# Microplastics deposition in Arctic sediments of Greenland increases significantly after 1950

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## Supplementary Information

Supplementary Table 1. MP accumulation (MP acc.) across 85 years in a glacimarine sediment core. Years correspond to sediment layer depths (cm), polymer types in order of abundance, particle count and estimated mass (mg) normalized to dry weight (particles $Kg^{-1}$ and mg $Kg^{-1}$).

| **Year** | **Depth (cm)** | **Polymer type** | **MP Count** | **MP acc. (particles $Kg^{-1}$)** | **Mass (mg $Kg^{-1}$)** |
|---|---|---|---|---|---|
| 1930 ± 3 | 28 | PE | 10 | 559 | 0.0075 |
| | | PP | 4 | 223 | 0.0032 |
| MP Burial Rate<br>1,569 particles $m^{-2}$ $y^{-1}$ | | Polyester | 6 | 335 | 0.0292<br>0 |
| | | PC | 0 | 0 | 0 |
| MP Burial Rate Error<br>213 particles $m^{-2}$ $y^{-1}$ | | PS | 8 | 447 | 0.0174 |
| | | PVC | 5 | 279 | 0.0352 |
| | | PU | 0 | 0 | 0 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **33** | **1844** | **0.0925** |
| 1941 ± 2 | 26 | PE | 12 | 515 | 0.0073 |
| | | PP | 4 | 172 | 0.0006 |
| MP Burial Rate<br>785 particles $m^{-2}$ $y^{-1}$ | | Polyester | 6 | 258 | 0.0228 |
| | | PC | 0 | 0 | 0 |
| MP Burial Rate Error<br>87 particles $m^{-2}$ $y^{-1}$ | | PS | 0 | 0 | 0 |
| | | PVC | 1 | 43 | 0.0008 |
| | | PU | 0 | 0 | 0 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **23** | **987** | **0.0315** |
| 1951 ± 2 | 24 | PE | 5 | 253 | 0.0090 |
| | | PP | 3 | 152 | 0.0323 |
| MP Burial Rate<br>1,175 particles $m^{-2}$ $y^{-1}$ | | Polyester | 11 | 557 | 0.0333 |
| | | PC | 6 | 304 | 0.0165 |
| MP Burial Rate Error<br>133 particles $m^{-2}$ $y^{-1}$ | | PS | 0 | 0 | 0 |
| | | PVC | 0 | 0 | 0 |
| | | PU | 0 | 0 | 0 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **25** | **1265** | **0.091** |

| Year | Depth (cm) | Polymer type | MP Count | MP acc. (particles $Kg^{-1}$) | Mass (mg $Kg^{-1}$) |
|---|---|---|---|---|---|
| 1960 ± 2 | 22 | PE | 100 | 4139 | 0.3353 |
| | | PP | 4 | 166 | 0.0013 |
| MP Burial Rate 5,255 particles $m^{-2}$ $y^{-1}$ | | Polyester | 3 | 124 | 0.0345 |
| | | PC | 0 | 0 | 0 |
| MP Burial Rate Error 497 particles $m^{-2}$ $y^{-1}$ | | PS | 0 | 0 | 0 |
| | | PVC | 2 | 83 | 0.0008 |
| | | PU | 0 | 0 | 0 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **109** | **4512** | **0.372** |
| 1967 ± 2 | 20 | PE | 71 | 4616 | 0.0980 |
| | | PP | 167 | 10858 | 0.2714 |
| MP Burial Rate 18,529 particles $m^{-2}$ $y^{-1}$ | | Polyester | 7 | 455 | 0.0557 |
| | | PC | 2 | 130 | 0.0129 |
| MP Burial Rate Error 1,501 particles $m^{-2}$ $y^{-1}$ | | PS | 3 | 195 | 0.002 |
| | | PVC | 2 | 130 | 0.0071 |
| | | PU | 4 | 260 | 0.0725 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **256** | **16645** | **0.520** |
| 1974 ± 2 | 18 | PE | 61 | 3964 | 0.0932 |
| | | PP | 9 | 585 | 0.0335 |
| MP Burial Rate 6,793 particles $m^{-2}$ $y^{-1}$ | | Polyester | 7 | 455 | 0.0217 |
| | | PC | 1 | 65 | 0.0018 |
| MP Burial Rate Error 586 particles $m^{-2}$ $y^{-1}$ | | PS | 7 | 455 | 0.0312 |
| | | PVC | 2 | 130 | 0.0037 |
| | | PU | 0 | 0 | 0 |
| | | PMMA | 1 | 65 | 0.0069 |
| **Total** | | | **88** | **5718** | **0.1920** |
| 1980 ± 1 | 16 | PE | 28 | 1811 | 0.1125 |
| | | PP | 5 | 323 | 0.0547 |
| MP Burial Rate 3,339 particles $m^{-2}$ $y^{-1}$ | | Polyester | 1 | 65 | 0.0036 |
| | | PC | 0 | 0 | 0 |
| MP Burial Rate Error 264 particles $m^{-2}$ $y^{-1}$ | | PS | 0 | 0 | 0 |
| | | PVC | 0 | 0 | 0 |
| | | PU | 3 | 194 | 0.0589 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **37** | **2393** | **0.2297** |
| 1986 ± 1 | 14 | PE | 19 | 1226 | 0.087 |
| | | PP | 14 | 903 | 0.039 |
| MP Burial Rate 5,233 particles $m^{-2}$ $y^{-1}$ | | Polyester | 12 | 774 | 0.149 |
| | | PC | 0 | 0 | 0 |
| MP Burial Rate Error 454 particles $m^{-2}$ $y^{-1}$ | | PS | 4 | 258 | 0.011 |
| | | PVC | 0 | 0 | 0 |
| | | PU | 0 | 0 | 0 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **49** | **3161** | **0.286** |

| Year | Depth (cm) | Polymer type | MP Count | MP acc. (particles $Kg^{-1}$) | Mass (mg $Kg^{-1}$) |
|---|---|---|---|---|---|
| 1991 ± 1 | 12 | PE | 36 | 2294 | 0.050 |
| | | PP | 13 | 829 | 0.008 |
| MP Burial Rate 6,665 particles $m^{-2}$ $y^{-1}$ | | Polyester | 4 | 255 | 0.010 |
| | | PC | 1 | 64 | 0.0004 |
| MP Burial Rate Error 545 particles $m^{-2}$ $y^{-1}$ | | PS | 0 | 0 | 0 |
| | | PVC | 0 | 0 | 0 |
| | | PU | 0 | 0 | 0 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **54** | **3442** | **0.068** |
| 1996 ± 1 | 10 | PE | 8 | 534 | 0.108 |
| | | PP | 7 | 467 | 0.035 |
| MP Burial Rate 3,648 particles $m^{-2}$ $y^{-1}$ | | Polyester | 7 | 467 | 0.078 |
| | | PC | 1 | 67 | 0.002 |
| MP Burial Rate Error 291 particles $m^{-2}$ $y^{-1}$ | | PS | 4 | 268 | 0.011 |
| | | PVC | 1 | 67 | 0.004 |
| | | PU | 0 | 0 | 0 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **28** | **1869** | **0.239** |
| 2000 ± 1 | 8 | PE | 85 | 1576 | 0.1621 |
| | | PP | 26 | 5152 | 0.0363 |
| MP Burial Rate 14,267 particles $m^{-2}$ $y^{-1}$ | | Polyester | 9 | 546 | 0.0515 |
| | | PC | 2 | 121 | 0.1109 |
| MP Burial Rate Error 1,271 particles $m^{-2}$ $y^{-1}$ | | PS | 1 | 61 | 0.0007 |
| | | PVC | 2 | 121 | 0.0103 |
| | | PU | 0 | 0 | 0 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **125** | **7576** | **0.3718** |
| 2005 ± 1 | 6 | PE | 34 | 1580 | 0.214 |
| | | PP | 17 | 790 | 0.304 |
| MP Burial Rate 7,250 particles $m^{-2}$ $y^{-1}$ | | Polyester | 7 | 325 | 0.026 |
| | | PC | 1 | 46 | 0.002 |
| MP Burial Rate Error 517 particles $m^{-2}$ $y^{-1}$ | | PS | 9 | 418 | 0.093 |
| | | PVC | 7 | 325 | 0.036 |
| | | PU | 3 | 139 | 0.010 |
| | | PMMA | 1 | 46 | 0.0001 |
| **Total** | | | **79** | **3671** | **0.685** |
| 2009 ± 1 | 4 | PE | 19 | 1024 | 0.030 |
| | | PP | 15 | 809 | 0.029 |
| MP Burial Rate 4,652 particles $m^{-2}$ $y^{-1}$ | | Polyester | 3 | 162 | 0.058 |
| | | PC | 2 | 108 | 0.010 |
| MP Burial Rate Error 342 particles $m^{-2}$ $y^{-1}$ | | PS | 0 | 0 | |
| | | PVC | 0 | 0 | 0 |
| | | PU | 1 | 54 | 0.003 |
| | | PMMA | 0 | 0 | 0 |
| **Total** | | | **40** | **2156** | **0.131** |

| Year | Depth (cm) | Polymer type | MP Count | MP acc. (particles $Kg^{-1}$) | Mass (mg $Kg^{-1}$) |
|---|---|---|---|---|---|
| 2012 ± 1 | 2 | PE | 26 | 1736 | 0.106 |
| | | PP | 15 | 1001 | 0.041 |
| MP Burial Rate 10,815 particles $m^{-2}$ $y^{-1}$ | | Polyester | 11 | 735 | 0.106 |
| | | PC | 14 | 935 | 0.087 |
| MP Burial Rate Error 803 particles $m^{-2}$ $y^{-1}$ | | PS | 0 | 0 | 0 |
| | | PVC | 1 | 67 | 0.003 |
| | | PU | 1 | 67 | 0.0004 |
| | | PMMA | 0 | 0 | |
| **Total** | | | **66** | **4406** | **0.323** |
| 2015 ± 1 | 0 | PE | 12 | 1025 | 0.185 |
| | | PP | 16 | 1366 | 0.085 |
| MP Burial Rate 12,026 particles $m^{-2}$ $y^{-1}$ | | Polyester | 10 | 854 | 0.022 |
| | | PC | 10 | 854 | 0.046 |
| MP Burial Rate Error 686 particles $m^{-2}$ $y^{-1}$ | | PS | 1 | 85 | 0.018 |
| | | PVC | 1 | 85 | 0.011 |
| | | PU | 1 | 85 | 0.002 |
| | | PMMA | 3 | 256 | 0.002 |
| **Total** | | | **52** | **4441** | **0.368** |

Supplementary Table 2. Historical records of MP in aquatic sediments included based on thoroughness of sedimentary and MP analysis. NA refers to not reported. Sediment weight in dry weight (d.w.) unless specified otherwise. Different units are stated in the table and marked with an asterisk

| Location | Sediment type | Granulometry | Sampling technique | Analyzed amount (g d.w.) | Abundance (particles $Kg^{-1}$) | Mass (µg $Kg^{-1}$) | Size (µm) | Main polymers | Chronology | Accumulation period | Sedimentation rate (cm $y^{-1}$) | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Freshwater sediment** | | | | | | | | | | | | |
| China | Urban lake | Mud | Piston | 15 - 20 w.w* | 741 - 7,707 | NA | 100 - 5000 | PET, Rayon | $^{210}Pb + ^{137}Cs$ | 1959 - 2018 | 0.95 | Dong et al., 2020 |
| UK | Urban lake | Silt and clay | Piston | 20-90 | 16 - 539 | NA | 500 - 1,000 | PS | $^{210}Pb + ^{137}Cs$ | 1935 - 2009 | 0.193 (since 1960s) | Turner et al., 2019 |
| China | River delta | Silt | Gravity corer | 50 | 20 - 80 | NA | Unclear | NA | $^{210}Pb$, $^{239} + ^{240}Pu$ | 1950 - 2015 | 1.43 ± 0.08 | Wang et al., 2018 |
| **Shelf sediment** | | | | | | | | | | | | |
| Spain | Marine | Mud | PVC tubes | 21 | 68 - 3,819 | NA | >100 | PS, PVC, PU | $^{210}Pb + ^{241}Am$ | 1930 - 2015 | NA | Dahl et al., 2021 |
| Kuwait | Marine | NA | Kayak gravity corer | 10 | 100 - 500 | NA | NA | PE, PP, PS | $^{210}Pb$ | 1951 - 2009 | 1.15 ± 0.25 | Uddin et al., 2021 |
| China | Marine | NA | Pushcore sampler & Box corer | NA | > 1,000 | NA | Unclear | PE, PS, PP | $^{210}Pb + ^{137}Cs$ | 1980 - 2014 | 0.09 - 0.50 | Chen et al., 2020 |
| China | Salt marsh | NA | Columnar gravity sampler | 50 | 264 | NA | 100 - 1000 | PS, PE, PP, cellophane | $^{210}Pb$ | 1990 - 2015 | 4.89 - 5.03 | Li et al., 2020 |
| Saudi Arabia | Mangrove | Mud | PVC tubes | >60 | 7840 $Nm^{-2}$* | 29 - 64 mg $m^{-2}$ $y^{-1}$ | <500 | PE, PP | $^{210}Pb$ | 1930 - 2015 | NA | Martin et al., 2020 |
| China | Marine | NA | Gravity corer | NA | 33 - 1,200 | NA | 100 - 5,000 | PE, PP | $^{210}Pb + ^{137}Cs$ | 1897 - 2017 | NA | Xue et al., 2020 |
| Japan | Marine and moat | NA | Gravity corer | 10 | 1,100 - 7,000 | NA | 3000 - 5,000 | PE, PEP, PAK | $^{137}Cs$, layer counting & PCB | 1900 - 2000 | 0.161 g $y^{-1}$ $cm^{-2}$* | Matsuguma et al., 2017 |
| Australia | Estuary | Mud | NA | 52 - 63 | 2,430 - 4,200 | NA | 63 - 1000 | NA | $^{210}Pb$ | 1744 - 2004 | 0.04 - 0.7 | Willis et al., 2017 |
| **Deep sediment** | | | | | | | | | | | | |
| Mediterranean Sea | Marine | NA | Multicorer | 22-59 | 706 - 6,939 | 0.05 – 1,430 | 1 – 5000 | PS, PP, PET | $^{210}Pb$ | 1965 - 2016 | 0.12 ± 0.01 | Simon-Sanchez, et al., 2022 |
| North Atlantic | Marine | Sandy silt | Megacorer | 9-79.6 | 197 | NA | 60 - 12,000 | Polyester | $^{210}Pb + ^{241}Am$ | Unclear | 0.009 - 0.055 | Courtene-Jones et al., 2020 |
| **Arctic sediment** | | | | | | | | | | | | |
| Greenland | Marine | Silt | Lohr Rumor core | ~20 | 987 - 16,645 | NA | 20 - 654 | PE, PP, PET | $^{210}Pb + ^{241}Am$ | 1930 - 2015 | 0.337 - 1.057 | This study |
| Svalbard fjord | Marine | Silt and clay | Metallic box corer | 100 | 1.2 - 13.4 | NA | 100 - 2,780 | PE, Acrylate | $^{137}Cs$ | 1952 - 2018 | NA | Collard et al., 2021 |

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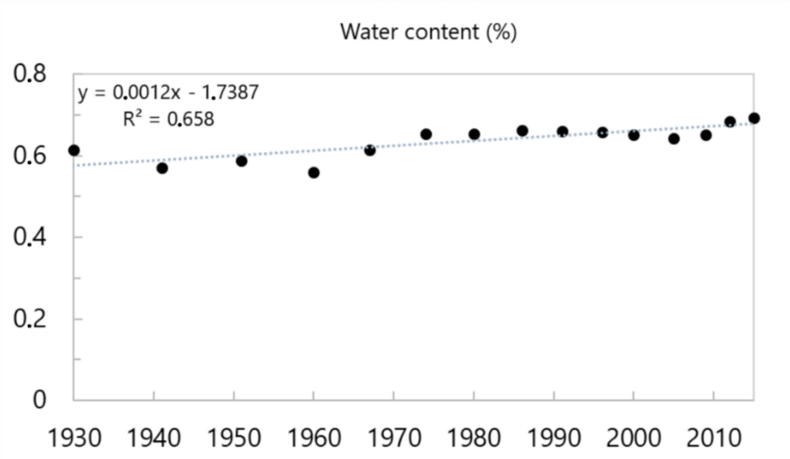
Supplementary Table 3. Waste categories and contribution in weight and percentage at the Receiving Station weight Ilulissat Incineration Plant in 2022. Total waste amounted to 2,224 tons mainly from construction materials and fisheries.

| **Waste category** | **Weight (Kg)** | **Percentage** |
|---|---|---|
| Large flammable waste | 1,092,900 | 49.13 |
| Wood waste | 360,680 | 16.21 |
| Iron and metal | 212,710 | 9.56 |
| Small flammable waste | 198,570 | 8.93 |
| Environmentally treated | 91,600 | 4.12 |
| Cardboard and paper | 85,900 | 3.86 |
| Plaster | 73,540 | 3.31 |
| Insulation | 68,900 | 3.10 |
| Electronic | 11,520 | 0.52 |
| Trawl, fishing nets and ropes without steel | 5,870 | 0.26 |
| Organic | 5,350 | 0.24 |
| Cables and wires | 3,700 | 0.17 |
| Clean glass | 3,500 | 0.16 |
| Refrigerators and freezers | 2,730 | 0.12 |
| Catch and organic waste from fishing | 2,220 | 0.10 |
| Customs goods | 1,550 | 0.07 |
| Concrete and masonry | 890 | 0.04 |
| Paint and varnish | 900 | 0.04 |
| Mixed waste | 570 | 0.03 |
| Meat waste and dead animals | 610 | 0.03 |
| Light bulbs | 400 | 0.02 |

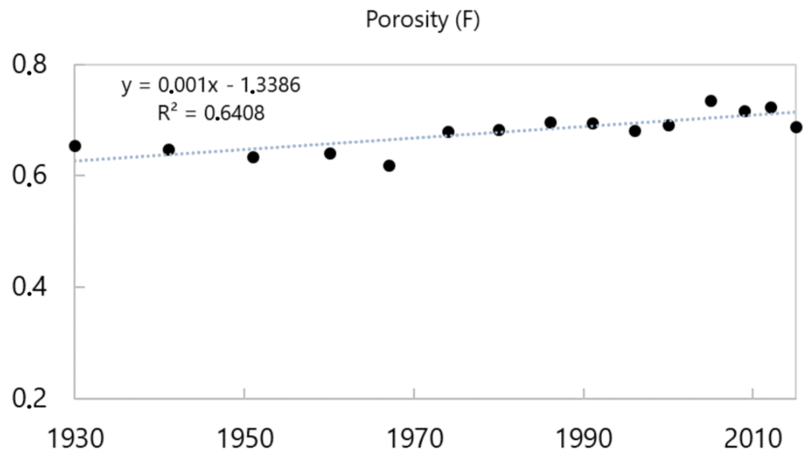
Supplementary Table 4. Limit of detection based on the procedural blanks. Number of particles detected per polymer type and size fraction. LoD was calculated based on the average and standard deviation (SD).

| **Polymer** | **Blank 1** | **Blank 2** | **Blank 3** | **Average** | **SD** | **LoD** |
|---|---|---|---|---|---|---|
| PE | 0 | 5 | 24 | 9.67 | 12.66 | 47.7 |
| PP | 4 | 18 | 8 | 10 | 7.21 | 31.6 |
| Polyester | 0 | 1 | 5 | 2 | 2.65 | 9.9 |
| PU | 0 | 0 | 1 | 0.33 | 0.58 | 2.1 |
| PS | 0 | 0 | 2 | 0.67 | 1.15 | 4.1 |
| **Total** | **4** | **24** | **40** | **22.67** | **18.04** | **76.8** |

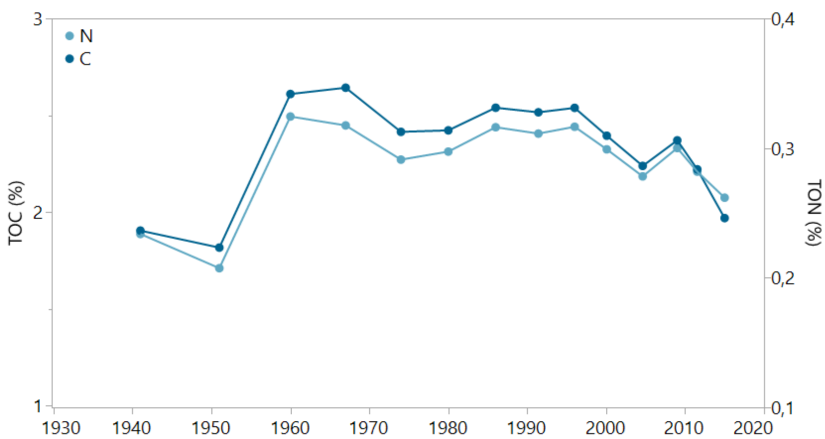
| **Particle size** | | | | |
|---|---|---|---|---|
| Small | 4 | 22 | 33 | 19.6 |
| Large | 0 | 2 | 7 | 3 |



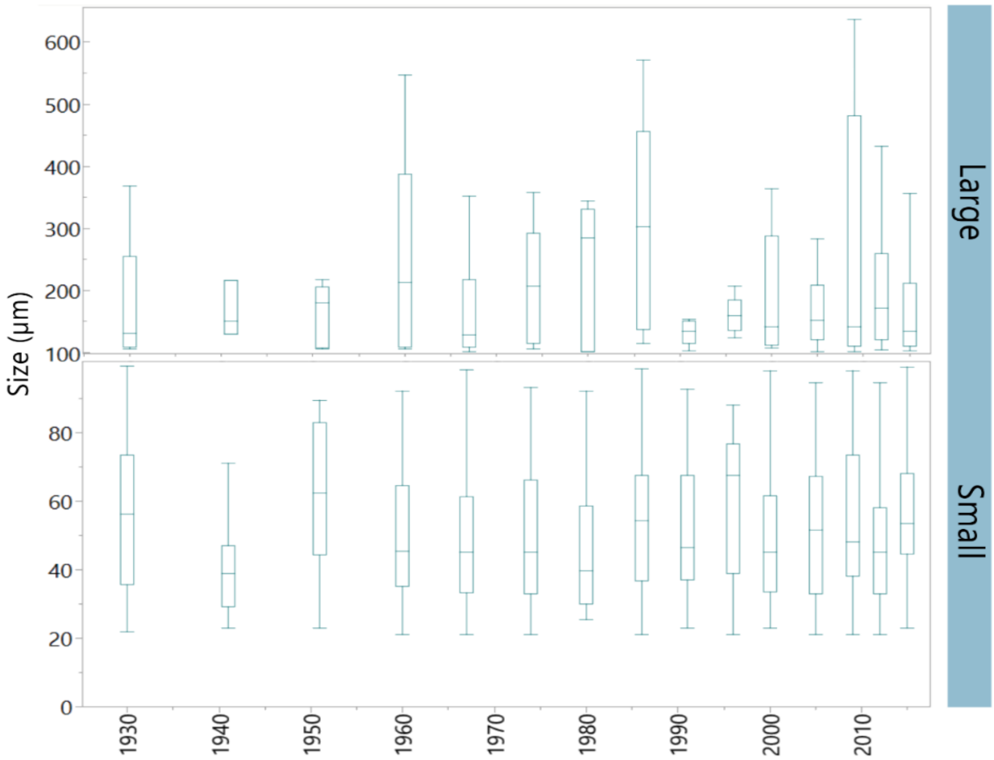

Supplementary Figure 1. Percentage of water content throughout the core. Water content significantly decreased with depth (Spearman's ρ, r= 0.7286, p=0.0021).



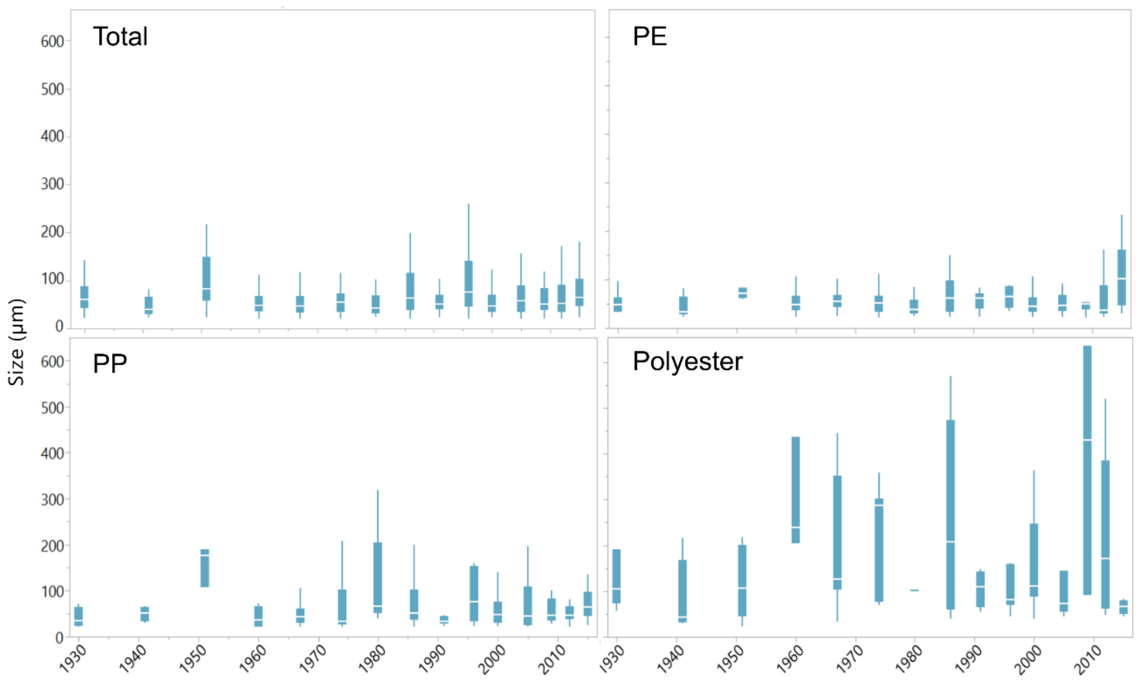

Supplementary Figure 2. Porosity of glacimarine sediments through the depth profile. The porosity significantly decreased with depth (Spearman's ρ, r= 0.7964, p=0.0004).



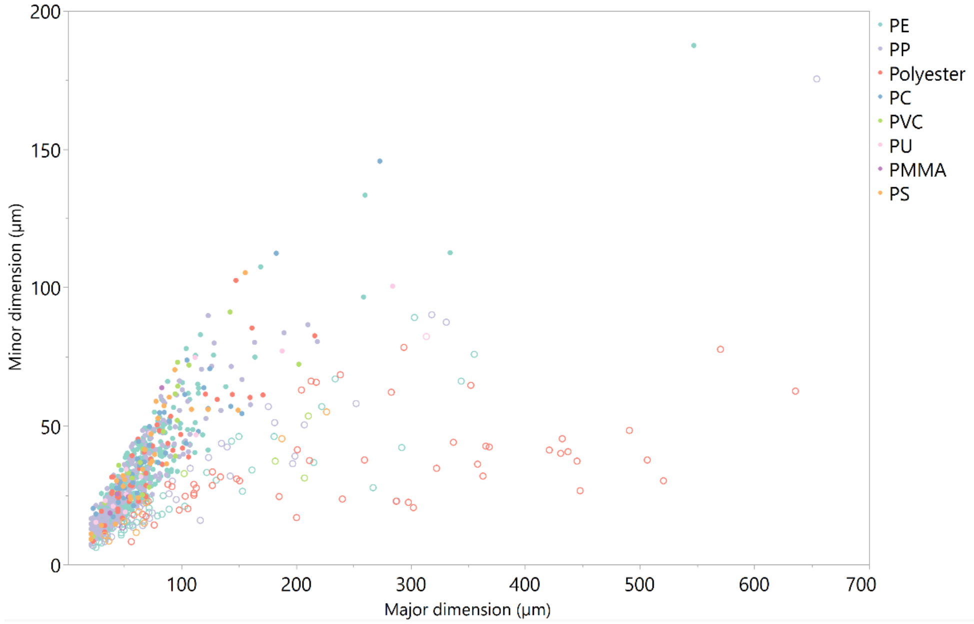

Supplementary Figure 3. Organic matter content through the depth profile in terms of total organic carbon (TOC) and total organic nitrogen (TON).




Supplementary Figure 4. Microplastics particle size distribution across time. Only 15% of MP particles were larger than 100 µm while small MP (20 – 100 µm) dominated the record (85%). No indication of fractionation was observed.




Supplementary Figure 5. Overall MP particle size distribution (Total) across time and size distribution of the most abundant polymers. PE and PP mean particle size was 60 µm, the abundance of PE particles increased in the last decade while PP particles did not show any trend towards the peak of 1967. Polyester mean particle size was 171 µm and displayed a larger size distribution.




Supplementary Figure 6. MP particles shapes based on the length to diameter ratio of the major and minor dimensions (3:1). Size limit of the minor dimension is 5.5 µm and 20 µm for the major dimension. Fragment-like particles (dots) accounted for 85% and fiber-like particles (open circles) accounted for 15%.

## Supplementary Note

**Reference spectra library for µFTIR imaging data processing with siMPle software.**

The spectra library (AU-library-v2022-1) is composed of the main plastic polymers produced worldwide: PE, PP, PET, PBT, PC, PS, PU, PVC, ABS and PA as well as natural materials such as cellulose and protein. Reference materials were created from pristine plastics and daily life plastics from different sources (e.g. food packaging, building materials, water bottles, toys) and levels of degradation. Plastic products were abraded to various size ranges (< 10 – 300 µm) and stored in ethanol 70%. The particles were placed on individual silicon filters to be analyzed via µFTIR hyperspectral imaging in transmission mode. Measurements were performed under similar conditions as described in the Spectroscopy section, which resemble routinely FTIR measurements. The thresholds of probability were set at 0.6, 0.4 and 0.3 for all polymers and natural materials.

| **Plastic polymer** | **Number of sources** |
|---|---|
| Polyamide (PA) | 8 |
| Polycarbonate (PC) | 5 |
| Polyethylene (PE) | 16 |
| Polyethylene terephthalate (PET) | 6 |
| Polybutylene terephthalate (PBT) | 4 |
| Polymethyl methacrylate (PMMA) | 5 |
| Polypropylene (PP) | 14 |
| Polystyrene (PS) | 4 |
| Polyurethane (PU) | 5 |
| Polyvinyl chloride (PVC) | 13 |
| Acrylonitrile butadiene styrene (ABS) | 7 |
| **Natural materials** | |
| Protein | 3 |
| Cellulose | 4 |

## Supplementary References

All references for Supplementary table 2 can be found in the published article except for the following references.


Collard, F., Husum, K., Eppe, G., Malherbe, C., Hallanger, I. G., Divine, D. V., & Gabrielsen, G. W. (2021). Anthropogenic particles in sediment from an Arctic fjord. Science of The Total Environment, 772, 145575. https://doi.org/10.1016/j.scitotenv.2021.145575

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