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The Epidemic Of Residual Synthetic Polymers In The Environment And Human Health

Aureliano da Silva Guedes, PhD*
Professor at Federal University of Pará/Campus of Ananindeua/ Faculty of Chemistry, Postdoc in ICPD.

Aureliano da Silva Guedes II
Master of Science in Risk Management and Disasters/UFPA

Abstract
Justification: *The big problem with synthetic polymers is when they lose their usefulness and, in many cases, end up in the environment, being present from beaches in small granules, often mixed with beach sand and being confused with it, to the stratosphere in nanoparticles that cannot be seen or identified without the aid of special equipment, and even present in the bloodstream of humans and animals, as some studies have already indicated.*
General objective: *to discuss the environmental impacts caused by the irregular disposal of synthetic polymers in nature.*
Specific objectives: *disseminate information to raise awareness about polymer recycling; produce information that can be applied to environmental education and the conscious use of synthetic polymers.*
Methodology: *research on the main electronic platforms for the environment and health, GreenFILE, Environment Index, LILACS, Medscape and Medline, using as descriptors: POLYMERS/+/ENVIRONMENTAL IMPACTS, PLASTIC, NANOPOLYMERS, POLYMERS/AND/HUMAN HEALTH, in Portuguese, French, Spanish and English, and the author's professional experience in environmental chemistry and teaching topics related to the environment and biomaterials.*
Conclusion: *Anthropogenic impacts by synthetic polymers have had a deleterious effect on human health, in many cases, affecting the circulatory system, stomach, brain; and the health of the biota composed of aquatic fauna, including placenta, testicles, etc., the same is happening in crustaceans, fish, turtles, and mammals. In this sense, there is a need to intensify studies, especially regarding the destination of synthetic polymer waste and possible ways of collecting and reusing those that are impacting the planet's oceans, rivers and soils, encouraging research into biodegradable materials with the least possible impact. All actions to reduce these anthropogenic impacts must involve communities at all levels, government and companies, in a participatory manner, sharing commitments and responsibilities, as the survival of the planet depends on urgent effective actions. It can be said that the synthetic polymer is a "sacer", it is useful, it is useless, it beautifies, it makes it ugly, it saves lives, it destroys human life and nature.*
Keywords: *Synthetic Polymers, Human health, Environment, Plastics, Environmental impacts, Anthropogenic impacts.*

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I. Introduction

Synthetic polymers are alloplastics that have impacted nature since their development in 1862 by Alexander Parker to replace rubber. They ended up being a synthetic or partially synthetic, economical and accessible option to replace glass, ceramics, metals, among others, in addition to being present in the packaging, textile, automotive, computer, medical equipment, robotics, colorants, furniture, toys, cosmetics, food industries, musical instruments, civil construction and various other industries, being part of humanity as a good and a necessary evil.

The big problem with synthetic polymers is when they lose their usefulness and, in many cases, end up in the environment, being present from beaches in microgranules, often mixed with sand and being confused with it, and even in the stratosphere in nanoparticles that cannot be seen or identified without the help of special equipment, and even present in the bloodstream of humans and animals, as some studies have already indicated.

In view of this, the general objective of this article is: to discuss the environmental impacts caused by the irregular disposal of synthetic polymers in nature and, as specific objectives: to disseminate information to raise awareness about polymer recycling; to produce information that can be applied to environmental education and the conscious use of synthetic polymers.

II. Methodology

Research in the main electronic platforms for the environment and health, GreenFILE, Environment Index, LILACS, Medscape and Medline, using as descriptors: POLYMERS /+/ ENVIRONMENTAL IMPACTS, NANOPOLYMERS, POLYMERS /AND/ HUMAN HEALTH, in Portuguese, French, Spanish and English, and the author's professional experience in environmental chemistry and lecturing topics related to the environment and biomaterials.

III. Environmental Impacts By Synthetic Polymers

Since ancient times, man has used polymers of natural origin to satisfy some of his needs. Asphalt was used in the Middle East in biblical times and cotton was known in Mexico before the arrival of Columbus. Also in pre-Columbian times, latex was known to some American peoples and the Mayans used it to make balls for playing. Columbus and other explorers who visited this continent were fascinated by this material and took samples of it back to Europe. There they found some applications for latex, where the most important were carried out after the discovery of the vulcanisation process. This discovery was made accidentally by the American Charles Goodyear in 1839 and gave rise to the rubber industry[1].

Polymers are long chains composed of covalently linked units, the monomers, grouped together to form a common structure[2], and are divided into two main classes: natural and synthetic[3].

All plastics are composed, at the molecular level, by organic polymeric molecules, which are very large units of matter, where a cut unit repeats itself once and again. All the raw materials (except chlorine) from which plastics are currently obtained from petroleum[4].

According to Guedes; Guedes II; Guedes, synthetic polymers are hydrocarbons, can be vinyl ethylene acetate - EVA ($C_4H_6O_2$), polyamide - PA ($C_6H_{11}ON$), polyvinyl chloride - PVC ($(C_2H_3Cl)_x$), polyethylene terephthalate or polyethylene terephthalate - PET ($(C_{10}H_8O_4)_n$), polystyrene - PS ($(C_6H_5C_2H_3)_x$), polytetrafluoroethylene - PTFE (CnF_{2n+2}), polyethylene or polyethylene - PE ($(CH_2\text{-}CH_2)_n$), polymethyl methacrylate - PMMA ($(C_5O_2H_8)_n$), polypropylene ($C_3H_6)_n$) and others that, due to their biophysiomechanical properties, such as: low degradation, flexibility, non-electrical conduction, in many cases mouldable even during surgical procedures, are widely used in medicine and dentistry[5].

The molecular weight of polymers is a property of fundamental importance for their application. The usefulness and mechanical properties associated with polymeric materials are a consequence of their molecular weight, on which they depend considerably. In most cases, it is only for a certain molecular weight range that a particular property of a polymer will be ideal for a specific application. For these reasons, molecular weight control is essential for the practical application of a polymerisation process. The average molecular weight value can be indicated by an expression of the type: $\bar{M} = \sum niMi$ (1).[1]

Because it has a low weight and long molecular chain, it makes it easier for synthetic polymeric materials to undergo easy leaching into continental and oceanic waters, in addition to its slow degradation; for this reason, it has even been detected in the Earth's stratosphere, impacting the environment and causing many problems to human and environmental health.

The anthropogenic impacts of synthetic polymers have already reached the bottom of rivers and oceans, compromising, in the case of hyipolimyum, the health of crustaceans, fish and other benthic species on beaches in Brazil, and other countries already have microplastics in their sand, often confused by bathers with the sand on the beaches themselves, in addition to nanoplastics that are imperceptible to the human eye, but which cause serious impacts on limnological and oceanic fauna and flora.

Synthetic polymers from packaging abandoned by tourists in Crispim Beach (Brazil). Photo by Aureliano Guedes.

Plastic polymer pollution has been a global problem since 2016, when its production reached 322 million tons, excluding fibres. Daily discharges of microplastics (MPs, defined as <5 mm in size) are estimated to be in the range of 50,000 to 15 million particles, while there is still no information on the release of nanoplastics (NP, <100 nm). Different processes degraded these materials even further, producing more MPs and NPs[6].

The global occurrence of large-sized plastics, the patterns of formation of microplastics and nanoplastics from them, the presence and deposition of plastic particles from the atmosphere, and the fluxes of all types of plastics from soils to aquatic environments (e.g. through surface water runoff, soil infiltration) are still poorly understood[7].

Micro and nanoplastic residues are emerging contaminants. Although its occurrence has been demonstrated in almost all areas of the planet – in water, land, air and even in animals and humans – remediation concepts are still extremely rare and focused on microplastics[8].

Anthropogenic debris has been documented in Antarctica over the past 40 years. After decomposition, large pieces become microdebris, which reaches the seafloor through a variety of physical and biological processes. The Antarctic benthos, deeply dependent on sinking organic particles, is therefore vulnerable to microdebris ingestion[9].

In human health, nano/microplastics (NMPs) are emerging contaminants of human origin with worldwide occurrence. Their small size (below one micrometer), different chemical nature, and persistence make NMPs potential hazards with a probability of penetration and inflammation in tissues or as toxin accumulators[8].

The intrusion of MPs and NPs into the human body, whether through inhalation, ingestion, or skin exposure (via wounds, hair follicles, or sweat glands), has been linked to harmful biological effects, including inflammation, alterations in cellular metabolism, physical cellular damage, and reduced cell viability[10].

After analysing data from fifty-nine publications, an average mass was calculated for individual microplastics in the 0-1 mm size range. Subsequently, it is estimated that, globally, on average, humans may ingest 0.1-5 g of microplastics weekly through various exposure routes[11].

Research carried out by Hu and team revealed the presence of microplastics in all canine and human testicles they researched, with significant inter-individual variability. Average total levels of microplastics were 122.63 µg/g in dogs and 328.44 µg/g in humans. Both humans and canines exhibit relatively similar proportions of the main polymer types, with PE being dominant. Furthermore, a negative correlation was observed between specific polymers, such as PVC and PET, and normalised testicular weight. These findings highlight the widespread presence of microplastics in the male reproductive system in canine and human tests, with potential consequences for male fertility[12].

Among 62 placentas samples, Py-GC-MS revealed that microplastics were present in all participants' placentas, with concentrations ranging widely from 6.5 to 685 µg NMPs per gram of placental tissue, averaging 126.8 ± 147.5 µg/g (average ± SD). Polyethylene was the most prevalent polymer, accounting for 54% of total NMPs and consistently found in almost all samples (mean 68.8 ± 93.2 µg/g placenta). Polyvinyl chloride and nylon accounted for approximately 10% of the NMPs by weight, with the remaining 26% of the composition represented by 9 other polymers[13].

Zhu and team studied microplastic exposure through the respiratory and digestive systems, using laser direct infrared spectroscopy to identify microplastics with size > 20 µm in different human tissues. And they identified that microplastics of 20–100 µm were concentrated in all tissues, with polyvinyl chloride (PVC) being the dominant polymer. The highest quantity of microplastics was detected in lung tissue with an average of 14.19 ± 14.57 particles/g, followed by those in the small intestine, large intestine and tonsil (9.45 ± 13.13, 7.91 ± 7.00 and 6.03 ± 7.37 particles/g, respectively). The amount of microplastics was significantly higher in women than in men ($p < 0.05$). Despite the significant diversity, the estimate showed that the lungs accumulated greater amounts of microplastic. Additionally, PVC particles can pose potential health risks due to their high polymer hazard index and maximum hazard level[14].

Marfella and team conducted a study to explore whether MNPs are detectable in atherosclerotic plaque and whether MNP burden is associated with cardiovascular disease. They assessed the presence of these substances in surgically excised carotid artery plaque using pyrolysis-gas chromatography-mass spectrometry, stable isotope analysis, and electron microscopy. They then determined whether the presence of MNPs was associated with a composite outcome of myocardial infarction, stroke, or death from any cause. Of the 257 patients who completed a mean (±SD) follow-up of 33.7±6.9 months, 150 patients (58.4%) had a detectable amount of polyethylene in the excised carotid plaque, and 31 of them (12.1%) also had a measurable amount of polyvinyl chloride in the carotid plaque. Among patients with evidence of these MNPs in plaque, the mean polyethylene level was 21.7±24.5 µg per milligram of plaque, and the mean polyvinyl chloride level was 5.2±2.4 µg per milligram of plaque[15].

In a case series study examining olfactory bulb tissue, 8 of 15 deceased individuals' brains showed the presence of microplastics, most commonly polypropylene, a plastic commonly used in food packaging and water bottles[16].

In a report of Brauser it is said that in accord with researches the MNP accumulations in the brain increased from 2016 to 2024 and were found at higher levels in the brain than in other organs, and MNP levels were 7 to 30 times higher in the brain than in the liver or kidney. Interestingly, the accumulation of MNPs in the brain was even greater in samples from a cohort of 12 individuals with a documented diagnosis of dementia than in samples from those with no dementia. Investigators were quick to note that the findings show an association and not causation[17].

Data from experimental and clinical studies have revealed that the ability of MPs to promote inflammation, oxidative stress, and organ dysfunction and negatively affect clinical outcomes is associated with their accumulation in body fluids and tissues. Although evidence of the putative action of MPs in the human kidney is still scarce, there is growing interest in studying MPs in this organ. In addition, chronic kidney disease requires investigation because this condition is potentially prone to MP accumulation[18].

In the report by Moulun it is evident that microplastics also accumulate in organs. Thus, the amount of plastic in the lungs increases with age, suggesting that the particles may be bioaccumulative. The consequences for health are still poorly understood, but exposure to plastics appears to cause changes in the composition of the intestinal microbiota. Furthermore, a decrease in butyrate, a short-chain fatty acid beneficial to health, was observed in children's intestines. Inhaled nanoplastics can disrupt mucociliary clearance mechanisms of the respiratory system. The toxicity of inhaled plastic particles was demonstrated as early as the 1970s among workers in the flocking industry. Some developed impaired lung function, shortness of breath, inflammation, fibrosis and even lung cancer. Similar symptoms have been observed in workers in the textile and polyvinyl chloride industries[19].

These and other facts show the risks to human, animal and environmental health that synthetic polymers can cause, even though they are also used as biomaterials and in biocomposites that, in many cases, prolong or save lives.

IV. Analysis Of Results

The environmental impacts of different types of polymers have been felt in the environment for many decades. However, it has only recently begun to be realized that human health, as well as the health of aquatic animals and the environment, are being compromised by the inadequate way in which waste from this material has been discarded into the environment, without, in most cases, any other use, despite the fact that its recycling generates financial resources from collectors to owners of recycling industries.

Various types of impacts on human health have been identified through careful research showing microplastics and nanoplastics impacting the Digestive Tract, Respiratory Tract, Circulatory System and even the encephalon of human beings, male and female reproductive systems, among others.

In matters related to the fauna that makes up the aquatic biota, for decades we have seen images of sea turtles, dolphins, etc., with synthetic polymers stuck in their shells or even accumulated in large pieces in their stomachs and intestines. However, meticulous studies have revealed nanoplastics and microplastics reaching other organs of these animals, showing how harmful it is to discard synthetic polymers in nature. This can be related to the following diseases: arteritis, asthma, bronchiolitis, bronchitis, cancer, contact dermatitis, Graves-Basedow disease, hypersensitivity pneumonitis, recurrent enteritis, hypovitaminosis, myocardial infarction, oligospermia, polycystic ovary syndrome, among others.

It can be said that the synthetic polymer is a "sacer", it is useful, it is useless, it beautifies, it makes it ugly, it saves lives, it destroys human life and nature.

Some authors, such as those cited in this work, indicate 2016 as the period that raised the alert for this type of danger to the environment. However, it is believed that since synthetic polymers began to be used by humanity, they have gradually impacted the environment. However, with great growth at the start of the 21st century.

Currently, public policies to reduce use, recycle and dispose of waste properly are being discussed and implemented in several countries, some with simple measures, others more complex, but the fact is that efficient and effective measures must be put into practice immediately, as the planet Earth can no longer withstand these anthropogenic impacts.

V. Conclusion

The anthropogenic impacts caused by synthetic polymers have had a deleterious impact on human health, in many cases, affecting the circulatory system, stomach tract, brain, lungs, male and female reproductive system, among others; and on the health of the biota composed of aquatic fauna, this is also occurring with crustaceans, fish, turtles and mammals.

There is a need to intensify studies, especially regarding the impacts, forms of collection, methods and techniques for recycling and reusing synthetic polymers that are polluting the planet's oceans, rivers and soils, through incentives for research into biodegradable materials with the least possible impact, depollution processes, encourage the replacement of synthetic polymers with natural polymers, among others.

All actions to reduce these anthropogenic impacts must involve communities at all levels, government and companies, in a participatory manner, sharing commitments and responsibilities, as the survival of the planet depends on urgent effective actions.

References

[1] LÓPEZ CARRASQUERO, Francisco. Merida : Universidad De Los Andes, 2004.

[2] CRISTOVAM, Marcos Antonio Da Silva, Et Al. Degranulação De Neutrófilos Ex-Vivo Por Ação Do Polímero De Amido De Mandioca. Ciência Rural. 40 (5):1103-1108. Maio, 2010.

[3] BRAGA, Francisco José Correa. Materiais Aplicados Na Medicina E Odontologia. São Paulo : Artliber, 2015.

[4] BAIRD, Colin, CANN, Michael. Química Ambiental. 2 Ed. Barcelona : Reverté, 2014.

[5] GUEDES, Aureliano Da Silva; GUEDES II, Aureliano Da Silva; GUEDES, Catarynna Maciel Quaresma Da Silva. Introdução Aos Biomateriais. Belém : Editor Aureliano Guedes, 2023.

[6] PICO, Yolanda; ALFARHAN, Ahmed; BARCELO, Damia. Nano- And Microplastic Analysis: Focus On Their Occurrence In Freshwater Ecosystems And Remediation Technologies. Trac Trends In Analytical Chemistry. V. 113: 409-425. April 2019.

[7] SCHELL, Theresa; RICO, Andreu, VIGH, Marco. Occurrence, Fate And Fluxes Of Plastics And Microplastics In Terrestrial And Freshwater Ecosystems. Rev Environ Contam Toxicol. 250:1- 43. 2020.

[8] SARCLETTI, Marco, Et Al. The Remediation Of Nano-/Microplastics From Water. Materials Today. V. 48: 38-46. Sep., 2021.

[9] STEFANELLI-SILVA, Gabriel, Et Al. Bottom-Feeders Eat Their Fiber: Ingestion Of Anthropogenic Microdebris By Antarctic Deep-Sea Invertebrates Depends On Feeding Ecology. Environmental Science & Technology. 58 (50) 22355–22367. 20 Nov, 2024. Available At < Https://Pubs.Acs.Org/Doi/Epdf/10.1021/Acs.Est.4c09487?Ref=Article_Openpdf >Access In 31/01/2025.

[10] GAUZERI, Bernard-Alex. Lastic Pollution's Next Victim: The Human Urinary Tract. In: Medscape. Nov., 07, 2024. Avaliable At Https://Www.Medscape.Com/Viewarticle/Plastic-Pollutions-Next-Victim-Human-Urinary-Tract-2024a1000jzu?Ecd=WNL_Mdpls_241112_Mscpedit_Publ_Etid6992353&Uac=129420FV&Spon=42&Impid=6992353 > Access In 11/02/2025.

[11] SENATHIRAJAH, K.; ATTWOOD, S.; BHAGWAT, G.; CARBERY, M.; WILSON, S.; PALANISAMI, T. Estimation Of The Mass Of Microplastics Ingested - A Pivotal First Step Towards Human Health Risk Assessment. J Hazard Mater. 404.15 Feb.,2021.

[12] HU, Chelin Jamie, Et Al. Microplastic Presence In Dog And Human Testis And Its Potential Association With Sperm Count And Weights Of Testis And Epididymis. Toxicological Sciences. V.200 (2): 235–240. Aug. 2024.

[13] GARCIA, Marcus A., Et Al. Quantitation And Identification Of Microplastics Accumulation In Human Placental Specimens Using Pyrolysis Gas Chromatography Mass Spectrometry. Toxicological Sciences. V.199 (1): 81–88. May., 2024.

[14] ZHU,Et Al. Tissue Accumulation Of Microplastics And Potential Health Risks In Human. Science Of The Total Environment. V. 915. Mar., 2024.

[15] MARFELLA, Raffaele, Et Al. Microplastics And Nanoplastics In Atheromas And Cardiovascular Events. In: The New England Journal Of Medicine. 390 (10). Mar, 2024. Available At < Https://Www.Nejm.Org/Doi/Full/10.1056/Nejmoa2309822?Query=Featured_Home&Logout=True >Access In 11/02/2024.

[16] BRAUSER, Débora. Microplastics Have Been Found In The Human Brain. Now What?. In: Medscape. Nov., 27, 2024. Available At<Https://Www.Medscape.Com/Viewarticle/Microplastics-Have-Been-Found-Human-Brain-Now-What-2024a1000ln0?Ecd=Mkm_Ret_241229_Mscpmrk_Neuro_Top-Content_Etid7125565&Uac=129420FV&Impid=7125565 > Access In 11/02/2025.

[17] BRAUSER, Débora. Microplastic Accumulation In The Brain On The Rise? In: Medscape. Fev., 19, 2025. Available At < Https://Www.Medscape.Com/Viewarticle/Microplastic-Accumulation-Brain-Rise-2025a10004a8?Ecd=Wnl_Dne1_250221_MSCPEDIT_Etid7246077&Uac=129420FV&Impid=7246077> Access In 24/02/2025

[18] OLIVEIRA, Rodrigo Bueno De, Et Al. Effects Of Microplastics On The Kidneys: A Narrative Review. In: Kidney International. 106 (3): 400 – 407. Set., 2024. Available At < Https://Www.Kidney-International.Org/Article/S0085-2538(24)00404-6/Abstract > Access In 13/02/2024.

[19] MOULUN, Anne-Gaëlle. Health Impacts Of Micro- And Nanoplastics. Medscape Medical New. December 13, 2024.