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Combined Application of Gamma Radiation, Cleaning and Chemical Sanitizers in Decontamination of Vehicle Air Conditioning Filters

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1. Introduction

Indoor air quality is an indicator of environmental health that takes into account thermal comfort, factors that interfere in precarious air conditions, such as the presence of fungi, bacteria and carbon dioxide in indoor air-conditioned environments [1]. The lack of studies on air quality within automotive vehicles especially in the city of São Paulo, one of the most polluted cities in the world and with the largest fleet of vehicles in Brazil, was the objective of the study of Aquino et al. [1] that aimed to analyze the fungal contamination in air-conditioning filters collected from twenty one automotive vehicles and the results of the study showed seventeen fungal genera in all samples collected (100%), including toxigenic fungi such as *Penicillium*, *Fusarium* and *Aspergillus*, indicating that indoor air quality can compromise the health of a portion of the population, such as professional drivers. According to IAEA [2], the combinations of the processes and their applications are being pursued to meet the end objectives of improved decontamination, waste volume reduction, safety and overall cost-effectiveness in the irradiation treatment. According to Thakur and Singh [3], the use of combined processes has been found to inhibit the development of undesirable changes caused by irradiation into substrate material. One way to prevent these changes is to reduce the radiation doses and use combined irradiation with heating, cryogenic temperature and modified atmosphere. The decreased cost of irradiation at lowered absorbed doses may offset the additional cost of any other applied process, depending upon the cost of the process relative to the cost of irradiation. In this study it is convenient to try previous cleaning and chemical treatment of 15 filters of vehicles before irradiation in order to use 17 kGy of dose of radiation.

2. Methodology

Fungal isolation was entirely based on inoculation in Petri dishes with swabs directly in Sabouraud agar and the incubation of samples during 7 days at 25ºC was under carefully standardized conditions, in a Biochemical Oxygen Demand (BOD) incubator. The fungal identification was performed using lactophenol cotton blue solution for microscopy, for staining molds, as described by Pitt and Hocking [4]. After the fungal analysis of control group, 15 filter samples were cleaning with a vacuum system and treated by sanitizer for vehicle air conditioning filters. The air conditioner sanitizer spray was used in the samples for 5 minutes, and they were composed by denatonium benzoate. The samples were kept in bags (Figure 1) with an atmosphere filled with sanitizer spray and kept in cardboard boxes before the gamma radiation treatment with the dose of 17 kGy, using 5.5 kGy/h at a multipurpose irradiator and the dosimetry was carried out with PMMA dosimeter Harwell Red Perpex.

Figure 1: Filter samples kept in bags with sanitizer spray of denatonium benzoate.

After all treatment procedures, the samples were analyzed in Petri dishes, in triplicate (Figure 2), according to Pitt and Hocking methods [4], to fungal counting, expressed as percentage (%).

Figure 2: Platting onto Sabouraud agar in Petri dishes (in triplicate).

3. Results and Discussion

Modern automotive air conditioning (AC) installations become quite often an active source of harmful biological agents emission. The development of microbes is a result of surface contamination of the AC system, strongly supported by the increase in air humidity caused by the small diameter of air-conditioning cords, air cleaners, air refrigerators, etc. [5]. The control samples showed were contaminated with a diversity of 10 genera. The results of the control group (0 kGy) demonstrated the presence of *Alternaria alternata, Aspergillus flavus, Aspergillus fumigatus, Aspergillus niger, Aspergillus terreus, Cladosporium* spp., Not Sporulated Fungi (NSF), *Fusarium* spp., yeasts, *Penicillium* spp., *Phoma* spp., *Rhizopus* spp., *Rhodotorula* spp. and *Trichoderma* spp. The vacuum cleaning samples showed 12 fungal genera, the same 10 genera found in control samples, but with two more such as *Mucor* spp. and *Nigrospora* spp. The cleaning and chemical treatment samples showed 11 fungal genera (with *Phoma* spp.).

Figure 3: Petri dishes with fungi in control samples, vacuum cleaning and vacuum cleaning and sanitizer spray treatment.

Udaya et al. [6] isolated 17 genera from the surface of bus seats. *Aspergillus* spp. was most frequently represented inside the vehicle. Viegas et al. [7] reported that *Cladosporium* spp. was the most prevalent fungal species from taxi filters in three cities of Portugal (Lisbon, Loures and Setúbal). In this present study in São Paulo city, the *Aspergillus* genera was predominant, after NSF and *Cladosporium* spp. The vacuum cleaning treatment showed more fungal contamination in 46.6% of samples, comparing with control samples. However, the samples treated by vacuum cleaning and sanitizer spray showed the increase of fungal counting in ten samples (66.0%). The size and nature of fungal spores can contribute to their efficient long-distance dispersal in the air. Besides, fungal spores are hydrophobic in water, they are not easily wetted and tend to float on the water surface. The fungal growth was favored by high humidity conditions in samples that were sprayed with sanitizer, that did not inhibit the fungal contamination. According to Reponen and colleagues [8], the relative humidity changes the spore size. The same authors reported that the highest change of the aerodynamic diameter was found in *Cladosporium cladosporioides* spores, that increased from 1.8 μm to 2.3 μm when the relative humidity increased from 30% to ~ 100%. The size increase corresponds to an approximate doubling of the particle volume [8]. On the other hand, the combined methods in association with gamma radiation (17 kGy) showed the reduction on fungal contamination in 80% of samples (Figure 4). Two samples showed 2 UFC (colony-forming units) of NSF and one showed 1 CFU of yeasts.

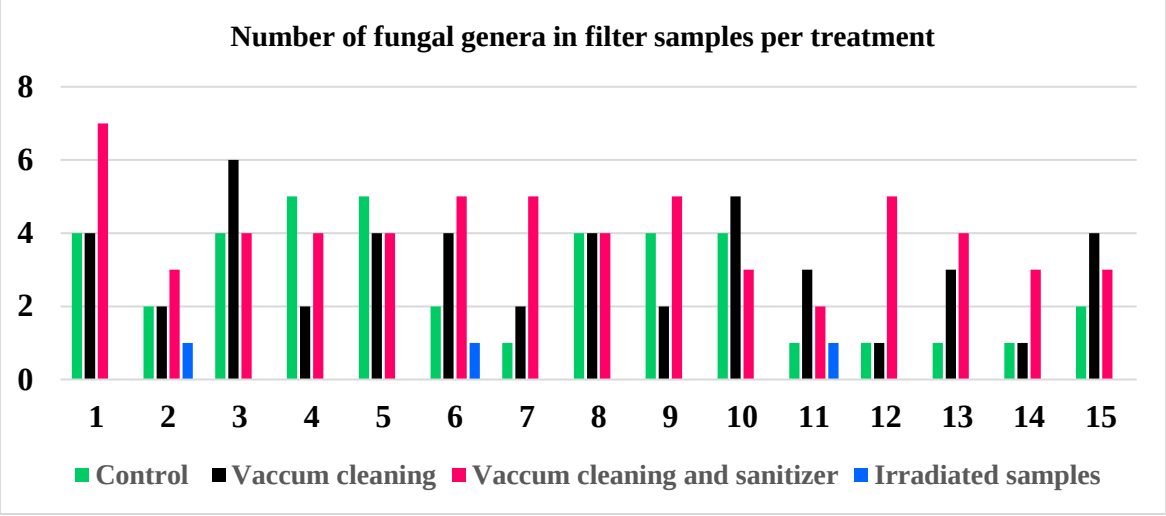

Figure 4: Number of fungal genera in samples per treatment, before irradiation.

4. Conclusions

The methods of vacuum cleaning and sanitizer spray (denatonium benzoate) were not efficient to fungal control. The association with a dose of 17 kGy showed that 80% of samples were completely sterilized after five days. Two samples demonstrated only the growth of yeasts (not pathogenic fungi). No mycotoxigenic fungi such as *Aspergillus, Penicillium*, and *Fusarium* genera were detected in irradiated samples using combined methods. In order to establish a method for the control of fungi in air filters, the use of gamma radiation and sanitizer products showed that it is an efficient way to control mycotoxigenic or pathogenic fungi, using low doses to recycle the material against radiorresistant species.

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