MICRONANOPLASTICS : AN INEVITABLE FUTURE

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CANDIDATE'S DECLARTION

I Megha (2K21/MSCCHE/62) , student of M.Sc (Chemistry) hereby declare that the project Dissertation titled "Micronanoplastics : An inevitable future " which is submitted by me to the Department of Applied Chemistry, Delhi Technological University, Delhi in the partial fulfilment of the requirement for the award of the degree of Master of Science, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma, Associateship. Fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that the Project Dissertation titled "Micronanoplastics : an inevitable future" which is submitted by Megha (2K21/MSCCHE/59), Department of Applied Chemistry, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the Master of Science, is a record of the project work carried out by the student under my supervision. To the best of my/our knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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MEGHA

ABSTRACT

In the past few decades, plastics have become an integral part of our lives. It is extensively used in our daily lives and is completely mingled with our ecosystem. It accumulates in our surroundings as well as in our human body too. It can adversely affect our health and could lead to such deteriorating circumstances that could not be reciprocated.

This review paper gives an overall understanding of micro nanoplastics, including their definition, sources, and impacts, and provides an overall understanding of this topic.

It further covers, in detail, the three most common ecosystems in which these microplastics have their highest effects, namely marine, soil-plant and air borne microplastics.

This paper discusses various methodologies to assess the effects of micronanoplastics, and provides an insight into their management and future aspects for this grave problem.

Keywords:

MP's (Microplastics), NP's (Nanoplastics), Marine pollution, plastic, degradation, Air pollution.

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CHAPTER NO 1 INTRODUCTION AND LITERATURE REVIEW

As civilization began to use large amounts of plastic in every aspect of our lives, including healthcare, agriculture, and industry, in the 1940s, plastic production has increased significantly. Because of its preferred qualities, including lightness, durability, flexibility, versatility, and cost effectiveness, the market for plastic has grown dramatically in recent years. Yet, the widespread use of plastics has had negative environmental effects. Plastic litter can also remain in the environment for a very long time before it decomposes once it enters the environment and breaks down into smaller pieces through biological, physical, & chemical processes into mesoplastics, microplastics, and even nanoplastics (NPs, 100 nm).

MPs have been classified as small MPs (1.00 mm) and medium-sized MPs (1.01-5 mm), while NPs have at least one size that is within 100 nm[1] . Physiological processes can be altered by NPs because they can concentrate in organs and more easily enter tissues and cells. they are widely discovered in various ecosystems mainly three of them are discussed below

1.1 Marine ecosystem

In recent decades, plastic has been widely used, causing negative environmental effects. Marine trash and floating debris were thought to be mostly plastic in 2008[2], making this the main type of marine debris. This is the most rapidly growing platform for nanoplastics and is mostly scrutinised in the present scenario. [3]

1.2 The soil plant network

The soil-plant network, which supports the world's biosphere and produces food for people, is one of the most crucial environmental compartments in the terrestrial environment. MPs were more likely to be found in soils, particularly agricultural soils, where there were several sources of plastic on the land. Furthermore, there is a chance that MNPs will take plants from soils and add them to the human food web. The destiny of

MNPs in the terrestrial ecosystem is a contentious but crucial issue since it has a direct impact on human health, food safety, and food contamination. [4]

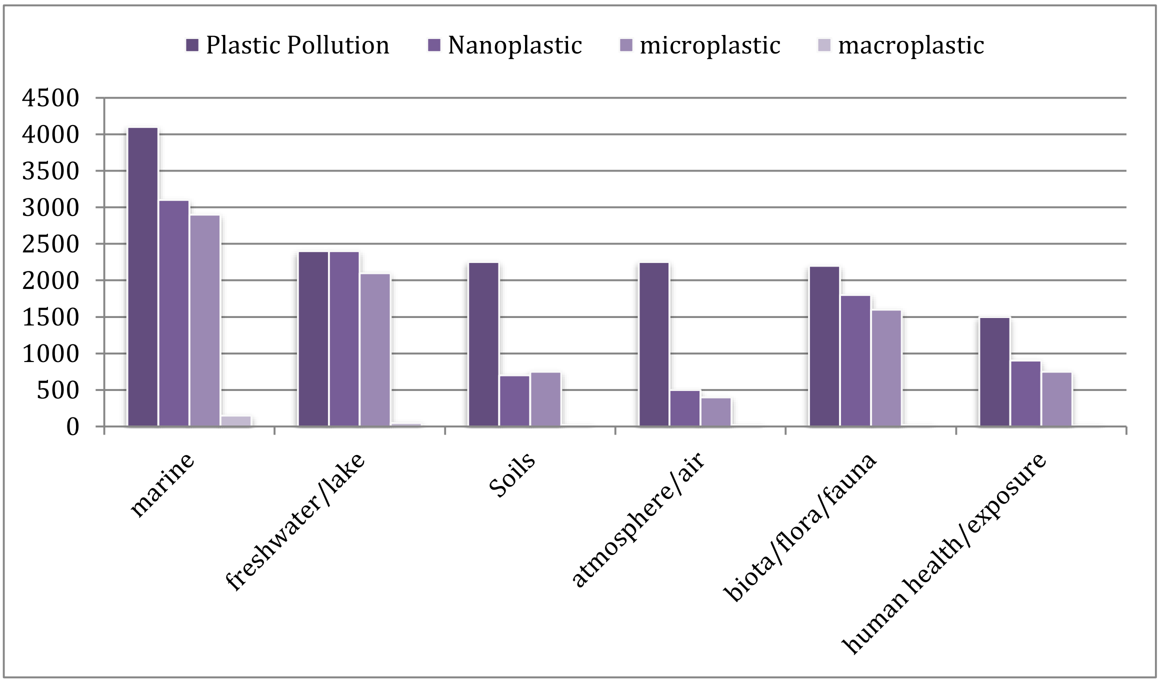
1.3 Airborne Microplastics

The contamination of the environment may be caused by the atmospheric fallout of micro (nano)plastics. In addition, various factors, including vectors, run-off, vectors, wind, soil erosion, water currents, etc., have an impact on the amount of micro (nano)plastics in every environmental compartment. Industries play a key role in this type of pollution, which causes various deadly diseases such as respiratory disorders and several gene mutations. [5]

They can be degraded by various factors such as bacteria, algae, and chemicals, which form the basis of their management techniques apart from the ones employed by different governments in different parts of the world. [6]

2. MICRO NANO PLASTICS

As a result of the widespread use of plastic in our daily lives, a significant amount of plastic garbage is released into the environment. Mechanical abrasion, ultraviolet degradation, oxidation, and biotic action can all break down or disintegrate plastic garbage into tiny pieces. A microplastic is a particle that is 100 nm to 500 nm in diameter, whereas a nanoplastic is a particle that is 1 nm to 100 nm in diameter (NPs [7]



(FIG. 1 the above graph represents distribution of various types of plastics in different ecosystems)

2.1 DIFFERENT WAYS OF MP-NP EXPOSURE

2.1.1 DRINKING WATER

Various MP-NP have been found in soil and various marine ecosystems, including freshwater, which is used for drinking purposes, particularly when particles of plastic pass through the membrane of the filtration system of water treatment plants.
Daily estimated discharge is approximately up to 15 million particles of MP-NP [8]

2.1.2 FOOD CHAIN

As a result of loading water or feeding from other organisms, aquatic organisms may become contaminated with MPs-NPs and may serve as a source of exposure for humans [9].People consume whole soft tissues from bivalves, which may contain microscopic plastic particles or they can be contaminated by micro nano plastics after fishing when they are kept in plastic containers for storage and transportation purposes [10].

2.1.3 MP-NP IN COSMETICS

Dermal contact may occur when human skin interacts with nanoplastics found in various cosmetic products or simply in water [11]

Smaller size nanoplastics (approximately 100 nm) can penetrate human skin from water contaminated with MPs-NPs during scrubbing or washing of the face. Although a large range of micro nano plastics could not pass through the skin because of their larger size or the ineffective penetration of the stratum corneum [12]

Still, some nanoplastics can penetrate and severely harm humans.

2.1.4 AIR BORNE MPs-NPS

xHumans can intake micro nano plastics by air as well. As has been well documented, air pollution contains a large amount of nano plastics, which can severely harm our respiratory tract and cause various lung diseases. Micronanoplastics are also found in air. as suggested by reports, an urban rooftop has approximately 29- 280 particles per metre square per day [13].

3. IMPACT OF MP-NPs ON HUMAN HEALTH

Due to MPs' intake capacity in humans, which causes intestinal blockage, their presence may be hazardous. In various aspects.

MPs/NPs have negative consequences due to a combination of the plastic's inherent toxicity (such as physical damage), chemical makeup (such as additive leaching), and capacity to absorb, concentrate, and release environmental toxins into organisms. [14]

MPs might also act as a pathogen vector, which might cause organisms to spread out into a different ecosystem. It is possible to use MPs and NPs as vectors for environmental pollutant exposure because of their hydrophobicity and high surface area-to-volume ratio. The likelihood that these compounds could bio-amplify in predators, including humans, is increased by the transfer of toxins into creatures at below-trophic levels.[15]

Moreover, MPs may become colonised by microorganisms, which are thought of as vehicles for exposure to potential diseases. In the North and Baltic Seas, Vibrio parahaemolyticus was found on a range of MP particles, including PE (polyethylene), PP (polypropylene), and PS (polystyrene [16]

3.1 INDIRECT EFFECT OF MPs-NPsADDITIVES LEACHING IN ENVIRONMENT

Plastic polymers are typically regarded as neutral and having no impact on human health. Generally, the large variety of plastic compounds they may include are to blame for any health hazards associated with their use.

Catalysts based on metals can leak into water supplies during the manufacturing of water bottles [17].

It has been demonstrated that antimony (Sb), a catalyst used in commercial PET plastic bottles, releases when subjected to high temperatures. These kinds of plastic bottles & their storage at elevated temperatures that encourage the deterioration of water quality should be avoided because this may have negative health effects (such as nausea, puking, and diarrhea). [18]

Food and beverage exposure are primarily caused by polymer constituents and additives migrating into food and beverage products. [19]

While the potential for MPs to spread contaminants, such as phthalates, between species has been discussed, other contaminated sources, including sediment, food, and water, may be just as important, if not more so, for the transfer of chemicals in aquatic creatures.[20]

4. METHODOLOGIES TO QUANTIFY AND ASSESS THE EFFECT OF MICRONANOPLASTICS CURRENT TECHNIQUES FOR ASSESSMENT

4.1 SIZE EXCLUSION

Microplastics' dimensions are always tied to a realistic identification procedure. Thus, analysis will be more demanding the smaller the microplastics are. Hence, spectroscopic measurements or equivalent alternatives cannot be avoided when dealing with actual microparticles.[21]

On the other hand, visual examination of large microplastics is frequently effective for the task, and there are adequate identification techniques that permit precise results. [22]

Despite accuracy being the main goal, practicality becomes crucial when characterization of microplastics involves a high sample throughput. The identification method may be determined by particle diameters, and various other factors. [23]

4.2 SAMPLE PRETREATMENT

This process is mainly done in two steps;

Methods like ultrasonic baths and hydrogen peroxide treatments are suggested for cleaning up microplastics. [24] In addition to ensuring the extraction and purification of microplastics, it also prevents secondary microplastics from being produced artificially. Thesecond step is to eliminate pollutants. It is done by putting potent acids, bases, or enzyme solutions on samples.

However, many researchers believe that these sample pretreatments have very negligible effects and success, and this process can only be done by using potassium hydroxide (KOH).[25]

Also sample pretreatment steps should be done efficiently to reduce contamination of sample hence,It is highly recommended to conduct quality control samples.

4.3 VISUAL CHECKING

It is the most controversial yet most used technique used worldwide, about 79 percent of examination of microplastics are done by this method.[26]

It is possible to visualize an object by dissecting it with a microscope or by using the naked eye. In many cases SEM (scanning electron microscopy) is also used for several smaller fragments. But it is a complex mechanism to follow, hence not practical enough and time consuming.[27] [28] [29]

Despite the fact that visual examination is a common methodology, we concur with many other researchers in that we cannot suggest it as a stand-alone approach. In our opinion, it is a valuable tool for supporting additional analytical applications due to its precision and ability to identify polymer type restrictions.

4.4 FTIR TECHNIQUE

The most technologically favorable method is FTIR (Fourierier transform infrared spectroscopy).

Its principle consists of;

1. Spectroscopic test for randomly chosen fragments.[30]
2. Chemical imaging using FPA (focal plane array) detector.[31]

After recording the required spectroscopic data, two common methods can be done;

The first one is a manual interpretation of vibrational bands in reference to literature, which is a bit time-consuming. Secondly, various commercial methods available can be used.[32]

The majority of FTIR software uses library searching, which is how the majority of spectra are evaluated.[33]

Only a few academics are focused on this subject, despite the existence of numerous different methods to determine the Hit Quality Index, which measures how closely a measured sample and reference spectrum resemble each other.

Generally, HQI > 0.7 is considered its lower limit.[34]

4.5 RAMAN SPECTROSCOPY

Raman spectroscopy is recently used as an alternative of infrared spectroscopy for very smaller size fragments of particles.

Most Raman operators use their own system for such operations with laser wavelength of approx. 532 nm and 785 nm.[35][36]

5. MARINE POLLUTION BY MICRO NANO PLASTICS

In recent decades, plastic has been widely used, causing negative environmental effects. In 2008, it was projected that floating particles and 60-80% of all marine garbage were made up of plastic pieces. [37]

One of the top 10 developing worldwide environmental issues, according to the UNEP (United Nations Environment Program), is the ocean's plastic pollution, which has been estimated to harm marine ecosystems to the tune of US$13 billion annually. [38] There are several stunning examples of plastic waste in the oceans, including the North Atlantic Garbage Patch (Atlantic Ocean), the Indian Ocean Garbage Patch, and the Pacific Garbage Patch. [39]

Polymers can withstand centuries in the environment and have a very low rate of degradation. Large plastic particles are first broken down into meso particles then microparticles, and then nano particles before degradation according to decreasing sizes. [40]

5.1 SOURCES OF MARINE NANO PLASTICS

The majority of plastic litter, including macroplastics, NPs, and MPs, is dumped directly onto land because the majority of human activities—including all human activities—take place on land and because the entire human population resides there. Since the majority of primary and secondary MPs and NPs in the waters come from land, land-based sources account for the majority. [41]

Inefficient waste management, unlawful dumping, unavoidable spills, and discharges from industries like buildings, manufacturing, farming, household use, and recreation are frequently to blame.

With ocean-related activities including fishing, boating, and aquaculture, plastic waste may be introduced directly into the marine ecosystem.[42]

Approximately 98 percent of marine pollution of micronanoplastics are due to land-based sources and only 2 percent water-based activities are responsible for it. It can be rightfully concluded that with proper management of land-basednanoplastics, we can surely reduce their effect on marine ecosystems. [43]

5.2 TRANSFER OF MICRONANOPLASTICS IN OCEANS

Individual micronanoplastics and bulk micronanoplastics would transfer horizontally and vertically once they entered the oceans.

These transfers in depending on various factors as

1. Physicochemical characteristics (include chemical composition, surface charge, size shape etc.) [44]
2. Ocean dynamic condition (include waves, wind, water current, eddies etc.
3. Ocean geometry (slope etc.)
4. Shoreline characteristics (coastal vegetation, surface ice)
5. Bio life interaction (ingestion from marine animals) [45]
6. Human activities (industries, tourism etc.)[46]

5.3 DISTRIBUTION OF MP-NPS IN MARINE SYSTEM

Micronanoplastics are widely spread across various marine forms, especially marine debris patches, which are observed in the Pacific Ocean, Indian Ocean, and Atlantic Ocean.

5.3.1 MPNPS IN SEA WATER

Samples taken from different places carry different amounts of micronanoplastics, depending on various socio- economic -political factors in that place. For example, in China and other Asian countries, seawater is found to be more polluted by mp-nps than seawater in Japan and North America, indicating the strict waste management systems of their respective governments.

5.3.2 MPNP IN SEDIMENTS AND BEACH SAND

Heavy accumulation of MP - NPS in sediments and beach sand can be present because of various tourist activities, heavy MP - NPS are settled at ocean bed and contaminate ocean bed , whereas lighter MP - NPS float on the surface of water and when washed on the beach accumulate itself in various clusters and results in beach pollution.[47]

5.3.3 MP - NPS IN MARINE ANIMALS

MPs and macroplastics can be consumed by a wide range of filter feeders and seabirds, which can build up over time and move up the food chain. Several studies have shown that MPNPS affect not only marine animals, but also humans as they are widely consumed by humans, and as they move down the tropics, these pollutants can be biomagnified. Hence the accumulation of these MPNPs in marine systems is the most widely researched topic of this genre, and various steps are taken for their management.

5.4 THREATS OF MP - NPS IN MARINE ECOSYSTEM AND HOW IT EFFECTS HUMAN HEALTH

MPs pose serious risks to ecosystems, food webs, and ultimately humans, regardless of whether they exist alone or in combination with macroplastic trash. These dangers include everything from a sharp decline in the value of tourism to the extinction of marine life and possibly negative effects on human health.[48]

5.4.1 RELEASE OF POLLUTANT

Furthermore, MPs have a large specific surface area, which enhances the release of additives into the surrounding water, such as UV stabilisers, colors, and retardants. These chemicals lead to toxic effects on aquatic flora and fauna.

5.4.2 THREATS TO ANIMALS

The findings of experimental investigations indicate that MPs ingested mainly remain in the digestive tract. They may remain inside the digestive tubules, gills, intestines, and of a wide range of species, including the pelagic fish Platycephalus indicus and the mussel Mytilus edulis, which were managed by epithelium activity or ciliate action. [49]

5.4.3 INFLAMMATION

The lingering MPs have the potential to harm the ingesting system's organs, tissues, cells, and molecules, as well as other organs, if they travel there. The tissues that have been injured by this injury may become inflamed. [50]

5.4.4 THREAT TO HUMAN HEALTH

Human carcinogenesis cells have shown unfavorable effects of MPs on the metabolism of sex hormones. [51]
Also, these micro nanoplastics accumulate in non-digestive organs and serve as carriers of different pathogens. [52]

5.5 CONCLUSIONS OF MARINE MICRO NANOPLASTICS

The oceans may be contaminated with MPs and NPs released as a result of ocean-based activities. The majority of them, however, come from other sources and enter the oceans via pathways in the soil, water, or air. Whereas NPs have only been recorded in animal samples due to their elusiveness, Oceans and beaches around the world have been found with MPs in their water and sediment samples [53]
Microplastics and Nanoplastics have the potential to diffuse through the cells of various organs and may harm various organs, including the vascular system, brain, and livers, through physical, biochemical, and biological poisons. Since plastics are so resilient, they might build up in animal bodies and harm them over time.[54]

6. MICRONANOPLASTICS IN FOOD AND SOIL

The soil-plant system, which supports the world's ecosystem and produces food for people, is one of the most significant environmental divisions within earth. MPs were more likely to be found in soils, particularly agricultural soils, where there were several sources of plastic on the land. The idea of MNPs ingesting plants from soils and passing them on to the human food web is also a probability. Notwithstanding disagreement, the destiny of MNPs in soil-plant systems is one of the most crucial topics since it is intimately related to food pollution and human life.[55]

6.1 MP-NPS INTAKE IN PLANTS

The world's food calories come primarily from crops, which produce 98.8% of all calories consumed. However, the extensive distribution of MPs in soils poses a significant risk of MP contamination of crops, which would then enter the food chain. MPs would also have an impact on soil characteristics, plant development, and long-term crop quality.[56]

6.2 EFFECT OF MP-NPS ON PLANTS

The presence of MNPs may then affect the biophysical conditions of land and have effects on plants. MPs affected bulk density, water holding capacity, and hydraulic conductivity of four prevalent microplastic forms in soil, according to de Souza Machado et al. [57] Another study found significant changes in saturated hydraulic conductivity, bulk density, field capacity, porosity and groundwater barrier properties.[58]

6.3 MP-NPS TRANSLOCATION IN HUMAN-SOIL- PLANT SYSTEM

Nanoparticles have been identified in human excrement, according to a new study, confirming that we do in fact absorb MNPs. MNP-polluted fruits and vegetables may be consumed by people as a source of food. Researchers have postulated that individuals exposed to MNPs could cause oxidative stress, Mutagenesis, inflammatory processes, and other negative effects based on studies involving animals.[59]
In addition, it was discovered that NPs entered the lungs, liver and brain extensively. A MP or NP can cross both the blood-brain and gastrointestinal membranes. Even more so via soil-plant-food loop, the possible health concerns of MNPs are receiving more and more attention.

6.4 MP-NPS IN VARIOUS DAILY FOOD ITEMS

6.4.1 HONEY

Various nations' honey contained an average of 166 fibres and nine fragments per kilogram, according to a 2013 study. A significant standard deviation might be seen. The authors discovered colored and translucent fibers and particles. [60]

The oxidising specimen pre-treatment resulted in the decolorization of both chitin fragments and cellulose fibers. Hence, cellulose made up the majority of clear fibres. Also, by staining them with fuchsine, they are recognized as cellulose. According to the scientists, cellulose fibres may have come from the beekeepers' garments. However, it can also be shown that using cellulose nitrate filters to filter honey as part of the sample preparation technique could ultimately be just another origin of cellulose fiber contamination in that analysis. 61]

6.4.2 SALT

Microplastic contamination in the marine ecosystem leads to the possibility of plastic litter in sea salt. On this subject, there are more studies available. The results of the research that is currently available, however, all came to the same conclusion: salt samples do include microplastics, but the levels vary significantly.

With 16 different brands of Turkish salt, Gündoğdu (2018) used Raman spectroscopy to identify microplastic particles. A rock salt was composed of 9 to 16 particles/kg, lake salt was composed of 8 to 102 particles/kg, and sea salt was composed of 16 to 84 particles/kg. For rock salt, the source of the impurity is less clear and most likely connected to the manufacturing. Polyethylene (22.9%) and polypropylene (19.2%) were the most often discovered plastic polymers. [62]

6.4.3 SUGAR

The most synthetic fibres and particles were found in unrefined cane sugar. Nevertheless, the authors note that the quantities discovered in both honey and sugar are likely below the European regulatory thresholds (0.1% permitted percentage of insoluble residues in honey & no regulation for refined sugar). [63]

6.4.4 BEER

Another contentious topic was the contamination of beer with nanoplastics. Plastic particles were found in German beers in 2014, according to the authors. With the exception of wheat beers, which were filtered through a 40 micrometre sieve because they may percolate, fibers, pieces, and particles were discovered following filtration through a 0.8 micrometre cellulose filter. [64]

6.5 CONTAMINATION FROM FOOD PACKAGING

Food packaging-related contamination of micro- and nanoplastic particles is another possibility. Chemical components, such as leftover monomers, preservatives, and production auxiliaries, could transfer from food packaging into the food product with which they are in contact.

Incorrect handling of plastic food packaging can lead to fragments of plastic becoming embedded in edible products and contaminating them.The plastic bits in such circumstances could be easily identified if the shop hadn't thrown out the product, and they could likely be removed before eating if the shop hadn't thrown out the product. [65]

In contrast to this, a variety of nanomaterials, such as clays, metallic silver, and metal-oxide nanoparticles, that are similar yet distinct from plastic, are increasingly used in applications for smart food packaging. The integrated nanoparticles give the host packaging material better functional features due to their unique physicochemical characteristics. Extending the shelf life & maintaining the freshness of the contained food is the goal of these functional qualities, which include considerable barrier capabilities, biomechanical, rheological, refractive, enzymatic, and even antibacterial properties. [66]

Much of the food packaging made with nanotechnology now on the market is composed of silver nanoparticles (AgNPs) and nano clay. A growing concern is the possibility that such nanoparticles could migrate from food contact materials to foods. [67]Nevertheless, at this time, there is not enough information to estimate how access to and mobility of nanomaterials may affect the environment and people. Similar to this, there are currently not enough studies linking packaging materials to contamination by micro- nanoplastic particles.

6.6 FUTURE LESSONS TO BE CONSIDERED

There are at least two hurdles to overcome before we can accurately estimate global exposure to microplastics through diet:

1. The requirement for a thorough and widely accepted definition of micro- & nano-plastics;
2. The requirement for standardised procedures and quality control.

These subjects require additional scientific research.

Concerns about how human activity affects the entire food chain are developing, and it is reasonable to worry that the lesser plastic percentage may eventually contaminate humans through trophic transfer and bioaccumulation. The extent to which micro- and nanoplastics contaminate the biosphere, as well as the toxic effects of ingesting micro- and nanoplastics on humans, remains uncertain. Despite the obvious presence of large volumes of litter, scientists do not know how much micro- and nanoplastics are harming the biosphere. It is because of the absence of established methodologies (and approved reference materials) and a lack of uniformity across the data used in the analysis. It is very hard to determine how much micro- and nanoplastics humans are exposed to through food intake.

Micro- and nanoplastic contamination should be tracked using a substantial collection of samples corresponding to each characteristic of a population or environmental region. Laboratories must have a clean area, and processes free of cross-contamination (such as contamination of blank samples) must be created.

hence , with present technology and standard operative protocols available. It seems a long way to acquire micro nano plastics in food items.[63]

7. MICRONANO PLASTICS IN AIR POLLUTION

People can be exposed to airborne particulate matter, manufactured nanoparticles made of metal as well as carbon, and other micro- and nanoparticles are mostly dependent on inhalation. Many researchconducted in both in vitro and in real life have established the harmful mechanism of these air pollutants. Any kind of smaller microparticle can enter the lungs through breathing and can easily cross the pulmonary epithelial barrier to reach the lung surface and enter the bloodstream. Many body parts, including the central nervous system, are damaged as a result of their distribution

In this descriptive evaluation, we summarizes the evidence currently available to assess significant health harm caused by human inhalation to airborne micro- and nanoplastics. The above evidence, however, has largely concentrated on tracking and the influence of airborne pollutants. The hazard of nanoplastics has only been evaluated in a small number of in vitro experiments, and there is still no standardised technique for analysing them in environmental matrices.

7.1 SOURCES OF AIRBORNE MICRONANO PLASTICS

Individuals exposed to airborne MPs based on the abundance and spread of their source, which includes the deterioration of rubber tyres and synthetic textile fibres, which causes them to be widely distributed in city dust.[68]

The use of substances in agriculture, such as PS peat and wastewater sludge as fertiliser, as well as structures, waste incineration, dumps, industrial discharges, and textiles and domestic furnishings, could all be considered secondary sources.

There is evidence to suggest that each article of clothing has the potential to release roughly 1900 fibres each time it is washed. Which is one of the main reasons for nanoparticles in air and water.[69]

further industries improper disposal of waste in forms of various forms of materials (including gaseous waste, liquid waste, and solid waste) contain various units and subunits of plastic particles in our ecosystem , which accumulate in our environment and our body and cause further lethal effects.

Prior French research found that air fallout collected with a steel funnel attached to a 20 L glass jar contained quantities of 118 MPs m2/day.[70]

Also when measured in a Chinese city named Dongguan the figures were 53 to 115 m2 / day , and Data analysis showed variability in the amount of microplastics in different places of the world.[71]

This large variability is undoubtedly influenced by several climatic factors, seasonality, as well as various sample techniques. Due to the availability of many sources, smaller dilution volumes, and variables that contribute to the dispersion of plastic particles, higher concentrations are believed to be present in indoor environments. It discovered concentrations of 3 to 15 particles/m3 in indoor air.[72]

Furthermore, a recent French research reveals that the concentration of plastic fibres in the interior environment ranged from 0.4 to 59.5 particles/m3, but the amount was 0.3 to 1.5 particles/m3 outside.

To identify small MPs (lower limit 5.5 m) and reduce artefacts, Vianello et al. used focal plane array imaging analysis (FPA) along with traditional Fourier transform infrared spectroscopy (FTIR).As further suggested by some scientists, new and advanced technologies should be introduced for better detection of sources and concentration of micro nanoplastics in our environment.[73]

7.2 FACTORS FOR HUMAN EXPOSURE OF AIRBORNE NANOPLASTICS

For both indoor as well as outdoor situations, a number of factors affect how any kind of airborne particle spreads and how much of a risk it poses to humans.

1. vertical inclination, with increased pollution levels near the surface and as a result of subatomic re-suspension
2. wind velocity, with greater gusts of wind resulting in lower pollutant concentrations.
3. An obstruction's position in relation to the wind direction and the perpendicularity of the wind. Nanoparticle sedimentation more than 2.5 mm;
4. temperature, with lower temperatures causing the particles to condense and form more crystals, leading in higher atmospheric levels.[74]

Outdoor exposure to MPs is influenced by geological and meteorological factors. Rainfall, air, and local circumstances, in particular, have a significant impact on
the air persistence of MPs and the ensuing fallout, in adding to size of particles as bigger particles settle by gravity.

Microplastics with a lighter density can therefore be spread by the wind, causing widespread pollution of the environment. [75]

As a result, particle dispersion is thought to cause human exposure to low quantities of airborne MPs in outdoor settings. However, under some atmospheric circumstances (such

as inadequate ventilation), the dilution & elimination of MPs may be inhibited, potentially leading to a higher-grade toxicity.
An unventilated room will have higher concentrations of airborne MPs because of how the rooms are laid up and how well they are aired. According to Seaton et alatmospheric nanoparticles (less than 100 nm), of which nanoplastics are a part, quickly move across compartments and linger in the atmosphere.[76]

Due to these factors and the fact that humans spend 70-90% of their time indoors, airborne MPs are important to our health. Last but not least, indoor MPs may transition to outdoor air and dissipate there.[72]

7.3 OCCUPATIONAL EXPOSURE TO MICRONANOPLASTICS

The biggest exposure to atmospheric MPs was undoubtedly generated more frequently from working situations than from spending time at home, leading to chronic vulnerability to these pollutants. Airborne concentrations at elevated levels can increase the risk of occupational illnesses for certain worker groups. To research the effects of airborne MP contact, workers from two types of industries, specifically the synthetic textile sector and the vinyl chloride (VC) and polyvinyl chloride (PVC) sectors, have been assessed.
In recent studies a further airborne pollutant is discovered in 3D printers industries, in which a the plastics is used named acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA). which is discovered as very lethal to human beings.[77]

7.3.1 HAZARDS IN TEXTILE INDUSTRIES

There is evidence that some worker groups are more likely to develop occupational illnesses if exposed to elevated airborne concentrations. The majority of earlier investigations revealed a connection between breathing in these synthetic fibers and respiratory illnesses.
Persistent irritation and long-lasting synthetic fiber exposure has indeed been linked to cancer, specifically after 10–20 years.[78]

Furthermore, it has been demonstrated that some natural fibers, such as hemp, may cause dyspnea more frequently than synthetic fibres, likely as a result of their ability to obstruct critical physiological processes. Even Though cancer risk was considered to be the same for synthetic as well as natural fibres.[79]

The flock industry is a specific subset of the synthetic textile industry. It involves applying pulverised or cut fibres, known as flock, with a diameter of 0.2 to 5.0 mm and frequently made of polyester, polypropylene, nylon and polyethylene to materials with an adhesive coating to create fabrics with a velvet-like or fleeced appearance.

from these industries small particles which can be inhaled and accumulate in respiratory tract are released in air , and causes a deadly disease called "flock worker's lung".[80] it makes lungs vulnerable and increases risk of lung cancer up to three times to the normal individual.In regards to the toxicity of the fibres themselves, granules and completing agents (such as tannic acid and potato starch), thermal degradation products (such as nitrogen dioxide), acetaldehyde, metals, microbes, and even aflatoxins ejected by Fusarium sp. increases in adhesive containers have indeed been proposed as potential contributors to the disease's pathogenesis.[81]

In an in vivo study performed by Porter et al., rats were given intratracheally cleansed flock fragments to remove impurities. Similar to what is seen in humans, the incorporation produced symptoms, but the washing media was considerably less active.[82]

7.3.2 IN PVC INDUSTRIES

Exposure to chemicals such as VC and PVC used in PVC industries (a white powder that produces a dust that can be inhaled) .PVC dust and VC monomers are associated with undifferentiated restrictive pulmonary illnesses (like cancer and tuberculosis), supporting their pathogenic significance. In addition to finding PVC particles in monocytes of patients, researchers have found that rats' lungs undergo pathomorphological changes after inhaling PVC dust [83].Also, it has been demonstrated that the toxic effects of PVC powder may lead to physical injury and the gradual release of VC subunits from the nanoparticles to the nearby lung tissue. Also, studies done in vitro on rat lung cells revealed that utilising PVC particles with additives resulted in a larger risk for inflammation than did using PVC particles without additives. Lastly, both PVC, which raises the risk of lung cancer in workers, and VC, which causes malignancies in mice and rats, have been connected to a carcinogenic .these were mainly two industries taken into account here , further their can be many more such workshops whose manufacturing processes can seriously lead to lethal effects in their workers life . [84] The nastiness of plastic products or leachates after inhalation frequently causes the occupational disorders indicated. The response to breathed particles in humans can be classified into immediate respiratory effects (asthma-like), interstitial lung disease and granulomas with fibre inclusions (extrinsic allergic alveolitis, chronic pneumonia) based on individual differences in metabolism and susceptibility. Chronic bronchitis and peribronchitis are inflammatory and fibrotic changes, while pneumothorax occurs when the interalveolar septa is ruptured. [85]

industries being the backbone of our development, without proper rules regulation and safety equipment can seriously be a bane in individuals' life. also, the standard operating procedure should be developed as such so that these effects can be reduced.

7.4 TOXICITY OF AIR BORNE MP-NPS

In order to better understand the toxicity of airborne MPs, a number of pathophysiological processes that produce inflammation have been identified. They include the deterioration of mechanisms that control dust saturation disposal, oxidative stress, neurotoxicity, and translocation.

It is more likely for fine particles with a lower density (like PE) to reach deep lungs after they have been breathed in. Depending on the particle quality, the lung anatomy, and the patient characteristics, MPs are deposited in the airways. [86]

Particles from 1 to 5 micrometres in diameter enter the small airways through deposition and diffusion, whereas particles 5 to 30 micrometres deposit in the upper airways by obstruction with the rhino-pharyngeal membranes. Brownian motion causes the accumulation of particles upto size of 1micrometre.[87]

After adsorption, MP particles are cleared by a variety of methods, including phagocytosis by alveolar macrophages, mucous advancement controlled by ciliary activity, and lymphatic system migrations. However these mechanisms are not very profound to remove particles sized more than 250 micrometres and they are found in deep lung alveoli.

their movement across cells can be tracked down by various endocytic or energy dependent processes. Furthermore, as well as energy-dependent endocytic routes, hydrophobic particles such as MP-NPs can also traverse the cellular membrane bilayer by passive diffusion as a result of their adhesion. These micro- and nanoparticles do not leave persistent openings in the membrane due to its flexible nature, as with red blood cell membranes where diffusion is only possible without energy. [88]

In addition to cytotoxicity, oxidative stress can also cause genotoxicity (DNA damage such as mutations and adducts), which can lead to carcinogenesis.Furthermore, additional mechanisms contribute to cancer growth, including the direct impact of particles and pro-inflammatory factors that promote angiogenesis and mitogenesis.Comparatively, we found that nanoparticles only cause cytotoxicity at high levels, but when present in low quantities, they altered the endoplasmic reticulum's metabolism and caused stress. Agrochemical pollutants (MPs) can be carried by the wind from the application of fertilisers, dried slurry and waste water purification products, synthetic garment materials, industrial discharges, urban runoff, and marine nanoparticles.[89]

According to Pauly et al., 87% of human lungs contain plant fibres (such as cotton) and plastic fibres, which could have implications for health. The airborne particles that could enter and stay in the lungs are more likely to be inhaled than larger particles. Urban roadways and industrial locations have been proven to present the highest hazards of inhaling MP-NPs. As a result, it is quite conceivable that these tiny and ultra-fine plastic particles can be ingested not just through contaminated food but also through conversation or walking down the street. Inhaled MP-NPs could result in cytotoxic and chronic inflammation effects, as well as immune disorders, since the living person lung has a very vast alveolar surface area of about 150 m2 and a very thin obstruction of less than 1 micrometer, allowing the microparticles to enter the circulatory system. Paget et al. demonstrated that lung epithelial cells and macrophages were subject to mutagenic and fatal effects from the 50 nm-sized Polystyrene nanoparticles.As a result of blood transfer, ingested particles may cause toxicity in additional areas, including the respiratory system. Furthermore, NP particles can pass through the respiratory pathway and enter the blood, especially during inflammation when endothelial and epithelial sensitivity is elevated. [90]

Depending on each person's unique metabolism and vulnerability, inhaled particles may cause.

1. immediate bronchial reactions (asthma-like)

2. granulomas and widespread cyst formation with fibre inclusion (extrinsic allergic alveolitis, chronic pneumonia)
3. The lungs (chronic bronchitis) show fibrotic changes and an inflammatory response.interalveolar septal lesions (pulmonary emphysema).
4. lung cancers
5. accumulation on various other organs of micro nanoparticles.

As with other nanoparticles, MP-NP exposure causes toxicities similar to those caused by exposure to graphene (fullerene and carbon nanostructures and nanotubes (CNTs [91] The existence of nanoplastics in pregnant women's placentas was also recently confirmed by a study, raising concerns in the scientific community and verifying what was previously just imaginable.Airborne MPs can cause toxic effects beyond the respiratory tract, as shown in rodents after inhaling rhodamine-labelled nano polystyrene beads. [92]

7.5 CONTAMINANTS LINKED TO MICRONANOPLASTICS

Plastic can include an abundance of chemical compounds that are employed as additives in combination to the monomers that make up plastic and the covalent connections that hold them together.[93] Additives can be discharged into the environment since they are not covalently linked to the polymer like its monomers. The emission of MPs in different environmental matrices can vary depending on the chemicals' molecular weight (air, water, and soil). About 200 to 2000 g/mol is thought to be the molecular weight range of compounds utilised as additives in polymer.[94]

Organic and inorganic substances called additives are incorporated into plastics to give them specific physical-chemical properties. These can be divided up into many groups.

1. fillers (for example glass fibres)
2. inert fillers (talc, kaolin, clay, calcium carbonate);
3. functional additives (stabilisers, flame-retardants, plasticizers, etc.);
4. dyes

MPs have a wide surface area, which makes it possible for them to absorb a variety of pollutants from the environment in addition to those purposefully introduced during the manufacturing process. MPs 'changes and modifications are determined by the degradation processes connected to overexposure.[95]

To put it another way, the adsorption affinities of recycled polymers and their virgin counterparts can differ due to environmental exposure

Many investigations have conclusively demonstrated the heavy metals present in MPs derived from sediment, soil, the marine environment, and creatures. The absorption of metals by airborne MPs is still largely unknown, in contrast to what has already been demonstrated by different types of particles. Similar to other air pollutants, it can be challenging to determine the exact function that each agent plays in the pathogenic mechanisms of the damage, and toxicity may also be caused by complicated interactions between combinations of pollutants. Clarification of each agent's function is required, particularly with regard to occupational exposure.[96]

7.6 CONCLUSIONS OF AIRBORNE MICRONANOPLASTICS

The air chamber is a significant source of human interaction to MPs, according to scientific research. According to studies, the fibres that make up airborne MPs are primarily between 200 and 600 micrometres in length.[97]

As human lungs have been shown to contain fibres as large as 250 micrometres.

The development of respiratory diseases is therefore at risk for vulnerable individuals.Because contact with these amounts lasts for a lifetime (24/24 h), regardless of our actions, researchers believe inhaling is much more common than ingestion, which is perceived as more dangerous by the general public.

When considering how the environment can affect a particular health issue, respiratory illnesses were the top concern, trailed by cancers, infectious diseases, genetic deformities, heart ailments, and cognitive impairments. [98] This demonstrates the significance of spreading awareness of not only traditional air pollutants but also these particular pollutants, as well as the relevance of fostering a green culture to raise both individual and collective accountability. Hence a combined effort is required from the government,researchers , industrialists as well as individuals for improvement of the quality index of our environment so that our future generations can be secured and we could have a sustainable development.

8. MANAGEMENT AND DEGRADATION TECHNIQUES

Public concern over micro(nano)plastic pollution has grown recently.MP was detected in rock salt from Turkey and China, as well as in 83% of all tap water samples collected from cities and municipalities across five continents. Plastic litter has been the subject of various policies and campaigns aimed at reducing it from a human perspective. [99][100][101]

8.1 BIOLOGICAL CONTROL

Researchers have discovered that biological management microorganisms have a favorable effect on the decomposition of micro(nano)plastic. One of the most crucial tactics for limiting micro(nano)plastic is biodegradation. Mealworms, fungus, and microorganisms all break down plastics. Plastic pollution can be treated with this method by digesting it without harming the environment. According to research by Bombelli et al., PE can be efficiently biodegraded by ethylene glycol, which is produced by wax moth larvae Galleria mellonella at a pace of 0.23 mg cm2 every hour.[102]

8.2 DEGRADATION TECHNIQUES OF MICRO NANOPLASTICS

8.2.1 bacterial degradation

Numerous scientists are researching how microbes break down plastics and create micro(nano)plastics.Web of Science and Scopus online resources claim that landfills are where the phylum of bacteria that break down plastics first emerged. In the majority of investigations on biodegradable plastic, proteobacteria, actinobacteria, and firmicutes were found. [103]

8.2.2 fungi degradation

It was demonstrated in a lab experiment that the ocean fungus Zalerionmaritimumutilised polyethylene as a growth substrate and significantly reduced the amount of polyethylene particles in just 28 days. [104]

8.2.3 algae degradation

Plastics' surfaces offer viable environments for the development of algae colonies, which break down the material using lignin and extrinsic polysaccharides. On polymeric surfaces with algae, plastic disintegration has also been seen with algae like green algae, diatoms, blue-green algae, Naviculapupula, & Scenedesmus dimorphus. [105]

8.2.4 IEB -Integrated Enzymatic Biodegradation

Despite requiring a specific enzyme from a specific organism, a unique catalytic mechanism, and a lengthy incubation period, IEB is a useful tool for degrading plastics and micro(nano)plastic. This is particularly true now, given the increased dominance of this organic breakdown process as a result of research on synthetic enzymes.Due of their poor potency and restricted range, naturally occurring enzymes alone are insufficient to respond to breakdown MPs. In order to increase the efficiency of enzyme breakdown, research is currently being done to produce enzymes. [106]

8.2.5 CHEMICAL DEGRADATION

High oxidative reactive organic molecules are a form of chemical degradation that comes before advanced oxidation processes (AOPs) and high oxidative reactive organic species (ROS) [107]. The breakdown of organic contaminants in soil and water is carried out by these organisms. AOPs that effectively apply MPs degradation are electrochemical oxidation, photocatalytic oxidation, and photochemical oxidation. The sulphate-based AOPs (SR-AOPs) technique degraded the MPs from the cosmetic sources by catalyzing the activation of peroxynitrite by magnetic nanocomposites. [108]

CHAPTER NO 2 CONCLUSION

Plastic is an essential commodity due to its greater consumption and share on the global market and its widespread use in daily life.Due to plastic's extreme tenacity and persistence, only a very small fraction of the total volume produced is collected for recycling, which results in a steady buildup of plastic waste in the environment. Despite the fact that the world community has concentrated specifically on a variety of legislative efforts in recent decades to prevent plastic pollution and its ecological effects, there are already restrictions on the production and use of plastics.

Some nations have rules in place that limit the production of plastics, such as carrying bags and beverage bottles. For instance, the Canadian province of Ontario recently enacted a law that outlaws the manufacturing of microbeads. In the United States, legislation prohibiting the use of small plastics has been enacted in an effort to reduce pollution. These tactics work together to lessen the amount of micro(nano)plastic in the air, water, and soil.

The manufacturing industry is largely responsible for the decrease in micro (nano)plastic usage across the supply chain. By encouraging the reuse of polymeric products through its production network, IKEA (Ingvar Kamprad, Elmtaryd, and Agunnaryd) included the EPR (extended manufacturer) method into its marketing strategy.

The establishment of a circular financial system, which includes recycling, reuse, and waste management practises, may also help to limit the use of plastic due to the significant negative social and ecological repercussions. One of the most practical and long-lasting measures to prevent contamination has been suggested: limiting the amount of micro(nano)plastic in a well. For instance, banning plastic bags would drastically cut down on the use of unnecessary plastic, which would limit the amount of plastic that ends up in microplastics.

Other businesses should appropriately label plastic products with instructions and information about how they can be recycled and how they can protect the environment. Moreover, initiatives educate individuals about their responsibilities for reducing MPs by choosing to throw away, limit, recycle, and reuse while also raising awareness of the difficulties posed by MPs among colleges, schools, organizations, and networks. Children's educational programs (such as those educating them about sea waste) will improve their comprehension, expectations of the results, and readiness to report them.

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