A study of airborne particulate metals in the surroundings of an electric arc furnace factory and its effect on the pulmonary function of school children in central Taiwan

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Abstract

Electric arc furnaces (EAF) are used in the steel industry to convert pig iron, scrap and other iron units to steel. It is widely used in Taiwan to produce carbon and steel alloys. However, it is estimated that approximately 10-25 kg of dust is generated per ton of steel produced when scrap is remelted by EAF. In Taiwan, EAFs discharge approximately 170,000 tons of dust annually. Moreover, chemical analysis showed that concentrations of Cr, Cu, Mn, Mo, Ni, Se, Ag, Sn, V, and Zn in EAF dust were significantly greater than background soil concentrations. The mass of respirable particles as well as the chemical composition of the particles has been identified to be potentially responsible for various deleterious effects on human health. The present study combined air sampling with pulmonary function tests (PFTs) to determine both the extent of air pollution proximal to an electric arc furnace and its impact on human health. The mass concentrations of PM_{10} and $PM_{2.5}$ in exposure areas were not significantly higher than the samples taken at a control area. However, the concentrations of five metal elements, Cd, Cr, Cu, Ni, and Zn in $PM_{2.5}$ were increased with decreasing distance from the emission source. PFTs showed that the average forced vital capacity (FVC) of boys was decreased with decreasing distance from the EAF factory. With normalization of pulmonary function by age, height and weight, we found that the △FVC became more negative with a decrease in distance from the EAF. Lastly, regression analysis was performed to analyze the impact of the concentrations of the five metals in $PM_{2.5}$ on the performance of pulmonary function. The results showed that the metals can be ranked from the highest to the lowest in terms of impact on the variation of △FVC of boys as follows: Cr, Cd, Ni, Cu, and Zn. This finding is consistent with the ranking of metal toxicity reported in the literature for a rat lung epithelial cell line.