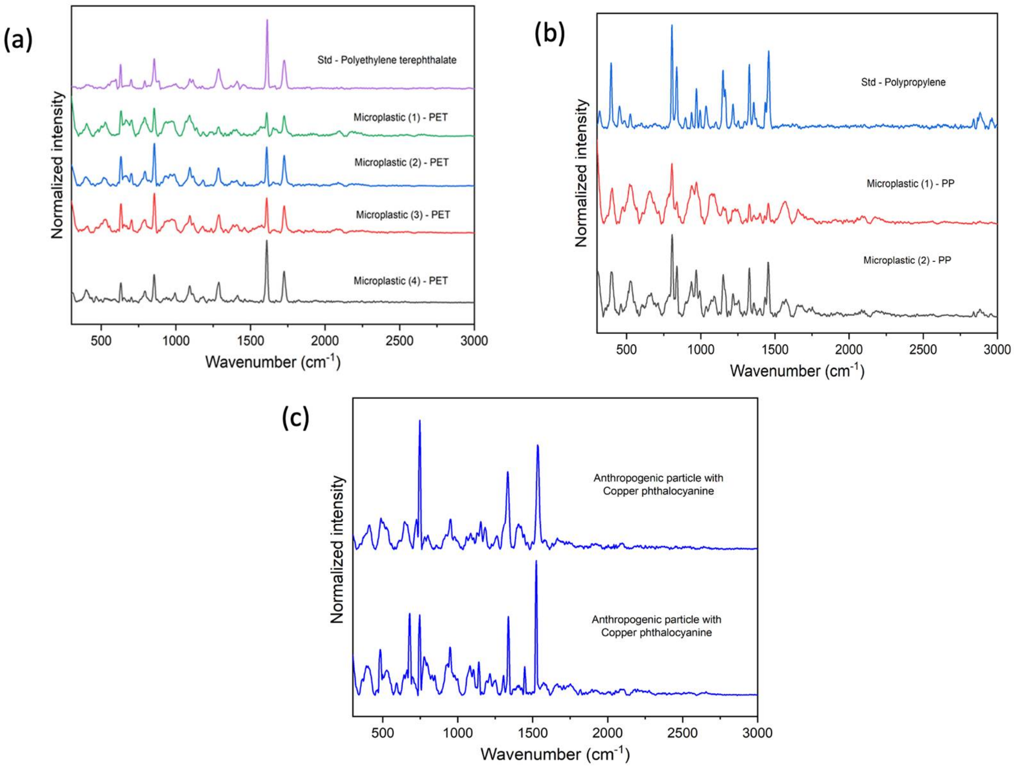

Figure 23: Raman spectra of identified plastics (a) PET (b) PP and (c) Anthropogenic particle with pigment(Site- A8)

The bar diagrams of different types of polymers and sizes of microplastics found in site A8 are given in Figure 24.

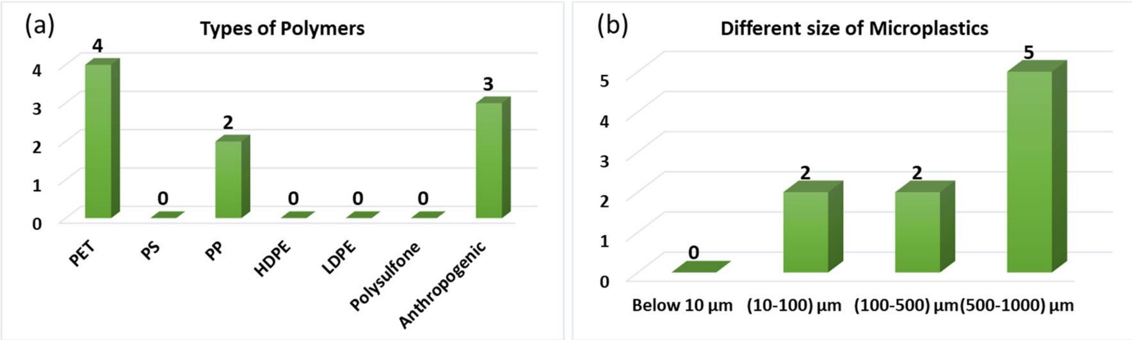

Figure 24: Bar diagrams representing (a) Types of polymers (b) Different sizes of microplastics (Site- A8)

The microscopic images of microplastics collected from the Arctic Ocean (Site- A8) are shown in Figure 25.

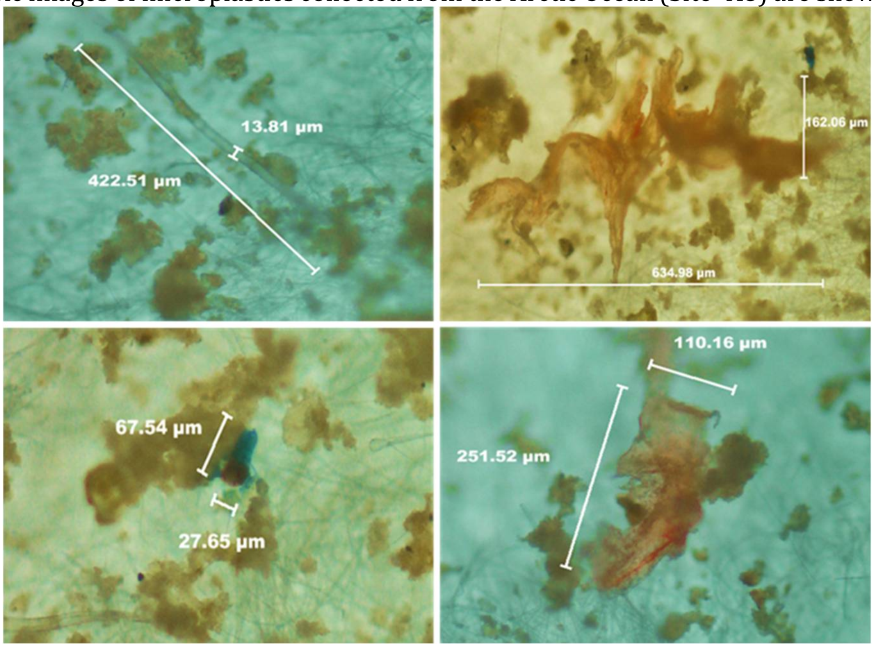

Figure 25: Microscopic images of microplastics from site A8

The Raman spectra of 25 particles were recorded from the sample collected from site A9. Among these particles, 4 particles were identified as PET, and 5 were identified as PP. 1 particle was identified as LDPE,1 particle was identified as polysulphone,14 particles were identified as anthropogenic particles that exhibited the spectrum of pink pigment and blue dye copper phthalocyanine. The Raman spectra of some microplastics recorded from site A9 are shown in Figure 26.

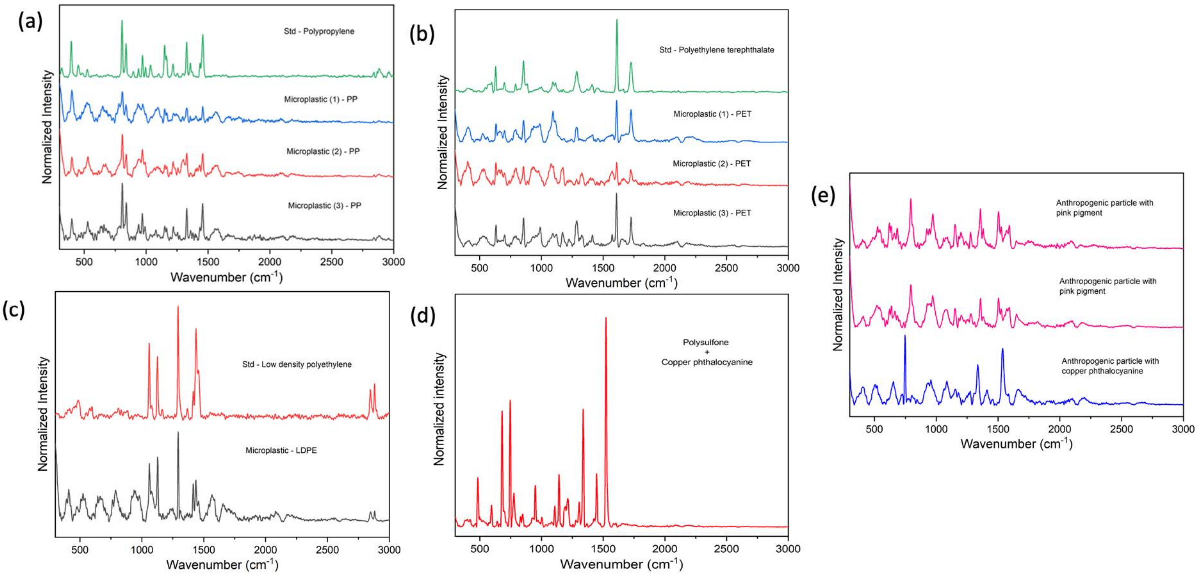

Figure 26: Raman spectra of identified plastics (a) PP (b) PET(c) LDPE (d)Polysulphone and (e) Anthropogenic particle with pigment(Site- A9)

The bar diagrams of different types of polymers and sizes of microplastics found in site A9 are given in Figure 27.

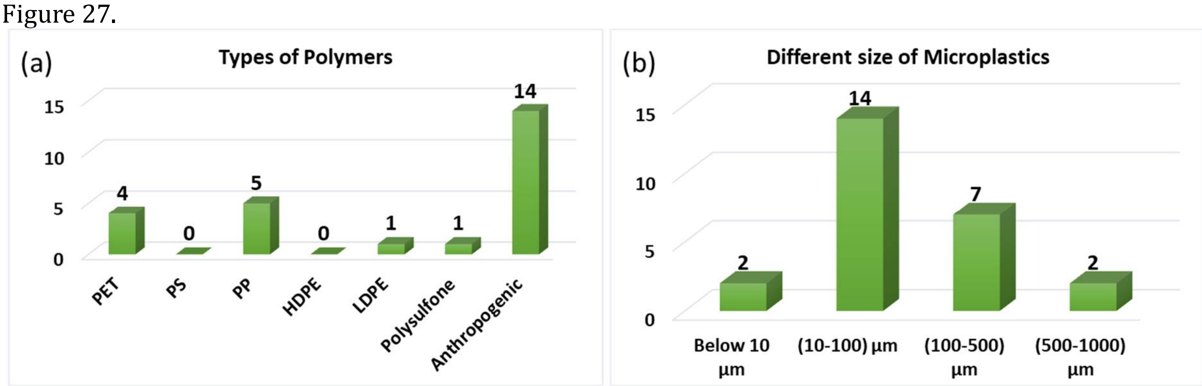

Figure 27: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (Site- A9)

The microscopic images of microplastics collected from the Arctic Ocean (Site- A9) are shown in Figure 28.

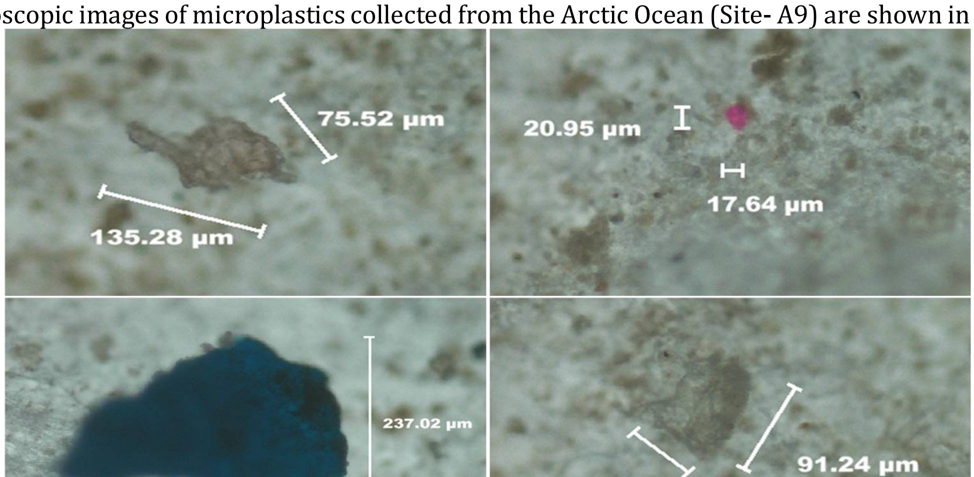

Figure 28: Microscopic images of microplastics from site A9

The Raman spectra of 34 particles were recorded from the sample collected from site A10. Among these particles, 7 particles were identified as PET, 2 particles were identified as PS and 5 were identified as PP. 1 particle was identified as HDPE,3 particles were identified as polysulphone,16 particles were identified as anthropogenic particles that exhibited the spectrum of pink pigment and blue dye copper phthalocyanine. The Raman spectra of some microplastics recorded from site A10 are shown in Figure 29.

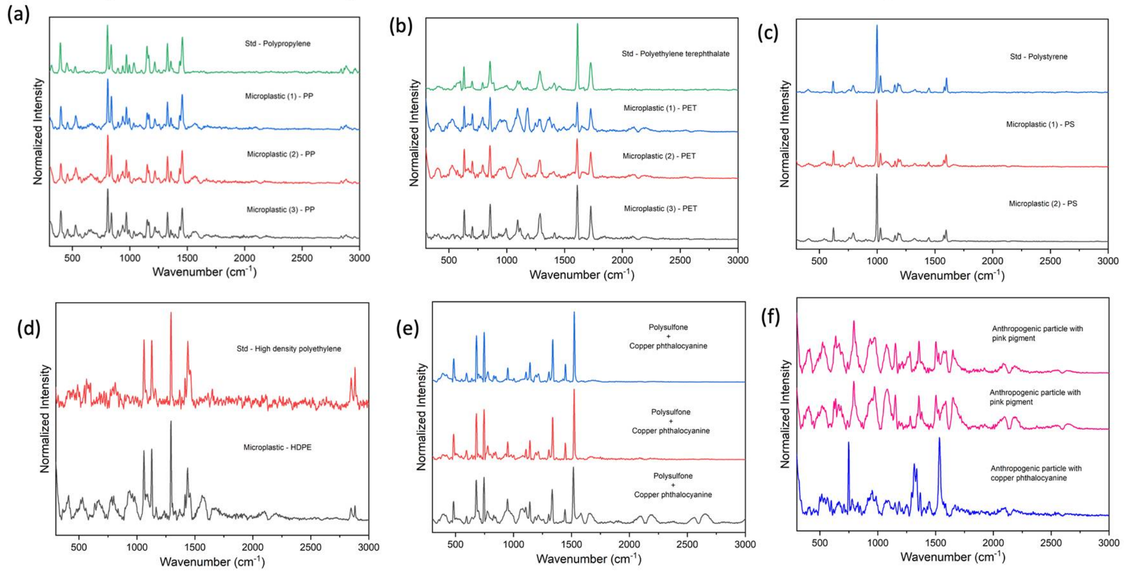

Figure 29: Raman spectra of identified plastics (a) PP (b) PET(c) PS,(d)HDPE,(e)Polysulfone and (f) Anthropogenic particle with pigment (Site- A10).

The bar diagrams of different types of polymers and sizes of microplastics found in site A10 are given in Figure 30.

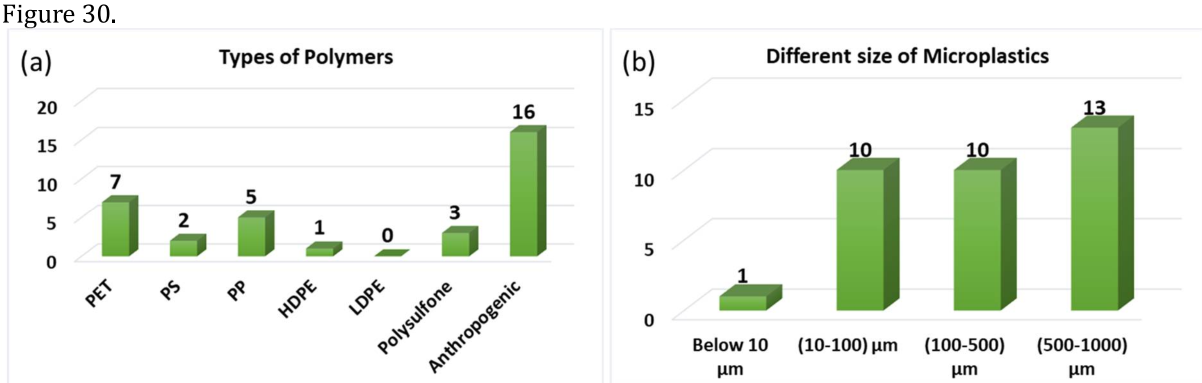

Figure 30: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (Site- A10).

The microscopic images of microplastics collected from the Arctic Ocean (Site- A10) are shown in Figure 31.

Figure 31: Microscopic images of microplastics from site A10

The Raman spectra of 12 particles were recorded from the sample collected from site A11. Among these particles,3 particles were identified as PET, and 1 was identified as PP. 1 particle was identified as LDPE,1 particle was identified as polysulphone, 6 particles were identified as anthropogenic particles that exhibited the spectrum of pink pigment and blue dye copper phthalocyanine. The Raman spectra of some microplastics recorded from site A11 are shown in Figure 32.

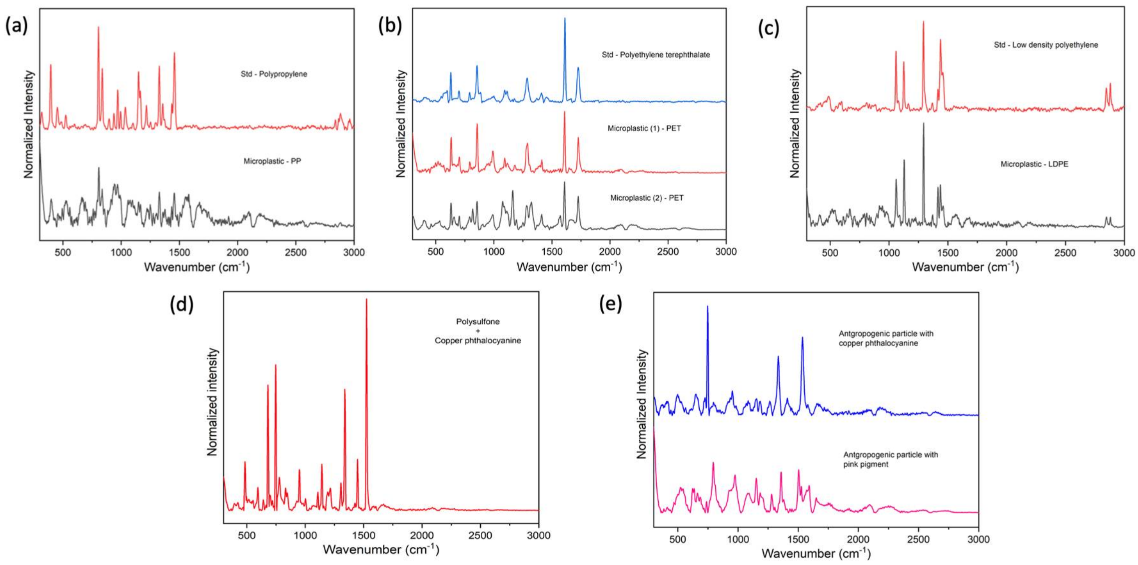

Figure 32: Raman spectra of identified plastics (a) PP (b) PET(c) LDPE,(d) Polysulfone and (e) Anthropogenic particle with pigment (Site- A11).

The bar diagrams of different types of polymers and sizes of microplastics found in site A11 are given in Figure 33.

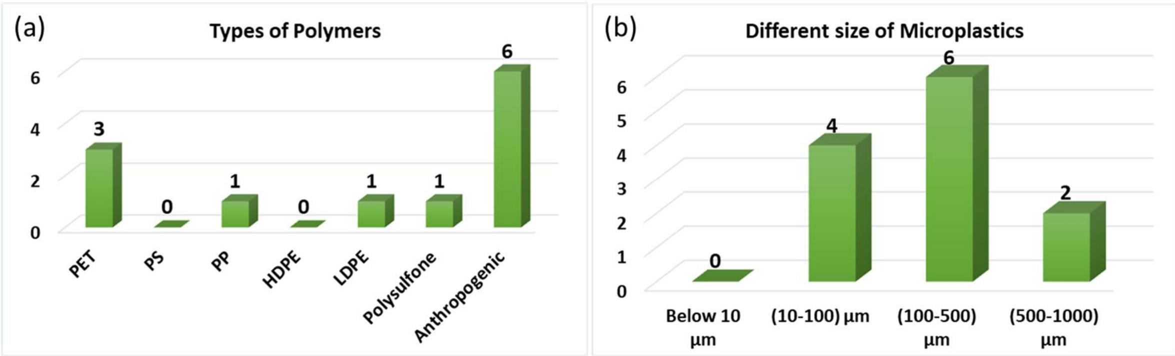

Figure 33: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (Site- A11).

The microscopic images of microplastics collected from the Arctic Ocean (Site- A11) are shown in Figure 34.

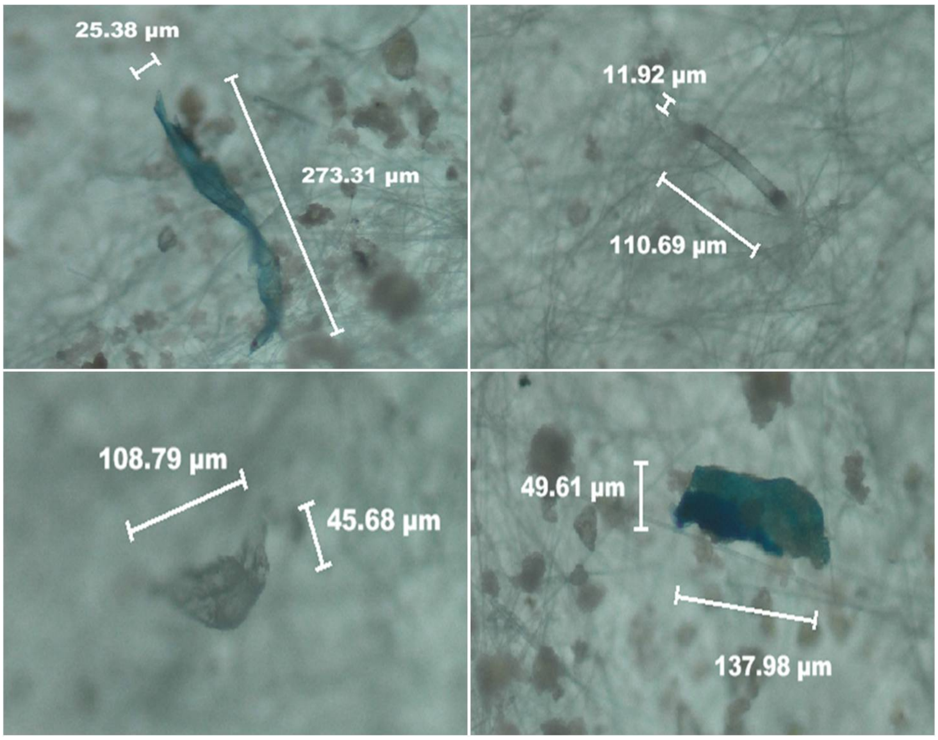

Figure 34: Microscopic images of microplastics from site A11

The Raman spectra of 48 particles were recorded from the sample collected from site A12. Among these particles, 3 particles were identified as PET, 3 particles were identified as PS and 29 were identified as PP. 2 particle was identified as LDPE,1 particle as polysulphone,10 particles were identified as anthropogenic particles that exhibited the spectrum of pink pigment, green pigment and blue dye copper phthalocyanine. The Raman spectra of some microplastics recorded from site A12 are shown in Figure 35.

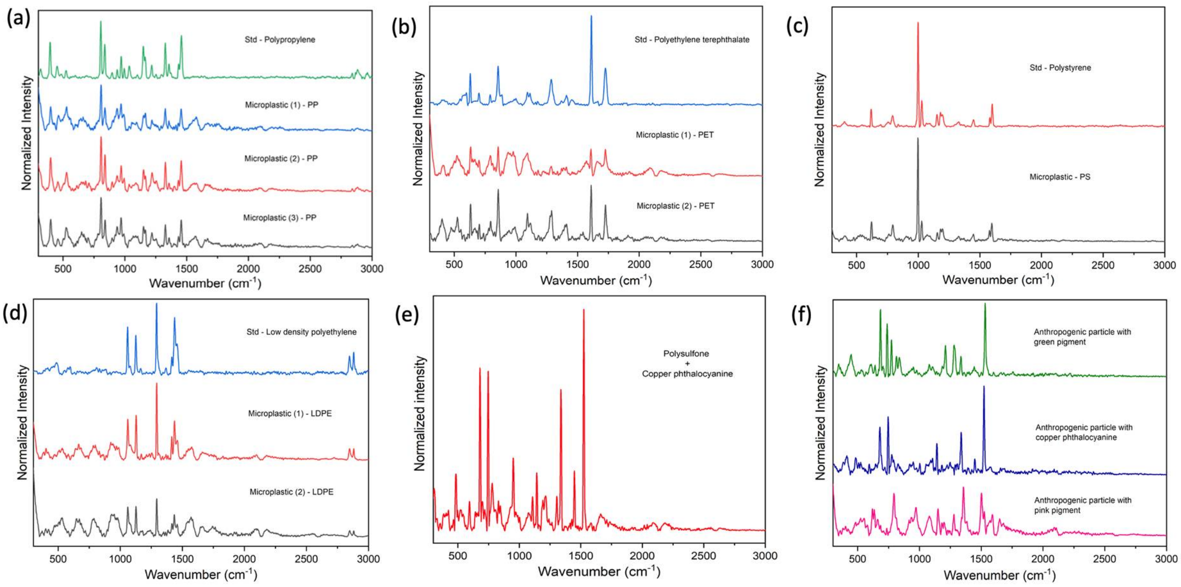

Figure 35: Raman spectra of identified plastics (a) PP (b) PET(c) PS,(d)LDPE,(e) Polysulfone and (f) Anthropogenic particle with pigment (Site- A12).

The bar diagrams of different types of polymers and sizes of microplastics found in site A12 are given in Figure 36.

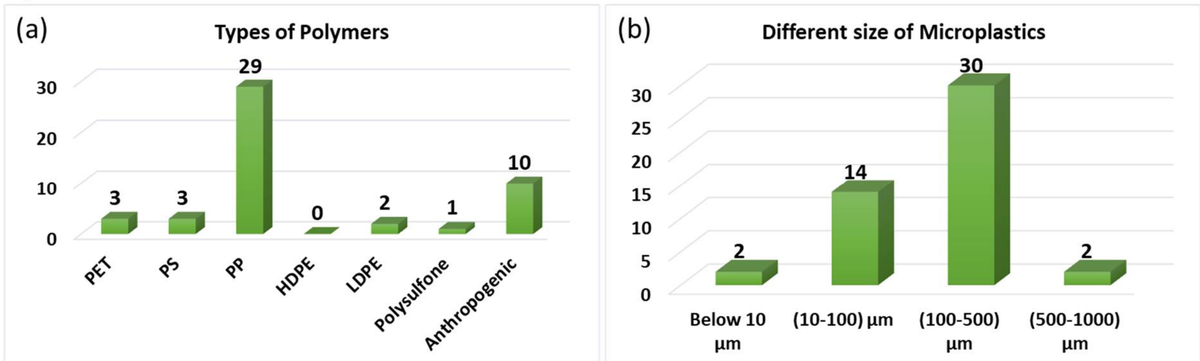

Figure 36: Bar diagrams representing (a) Types of polymers and (b) Different sizes of microplastics (Site- A12).

The microscopic images of microplastics collected from the Arctic Ocean (Site- A12) are shown in Figure 36.

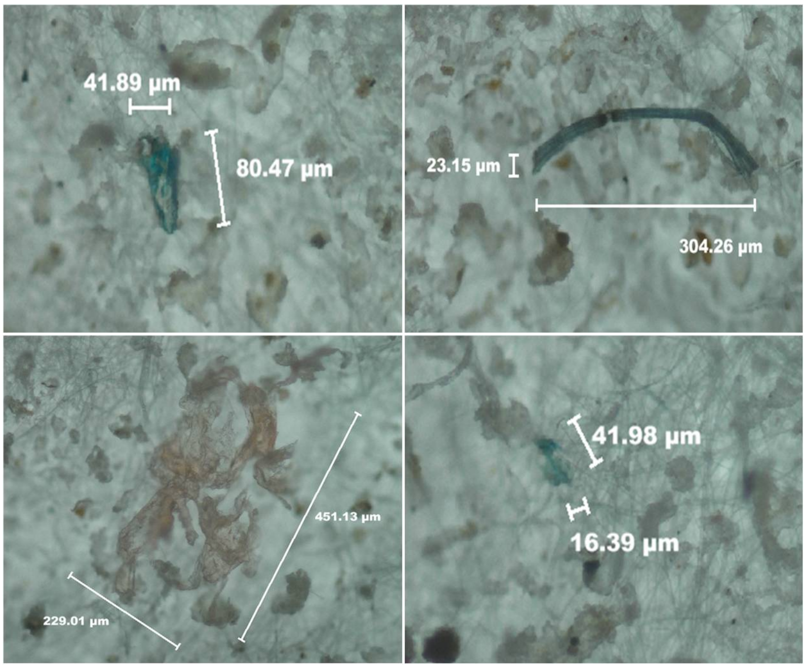

Figure 37: Microscopic images of microplastics from site A12

The sediments from the 12 sites of the study area showed the vivid distribution of polymer types such as PP, PET, PS, LDPE, LDPE, Polysulfone and Anthropogenic. The percentage variation of this polymer type is given in Figure 38. The distribution follows the order Anthropogenic (34 %) > PP(24%)> PET(15%)> LDPE(10%) > Polysulfone (8%) PS (6%)>HDPE(3%). La Daana et.al. [17] presented preliminary information regarding microplastics in surficial sediments of the Arctic Central Basin (ACB). The possible presence of microplastics, specifically low-density polymers such as polypropylene (PP) and polystyrene (PS), in the sediment phase of the ACB suggests that mechanisms are operating within this oceanic basin that are affecting the density of microplastics and that are potentially driving the vertical transport of these particles through the water column. Microplastics that are present in sediments of the ACB are likely to interact with organisms inhabiting or depending upon this environmental phase. The first record of microplastic contamination in the surface sediment was presented from the northern Bering and Chukchi Seas [21]. The highest level of microplastic contamination in the sediment was detected from the Chukchi Sea. Polypropylene (PP) accounted for the largest proportion (51.5%) of the identified microplastic particles, followed by polyethene terephthalate (PET) (35.2%) and rayon (13.3%). González- Pleiter et.al. [12] investigated the presence of microplastics in the sediments adhered to rocks of an Arctic freshwater lake at Ny-Ålesund (Svalbard Archipelago, 78°N; 11°E). The characterization of microparticles confirms the presence of poly(ethylene terephthalate) and a variety of other anthropogenic particles with industrial additives and/or non-natural colours.

Analysis of microplastics in the Arctic sediment from Hudson Bay to north Baffin Bay was done by Huntington et.al. [14]. Results found 85% of sediment samples, contained microplastics or other anthropogenic particles. The occurrence of microplastics in the sediments of Kongsfjorden, an Arctic fjord in the Svalbard archipelago revealed microplastics [26]. Polymer profile analysis confirmed high-density polyethene (HDPE), low-density polyethene (LDPE) and polyamide (PA) as the polymer components of the microplastics found in the sediment samples. Collard et.al. [7] developed two different sampling designs to collect 68 sediment subsamples in five locations in a remote Arctic fjord, Kongsfjorden, northwest of Svalbard. This highlighted the need for data on anthropogenic particles other than microplastics to better understand the distribution processes. Thirty-seven anthropogenic particles were found, nineteen were plastic polymers. Adams et.al. 2021reported the polymer profile analysis confirmed high-density polyethene (HDPE), low-density polyethene (LDPE) and polyamide (PA) as the polymer components of the microplastics found in the sediment samples.

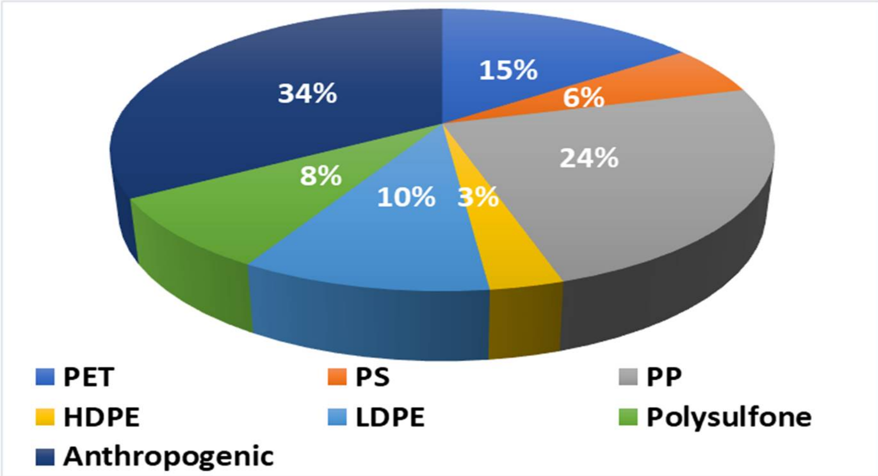

Figure 38: Percentage composition of polymers types

The percentage variation of size distribution in the study area is given in Figure 39. Most of the identified microplastics were in the size range of 100-500 micrometres which comprises 48% of the total number of identified microplastics. The size range of 10 -100 micrometres contributes 30% of the identified plastics. About 17% and 5% of contributions were in the size range of 500- 1000 micrometres and below 10 micrometres respectively. Bergmann et al. 2017 reported almost 80 % of the microplastics were ≤ 25 micrometres. The first Canadian Arctic-wide study of anthropogenic particles (APs, >125 μm), including microplastics, in marine sediments from 14 sites was reported (Adams et.al. 2021). Choudhary et.al. (2022) investigated the surface sediment of the Krossfjord Kongsfjord system to assess the distribution of microplastics. Results exhibit the presence of microplastic pollution, suggesting the influence of anthropogenic activity and transportation effects in the Arctic fjord and the need to reduce marine pollution which has become a potential threat to marine organisms.

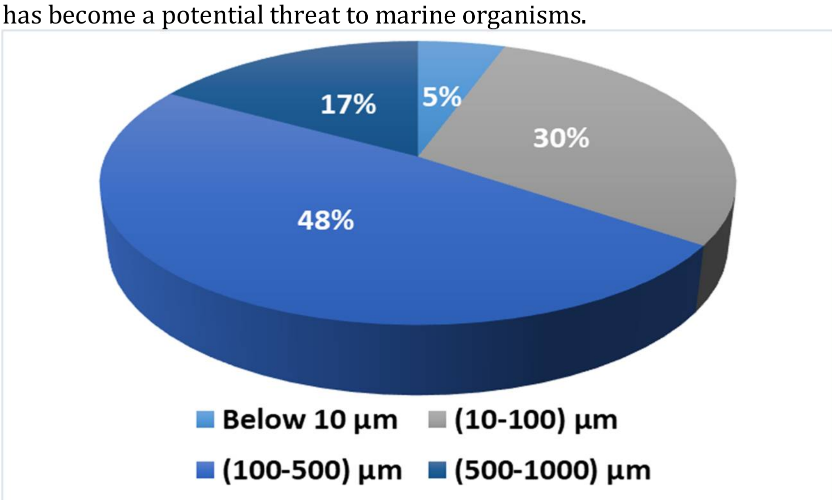

Figure 39: Percentage composition of polymers sizes

The ecological risk assessment of microplastics in sediments of the study area is assessed using PLI, PHI and PERI parameters. PLI is used to measure the degree of microplastic contamination (Pan et al., 2021). Based on PLI, the microplastic pollution load at each location was calculated. Hazard level terminology of microplastic pollution (Ranjaniet.al.2021) for PLI criteria generates 4 hazard levels minor (PLI < 10), high (PLI = 10 - 20), dangerous (PLI = 20 - 30) and extreme dangerous (PLI >10) In the study are PLI < 10 for all the sites showed hazard level I minor microplastic pollution. PLI revealed minor microplastic pollution in the whole study area. Previous reports by Choudhary et.al. (2022) also reported the overall risk of microplastic pollution based on PLI in Arctic sediments was categorized as Hazard Level I. The overall risk of microplastic pollution was categorized by PHI as Hazard level I, II, III, IV and V as minor (0-1), medium(1-10), high,(10-100), dangerous (100-1000) and extreme danger (> 1000) respectively. PHI showed mixed quality levels over the twelve sites showing minor to dangerous levels of microplastic pollution in the entire study area. The risk assessment of microplastic pollution was categorized by PERI as Hazard level I, II, III, IV and V as minor (<150), medium(150-300), high,(300-600), dangerous (600-1200) and extreme danger (> 1200) respectively. PERI showed mixed quality levels over the twelve sites showing minor to dangerous levels of microplastic pollution in the entire study area.

CONCLUSIONS

Microplastics are a new class of environmental pollutants and have become a pressing environmental and social problem, with adverse effects on global aquatic ecosystems. This study provides important information on the microplastic size range distribution and polymer type characterization in the sediments of Kongsfjorden, Svalbard, and the Arctic. In addition, associated pigment variations are also included. This investigation resulted in detailed polymer type distribution and size variation in the study area. The ecological risks of the polymer type of microplastics were analyzed using PLI, PHI, and PERI. Among the samples collected, polymer types were identified as PP, LDPE, PET, polysulfone, PS, and HDPE. Most of the identified microplastics were in the size range of 100–500 micrometres, which comprises 48% of the total number of identified microplastics. The particles collected from the Arctic have blue, pink, green, and red pigments identified. Risk assessment revealed moderate to severe contamination in the study area. PLI showed minor pollution in the study area. However, PHI and PERI revealed mixed pollution levels as minor to dangerous microplastic contamination. This study serves as a baseline for future research in the study area in terms of polymer type, size distribution, pigment variation, and hazard quality aspects of microplastics.

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