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Aspects of biological contamination in equipment of automotive air in Brazil

Odanir Guerra, Sonia Jurado*, Mateus Silva, Antonia Dalla Pria Bankoff

Federal University of Mato Grosso do Sul, Três Lagoas, Postal code 79620-080, Brazil

Abstract

Air quality plays an important role in occupational and environmental medicine and many airborne factor negatively influence human health. Circulation or air conditioning (AC) system was proven to improve the air quality inside the vehicles. However, its impact on the number of particles and microorganisms inside the vehicle - and by this its impact on the risk of an allergic reaction - is yet unknown. The aim of the present study was to evaluate bacteria and fungi present in the air-conditioned car filter. The quality of air was investigated in twenty-two cars of different brands that were all equipped with an automatic air conditioning system. Based on the recommendation of the American Public Health Association - APHA - held the collection of material in a square centimeter of the surface of each of the 22 filters of equipment automotive air conditioning. The material was collected using sterile swabs containing transport medium "Stuart".

The genera of bacteria found in the cars were: *Staphylococcus* spp, *Streptococcus* spp, *Bacillus* spp, *Escherichia* spp, *Enterobacter* spp, *Klebsiella* spp, *Proteus* spp, *Legionella* spp. The bacteria identified more frequently were *Bacillus* (100%, n = 22), *Staphylococcus* (95%, n = 21) and *Proteus* (95%, n = 21). The presence of Legionella indicates poor air quality inside cars. This bacterium was found in 82% of cars (n = 18). Our study identified several types of fungi, which are considered contaminants from the usual internal and external environment, such as *Penicillium*, *Aspergillus*, *Cladosporium*, *Rhodotorulla*, *Candida* and other yeasts or filamentous fungi. The most common fungi were *Aspergillus*, *Penicillium* and *Candida*, present in 95% of samples. Only two cars had a good air quality because their owners realized the cleaning of air conditioning and filter change a week before the survey. Nevertheless, we recommend regular maintenance of the system and replacement of older filters after defined changing intervals aiming to reduce allergic reactions by users of vehicles with air conditioning.

Keywords: Indoor air quality; cars; fungi; bacteria.

*Corresponding Author: srjurado@bol.com.br

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1. Introduction

In Brazil, studies on indoor air quality only began to be performed at least a decade. Studies indicate that the low rates of exchange of air in closed environments generated a significant increase in the concentration of chemical and biological pollutants. However, there are still few studies on the indoor air quality in means of transport.

A generally neglected aspect of urban transportation is the air quality inside motor vehicles – a place where Brazilians spend as much time now as they do outdoors. Levels of benzene (a human carcinogen), carbon monoxide, and nitrogen dioxide may be much higher inside the vehicle, especially in poorly maintained vehicles and in congested, slow moving traffic conditions such as those found in urban settings.

Yoshida & Matsunga (2005) studied the contamination by volatile organic compounds (VOCs) from new cars and found more than 160 different VOCs, and some of them in highconcentrations. The authors also found that the release of these compounds is more intense in summer than in winter. Thus, the interior of vehicles can contain pollutants harmful to health and little is known about indoor air quality in cars.

New cars also have problems of indoor air quality due to a mixture of chemicals, including VOCs, formaldehyde, polybrominated diphenyl ethers (PBDEs), flame retardants used to; and phthalic acid esters (phthalates), which are emitted from materials and finishes used to make car interiors, such as plastics, wood, leather, textiles, seat cushions, glues and sealants. Exposure to these substances can exacerbate allergy and asthma symptoms and cause eye, nose and throat irritation; cough; headache; general flu-like illnesses; and skin irritation. Also some are known to cause cancer and neurological effects (Air Quality Sciences, 2006).

Silva et al. (2009) studied the levels of carbon dioxide within thirty automotive vehicles in Brazil and found a mean of 1,546 ppm CO_2 after 10 minutes of operation of the air conditioner. The high levels of carbon dioxide found in a few minutes of running air conditioners are worrying because on long trips when the devices are used for hours and the levels remain elevated CO_2 may contribute to sleepiness, lack of attention, fatigue and lethargy for the driver, increasing the chances of traffic accidents.

Another study(Riediker et al., 2004) showed that exposure to particulate matter ($PM_{2.5}$) in-vehicle in young, healthy, non-smoking, male North Carolina Highway Patrol troopers may cause pathophysiologic changes that involve inflammation, coagulation, and cardiac rhythm.

However, the impact the microorganisms inside the vehicle, the risk of allergic reactions and respiratory diseases is yet unknown. Aim of the present study was to evaluate bacteria and fungi present in the air-conditioned car filter.

2. Methods

The quality of air was investigated in twenty-two cars of different brands that were all equipped with an automatic air conditioning system (Table 1). Based on the recommendation of the American Public Health Association - APHA - the collection of material was performed in a square centimeter of the surface of each of the 22 filters of equipment automotive air conditioning. The material was collected using sterile swabs containing transport medium "Stuart". In this research, fungal and bacteria genera were considered. Differentiation of fungi and bacteria was performed in the Federal University of Mato Grosso do Sul, Brazil.

Table 1. Cars used in this study.

Company name of car	Type of car	Year of construction	Running distance on record (km)
Toyota	Pickup truck	2012	20,000
Renault	Small car	2013	6,447
Volkswagen	Small car	2012	6,775
Volkswagen	Small car	2011	61,596
Volkswagen	Small car	2011	72,200
Fiat	Small car	2012	52,917
Toyota	Pickup truck	2007	196,920
Fiat	Small car	2010	62,293
Toyota	Pickup truck	2002	356,654
Chevrolet	Pickup truck	1994	411,252
Renault	Small car	2011	13,688
Mercedes-Benz	Truck	2010	335,018
Fiat	Small car	2006	67,950
Volkswagen	Small car	2013	50,585
Citroen	Small car	2008	89,546
Volkswagen	Small car	2005	11,231
Volkswagen	Small car	2011	101,311
Chevrolet	Pickup truck	2013	38,374
Chevrolet	Pickup truck	2011	52,685
Volkswagen	Small car	2005	136,127
Ford	Small car	2007	104,483
Volkswagen	Small car	1999	188,197

3. Results

The genera of bacteria found in the cars were: *Staphylococcus spp*, *Streptococcus spp*, *Bacillus* spp, *Escherichia* spp, *Enterobacter* spp, *Klebsiella* spp, *Proteus* spp, *Legionella* spp.

The bacteria identified more frequently were Bacillus (100%, n = 22), *Staphylococcus* (95%, n = 21) and *Proteus* (95%, n = 21). The presence of *Legionella* indicates poor air quality inside the cars. This bacterium was found in 82% of cars (n = 18).

Our study identified several types of fungi, which are considered contaminants from the usual internal and external environment, such as *Penicillium*, *Aspergillus*, *Cladosporium*, *Rhodotorulla*, *Candida* and other yeasts or filamentous fungi. The most common fungi were *Aspergillus*, *Penicillium* and *Candida*, present in 95% of samples.

Only two cars had a good air quality because their owners realized the cleaning of air conditioning and filter change a week before the survey.

4. Discussion

Many cars are supplied with air conditioning (AC) systems these days. A moderate cooling by AC systems increases the comfort for all passengers especially at hot temperatures outside the car. On the one hand, compared to air supply systems in buildings, AC systems in vehicles come with some disadvantages due to the small space available in cars. Tiny air conduits and frequent changes of the direction of air flow in cars support deposition of airborne particles and microorganisms within the airways (Simmons et al., 1999). Once those particles or microorganisms happen to reach the cabin of the car, a possibility for allergic reactions (e.g., of the respiratory tract) for passengers exists in principle (Kumar et al., 1984). There are also some concerns that persons with some kind of a severe immnodeficiency may be at risk of an airborne infection caused by an AC system.

Simons et al. (1999) studied the air quality twelve cars that had odor problems. The authors detected the occurrence of mixed bacterial-fungal biofilms in automobile air conditioning systems. Similarly to our study, Simons et al. (1999) and Jo & Lee (2008) also found principally the following genera of fungi: *Penicillium*, *Aspergillus* and *Cladosporium* inside the cars. Species of *Methylobacterium* were frequently found in the study by Simons et al. (1999). *Methylobacterium* are found in are common environmental organisms found in fresh water, soil, dust, and air. They are resistant to chlorine treatment, and some species are resistant to penicillin, chloramphenicol, as well as other antibiotics.

In this study, the bacteria most commonly found were *Bacillus*, *Staphylococcus*, *Proteus* and *Legionella*. Typical and most important bacterial strains found in an indoor atmosphere are representatives of the genera *Bacillus*, *Micrococcus*, *Kocuria* and *Staphylococcus*. Bacilli have the ability to form spores which are characterized by their resistance to harsh environmental conditions such as UV radiation, desiccation, lack of nutrients, or extreme temperatures. These metabolic capabilities facilitate the distribution and survival (Mandal & Brandl, 2011).

The presence of *Staphylococcus* in the indoor air of cars could be attributed to its easy way of transmission through agents such as the throat, skin, nails and nasopharynx. *Proteus* spp consist of gram-negative, motile, aerobic rod-shaped bacilli belonging to the family Enterobacteriaceae. They are part of normal flora of human gastrointestinal tract and are also widespread in the environment, including animals, soil, and polluted water. They are important causative agents in community-acquired and nosocomial UTIs (Abbott, 2007).

Legionella may be derived from the environment (Bolling et al., 1985), others include contaminated food, water or through vectors. *Legionella pneumophila* causes human legionellosis and community-acquired and nosocomial pneumonia in adults following either occupational or non-occupational exposures. Legionellae become airborne often as a result of active aerosolising processes (aeration of contaminated water) and may inhabit various water environments including man-made water systems, often in biofilms in cooling towers, air conditioning systems, etc (Srikanth et al., 2008).

Our results indicate that the lack of hygiene in automotive air conditioning equipment affect the quality of indoor air with the presence of pathogenic microorganisms. Proper maintenance of the AC thus appears to be essential.

5. Conclusions

If examined and exchanged regularly, AC systems in cars may significantly improve the quality of air inside the car's cabin, promoting the well-being of users.

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