USING METALLIC CYCLONES IN PARTICULATE MATTER SAMPLING DEVICES FOR CHEMICAL ANALYSES

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Epidemiological studies have linked the inhalation of fine particulate matter ($PM_{2.5}$) with increased respiratory and cardiovascular diseases that can cause premature death [1]. Major ongoing studies have investigated the physicochemical characteristics and toxicity of atmospheric aerosol particles to identify the origins of ambient particles and assess their effect on the environment and human health [2].

Filter-based sampling is commonly used to collect $PM_{2.5}$ samples due to its high collection efficiency [3]. However, this method requires crude particle extraction, leading to a loss of PM components and altered particle toxicity. Moreover, the levels of components in filter samples can be changed by unexpected artifacts [3,4].

To avoid these issues, researchers have investigated cyclone devices to collect $PM_{2.5}$ samples globally. Exposure to cyclone particles may cause stronger biological responses than those observed after exposure to extracted particles from filter materials and induce lung inflammation. Powder samples collected using cyclones can be directly subjected to in vitro and in vivo assays without losing components or experiencing unexpected artifacts [5,6].

This study aimed to evaluate the effects of cyclone materials on the chemical compositions of the samples.

The cyclones in the sampling system and their dimensions are provided in a previous study [7]. The sampling system included large steel (HVS3, CS3 Inc., Sandpoint, ID) and small aluminum (URG-2000-30EHB, URG) cyclones. Detailed information about the sampling site and elemental analysis was provided in a previous study [7,8].

Figure 1 shows the elemental analysis results of the $PM_{2.5}$ samples collected using the small and large cyclones. The samples' significant elements, such as Ti, V, Cr, Mn, Fe, Cu, Zn, Ni, and Pb, were compared. We have excluded Al data from further discussion due to possible contamination because the small cyclone was made of aluminum. The total metal abundance in the $PM_{2.5}$ collected from 10 December 2020 to 6 January 2021 and 10 March to 14 April 2021 was 6,504 and 18,516 part per million weight (ppmw) for the small cyclone and 46,002 and 21,704 ppmw for the large cyclone, respectively. Figure 1 is presented without Fe data because the difference between the metal components was somewhat invisible due to the high content of Fe compared with other metals in the samples of both cyclones. The abundance of Fe (out of nine metal components in total) collected from 10 December 2020 to 6 January 2021 and from 10 March to 14 April 2021 was 59.1% and 72.9% for the small cyclone and 84.8% and 83.4% for the large cyclone, respectively. V, Cr, Ni, and Pb were determined to be less than 1% of the sum of the total metal components for both cyclones. Cu and V exhibited a higher mass portion in the small cyclone samples than in the large cyclone samples, whereas Fe and Ti were higher in the large cyclone samples than in the small cyclone samples for both periods. The abundance of Cr, Zn, Mn, Ni, and Pb in the small and large cyclone samples varied for the sampling periods.

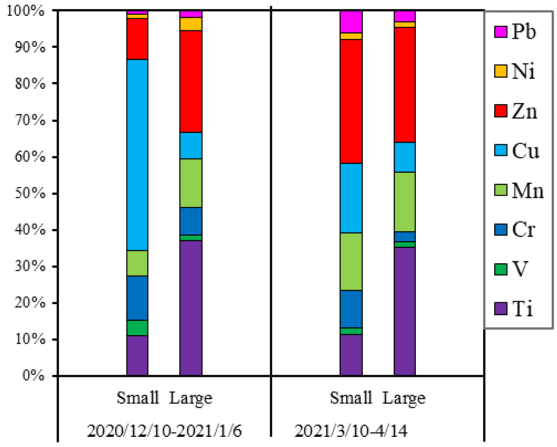

Figure 1. Percentage variations of elements in total elemental components (except Fe) of the $PM_{2.5}$ collected using the small and large cyclones. Small and large are the small and large cyclones, respectively.

In this study, we investigated the effect of cyclone materials on chemical composition analysis of $PM_{2.5}$. A comparison of the chemical compositions of $PM_{2.5}$ showed that the metals (e.g., V, Cr, Mn, Ni, Cu, Zn, Pb) exhibited a higher mass portion in the small cyclone samples than in the large ones. The metals that determined a higher content in the large cyclone samples than in the small ones were light (e.g., Mg^{2+} and Ca^{2+}) and crustal elements (e.g., Ti, and Fe). This study found that using cyclones to collect $PM_{2.5}$ particles has several advantages compared to traditional filter sampling methods. However, the experiments observed that the cyclone samples were contaminated with metal from the cyclone materials. Future research is required to enhance the efficiency of cyclone-based sampling and prevent contamination of the collected samples with cyclone materials.

References

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