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Development of a low-cost system for sampling microplastics in water

A sampling system for microplastics in water was developed using low-cost materials based on the international standard protocol of the National Oceanic and Atmospheric Administration with the use of a nylon sampling net fixed to a treated wood structure and with plastic tubes responsible for buoyancy. The sampling was done in marine and fresh waters off the coast of Santa Catarina, using boats as trailers in order to collect samples along the coastal strip. The structure developed showed excellent performances regarding stability and robustness during the sampling process. The analysis and characterization of the microplastics was done within the protocol recommendations using separation sieves. The developed system can be used in environmental monitoring involving the sampling of microplastics in water, added to its cost-benefit ratio and accessibility for professionals in the area.

Palavras-chave: Microplastics; Sampling; Water; Ocean; Rivers.

Desenvolvimento de um sistema de baixo custo para amostragem de microplásticos em água

Foi desenvolvido um sistema de amostragem de microplásticos na água utilizando materiais de baixo custo com base no protocolo padrão internacional da National Oceanic and Atmospheric Administration com o uso de uma rede de amostragem de nylon fixada a uma estrutura de madeira tratada e com tubos plásticos responsáveis pela flutuabilidade. A amostragem foi feita em águas marinhas e doces no litoral de Santa Catarina, utilizando barcos como reboques para coleta de amostras ao longo da faixa litorânea. A estrutura desenvolvida apresentou excelentes desempenhos quanto à estabilidade e robustez durante o processo de amostragem. A análise e caracterização dos microplásticos foi feita dentro das recomendações do protocolo usando peneiras de separação. O sistema desenvolvido pode ser utilizado em monitoramento ambiental envolvendo a amostragem de microplásticos em água, somado a sua relação custo-benefício e acessibilidade para profissionais da área.

Keywords: Microplásticos; Amostragem; Água; Oceano; Rios.

Topic: **Notas Científicas**

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INTRODUCTION

Monitoring marine environments with respect to the presence of plastic litter enables a much-needed assessment of the extent and impacts of marine plastic litter, which makes it possible to design mitigation actions as well as to evaluate their effectiveness. However, for effective monitoring routines, it is essential to use standardized and reliable sampling and sample characterization methods (GESAMP, 2019).

Plastics are polymers but not all polymers are plastics, they are mostly obtained from fossil fuels (UNEP, 2018), formed by monomeric units linked together forming long polymer chains; however, some plastics, such as drop-in bioplastics, can be obtained in an unconventional way through biological bases, (BARBATO et al., 2022) therefore are hybrid versions of traditional plastics.

Plastics are widely present in nature, creating a major challenge to society and the global economy, impacting soils, freshwaters and oceans with macro, micro and nanoplastic contaminations (MURPHY et al., 2016) (HAMILTON et al., 2019); where human ingestion of microplastic particles ranges from 74 to 121,000 particles per year (COX, 2019).

Microplastics were first observed in North America along the New England coast in the 1970s (CARPENTER et al., 1972), stemming from the exploitation of fossil fuels and the large-scale production of plastics starting in the 1950s. To categorize plastic fragments, a classification based on polymer sizes is commonly adopted classifying polymer waste into macro-plastics (1000-25 mm), meso-plastics (25-5 mm) and microplastics (< 5mm) (GESAMP, 2019); therefore, microplastics are plastic particles smaller than 5.0 mm in size (MOORE, 2008).

Regarding their origin, microplastics are classified into primary and secondary. Primary microplastics are the fragments of polymers that are introduced into the environment in (dimensions smaller) than 5mm, they are present in consumer materials such as microspheres used in cosmetic products (LEI et al., 2017) and microfibers of fabrics from fabric washing (GALVÃO et al., 2020). Secondary microplastics are small fragments that are indirectly introduced into the environment by the degradation of pieces through physical, chemical, and biological processes that result in the fragmentation of plastic debris (ANDRADY, 2011).

The presence of plastic waste in the oceans has grown significantly, and according to estimates the amount of plastic waste entering the oceans annually is between 4.8 and 12.7 million metric tons (JAMBECK et al., 2015). World plastic production in 2020 was 367 million tons[1] and according to a report published by WWF in 2019, 75% of all plastic produced has already become waste (HAMILTON et al., 2019). Plastic waste accounts for up to 80% of all waste found in the oceans (UNEP, 2016), and has been recognized as a global problem (LI et al., 2021) by governments and international environmental organizations since the 1990s (MASURA et al., 2015). Marine environments act as the destination of natural and anthropogenic waste and are one of the most researched ecosystems in relation to pollution involving plastics.

Research involving microplastics worldwide is concentrated in a higher percentage (86%) in North America, Europe, and Asia (AJITH et al., 2020). The amount of research conducted in Latin America regarding

[1] https://plasticseurope.org/knowledge-hub/plastics-the-facts-2021/

the occurrence of microplastics has increased in recent years, and Brazil stands out as the country that has been developing the most research in the area (KUTRALAM et al., 2020).

Studies involving the development of protocols for sampling, opening, sample preparation, and characterization of microplastics have been carried out and developed; however, the lack of standardization and normatization makes it impossible to carry out comparative monitoring studies about microplastics in environmental matrices with the aim of establishing a cohesive baseline that allows monitoring programs to be implemented (GRILLO et al., 2022).

Recently the protocols developed by the Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP, 2019) and National Oceanic and Atmospheric Administration (MASURA et al., 2015) are referenced and enable the standardization of procedures involving research in the area of plastic waste. Due to the difficulties inherent in the process of sampling representativeness of microplastics in aqueous matrices, the protocol developed by NOAA presents as an alternative the adaptation of a Nêuston net (Figure 1) commonly used in plankton sampling, therefore the analysis of microplastics in waters is possible by the adaptation of a sampling system of aquatic microorganisms (Nêuston nets) involving protocols for the evaluation (CETESB, 2012).

Figure 1: Nêuston net (sampling aquatic microorganisms) and collecting cups.

Adapted Neuston nets have been one of the most used sampler options for capturing microplastics and mesoplastics (GESAMP, 2019), with the net mesh aperture used ranging in size from 50 µm to 500 µm, with 330 µm being most commonly used (HIDALGO et al. 2012). The adaptation of a floating system (Figure 2) on a trailer involving boats has shown excellent results according to the NOAA protocol.

Figure 2: Floating sampler attached to a Neuston net coupled to a trailer (boat) in waters.

REPORT

Low-cost materials were used to construct the microplastic sampling system (Table 1). A nylon net whose material is not easily susceptible to changes and deformities with 300 µm openings, similar to the Nêuston net, was used as the drag system. The development of the Low Cost Microplastic Net was intended to make the sampling of microplastics in waters accessible and feasible, considering the ease of acquisition of the materials needed in the construction, added to the excellent results acquired.

The construction of the Low Cost Microplastics Net system was based on the principle of buoyancy using PVC pipes, observing the pipe sizes in relation to the dimensions of the wooden structure to facilitate stability (Figure 3); emphasizing that the pipes should be properly sealed with PVC plastic adhesive plugs and internal insulation with silicone, so that water infiltration into the buoyancy system does not occur.

The collecting cup was fixed to the lower end of the net by a clamp (Figure 3), and constructed from the end of a PVC pipe with a side window where the opening was made with a drill and cup drill bit and fixed with rivets. The collecting cup has holes sealed with nylon mesh (300 µm) to reduce the accumulation of water inside where it will retain the microplastics.

Figure 3: Low-cost Net for Microplastics and the collecting cup attached to the net.

In the front part of the Microplastic Low-Cost Net (Figure 4), 3 holes were drilled to fix the nylon ropes with approximately 50 cm in length in order to keep the system horizontal during towing. The pipe buoyancy system (Figure 4) was made with a lateral inclination of approximately a 30° angle in relation to the central wooden structure, so that the water blade can enter the net and increase stability in surface waters. The central rectangular wooden structure treated with marine varnish (Figure 4) was made with dimensions 50x30x15 cm mounted with screws, where the net was fixed with nylon ties.

Figure 4: Front view of the Low-Cost Microplastic Net made of wood treated with marine varnish coupled with a Neuston net and PVC pipes responsible for buoyancy.

The PVC pipes were attached to each other (Figure 5) in a sequence of nylon ties in order to provide mechanical stability during the towing process in the waters.

Figure 5: Side view of the PVC buoyancy system and attachment with interlaced clamps for added strength.

Table 1 lists the materials used to make the Low-Cost Microplastic Net; the materials were purchased from easily accessible, low-cost building supply stores.

Table 1: List of materials for the construction of the RBCM system.

Quantities	Materials used for construction
2	pine wood with dimensions 50 cm x 15 cm
2	pine wood with dimensions 30 cm x 15 cm
2	pine wood with dimensions 40cm x 7 cm
8	french screws with hexagonal thread and arroela 5 mm x 16mm.
8	fixer screws for wood 4,5mm x 60mm
8	75mm pipes with dimensions of 50cm
17	75mm pipe plugs
1	75mm pipe with 30 cm dimension (needs to be the end of the pipe for better clamping)
30	self-locking nylon clamps 3mm x 200mm
1	1.5m of 0.3mm nylon mesh
8	2cm diameter eyelets
1	80 cm of cotton fabric
8	rivet units
6	meters of nylon braided rope 1,5mm
1	50 ml marine varnish

RESULTS AND DISCUSSION

The sampling tests in aqueous matrices for microplastics were done in marine and fresh waters (Figure 6) during a circuit of approximately 3 km in different sampling campaigns in the northern region of the coast of Santa Catarina. The Microplastic Low-cost Net was coupled to a motor-driven sport fishing dinghy model boat using nautical nylon ropes for towing.

The Low Cost Microplastic Net, because it is constructed of lightweight materials, was easy to handle during insertion and manipulation inside the vessel; excellent results of buoyancy and mechanical strength were observed without any modification of the structure during and after the sampling processes.

The Low Cost Microplastic Net makes it possible to sample water depths of approximately 40 cm. Taking into account the net opening and the speed of the boat it is possible to calculate the volume of water sampled.

Figure 7 shows the volume sampled in the collecting beaker of the Low Cost (Net) for Microplastics, as well as a comparative study of samples according to the NOAA protocol, the samples were transferred to (glass jars with screw lids). It should be noted that after collection, the collection beaker should be rinsed with deionized water for total transfer of the samples, aiming to remove all material in suspension contained therein.

Figure 6. Sampling study using the Low-cost Net for Microplastics in fresh and marine waters.

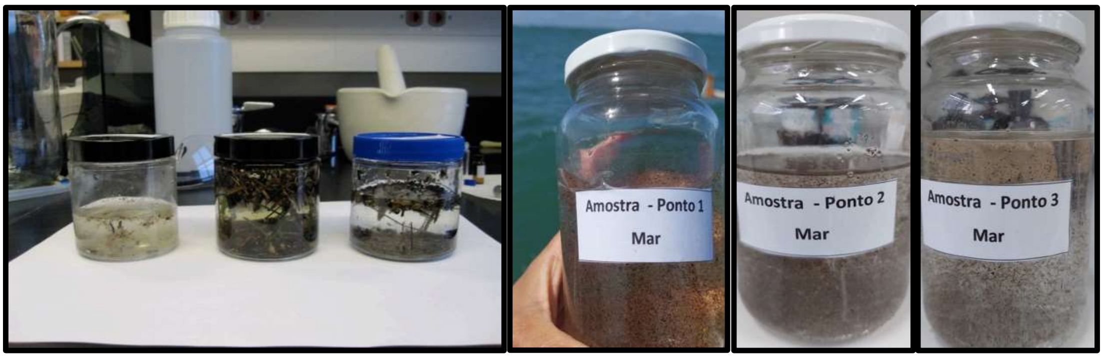

Figure 7. NOAA protocol sampling and Low Cost (Net) sampling for microplastics.

The samples obtained from the collection were taken to the laboratory and proceeded to the separation process according to the NOAA protocol. One of the first steps of the protocol involves sieving (Figure 8) using sieves (5.6, 1.0 and 0.3 mm) to separate the materials that are in the surface waters, with the objective of obtaining possible fragments smaller than 5 mm, characteristic of microplastics.

CONCLUSIONS AND PERSPECTIVES

The Low Cost (Microplastic Net) is intended to make the sampling of microplastics in surface waters feasible and therefore affordable; highlighting the ease of acquisition of materials and construction of the sampling system, added to the excellent results acquired in marine waters and rivers. The materials used were purchased in commercial stores in the area of construction; therefore, with relatively low costs compared to the acquisition of an imported sampling system according to the NOAA protocol.

The Low-cost Microplastic Net, because it was built with light materials, was easy to handle during the manipulation in the vessel; excellent results of buoyancy, stability and mechanical resistance were observed without any modification of the structure during and after the sampling processes. The collecting cup retained with excellent results the sampling of microplastics in the surface water slide.

Therefore, the Microplastic Low-cost Net is indicated as an alternative for the sampling of microplastics in aqueous matrices both marine and in surface water in rivers. Enabling the realization of the monitoring of microplastics in waters in view of the urgent need for monitoring of the anthropogenic impact on aquatic environments by research institutes and environmental monitoring and control agencies, among others. The work will be continued under the NOAA protocol involving separation and identification through microscopic and FTIR spectroscopic characterization, as well as monitoring of surface waters in cooperative work.

Figure 8. NOAA protocol sieve separation process and sample separation obtained after sampling by the Low-cost Net for Microplastics with fragments smaller than 5 mm.

REFERÊNCIAS

AJITH, N. ARAMUGAM, S.; PARTHASARATHY, S.; MANUPOORI, S.; JANAKIRAMAN, S.. Global distribution of microplastics and its impact on marine environment: a review. **Environmental Science and Pollution**, v.27, p.25970-25986, 2020.

ANDRADY, A. L.. Microplastics in the marine environment. **Marine Pollution Bulletin**, v.12, n.8, p.1596-1605, 2011.

BARBATO, A. G.; PAMPLONA, B.. Os Desafios para a Difusão dos Bioplásticos no Brasil. **Revista Gestão e Sustentabilidade Ambiental**., v.11, 2022.

CARPENTER, E. J.; SMITH, K. L.. Plastics on the Sargasso sea surface. **Science**, v.175, n.4027, p.1240-1241, 1972.

CETESB. Companhia Ambiental do Estado de São Paulo. **Guia nacional de coleta e preservação de amostras**: água, sedimento, comunidades aquáticas e efluentes líquidas. São Paulo: CETESB,2011.

COX, K. D.; COVERNTON G. A.; DAVIES H. L.; DOWER J. F.; JUANES F.; DUDAS S. E.. Human Consumption of Microplastics. **Environmental Science and Technology**, v.53, n.12, p. 7068-7074, 2019.

GALVÃO, A. ALEIXO M.; DE PABRO H.; LOPES C.; RAIMUNDO J.. Microplastics in wastewater: microfiber emissions from common household laundry. **Environmental Science and Pollution Research**, v.27, n.21, p.26643-26649, 2020.

GRILLO, J. F.; REBOLLEDO, G.; SABINO, M. A.; RAMOS, R.. Microplastics in Latin America and the Caribbean: On the adoption of reporting standards and quality assurance and quality control protocols. **Environmental Advances**, v.8, p.100236, 2022.

DEWIT, W; HAMILTON, A.; SCHEER, R.; STAKES SIMON ALLAN, T. **Solucionar a Poluição Plástica**: Transparência e Responsabilização Este. Gland: WWF, 2019.

JAMBECK, J. R.; GEYER, R.; WILCOX, C.; SIEGLER, T.R.; PERRYMAN, M.; ANDRADY, A.; NARAYAN, R.; LAW, K. L.. Plastic waste inputs from land into the ocean. **Science**, v.347, n.6223, p.768-771, 2015.

KUTRALAM, G. M.; GUEVARA, F. P.; MARTÍNEZ, E.; SHRUTI, V. C.. Review of current trends, advances and analytical challenges for microplastics contamination in Latin America. **Environmental Pollution**, v.10, 2020.

LEI, K. Q. F.; LIUA, Q.; WEIA, Z.; QIB, H.; CUIC, S.; YUEA, X.; DENGA, Y.; ANA, L.. Microplastics releasing from personal care and cosmetic products in China. **Marine Pollution Bulletin**, v.123, n.1-2, p.122-126, 2017.

LI, L.; ZUO, J.; DUAN, X.; WANG, S.; HU, K.; CHANG, R.. Impacts and mitigation measures of plastic waste: A critical review. **Environmental Impact Assessment Review**, v.90, 2021.

MASURA, J.; BAKER, J.; FOSTER, G.; ARTHUR, C.; HERRING, C.. **Laboratory methods for the analysis of microplastics in the marine environment**: recommendations for quantifying synthetic particles in waters and sediments. Silver Spring: NOAA Technical Memorandum, 2015.

MOORE, C. J.. Synthetic polymers in the marine environment: A rapidly increasing, long-term threat. **Environmental Research**, v.108, n.2, p.131-139, 2008.

MURPHY, F.; EWINS, C.; CARBONNIER, F.; QUINN, B.. Wastewater Treatment Works (WwTW) as a Source of Microplastics in the Aquatic Environment. Environmental **Science and Technology**, v.50, n.11, p.5800-5808, 2016.

UNEP. **Marine plastic debris and microplastics**: Global lessons and research to inspire action and guide policy change. Nairob: United Nations Environment Programme 2016.

UNEP. **El estado de los plásticos**: Perspectiva del día mundial del medio ambiente. Nairob: United Nations Environment Programme, 2016.