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EFFECT OF WEARABLE IONIZERS ON THE CONCENTRATION OF RESPIRABLE AIRBORNE PARTICLES AND MICROORGANISMS

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INTRODUCTION

Health effects associated with respirable biological and non-biological particles are of special concern. Numerous techniques have been developed over the years to reduce bioaerosol concentrations in indoor environments. Some of these techniques target viable microorganisms, while others aim at the overall reduction of the bioaerosol concentration. Indoor air purifiers include mechanical filters, electrostatic precipitators (ESP), ionizers, hybrid filters, gas phase filters, and ozone generators. Although most of the conventional air purifiers are stationary devices, several models of portable wearable ionizers have recently become available to clean the air in the human breathing zone (e.g., Air Supply*, Wein Products Inc., Los Angeles, CA, USA). The ion wind produced by corona discharge inside these small, battery-operated devices emits ions into the air environment where they charge airborne particles. Some ionizers have an electrostatic precipitation section designed to collect charged panicles. While these devices are commercially available and widely used, their air cleaning mechanisms are not well understood. In this study, we investigated the effect of a portable ionizer on the aerosol concentration measured in the vicinity of a human manikin placed in a 2 m^3 walk-in environmental chamber.

METHOD

Three types of respirable panicles were used for testing: polydisperse NaCl panicles ranging from d_p = 0.3 to 3.0 um, monodisperse PSL spheres of the same size range, and *Pseudomonas fluorescens* bacteria of dp = 0.8 urn. The test panicles represent the size range of microbial fragments, single bacteria, most of fungal spores, and microbial aggregates. Aerosolized with a standard Collison Nebulizer (BGI Inc., Waltham. MA, USA) and mixed with dry filtered air, the test particles were carried through a 10-mCi 85Kr particle charge neutralizer into the environmental chamber through an air laminarizing and distributing unit. An external pump, whose inlet was positioned at the very bottom of the chamber, removed the air from the test chamber.

The airborne panicle concentration and size distribution were monitored in real time at various locations of the chamber using an Optical Panicle Counter (OPC) (model 1.108, Grimm Technologies Inc., Douglasville, GA, USA). A nephelometer (model pDR-lOOOAN. \OE. Inc., Bedford. MA, USA) was used in parallel to measure the airborne panicle mass concentration.

In most of the experiments, the air purifier was positioned on the chest of a manikin so that the unit's outlet would be in line with the manikin's nose. The experiments were conducted under calm air conditions with breathing and with non-breathing manikins, as well as in mixed air. Ionizer AS-150 (Wein Products Inc.. operating voltage = 5 V, nominal current = 70 mA) generating positive ions was tested in two regimes: (i) with a metal grid acting as an ESP and (ii) without the ESP section. The ion density measured in the nose/mouth region (19 cm above the ionizer located on the chest) ranged from 5x10* to 2x10° ions,cm^J: the maximum velocity' of the ion jet in front of the device was about 400 era's. The evolution ot the aerosol concentration was determined during two 3-hour periods: first, with the ionizer turned off (to account for the natural decay) and, second, when the device was continuously

operating. Tiie part:cie removal efficiency (defined as the relative aerosol concentration decrease! was determined a.s

$$Efficiency = \frac{C_{\,device\,off} - C_{\,device\,on}}{C_{\,device\,off}}$$

where C is the aerosol concentration for a specific particle size. Each experiment was repeated three times.

RESULTS

The results of selected experiments are presented in Figure 1. The particle removal efficiency was not significantly affected by the particle size within the size range tested, nor by the panicle type (NaC! versus PSL, biological versus non-biological). Thus, the data shown in Figure I hold true for all the tested panicles. The particle removal efficiency was found to increase with time. It moderately depended on the distance from the ionizer (19 cm above the unit = nose/mouth region; 10 cm above the unit = upper chest level). When the ionizer operated with the ESP section, it removed about 50% of particles under the nose in 1.5 hours of continuous operation without air mixing. The ionizer without the ESP section operating in calm air performed better than the one with the ESP: the particle removal efficiency in the breathing zone reached about 80% in 30 minutes of operation and about 100% in 1.5 hours.

Air mixing increased the particle removal efficiency. The effect of inhalation and exhalation on air cleaning was marginal (the data were not significantly affected by the manikin's breathing). The particle removal mechanisms due to their charging as well as the ESP effect are discussed.

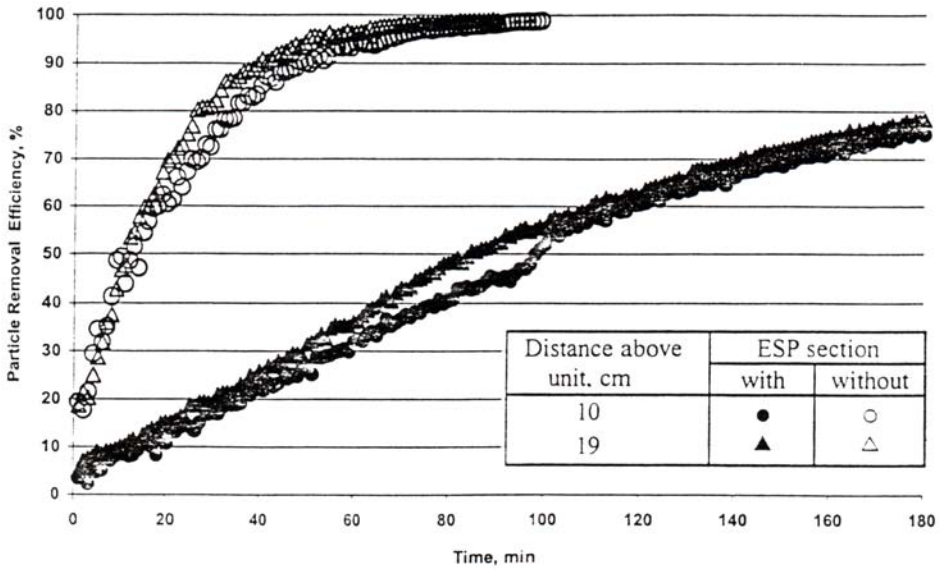

Figure 1. Particle removal efficiency of the ionizer with and without the ESP section at two distances above the units as measured by the Grimm OPC in calm air. The presented data are averaged over the particle size range of d, = 0.3-3 u.m.