Energy efficient air purification indoors

Introduction

The concentration of air borne particles indoors is the best measure of the quality of the indoor air. The reason is most of the particles due to their size and compositions are biologically active and therefore constitute a bioload. This bioload is generated by different classes of particles as summarized below.

Particle size, their source, main impact and air purification measures indoors.

Particles indoors, size	Main source	Main impact	Air purification indoors
>10 µm	Dust, lost skin and hair, building material, pollen	Irritation of membranes; nose, throat and eyes. Dry eyes and cough	Cleaning, sanitation, ventilation [2]
2,5 – 10 µm PM10	Activity generated, number of people, microorganisms[1], allergens, traffic, road surface wear and tear.	Allergies, infections, immunological stress	Less people, ventilation[2], air purifiers – electrostatic or mechanical, optimal humidity[3]
1,0 – 2,5 µm, PM2.5	Exhausts, soot, solid fuel combustion, candles	Reduced lung function, allergies, immunological stress	Air purifiers, filtering of ambient air at intake
0,1 – 1,0 µm, PM 2.5	Fuel combustion , microorganisms,	General oxidative stress, viral infections, mycotoxin related symptoms	Air purifiers, filtering of ambient air at intake optimal humidity[3]
<0,1 µm, ultra-fine nano-size particles	Fuel combustion, diesel engine	Multi organ symptoms due to general inflammatory reactions	Electrostatic air purifiers

1. Mould spores; 1 – 40 µm, mould hyphae 0,1 - >10 µm, incl. mycotoxins, proteases, glucans (potential allergens).
2. Does not affect the peak concentration of the activity generated particles or submikron size particles.
3. Dry air generates electrostatic forces that make fine particulates stay air borne.

The ultra-fine particles

Of special concern are the finest, nano-size particles, often generated outdoors. A measure of these is the PM2.5 index used as a measure of the ambient air quality and risk factor. Today, we know that 90% of citizens in major European cities from 41 countries are exposed to levels exceeding the WHO safety limit of 10µg/m^3. As a consequence there are 467 000 premature deaths due to stroke, heart infarcts and cancer (www.eea.europa.eu/publications/air-quality-in-europe-2016). Increasing epidemiological evidence suggests that exposure to air pollutants plays a major role in the development

and/or acceleration of Alzheimer's disease. Urban polluted environments and occupational exposures with ubiquitous distribution of high concentrations of ultrafine particulate matter are of great concern for the central nervous system due to their ease to go through biological barriers, causing an uncontrolled inflammatory response.

Our children

Recently, UNICEF (https://www.unicef.org/environment/files/Danger_in_the_Air.pdf) declared these nano-sized particles to be a major risk in the development of the brain.
Air pollution is also linked with asthma, bronchitis and other respiratory infections and diseases, which can be debilitating, force children to miss school, and even cause long-lasting damage to their health and wellbeing.
These effects are well established. But a growing body of scientific research points to a potential new risk that air pollution poses to children's lives and futures: its impact on their developing brains. This should concern us all. Few things are as important to a child's future as the first 1,000 days of life, when the brain undergoes the most critical and rapid growth. Every neural connection made during this critical window of brain development in early childhood forms the foundation for future neural connections, and ultimately influences the likelihood of healthy development of a child's brain. This, in turn, is crucial to children's ability to learn and later, to earn a living and fulfil their potential as adults.
Furthermore, young children's immune systems are still developing, and their lungs are still growing. With every breath, children take in more air per unit of body weight than adults. By extension, when air is toxic, they take in more toxic air per unit of body weight than adults. Unfortunately, staying indoors does not provide protection. In fact, the situation may become even worse as the ultra-fine particles enter easily and are added to by the air pollutants generated by the indoor activity.

What to do.

The only air we can control is the indoor air or the air in the car we drive. The problem is that staying indoors is not enough as the indoor air may become even more risky and fine and ultra-fine particles will enter indoors as well. Therefor some sort of air purification is required unless we do what people did 100 years ago - choose to spend time in the mountains or by the sea-side just to recover from air pollution.

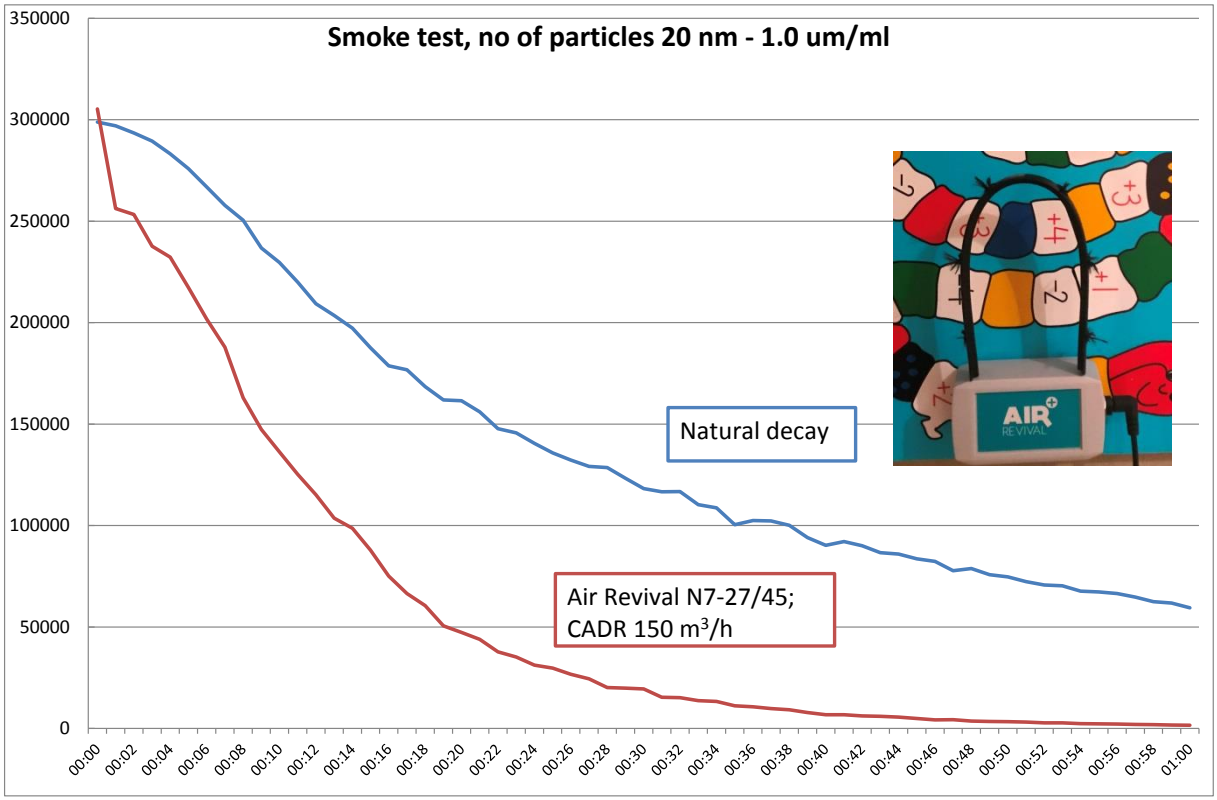
An alternative is to install air filtration units at home but these are complex to operate, expensive to run and require regular maintenance. However, Danish researchers has shown that when this high-tech technology was used in homes of 60+ year old healthy people living in Copenhagen, their ability to regulate the blood flow improved already after 48 hours and this improvement was related to a reduction in the ultra-fine particles. Now we know what to target therefore there is an opportunity to develop new and more environmental friendly technology. Could a controlled electrostatic field operating in the room become an alternative?

The AirRevival technology

This was the question scientists and clinicians working at the University of Plymouth, UK headed by Prof. Karl Rosén asked themselves some 25 years ago. After a combination of basic and applied research studying what happened to the chemistry of the air when electrons were released to generate a negatively charged electrostatic field and tests in schools and offices in the UK and Sweden, the basis was laid for the development of the AirRevival technology by a Swedish company, Neoventor AB working in close collaboration with the researchers.

Electrons may be used for many different purposes. In the body, the role of oxygen is to capture electrons released when energy is generated. In the air, the same happens in the air and a small amount of hydrogen peroxide (H_2O_2) is generated when vapor is added. We produce ourselves H_2O_2 when the immune system has to fight against microorganisms and it could be demonstrated that the AirRevival technology could reduce the bioload of the air by "starving" molds indoors and most likely kill viruses. Already in the first study in Swedish preschools published in 1999 a more than 60% reduction in particles could be demonstrated by the electrostatic air cleaning (EAC) technology and most importantly, the non-attendance rate was reduced by 55% i.e. the children had less viral infections. Not only was it possible to purify the air from particles generated by the traffic as well as those generated by the activity of the children but is was also possible to reduce the bioload indoors and have healthier children. However, further work on design and documentation on efficacy was required.

This has now been completed in that independent tests has documented the ability of one AirRevival unit applied to a window to produce 96.6 m^3 of air free from the most hazardous 100 nm size particles per hour when the air is circulating. When it comes to the nano-size particles, the Clean Air Delivery Rate (CADR) is even higher as illustrated by Figure 1 using the smallest AirRevival unit in a situation with no air circulating.



The energy requirement I only 0.6W per unit and the only maintenance required is to wipe the black sooth from the easy to clean surface (window glass or board connected to ground) on where it sits. Furthermore, the use of carbon fibers as electron emitters has prevented the generation of ozone, a problem related to the old ionizer technology. There are many other features that make an AirRevival unit, the most important is its unique air cleaning capacity in relation to ultra-fine particles.

The most important outcome of the work done so far has been the ability of the modern AirRevival technology to achieve the same outcome as previously noted in pre-schools. Recently Karl Rosén and collaborators could demonstrate a reduction in days being sick from 12 to 5 days per year.

One could argue; “Clean air should be the expectation of all, not the luxury of some”. It seems as if electrostatic air purification and the AirRevival technology provide such an opportunity.

Fig. 2. An AirRevival N7-70/90 unit placed in a preschool window. Note the accumulation of particles on the glass behind the emitter arch.

Kungälv, Sweden
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Prof Karl G Rosén, MD, PhD
Karantänsgatan 13
SE44235 Kungälv
Sweden
e-mail: kg.rosen@neoventor.se
www.airrevival.com, www.neoventor.com