Development and evaluation of an air filtration system combining Electrostatic Precipitators for airborne microplastics

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Abstract:
Micro plastic particles released into the air as waste pose a significant threat to human beings for a variety of different reasons. Microplastics disperse silently throughout industrial and urban areas, infiltrating the respiratory system and directly serving as a means of spreading toxic waste. In regard to airborne microplastics, research states that those microplastics can be captured through a non-contact process using energy-efficient corona ionization through a novel filtration approach. The microplastics filtration system employs a Van de Graaf genera- tor which generates 200–220 V, allowing for corona ionization of air to a charged mesh screen, leading to collection of particles on a diamond-cut and curved copper collector with ideal field exposure and laminar flow retention. The cylindrical design is reinforced using SolidWorks and CFD, maintaining low pressure drop and high throughput. PLA and PETE tests confirmed the theoretical model's effectiveness, showcasing a microplastic capture efficiency above 85%. It requires no tools and maintenance, shape-preserving collection morphology, and a modular form factor, which allow it to be integrated into industrial exhausts, indoor environments, and even urban air grids. In contrast to expensive membrane technologies or low-life HEPA filters, this solution is field-deployable, cost-effective, and scalable, targeting one of the most elusive and biologically active pollutants of the modern era. This work expands the use of electrostatic filtration beyond micro-level technologies to a systems-level approach for intervention to pre- serve breathable air at its source. It is not only a machine but a protective shield that redefines clean air in an era of pervasive microplastic pollution.

Keywords: *Electrostatic Precipitator (ESP), Dust Collection System, Particulate Matter (PM) Removal, Indoor Air Purification, Electrostatic Dust Trapping, Particle Charging and Collection, Airborne Particulate Filtration, Electrostatic Field Separation.*

Introduction

Microplastics are small fragments of plastic which are found in various ecosystems, including aquatic systems and even in the air. They are a global health hazard to all life forms as their toxic chemical constituents disrupt endocrine systems, cause respiratory and cardiovascular diseases, increase risk of cancer etc. The concentration of microplastics in the air has been on the rise due to their emission by factories and large scale industries. Microplastic pollution is a major threat to ecosystems and is impacting abiotic and biotic components. They carry harmful contaminants and microbes and can themselves be toxic in nature. The concentration of microplastics in our environment has been rising steadily over the past few years. Microplastic concentration, reported as number of particles spanned ten orders of magnitude (1×10^{-2} to 10^8 per m^3) across all samples and water types [15]. In water too, microplastics are abundant. The average concentrations of pump filtration samples were 1.8 ± 2.3 ($> 300\,\mu m$), 12 ± 17 ($100-300\,\mu m$), 155 ± 73 ($20-100\,\mu m$) MPs/m^3 [16]. In ground and soil samples, concentrations were extremely high as found by Zhou et al. for e.g. horticultures soil (min 43000 items/kg ; max 620000 items/kg). Also stated in the same paper, was the fact that near industrial sites extreme values can exceed normal levels by 2 to 4 orders of magnitude, indicating a heavy correlation with land use and human activity [17]. Microplastics in air are a major cause of concern for most of the urban populace as the air in cities and near industrial sites are heavily polluted. To reduce the amount of microplastics breathed in and emitted out of factories, they must be filtered out. Some methods of filtration are: HEPA filters- HEPA or High Efficiency Particulate Air filters trap particles using pleated filters; Electrokinetic-assisted filtration - can filter microplastics from water with a high degree of accuracy; Membrane Filters: Microplastics are filtered out using specific membrane filters depending on the types of microplastics to ensure high degree of filtration; Korona–Walzen–Scheider: Microplastics are filtered out by passing high voltage through the air, utilizing the electrostatic properties of microplastics.

But these solutions have many drawbacks in an industrial filtration setting. HEPA filters are not optimized for industrial scale use, and the size of plastics produced in a factory varies greatly and may be larger than 0.3 µm, which HEPA filters are best at filtering. HEPA filters can also easily get clogged, as larger microplastics can become stuck in the

filter fibres. Electrokinetic filters show promising results in water-based mediums, but their efficiency in an air-based medium has not yet been established. There is a significant lack of research on their efficiency, economic feasibility, and scalability in the context of industrial filtration of airborne microplastics. Membrane filters too are not optimal for the required filtration, as the air moves too fast and contains microplastics of various sizes and shapes. They are also highly expensive to implement for industrial filtration. Korona–Walzen–Scheider filters have low recovery rates for particles below 50 µm.
Microplastics are easily filtered out of air via electrostatic precipitation, which is also a very cost-effective method. The study provides a methodology using the electrostatic precipitation method, which filters air using high voltage and low current. The electrostatic precipitator will be fed high-volume air. A filter (strainer) is integrated to ensure that the microplastics are separated from the other charged particles filtered out. This air is passed through the coarse mesh (strainer) through which high voltage (220 V) is applied. The air is ionized due to the high voltage by the corona effect. The small particles also get ionized. They are then attracted to the copper grounding plate (0.2 mm thick copper sheet) and are thus filtered out of the air. This allows for filtration of extremely small and light microplastics present in the air, as the high voltage ensures that even the most minute particles are ionized and filtered without causing any physical interference in airflow, resulting in highly filtered air.

Literature Review

Fethi Miloua et al. [1] investigated the challenges of recycling shredded waste plastics, particularly focusing on the limitations of tribo-electrostatic separators. The authors employed an innovative approach by designing a new electrostatic separator that uses two rotating coaxial vertical cylindrical electrodes complemented by an airflow oriented downward, reducing parti- clelectrode impacts and thereby improving the quality of the recovered products. The study found that applying a voltage of 50 kV along with an airflow rate of 1700 m^3/min maximized both the recovery and the purity of the products collected. The paper notes that the design and operating conditions of the fluidized bed turbocharger were not optimized and suggests that further enhancements in triboelectric charging efficiency are necessary to improve the overall performance of the electrostatic separation process.
Cheng Fang et al. [2] investigated the challenge of identifying and quantifying microplastics in indoor air. The study employs Raman imaging analysis to characterize the MPs. A confocal Raman microscope is utilized to record signals. Images of the Raman spectra were mapped and merged with different characteristic peaks using software like ImageJ. The results indicate that only a small percentage (1–10%) of fibers can be confidently identified as PET plastic. Bundled fibers complicate identification. Raman imaging combined with scanning electron microscopy is suggested to enhance the robustness of results and improve flexibility in sample analysis. The difficulty in achieving well-focused images of bundled fibers also limits the accuracy of mapping MPs.
Yilun Gao et al. [3] address the health problems posed by particulate matter, especially PM2.5. PMs are associated with over 4 million premature deaths each year, and the need for effective filtration is highlighted. The purpose of the study was to filter PMs out of the air using electrostatic fibrous filters. The paper provides a comprehensive overview of the filters, detailing their principles, fabrication processes, and electrical properties. The authors analyze PM–fiber adhesion forces and classify filters into monopolar and dipolar charged types. The study finds that electrostatic filters achieve high filtration efficiency while reducing airflow resistance and can filter a wide range of fibers. The paper notes that improper laboratory scales can lead to misleading reports on system effectiveness.
Defu He et al. [4] addressed the problem of microplastics, which are widespread in oceans and freshwater systems. They designed a filtration system that uses mechanical and pneumatic components. The system includes various iterations of components such as power rails, intake mechanisms, and mechanical links to optimize the collection process. The design also incorporates calculations to determine force and efficiency. The results indicate that the system can clean a significant volume of water per hour, demonstrating its potential for practical application in reducing microplastic pollution. However, the paper does not fully address scalability for larger bodies of water, nor does it provide the exact amount of water that the system can filter. Disposal methods are also not thoroughly discussed.
Pramod Kumar Vishwakarma et al. [5] addressed the problem of air pollution caused by particulate matter (PM), microplastics (MP), and bioaerosols (BA). The most widely used method of filtering these pollutants is HEPA filters, but their efficiency is reduced by moisture accumulation due to their hydrophilic nature. The authors developed a lightweight, free-standing, and flexible multi-walled carbon nanotube membrane filtration system that is hydrophobic and thus able to enhance filtration efficiency and self-cleaning capabilities. The system's filtration efficiency was tested, and results indicated significant reduction in pollutant concentration. The system achieved over 99% efficiency in capturing PM0.3 and MP0.3. The paper does not discuss scalability in depth, nor does it include long-term durability data.
Lucas Kurzweg et al. [6] investigated challenges associated with microplastic analysis in river sediments. The study uses a combination of electrostatic separation, density separation, and differential scanning calorimetry (DSC) to analyze

microplastics in sediments. Electrostatic separation is performed first to reduce sample mass before density separation, effectively isolating microplastics. The methodology involves processing large samples spiked with microplastics and measuring recovery rates. Recoveries varied by polymer type: in 100 g samples, averages were 74% for PCL, 93% for LD-PE, and 120% for PET; in 1000 g samples, 50%, 114%, and 82%, respectively. The study found that recovery was independent of the particulate matrix. Identified gaps include risks of microplastic loss during enrichment and uncertainties in DSC-based determination.

Zhao et al. [7] addressed issues related to airborne microplastics. The paper highlights increasingly high concentrations of MPs. The authors conducted a systematic review of over 140 papers, gathering extensive data on risks associated with airborne microplastics. Findings indicate that MPs adversely affect many biological systems, reducing photosynthesis and retarding growth. The paper suggests mitigation through HEPA filtration and source regulation. Significant knowledge gaps remain regarding impacts on plants and aquatic systems.

Kaijie Xu et al. [8] investigated the agglomeration of dust in Electrostatic Precipitators, which can significantly affect ESP efficiency. The researchers observed operating ESPs for 100 days and collected dust samples from four locations. These samples were tested for physical and chemical properties, and X-ray diffraction was used to study crystal structures. Unburnt carbon was the primary cause of agglomeration. The particle size range was 30–50 µm, and they showed strong magnetic properties. The study identifies the need for comprehensive evaluation of temperature, humidity, and operational parameters, and highlights the need for long-term studies.

Stuti Dubey et al. [9] investigated HEPA filter efficiency in controlling indoor particulate pollution. Filter papers exposed to indoor pollutants were dissolved in distilled water, filtered, and analyzed using ion chromatography. PM concentrations of different sizes were quantified during filtering and non-filtering periods. Results showed HEPA filters were more effective at removing smaller particles. Air purifiers with higher CADR were more effective for PM and ion removal. The study was conducted over a short period and did not evaluate filtration efficiency for toxic chemicals.

Kristina Enders et al,[10] investigated the challenge of effectively extracting microplastics (MP) from mineral-rich environmental samples. The study evaluates the effectiveness of the Korona-Walzen-Scheider (KWS) system. The methodology involves: Charging particles in a high-voltage electrical field; conducting multiple runs to enhance recovery rates; additional density separation is performed to analyze smaller microplastics. The results indicate varying recovery rates for different sizes of microplastics: MP $\geq$ 2 mm achieved 99–100% recovery, MP sizes between 63−450 μm achieved recovery rates of ∼ 60−95%. The study also found that mass reduction rates differed significantly between beach and commercial reference sand. There is a need for further treatment steps, such as density separation and digestion.

Defu He et al. [11] investigated methods for separating microplastics from complex solid matrices. They conducted a comparative analysis of methods such as density separation and magnetic separation. Density separation is effective for large MPs but less for small ones; magnetic separation can detect MPs smaller than 20 µm. Lack of standardized methods complicates large-scale quantification.

Abolfazl Sadeghpour et al. [12] investigated emission of fine particles in air using a string- based two-stage wet electrostatic precipitator (WESP). Key parameters studied were electrode bias voltage, air velocity, and water flow rate. Fractional collection efficiency for particles 10 nm–2.5 µm was analyzed. The model showed ¿70% efficiency at airflow rate 4.36 m^3/s per m^3. Higher efficiency was achieved at lower water-to-air ratios. Temperature and long-term performance were not studied.Christian Ebere Enyoh et al. [13] highlighted growing airborne microplastic pollution. Indoor MPs were sampled using vacuum and pump systems; outdoor MPs via rain samplers and fallout collectors. Spectroscopic methods like micro-FTIR and micro-Raman were used. Organic and inorganic contaminants interfered with MP identification. The paper notes a lack of research outside Asia and Europe and calls for standardized sampling and analytical protocols.

Stefanie Felsing et al. [14] investigated environmental MPs and their ability to accumulate harmful contaminants. The study used the KWS system, achieving up to 99% mass removal without losing MPs. The method preserves MP integrity for analysis. Recovery was nearly 100% for tested materials. A gap identified is the need for further exploration of conductivity- based separation of different plastics.

Tzu-Ming Chen et al. [15] addressed removal of nano- and microparticles emitted during semiconductor manufacturing. The authors designed a wire-to-plate single-stage WESP us- ing tungsten electrodes and 15 kV voltage. Water mist improved nanoparticle condensation and significantly increased collection efficiency. Results showed 99.2%–99.7% efficiency with water mist. Long-term operational challenges such as electrode cleaning were not discussed.

Methodology

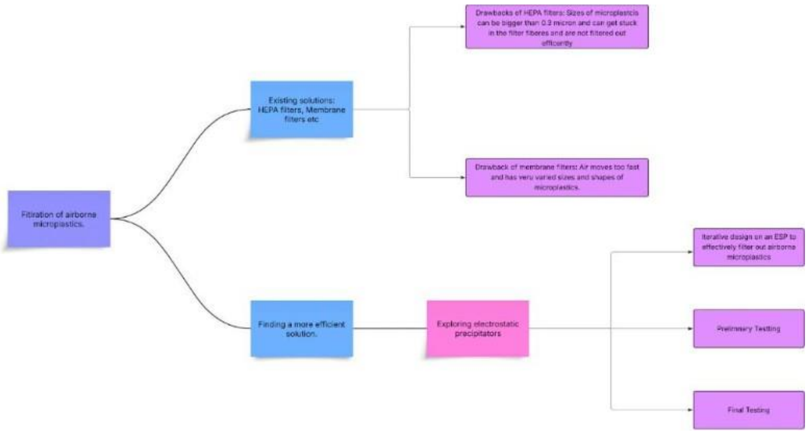


Figure 1: Methodology Flowchart

Design terminology:
As shown in Fig.1 the design includes a structure which will have a mesh integrated with it and will have a copper grounding plate attached to the topmost section of the system to attract the particles which are strained from the mesh and passed on from the airflow.
Structural integrity design:
The structure is essentially a 3 part system. The air is fed into the main charged mesh/strainer and the particulate matter is then attracted to the copper grounding plate and filtered out. The structure was designed on a CAD software (SolidWorks). A cylindrical design was chosen as it required less manufacturing effort, provided a balanced airflow throughout the system, and allowed for easier scalability. The design includes a chimney slot for the outlet of the airflow and to clean the grounding plate. The system is designed to maintain a breathable airflow tobalance out and ensure there is even pressure drop throughout the body of the filter which increases the durability and longevity of the filter.
Copper plate:
A copper plate of thickness 0.2 mm is chosen to be the grounding plate. 220 V runs through it which allows it to attract all the charged particles in the air above it. Diamond cuts are made across it to increase the surface area. The copper plate curves across the cylindrical surface of the body to ensure maximum surface area. After filtration, the plate is washed with hot water and detergent for cleaning. The runoff is run through filter paper to separate the microplastics from the other particles.
Strainer/Filter:
A coarse mesh has been chosen as a filter. High amount of volts, generated by the Van de Graaff generator, are passed through this filter. Air laden with microplastics passes through the mesh and is ionized.
Airflow:
Air is pulled through the body of the filter (mesh and copper plate) by a fan attached to the opposite end of the filter (Fig.2). This prevents the breaking/tearing of microplastics inside the filter and thus aids in the filtration process and increases filtration efficiency.
Readings:
A DHT11 and an optical dust sensor are attached to the system to help take and analyze the readings. The DHT11 sensor allows for the measurement of humidity levels and temperature, both of which significantly affect collection efficiency. The optical dust sensor allows for the measurement of the amount of microplastics in the air samples before and after filtration and thus allows for the actual calculation of the collection efficiency. Both the sensors are controlled with the help of an Arduino.
Microplastics used: PLA and PETE.
PLA: Polylactic acid is a thermoplastic monomer. Breakdown of larger PLA articles leads to formation of PLA microplastics. These microplastics, despite being biodegradable, disrupt gut function, alter metabolism and contribute to inflammation.
PETE: PETE or PET plastics are the most widely used plastics. PETE microplastics can easily enter the bloodstream and cause inflammation, oxidative stress, and even disrupt the endocrine system as shown in Fig.2.

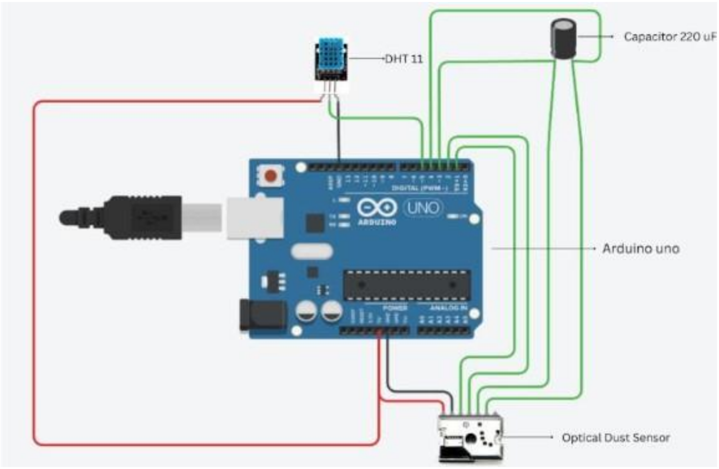


Figure 2: Circuit Diagram of Filter

Calculation:
Air can withstand 30 kV/cm before breaking down and allowing current pass through. How- ever, voltages in the range of 35–65 kV have been found to be the most effective. A Van de Graaff generator can provide the required voltage easily without producing much current. It accumulates charges onto a hollow metallic sphere by moving them on a belt, this separation of charges creates a high electric potential and thus a high voltage. The voltage a Van de Graaff generator can produce is given by the formula:

$$V = k \cdot \frac{Q}{r}$$

where V is the electric potential/voltage, k is the electrostatic constant (8.99×10^9 N·m^2/C^2), Q is the amount of electric charge accumulated on the metal sphere and r is the radius of the sphere.
Let the radius of the small sphere at the center of the hollow sphere be r with charge q on it, then the potential on its surface is given by:

$$V(r) = \frac{kq}{r}$$

Let the radius of the hollow sphere be R with charge q accumulated on it, then the potential on its surface is given by:

$$V(R) = \frac{kq}{R}$$

Therefore, total potential is:

$$V(R) - V(r) = kq \left(\frac{1}{R} - \frac{1}{r} \right)$$

Connecting the small sphere with charge q to the large sphere with a wire transfers charge q onto the large sphere. Thus if a small charged sphere is introduced into the large hollow sphere, the charge of the sphere keeps on increasing.

Components:
Voltage generator: A Van de Graaff generator is used to produce sufficiently high voltage to ionize the air passing through.
Air-ionizing mesh: The voltage produced will pass through a mesh that will then ionize the air passing through it. It will hold a positive charge and will be connected to the positive end of the Van de Graaff generator.
Collection of particulate matter: The fine particulate matter present in the air is ionized by the charged mesh. These particles are then attracted and stuck onto a grounding plate (connected to the grounding of the Van de Graaff generator).
The study will also optimize wind velocity (rate of inflow of air) to maximize capture effi- ciency. According to a study, a cylindrical design requires less electrode area per unit and also minimizes the exposed high-voltage area and costs. This makes it viable for large-scale applications. A vertical design helps with airflow and waterflow (to clean the ESP). Thus, a circular vertical design is chosen as it provides all the listed benefits along with a high filtration efficiency.
Parameters affecting the study:
The voltage, density and average size of microplastics in the influx and the influx velocity are some parameters that significantly affect the study. The size, capacity, aspect ratio, and specific collection area of the electrostatic precipitator body and the testing methodology also affect the study.
The voltage passed through the system is a crucial parameter as it determines the efficiency of the ionization of air passed through, as well as the energy consumed, and thus the cost of running the filter. It can be easily varied by changing the electric potential built in the Van de Graaff generator.
The amount of microplastics present in the influx affects the percentage of filtration efficiency. The variable can be adjusted by varying the weight of the microplastics fed into the filter.
The size of the microplastics affects the ease of ionization. Larger sizes lead to easier ionization and thus a higher filtration efficiency. This variable can be varied by feeding the filter different sizes of microplastics in different sets and iterations.
The speed of influx affects the time spent by the particles in the region of ionization, and thus affects the amount of particles actually ionized. This in turn affects the filtration efficiency. This variable can be adjusted by changing the speed of the fan pulling air out of the body.
The dimensions of the filter affect the amount of air that can be filtered at once. It also affects the amount of residue that the filter can hold before it needs to be cleaned. It affects the Aspect Ratio or the horizontal run of the filter by the height of the filter as well as the specific collection area, which is the total surface area of the collection plates by volumetric flow gas. The ideal dimensions are found after many iterations on the size of the filter.
The filter is tested by calculating the filtration efficiency. Filtration efficiency is the weight of microplastics filtered out (filtrate) by the initial total weight of microplastics present in the air sample fed into the filter. This calculation can be done in two ways: the microplastics stuck to the grounding plate as well as the microplastics which have fallen off the plate can be considered as the filtrate - total filtration; or only the microplastics stuck to the plate are considered as the filtrate - only electrostatic filtration.

Testing Methodology:
The prototype is tested by feeding the filter air contaminated with microplastics of various sizes and shapes, in batches of varying total weight. The total (including microplastics that have fallen off the plate and that are stuck on the plate) and electrostatic filtration (including only those stuck to the plate) will be calculated. The Van de Graaff generator and the exhaust fan can be varied to produce different voltage and airflow speeds to determine the most optimal ratio of the two as shown in Fig.3 and Fig.4.

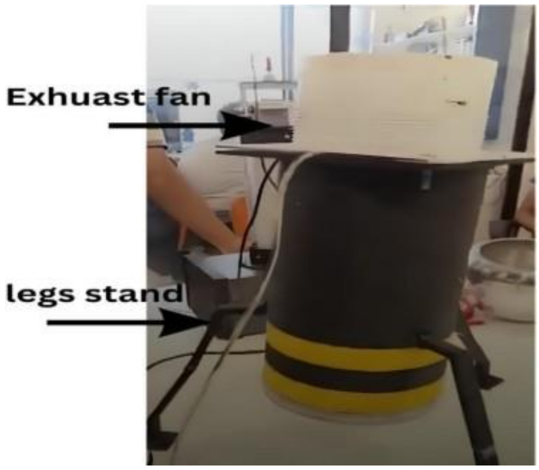
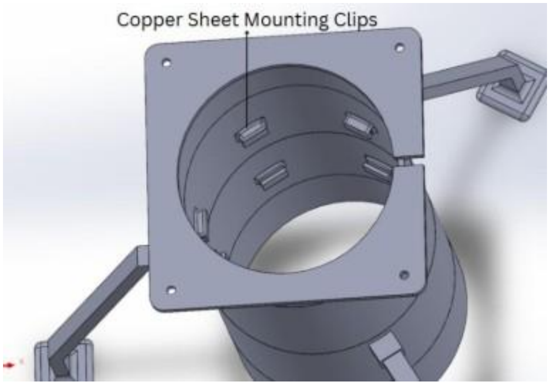


Figure 3: Testing images of the prototype

Figure 4: Testing image of the prototype with running suction fan



Result and Discussion

Final Design

The electrostatic precipitator is designed to be a vertical and cylindrical filtration system. The main body consists of a long tube/pipe (acrylic tube). Inside it, the main positively charged mesh/filter is fit, which is attached to the Van de Graaff generator via thin copper wires. The grounded negatively charged copper plate (0.2 mm) is ahead of it. The power source is from a general home power supply of about 250 volts and 20 amperes, and 220 V was passed through the mesh. A fan is fixed at the end of the body to pull air out of the filter. This ensures that the microplastics do not break or tear, as shown in Fig.5 and Fig.6.

Collection Efficiency of Microplastics

The electrostatic precipitator system, powered by a Van de Graaff generator, demonstrated measurable success in capturing airborne microplastics from a controlled airflow environment. Microplastic-laden air was fed into the system at different speeds, temperatures, and humidity levels. The air was ionized as it passed through the charged mesh (high voltage produced by the Van de Graaff generator) as shown in Fig.7, Fig.8, Fig.9. The test runs were done in batches of 25g, 50g and 80g for both PLA and PETE plastics. The 4th test run included 80g of PLA and PETE plastics mixed together. The velocity of influx was 33 m/sec.

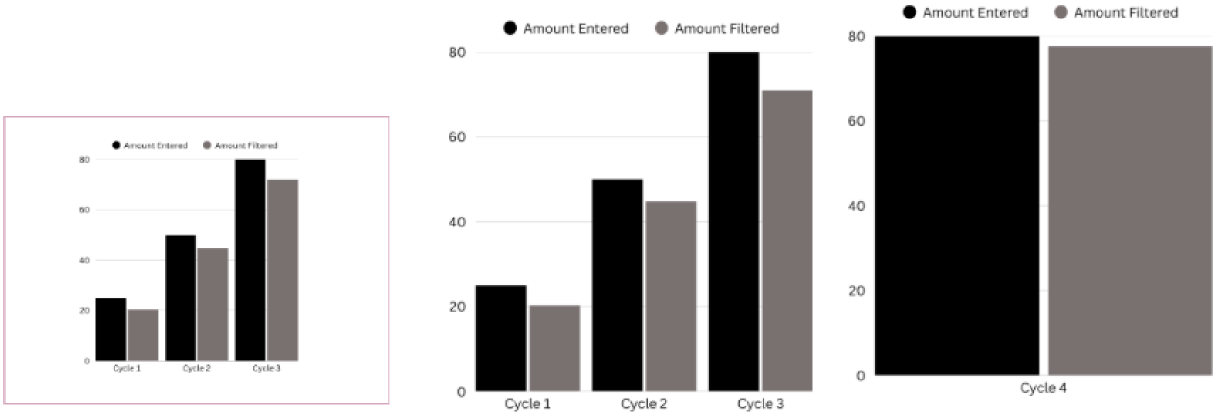


Figure 7: PETE Microplastic Filtration Chart

Across four test runs, an average collection efficiency of 78–85% was observed for microplas- tic particles smaller than 10 µm. For larger particles (¿10 µm), efficiencies approached 90%, suggesting effective Coulombic attraction due to their larger surface area and mass.

Cycle Data

As shown in Table 1 and Table 2, 19.5g, 45g and 72g out of 25g, 50g, 80g respectively of PETE microplastics were filtered for a collection efficiency of 86%. 20.3g, 44.8g and 70.8g out of 25g, 50g and 80g respectively of PLA microplastics were filtered out for a collection efficiency of 86.4%. When both PLA and PETE microplastics were mixed together, 77.6g of microplastics were filtered out of 80g showing a collection efficiency of 97%.

Table 1: Collection data of PETE and PLA microplastics as inputs.

Cycle No	Input (PETE)	Output (PETE)	Input (PLA)	Output (PLA)
Cycle 1	25g	19.5g	25g	20.3g
Cycle 2	50g	45g	50g	44.8g
Cycle 3	80g	72g	80g	70.8g

Table 2: Collection data on both PETE and PLA microplastics mixed together as inputs.

Cycle Number	Input (Mixed PLA and PETE)	Output (Mixed PLA and PETE)
Cycle 4	80g	77.6g

Particle Morphology Post-Filtration

Captured microplastics were analyzed using microscopy. Most particles retained their struc- ture, confirming that electrostatic collection was non-destructive and thus suitable for down- stream analysis (e.g., spectroscopic identification). These results validate the potential of elec- trostatic methods for not only removing microplastics from air but also preserving their in- tegrity for forensic or environmental analysis.

Limitations and Improvements

Bipolar Ionization Integration: Adding wires that produce positive and negative ions widens the electric field, trapping more microplastics of both charges, even when air currents shift.
Humidity-Resistant Insulation: Swapping in high-dielectric, moisture-proof insulation curbs charge bleed in damp weather, keeping the system dependable when humidity swings.
Self-Cleaning Collector Mechanism: Built-in wipes, gentle vibrations, or scheduled sprays clear the plates, so

collection stays strong, downtime drops, and the unit keeps running under heavy load.
Portable, Modular Design: Lightweight, snap-together parts powered by a small battery let crews carry the unit into factories or neighborhoods, treating the air and logging readings on the spot.

Conclusion

Airborne microplastics are a growing concern in today's world. Not only do they have adverse effects on all ecosystems and organisms, but they also affect most industrial machines, causing them to operate less efficiently over time. Thus the study focuses on building a filtration system for airborne microplastics. The electrostatic precipitator was developed as a filter for the afore- mentioned microplastics. Air laden with microplastics was passed through a positively charged mesh, which ionized all the particles present in the influx. These positively charged particles were then attracted to negatively charged copper grounding plates and were thus filtered out of the air. The mesh and the copper plates were connected to the positive and negative ends respectively of a Van de Graaff generator, which operated on 220 V. The air was fed into the body of the filter and pulled out by an exhaust fan, ensuring that the microplastics were not damaged or broken down into smaller pieces. The velocity of the influx was 33 m/sec. The prototype was tested on batches of 25g, 50g, and 80g of PLA and PETE microplastics. The results showed an 86.4% and 86% collection efficiency for PLA and PETE microplastics re- spectively. The design was also tested on a batch of 80g of both PLA and PETE microplastics mixed together. The results on this batch showed a collection efficiency of 97%. The prototype was designed to be cost effective and to be easily integrated into an industrial setting. All the components of the filter are easily sourced and thus allows for easy large scale production. All the parameters affecting the study such as voltage, type of microplastics, influx velocity etc were carefully considered during the designing process. The type of microplastics tested could be increased to further validate the ver- satility of the model. An easier way to clean the model could be implemented. Further changes to the model to allow for better filtration from solids and liquids as well could be implemented. Long term testing should also be carried out to test the longevity of the system. Thus, the model can filter out dangerous microplastics, without breaking them down and does so in a clean and efficient manner. The study has validated that it is a very efficient solution and is a technological base for the growing problem of microplastics. It is engineering ready and can be deployed in many industries across various sectors.

References

[1] Miloua, F., et al. "Air-Assisted Tribo-Electrostatic Separator for Recycling of Shredded Waste Plastics." Sustainability 16(24), 11142 (2024). DOI link.

[2] Fang, C., et al. "Characterising Microplastics in Indoor Air: Insights from Raman Imaging Analysis of Air Filter Samples." Journal of Hazardous Materials 464, 132969 (2024). DOI link.

[3] Gao, Y., et al. "Utilizing Electrostatic Effect in Fibrous Filters for Efficient Airborne Parti- cles Removal: Principles, Fabrication, and Material Properties." Applied Materials Today 26, 101369 (2022). DOI link.

[4] Vishwakarma, P.K., et al. "Multiwalled Carbon Nanotube-Based Freestanding Filters for Efficient Removal of Fine Particulate Matters (PM0.3), Microplastics (MP0.3), and Bioaerosols." ACS Applied Nano Materials 5(7), 9306–9318 (2022). DOI link.

[5] Kurzweg, L., et al. "Application of Electrostatic Separation and Differential Scanning Calorimetry for Microplastic Analysis in River Sediments." Frontiers in Environmental Science 10, 1032005 (2022). DOI link.

[6] Zhao, X., et al. "Airborne Microplastics: Occurrence, Sources, Fate, Risks and Mitiga- tion." Science of The Total Environment 858, 159943 (2023). DOI link.

[7] Xu, K., et al. "Dust Agglomeration in an Electrostatic Precipitator." Aerosol and Air Qual- ity Research 21(8), 210145 (2021). DOI link.

[8] Dubey, S., Rohra, H., Taneja, A. "Assessing Effectiveness of Air Purifiers (HEPA) for Controlling Indoor Particulate Pollution." Heliyon 7(9), e07895 (2021). DOI link.

[9] Enders, K., Tagg, A.S., Labrenz, M. "Evaluation of Electrostatic Separation of Microplas- tics from Mineral-Rich Environmental Samples." Frontiers in Environmental Science 8, 112 (2020). DOI link.

[10] He, D., Zhang, X., Hu, J. "Methods for Separating Microplastics from Complex Solid Matrices: Comparative Analysis." Journal of Hazardous Materials 409, 124640 (2021). DOI link.

[11] Sadeghpour, A., et al. "Experimental Study of a String-Based Counterflow Wet Electro- static Precipitator for Collection of Fine and Ultrafine Particles." Journal of the Air & Waste Management Association 71(7), 851–865 (2021). DOI link.

[12] Enyoh, C.E., et al. "Airborne Microplastics: A Review Study on Method for Analysis, Occurrence, Movement and Risks." Environmental Monitoring and Assessment 191, 1–17 (2019). DOI link.

[13] Felsing, S., et al. "A New Approach in Separating Microplastics from Environmental Samples Based on Their Electrostatic Behavior." Environmental Pollution 234, 20–28 (2018). DOI link.

[14] Chen, T.M., et al. "An Efficient Wet Electrostatic Precipitator for Removing Nanopar- ticles, Submicron and Micron-Sized Particles." Separation and Purification Technology 136, 27–35 (2014). DOI link.

[15] Koelmans, A.A. "Microplastics in Freshwaters and Drinking Water: Critical Review and Assessment of Data Quality." (2019). DOI link.

[16] Uurasjärvi, E. "Microplastic Concentrations, Size Distribution, and Polymer Types in the Surface Waters of a Northern European Lake." (2019). DOI link.

[17] Büks, F. "Global Concentrations of Microplastics in Soils – A Review." (2019). DOI link.

[18] Panicker, P.K. "Ionization of Air by Corona Discharge." PhD Thesis, University of Texas at Arlington (2003).

[19] Mashiuth, A., Hashim, R.A., Mahmood, R. "Impact of Ethical Culture on Ethical Prac- tices Among Managers and Supervisors in Bangladesh Textile Industry." EuroMid Journal of Business and Tech-Innovation 3(3), 1–13 (2024). DOI link.

[20] Ruzieh, A.S., Awwad, B.S., Razia, B.S. "Review of Logistics Challenges within the Con- struction Industry." EuroMid Journal of Business and Tech-Innovation 4(1), 1–28 (2025). DOI link.