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"Micro and Nano Plastic as an Emerging Threat on Human Health"

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ABSTRACT
The term "plastics," which comes from the Greek word "plastikos," refers to a broad category of synthetic and semi-synthetic materials that have not only contributed to human development but also caused serious problems for the environment and human health. Larger plastic objects break down to produce microplastics (less than 5 mm) and nanoplastics (less than 0.1 µm), which are dangerous to human health and common in ecosystems. Both marine and terrestrial habitats include these microscopic plastic particles, which come from sources like tire wear, synthetic fibers, plastic breakdown, personal care items, and industrial operations. Their broad rate causes worry about how they may affect important organs like the brain, liver, skin, kidneys, reproductive system, and gastrointestinal tract. Liver damage, neurotoxicity, and cancer have all been connected to micro and nanoplastics. To solve this problem, several remediation techniques have been developed, such as physical, chemical, biological, and nano-remediation; nonetheless, there are still obstacles in the way of completely getting clear of these contaminants.

KEYWORD: Plastic, Plastikos, Synthetic materials, Semi-synthetic materials, Polymer,Polymerization

I. INTRODUCTION

The word plastic is derived from the greek work "plastikos" meaning "capable of being shaped or molded".Plastics are a wide range of synthetic and semi synthetic material that use polymer as a main ingredient. It is large chemical compound produced through industrial polymerization processes. By introducing specific additives to these polymers or blending them with other substances like carbon fibres [1].The chain of plastic consists of thousands of repeating units formed from monomer. For the ease and good quality of human life, plastics are used in various products such as PVC (polyvinylchloride) products, equipment used for medical purposes and packaging of food. Improper and poor management of plastic is the main cause of negative effects of plastic among human[2].In 2019, plastic use was growing which exceeded to 368 milliontones. Natural material undergoes main processes like polycondensation and polymerization. Disposed plastic waste when exposed to biological,chemical and environmental elements and breaks in huge amount of microplastic(<5 mm) and nanoplastics(<0.1 micrometer) [3].Microplastics have false or negative impact on health affecting skin leading to skin irritation, inflammation and disruption of natural skin function, lungs, kidney (disrupting renal function), liver, lung, reproductive system etc. [4].Microplastics are fragment of plastic less than 5mm in length [5]. According to U.S. National Oceanic and Atmospheric Administrationand Europian Chemical Agency. A nanoparticle also called ultrafine particle has diameter of 1-100 [6].The production of nanoparticle with specific properties is a branch of nanotechnology. Nanoparticle and Microparticle both cause pollution by entering natural ecosystem from a variety of sources including cosmetics, clothing, food packaging and industrial processes.

Micro and nanoplastics are particles smaller than a millimeter that are present in both marine and terrestrial ecosystems. They have emerged as a significant worldwide environmental concern in recent decades, and new research has shown that these pieces may be found everywhere, even in previously believed to be pristine regions.

1. **SOURCES OF MICRO AND NANO PLASTIC**Small plastic particles known as micro and nanoplastics are produced actively for a variety of uses or are produced as a result of the breakdown of bigger plastic pieces. The primary sources of micro and nanoplastics are listed below, with a reference:

1.1BREAKDOWN OF LARGER PLASTICS

The main source of microplastics is the breakdown of larger plastics, such bottles,

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wrapping, and other consumer products, caused on by contact with the environment (sunlight, wind, and water). [7]

1.2SYNTHETIC FIBERS FROM TEXTILE

When synthetic fibers like polyester, nylon, and acrylic are cleaned, they release microfibers that damage lakes with microplastics. [8]

1.3TIRES AND ROAD WEAR

Tiny particles of plastic and synthetic rubber break down as tires on automobile wear down. These particles are a major source of microplastic contamination.[9]

1.4PERSONAL CARE PRODUCTS

Certain personal care items, such as toothpaste, washing gels, and polishing scrubs, contain microscopic plastic particles called tiny beads. [10]Transport and handling can result in the loss of industrial

1.5 PLASTIC PELLET LOSSPLASTIC PARTICLES,

which are rawmaterials needed to make plastic items, contaminating the environment with microplastics. [11].

1.6 MARINEACTIVITIES AND FISHING GEAR

Microplastics in the waters are a result of shipping-related plastic trash as well as lost, abandoned, or discarded fishing nets and other equipment. [12]

1.7PAINTS AND COATINGS

Plastic particles found in some paints, particularly sea paints, contribute to microplastic contamination as they detach or break down. [13]

1.8 COSMETIC AND PHARMACEUTICAL PRODUCTS

Certain cosmetics and pharmaceuticals, such slow-release pills, have plastic ingredients that break down into micro and nanoparticles.[14]

2. REMEDIATIONSTRATERGIESAND METHODS

Need for remediation methods for MPs and NPs has been highlighted by their broad presence in the environment, and the current methods may be divided into four groups: physical, chemical, biological, and nano-remediation. [15,16]

Table 1. provides a literature summary of the typesof plastics used in remediation methods, which can be referred to for further information.

Sr. No.	Material	Type of Remediation	Used Techniques	Refs.
1	PE	Physical	Fe-Based Coagulation and UF	17
2	MPs	Physical	RO and Nanofiltration	18
3	Fiber MPs	Physical	UF	19
4	MPs	Physical	RO	20
5	PET	Chemical	Photolysis	21,22
6	PE, PS, PET, and PVC	Chemical	UV Radiation	23
7	PE and PS	Chemical	TiO2 Photocatalysts Under UV Illumination	24
8	Marine Plastics	Bioremediation	ocuria palustris M16, Rhodococcus sp. 36, and Bacillus strains	25
9	PET	Bioremediation	deonella sakaiensis 201-F6 strain	26
10	PAM and Small Size MP	Nanoremediation	Coagulation, Sedimentation and GAC Filtration	27
11	MPs	Nanoremediation	Green Nanoscale Semiconductors	28
12	MPs	Bioremediation	Lysozyme Amyloid Fibrils	29

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2.1 PHYSICAL REMEDIATION METHODS:

Physical techniques include coagulation, magnetic separation, filtration, sedimentation, and ultrasonic treatments. They can also be combined with other materials, such as graphene-based filters, however they may not be capable to completely remove all plastic particles. [30-32]

2.2 CHEMICAL REMEDIATION METHODS:

These procedures use a variety of techniques, including heat, light, plasma, ultrasound, and catalysts, to efficiently generate reactive oxygen species (ROS), typically referred to as radicals, throughout the therapeutic process. By producing a variety of ROS, such as sulfate radical (SO4•−), hydroxyl radical (•OH), and chloride radicals, antioxidants are currently attracting attention as efficient techniques for removing persistent pollutants from water. This allows them to easily break down a wide range of contaminants. [33,34]

2.3BIOLOGICAL METHODS:

Biodegradation: It has been discovered that some microorganisms, such as bacteria, fungus, and algae, may break down particular types of plastics. To discover and enhance these organisms for widespread use in the degradation of microplastics, research continues to be done.[35] Enzyme-mediated Degradation: Certain enzymes have been found to break down plastic polymers, and researchers are studying ways to employ them for effective breakdown of microplastics.[36]

2.4 NANO REMEDIATION:

In the remediation process, nanomaterials can be employed as flocculants to catalysts, and absorbents [37–38]. For example, the high porosity and wide surface area of activated carbon, which has long been utilized as a solid adsorbent, make it effective [39]. The nature of the polymers affects the efficiency of the various kinds of nano-flocculants. For instance, given their great efficiency, synthetic polymers are environmentally harmful and non-biodegradable. However, the performance of biopolymers may be greatly improved by adding nanomaterials. Biopolymers, on the other hand, are water-soluble and biodegradable but less effective at low dosages. [40].

3.EFFECT OF MICRO AND NANO PARTICLE ON VITAL ORGANS

3.1GASTROINTESTINAL TRACT:

The gastrointestinal tract of human includes buccal cavity, oesophagus, stomach, large intestine, rectum and anus. The gastrointestinal tract is believed to be the main source or point of entry of micro and nano particle of plastics.

- Nano plastic are major cause of Crohn's disease, ulcerative colitis and cancer in gastro intestinal tract. Crohn's disease is caused by higher uptake of nano plastics in diet.
- 81% of 159 global tap water sample consist of micro plastic mainly fibres smaller than 5 mm[15]. The presence of microplastic were also detected in human stools, predominantly PP and PET [1] .According to Bonanomi M. et al.'s review, exposure to polystyrene acts as or may cause cancer in humans. Both acute and chronic exposure to polystyrene nanoparticles and microparticles may trigger changes in metabolic activity because they can be internalized by human colon cells. The treatment of the carcinogenic agent atomic oxygen molecules was linked to the metabolic alterations observed, and high-dose chemotherapy15 colon cancer cells exhibit four metabolic cancer treatments.[1]. According to Bonanomi M. et al.'s review, exposure to polystyrene acts as or may cause cancer in humans. Both acute and chronic exposure to polystyrene nanoparticles and microparticles might cause alterations in metabolic activity because they can be internalized by human colon cells. The metabolic changes seen were related to carcinogenic agent AOM treatment and HCT15 colon cancer cellsshows 4 metabolic cancer treatment.
- increased glucose oxidation via lactate even when oxygen is available
- reduced activity of mitochondria
- decoupling of nutrients(glucose and glutamine)
- reductive carboxylation of glutamine [41].

3.2BRAIN:

Because of their tiny size, micro- and nanoplastics may cross the blood-brain barrier and enter the brain. These particles may impair mental ability and possibly contribute to neurological conditions by causing neurological inflammation, oxidative stress, and neuronal toxicity once they are within. [42,43].

3.3LIVER:

One of the biggest problems of the twenty-first century is plastic pollution. A key component of the reticuloendothelial system, monocyte-phagocytic system, and kupffer cell is the liver. When exposed to microplastics or nanoplastics, the liver exhibits vacuolar degeneration, hepatocyte edema, and inflammatory cell infiltration, which both increase inflammation and activate the innate immune response [3]. Hepatocytes are are damaged by the antagonistic effects of nanoselenium and di-[2-ethyl hexyl]phthalate [DEHP] [44]. In their review, Liu W. et al. suggested that microplastics are a particular kind of pollutant that have a particular effect on the liver, which was demonstrated by tests using mice that included both nanoplastic and microplastics in their diet.

Microplastic-induced alterations in the liver immune microenvironment in mice with non-alcoholic fatty liver were examined using single cell genome analysis

3.4 SKIN:

Skincare has concerns about the widespread use of nanoparticles and microparticles in cosmetic formulations. One of the primary causes may also be contaminated water. By influencing the skin's outermost layer, the nanoplastics penetrate the striatum cornium [4]. It is uncertain what effects both acute and long-term exposure to NMP has on skincells [45].

The literature's scant material demonstrates its primary focus on the consequences of possible allergic reactions. Rarely, though, were allergic responses observed. Bisphenol A (BPA) is a notable example. Bisphenol A allergies have been documented in individuals wearing PVC (polyvinyl chloride) gloves [1].

3.5 KIDNEYS:

When micro and nanoplastics get into the circulation, they can damage the kidneys' filtration system, induce inflammation, and potentially cause nephrotoxicity. Plastic particles building up in renal tissues may have an effect on the kidneys' capacity to filter and eliminate waste.

According to studies, microplastics can cause oxidative stress and inflammation in animal models, which can result in kidney injury [46].

3.6 ENDOCRINE SYSTEM:

Chemical additives called plasticizers found in some plastics have the potential to cause problems with hormones. These substances have the ability to disrupt hormone signaling, which can result in metabolic, reproductive, and developmental problems.

In animal models, nanoplastics have been demonstrated to change hormone synthesis and interfere with thyroid function, raising the possibility of a health risk to humans, especially in susceptible groups [47].

3.7 NEUROTOXIC EFFECTS:

By passing across the blood-brain barrier and resulting in neuroinflammation, oxidative stress, and possible neurodegeneration, micro and nanoplastics may also have an impact on the nervous system. According to preliminary research in animal models, exposure to these particles may cause neurological and behavioral abnormalities. According to recent studies, microplastics can cause neuronal damage in mice' brains following oral exposure [48].

3.8 REPRODUCTIVE SYSTEM:

Exposure to microplastics, especially those containing endocrine-disrupting chemicals, may negatively affect reproductive health. Studies have found that microplastics can alter sperm quality and hormone regulation in males, and potentially impact fetal development.

Studies have shown that microplastic exposure affects reproductive organs in animals, with some evidence of decreased fertility in male rodents [49].

4.METHODS OF MICROPLASTIC
4.1VISUAL INSPECTION METHOD

Observations made with the naked eye, an optical microscope, and/or an electron microscope are examples of visual inspection techniques of MPs. These methods are used to choose and classify MPs and to examine the size and color of the tested object [50,51] (Figure.1). In addition to being time-consuming and incorrect [52], these methods also have a negative correlation between error rate and particle size [53].

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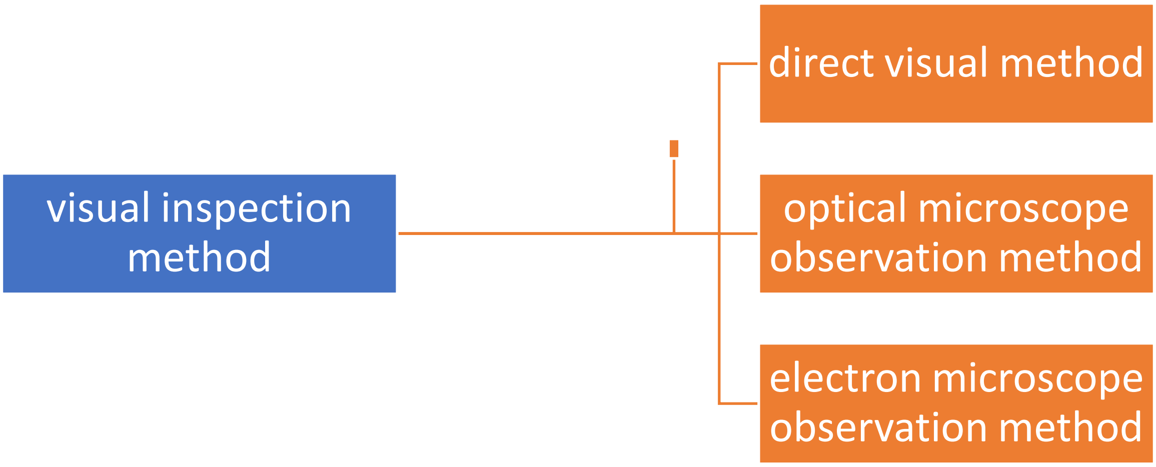

Figure.1 Classification of visual inspection methods.

The visual inspection method's benefits include the ability to quickly and easily provide an overall picture of the number of big MPs in samples that are easy to detect. The inability to determine the type of the samples and the requirement to combine identifying methods are the limits.

Even under a microscope, MPs smaller than 100 µm are hard to see or identify [54–56]. Therefore, in order to achieve more accurate and useful results, the development of technologies for MP identification is essential.

4.2THERMAL ANALYTICAL METHOD

Because of their superior detection accuracy, the Pyr-GC-MS, TED-GC-MS, and DSC methods are primarily employed to detect MPs in the environment.

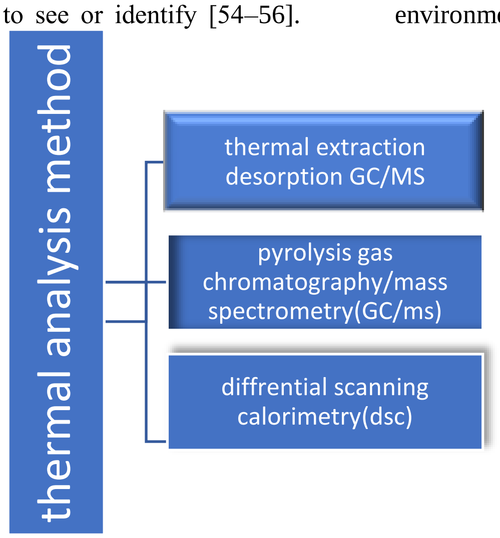

Figure 1.The classification of thermal analytical methods

4.3 SPECTRAL ANALYTICAL METHOD

In comparison to visual recognition alone, the spectral analytical method yields more accurate information [57]. As of now, spectroscopic techniques can both, detect and verify Water 2023, 15, 3535 11 of 32 the composition of MPs. This is due to the spectral signal's ability to reflect the distinctive characteristic peaks that each type of MP produces. The polymer types of MP particles with a minimum particle size of 10 µm and 1 µm, respectively, have been determined using FTIR and Raman spectroscopy.

4.4 OTHER ANALYTICAL METHODS

Scanning electron microscopy energy dispersive spectroscopy (SEM-EDS) is typically paired with vibration spectroscopy as an adjunct to the analysis to detect microplastics. There is not much research on the independent detection of MPs using SEM-EDS now, presumably because this technique cannot show chemical composition data [58]. There is not much research on the detection of MPs by High Performance Liquid Chromatography (HPLC), and the existing ones do not accurately identify the polymers. Therefore, more research is recommended. The combination detection of SEM-EDS and HPLC in the future may overcome the bottleneck of the existing MPs detection studies, based on the advantages and disadvantages analysis.

II. CONCLUSION:

In conclusion, because of their pervasiveness in both aquatic and terrestrial environments, microplastics (MPs) and nanoplastics (NPs) present serious risks to the environment and human health. These tiny plastic particles enter many surroundings, ecosystems, and even human beings. They can be actively produced or come out from the decomposition of bigger plastics. MPs and NPs interact with natural processes as they build up in the environment and can enter the human body through a variety of routes, including as ingestion, skin absorption, and inhalation. With potential effects ranging from serious brain, liver, renal, and reproductive system defects to gastrointestinal problems and skin irritation, the influence on human health is serious.

Several repair techniques, including as physical, chemical, biological, and nano-remediation procedures, have been developed as a result of efforts to reduce the amount of MPs and NPs in the environment. Even if some of these methods appear positive, the problem of dealing with the widespread nature of plastic pollution and the challenges of totally eliminating these pollutants from natural systems still exists. Global collaboration in cutting plastic manufacturing, enhancing waste management procedures, and developing research into appropriate remediation techniques are crucial to successfully counteracting the harmful impacts of MPs and NPs. Also, knowing the entire amount of microplastics and reducing their detrimental effects on the environment and human health would be made easier with ongoing monitoring and the development of improved analytical methods for their detection.

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