Elemental Analysis of Cigarette Butt Waste Using Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy

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Abstract: This study investigates the elemental composition of cigarette butt waste using Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX). SEM analysis provided surface observation of the cigarette butt residues, while EDX results identified the presence of carbon (C), oxygen (O), aluminum (Al), and magnesium (Mg) as elemental components. The elemental distribution suggests the presence of organic and inorganic materials originating from tobacco combustion and filter additives. These findings provide insights into the chemical constituents of cigarette butt waste.

Key Words: Cigarette Butts, SEM, EDX, Elemental Analysis, Environmental Waste, Carbon, Oxygen

1. Introduction

Cigarette butts are among the most discarded forms of litter worldwide and are considered a significant source of environmental pollution. Most cigarette filters are composed of cellulose acetate fibers, which are resistant to biodegradation and can persist in the environment for extended periods. Previous studies have reported that cigarette butts contain various organic and inorganic substances that may be released into the environment, posing potential risks to ecosystems and public health.

De Granda-Orive et al. (2016) reported that cigarette butts can negatively affect humans, animals, and the environment due to the accumulation and release of toxic substances during and after smoking. Their study emphasized the importance of recognizing cigarette butt waste as a major environmental concern.

Similarly, Roselli et al. (2021) investigated the release of metals from cigarette butts and found that discarded filters contain inorganic elements that may leach into the environment. El Hadri et al. (2021) further reported that cigarette filters can generate nanoplastics through the degradation of cellulose acetate fibers, while Shen et al. (2021) identified smoked cigarette butts as a significant source of environmental microplastic fibers. These findings highlight the complex composition of cigarette butt waste and its potential environmental impact.

This study aims to characterize the elemental composition of cigarette butt waste using Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX). The analysis was conducted to identify the elements present in the sample and provide insights into the chemical constituents of cigarette butt waste.

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2. Materials and Methods

A discarded cigarette butt was collected and prepared for SEM-EDX analysis. The filter material was carefully separated, and a small portion was mounted on an aluminum SEM stub using conductive carbon tape. To minimize charging effects during imaging, the sample was sputter-coated with a thin (~10 nm) layer of aluminum prior to analysis. Scanning Electron Microscopy (SEM) was performed using a field emission scanning electron microscope at an accelerating voltage of 15 kV and a working distance of 8.2 mm. Energy Dispersive X-ray Spectroscopy (EDX) analysis and elemental mapping were subsequently conducted to determine the elemental composition and spatial distribution of elements within the sample.

3. RESULTS AND DISCUSSION

3.1 Surface Morphology

The surface morphology of the cigarette butt waste was examined using Scanning Electron Microscopy (SEM). Figure 1 shows the SEM image of the

cigarette butt sample at 113× magnification. The image reveals a network of intertwined and irregularly arranged fibers characteristic of cellulose acetate filter material. The fibers appear densely packed and exhibit varying diameters and orientations, resulting in a porous structure. The observed fibrous morphology is consistent with the structure of commercial cigarette filters, which are designed to trap particulate matter generated during tobacco combustion. The complex arrangement of fibers may also contribute to the accumulation and retention of chemical residues and particulate contaminants within the filter material.

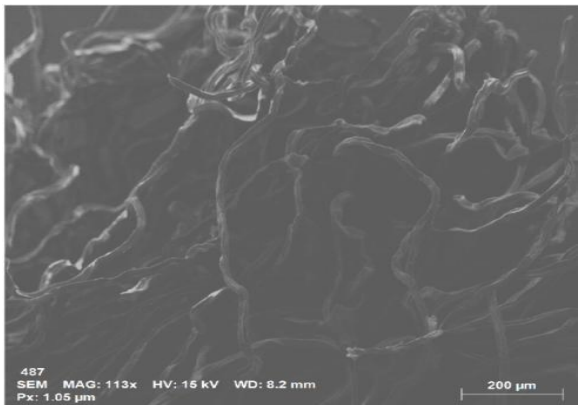


Figure 1. SEM image of cigarette butt waste at 113× magnification showing the intertwined fibrous structure of the filter material.

3.2 Elemental Composition and Distribution

Elemental analysis using energydispersive X-ray spectroscopy (EDX) was performed on the cigarette butt filter material, as shown in Figure 2. The EDX spectrum and elemental mapping reveal the presence of carbon (C), oxygen (O), aluminum (Al), and magnesium (Mg).

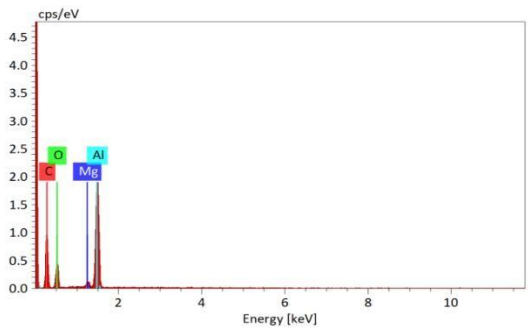
Carbon is the most dominant element, with a mass percentage of approximately 87.99% and an atomic percentage of 65.76%, consistent with the high organic carbon content expected from cellulose acetate fibers and combustion residues of tobacco. Oxygen is the second most abundant element at approximately 40.70% by mass (22.83 at.%), reflecting the oxidized nature of the filter material and residual combustion byproducts. Aluminum was detected at 32.83% by mass (10.92 at.%), which may be attributed to inorganic mineral particles absorbed by the tobacco plant during cultivation or from additives incorporated during the manufacturing process. Magnesium was present in trace amounts at 1.31% by mass (0.48 at.%), likely originating from mineral components naturally present in tobacco leaves retained within the filter material.

The elemental mapping confirms a relatively uniform distribution of carbon and oxygen throughout the fibrous matrix, consistent with the organic composition of the cellulose acetate filter. Aluminum appears more concentrated in localized regions, suggesting its association with specific inorganic particulates rather than being uniformly incorporated into the bulk fiber structure. No heavy metals such as iron (Fe), lead (Pb), or titanium (Ti) were detected in this sample, though their absence does not preclude their presence below the detection limit of the EDX system.

Figure 2. Elemental map and EDX spectrum of the cigarette butt filter material showing the presence of carbon (C), oxygen (O), aluminum (Al), and magnesium (Mg).

4. CONCLUSION

SEM and EDX analysis of cigarette butt waste revealed a porous, fibrous surface morphology characteristic of cellulose acetate filter material. Elemental analysis confirmed the presence of carbon and oxygen as the predominant elements, consistent with the organic nature of the filter and tobacco combustion residues. Aluminum was also detected in significant amounts, potentially originating from mineral particles absorbed during tobacco plant cultivation or from manufacturing additives. Trace amounts of magnesium were likewise detected, further indicating the presence of mineral-derived inorganic components within the filter material. These results provide insights into the elemental composition of cigarette butt waste and highlight the potential environmental burden posed by its improper disposal.



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