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How Photocatalysis may change quality of life for drivers

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ABSTRACT[1]
The data collected by this study showed that the cleaning of the air from pollutants which are present inside the drive passenger compartment had significantly improved nasal cells' vitality with a significant reduction in inflammatory cellularity. The improvement of the quality of life of professional transporters represents the primary objective of the current study and the analysis of the results provided us with encouraging data.

INTRODUCTION

Climate change and pollution are the main exponents of the changes of our leaving spaces both outdoor and indoor and have led to important variations in our health, our way of life and our life quality.
Indoor pollution is responsible for 2.7% of the global disease burden in the world (Global Health Risks: Mortality and burden of disease attributable to selected major risks WHO, 2009). In general, children represents the most affected group by the consequences of indoor air pollution, especially in the domestic places. (1,2)
In Europe indoor pollution is responsible for 4.6% of deaths from acute respiratory infections in children aged from 0 to 4 years. In some European countries 20-30% of households have humidity problems resulting in a 50% increase in risk of respiratory disorders and 13% of cases of childhood asthma (WHO 2009). (2)
Among the diseases related to indoor pollution, allergic respiratory diseases have a great deal relief for their impact on health and their incidence is increasing across Europe, currently asthma affects the adult European population by 3-8%, while the percentage in
pediatric population is even greater.
Surveys on citizens' lifestyles tell us that people spend most of their time indoors. The composition of indoor air is often characterized by a highly variable mixture of compounds
compared to what can be found in the external atmospheric air. Indoor pollutants are numerous and they can originate from different sources, their concentration can vary over time and depends on the nature of the source, the ventilation, the habits and activities carried out by the occupants in the affected environments. The results of numerous studies show that the concentration of pollutants in the indoor air is often higher than the respective external values, sometimes the presence of pollutants not detectable externally. (3,4,5,22,23)

Among the most common sources of pollutants we can find tobacco smoke, combustion processes, products for house cleaning and maintenance, pesticides, the use of glues, adhesives, solvents etc ..,the use of work tools such as printers, plotters and copiers and products for the hobby sector (e.g. glues and paints); also the emissions of the materials used for construction (e.g. insulation containing asbestos) and furnishings (e.g. furniture made of chipboard, plywood or panels of

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medium density wood fibers, or treated with pesticides, but also carpet and coatings) can contribute to the mixture of pollutants present. Finally, the malfunction of the ventilation system or incorrect placement of the air intakes near high areas pollution (e.g. high traffic routes, underground parking, garage, etc.) can cause an important entrance of pollutants from the outside. The air conditioning systems can also become a breeding ground for molds and other biological contaminants and spread them agents throughout the building.
The worst case scenario is represented by the stationing inside a vehicle cabine while the other vehicles are moving around us. (6,7,24,25)
The high-levels of pollutants are inside because the car absorb emissions from surrounding vehicles and recirculate them. Studies conducted in this direction have found that about half of the pollutants inside cars come from vehicles immediately ahead, especially if such vehicles are heavy contaminaters, like diesel trucks.
The pollutants enter the car's cabin through air vents and other openings, since vehicles are not built to be airtight.(8)
Although we spend only about 6% of our day driving, in that period we get up to half of our exposures to vehicle-related pollutants, while a professional worker spends 40% to 50% of his day, resulting in increased exposure to the pollution.
Concentrations of vehicle-related pollutants on the road are generally several times higher than the environmental (external) concentrations. The levels of certain pollutants and toxic compounds may be ten times higher inside vehicles than on the road and the overall air quality can be 15 times worse. (9,10,11,12)

MATERIALS AND METHODS

Five patients were selected, workers at two transport companies using their own vehicle for more than six hours a day.
Patients filled in a SNOT-20 questionnaire to analyze the quality of life also from a respiratory point of view. Patients were taken for nasal cytological examination.
After the above mentioned examinations, an air purification system was installed by means of photocatalysis inside all 5 patients' vehicles.
After three months, the patients recompiled a new SNOT 20 and underwent a new sampling for nasal cytological examination.
All patients did not take any systemic drug or topical nasal medication therapy since 15 days before the enlistment and until the follow-up exams were carried out.
Patients did not take extended working days off during the months between the pre and post-air treatment checks.

Nasal cytology examination involves the following steps:
- sampling: collection of superficial cells of the nasal mucosa with the help of a small disposable plastic curette (scraping). The withdrawal is carried out at the average portion of the lower turbinate, where there is a right ratio of ciliate cells to mucipare (1⁄4 in favour of ciliate cells);
- processing (which includes fixation and staining): time in which material cell phone is fixed by air-drying and then coloured according to the method of May-Grunwald Giemsa (MGG).
- microscopic observation: time performed with a common light microscope, provided that equipped with a lens capable of magnifying up to 1000X. For the analysis of the rhinocytogram it proceeds with a reading of 50 fields calculating the percentage of cellular elements important for diagnosis (eosinophils, mastic cells, neutrophils, bacteria, spores, etc.). (33,l26,27)

The SNOT-20 (Sino-Nasal Outcome test 20) is one of the most widely used tools to understand the quality of life of patients affected by rhinosinusitis and simple rhinitis. The SNOT-20 is a test made of 20 multiple-choice questions that are usually assigned with a single summary score (0–5). This test evaluates a wide range of quality of life issues related to health, including physical problems, functional limitations and emotional consequences (34).

Photocatalysis is the natural phenomenon in which a substance, called photocatalyst through the action of the light (natural or artificial) changes the speed of a chemical reaction. When exposed to light, the tungsten trioxide (WO3) absorbs and converts light's energy (photons) into electrons and electron gaps. WO3 reacts with the humidity of the air to create hydroxyl radicals (OH-) and with oxygen to create superoxide anions (O2-). Billions of these highly oxidizing species are created in a billionth of a second and work to break down matter at the molecular level. The result is an effective decomposition of organic and inorganic polluting substances (comparable to all particulate matter PM2.5 - PM10), organic and inorganic pollutants, microbes, viruses, nitrogen oxides, polycondensed aromatics, sulphur dioxide, sulphur dioxide, nitrogen oxides, nitrogen oxides, nitrogen oxides, carbon monoxide, formaldehyde, methanol, ethanol, benzene, ethylbenzene, nitrogen monoxide and dioxide, etc.
Photocatalysts do not lose their properties over the course of time, as they only act as process activators, do not bind to pollutants and remain available for new cycles of photocatalysis. The catalyst does not intervene directly in the reaction but favors the photocatalytic reaction by lending its electrons and regaining them from the environment after the reaction. (31,32)
The pollutants and toxic substances through the photocatalytic process are transformed into:
- sodium nitrate (NaNO3)
- sodium carbonates (Na2CO3)
- limestone (CaCO3)
- carbon dioxide (CO2)
- water vapor

All of them are harmless and measurable in parts per billion (ppb).
Specifically the sanitizer being tested is composed of a system of steel nets A304 subjected to specific industrial processing for cleaning with isopropyl alcohol and treatment with tungsten trioxide (WO3) in nanometric form, illuminated with a white light LED system of calculated intensity and to which the air transported by the ventilation system is conveyed. The sanitizing treatment, patent pending of the manufacturing company, takes place at the contact between the particles in the air and the illuminated (active) network.
(11,12,13,14,28,29,30)

RESULTS

The average age of the five enrolled patients was 49 years, with a work activity ranging from 10 to 25 years. All workers were eligible to carry out their activities after the evaluation of occupational medicine. Among these patients two were allergic and three were smokers with an average of 50 packets a year. All the patients were male.
They were all subjected to cytological examination before the implementation of environmental sanitation resulting in the followings:

Elements	1	2	3	4	5	total
Hair cell	x	x	x	x	X	5
Sis				+	+	2
Neutrophils	x	x	x	x		4
Mast Cells		x	x	x	x	4
Eosinophils					x	1
Bacteria	x			x		2
Spure		x	x		x	3

Table 1: *Nasal cytology showed mucosal cellularity of the enrolled patients before photocatalysis was placed inside the drive compartment.*

It's clear from Table 1 that 60% of patients showed cellular suffering; inflammatory cells and bacteria and fungal hyphae were found in all subjects.

After the photocatalytic system was put into operation, the data changed as follows:

Elements	1	2	3	4	5	total
Hair cell	x	x	x	x	X	5
Sis	+	+	+	+	+	5
Neutrophils	x					1
Mast Cells					x	1
Eosinophils					x	1
Bacteria						0
Spure						0

Table 2: *Nasal cytology after photocatalysis was placed inside the drive compartment.*

These data shows that the inflammatory cells inside the nasal secretion have significantly been reduced, the cell viability with positive SIS was found in all samples tested.
Another important fact is the lack of presence of bacteria and spores at the nasal level.
The purification of the air from pollutants inside the passenger drive compartment had significantly altered nasal cellularity with reduction in inflammatory cellularity. This indicates that the improvement of environmental conditions and the elimination of the pollutant elements has reduced the inflammatory response at the nasal level, improving the general condition of the subjects.

The analysis of the SNOT 22 questionnaires filled by the subjects before and after the environmental treatment showed a radical change in the personal conditions of the subjects with an improvement in all factors analyzed: from the quality of respiratory function, to the psychophysical state, including less tiredness during and after work.
The overall improvement could therefore be verified with particular reference to well-being during working-hours, in sleep quality, in the radical reduction of nasal inflammatory processes and (in the allergic patient) the absence of allergic seizures.

DISCUSSION

The main chemical contaminants found indoor are represented by carbon monoxide (CO), nitrogen dioxide (NO2), sulphur dioxide (SO2), volatile organic compounds (VOCs), formaldehyde (CH2O), benzene (C6H6), polycyclic aromatic hydrocarbons (PAH), ozone (O3), airborne particulate matter (PM10, PM2.5), compounds present in environmental tobacco smoke, pesticides, asbestos.
Biological contaminants are defined as a range of substances of biological origin that may affect negatively both indoor and outdoor air quality. The main sources of microbiological pollution in the premises are represented by the occupants (man, animals, plants), dust (excellent receptacle for microorganisms), structures and services of buildings. To these sources, must be add humidifiers and air conditioners, where the presence of high humidity and inadequate maintenance facilitates the settlement and multiplication of biological contaminants which then spread to various environments. Among the most common indoor biological contaminants we find:
- Bacteria, transmitted by people and animals but also present in places with conditions of temperature and humidity that promote its growth.
- Viruses, transmitted by infected people and animals.
- Plant pollen, mainly from the outside environment.
- Mushrooms and moulds that form inside confined places due to humidity problems or that can penetrate from outside.
- Mites are considered to be among the main causes of allergy and asthma because, through their feces,produce powerful allergens that are easily inhaled.
- Pets' allergens released mainly from saliva, dandruff and urine, which, an once dried and fragmented, they remain suspended in the air. The main source is the animals with fur (dogs, cats, rodents, etc.), but also birds, cockroaches and insects.
For completeness we also report the physical agents responsible for a bad quality of the environment indoor as Electromagnetic fields (c.e.m.), noise and radon gas.
The presence of contaminants in a confined environment, even at low concentrations, can have an important impact on the health and well-being of its occupants due to long-term exposures; in fact the risk, rather than the generally very low concentration of pollutants is linked to exposure's lenght (i.e. integrated concentration over time) considering that the average stay time in a confined environment reaches 80-90% of the daily available time. This is a key aspect in assessing the effects of indoor pollution.
Inside vehicles the situation is not very different than inside an office.
<u>Actually the air inside cars can be 15 times dirtyer than the air outside the very same car a few yards from the cockpit .</u>
The worst situation for pollutant's exposure occurs when we are stationing inside our car cabine while other cars are moving. The high-levels of pollutants are due to cars absorption of the surrounding vehicles' emissions. Recent studies showed that about half of the pollutants found inside a car's cabine come from the vehicles immediately ahead, especially if such vehicles are heavy

pollutants, such as diesel trucks. The pollutants enter the car's cab through air vents and other openings, since vehicles are not built to be airtight.
Concentrations of vehicle-related pollutants on the road are generally several times higher than the environmental (external) concentrations. The levels of certain pollutants and toxic compounds may be ten times higher inside vehicles than on the road and the overall air quality can be 15 times worse. (15,16,17)
The exhaust emission of a vehicle is a cocktail of dangerous pollutants, including:
- Nitrogen dioxide (NO2): foul-smelling gas that can cause breathing problems, irritation lung and reduced resistance to respiratory infections.
- Ozone (O3): natural compound that helps to block harmful UV light from the sun. However, to ground level, it's toxic. When vehicles emit nitrogen oxides (NO), sunlight acts on them to create ground-level ozone. Ozone is the main component of smog and it's a major pulmonary irritant. Long-term exposure can cause asthma and cause severe and permanent structural damage to the lungs: in particular carbon monoxide (CO) causes short-term effects similar to oxygen deprivation, such as dizziness, fatigue and confusion; sulfur dioxide (SO2) can cause shortness of breath and chest pain if inhaled, while in long term exposure can cause acute respiratory diseases and permanent changes in lungs; fine particles (PM2.5 represents about 9% of all airborne particles) with a diameter between 0.1 and 2.5 microns they can settle in lung tissue triggering respiratory diseases like asthma, bronchitis and emphysema: exposure to PM2.5 has been linked to the increase of potential for cardiovascular problems, such as arhythmic heartbeats and heart attacks; ultrafine particles (UFP) with a diameter of less than 0.1 micron, they represent about 90% of all airborne particles are this size: FFP are not only the most numerous airborne particles, but they are also the most dangerous to health as the small ultrafine particle sizes allow them to be easily inhaled and deposited in the lungs and absorbed directly into the bloodstream. (16,17,18.19)
These environmental conditions interfere with the physiological balance of the respiratory tract by stimulating the defense mechanisms our body has at its disposal. These alterations can increase the risk of diseases, especially respiratory diseases of the airways.(20,21)
These premises have been taken into account in analyzing how the quality has changed in hauliers' lives, given the small size of the cockpit and the long time spent inside it.
This simple study has shown that changes in ambient air quality in media transport, through the abatement of indoor pollutants, has significantly improved the quality of life for drivers by reducing the inflammatory cellular pattern at the level of the nasal respiratory tract and increasing cellular vitality; demonstrated by the presence of the cellular supernuclear hyperchromatic stria that was present at the nasal cytological control examination of all subjects.
The inflammatory component was reduced due to the lack of irritant factors present in the air: fine dust, spores and allergenic substances.
The cytological examination performed at the end of the period showed the reduction of inflammatory cells at the level of the nasal mucous membranes (such as neutrophils and mast cells) as a sign of the anti-inflammatory nasal effectiveness of the air treatment; while the disappearance of bacteria and spores also demonstrates the possibility to break down the bacterial and fungal load inside the air of the cockpit. The presence of the SIS inside the nasal cells is a precise vitality index and it is typically absent in case there are inflammatory, viral or fungus. This was well represented in all the samples examined after 3 months of air photocatalysis' treatment. Giving the SNOT- 20 data we can find that the subjects involved have a positive feedback on their life quality.
A study with a larger sample of patients and especially the detection of the substances present inside the passenger compartment is, however, necessary to validate the data obtained to date.

CONCLUSION

Polluting agents in small enviroments such, as a passenger drive compartment, for a long period of time can worsen the health condition of a subject.
The study endorsed, for a small group of truck drivers, that an efficient air cleaning system in the cockpit can contribute to a significant subjective improvement of the quality of life and a significant objective reduction of nasal inflammation.

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