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ABSTRACT
Air quality is an issue that schools have to address every day, with the air inside being sometimes 2 to 5 times more polluted than the outside air. The problem is that there is more than dust involved. Students and teachers alike face chemical fumes, volatile organic compounds, airborne bacteria, viruses and mold, smoke, allergens and other contaminants as well.

The best solution is an air purifier that can handle all of these pollutants in an effective, economical way, but this is more than just a HEPA filter, a UV or POC filter, or an electrostatic precipitator alone can handle. Each of these technologies has its focus, but none are good for everything and to deal with the unique challenges posed by school air quality issues, an air purifier that can handle everything and do it in an economical way that is friendly to school budgets, is precisely what is needed.

Luckily, there is such an air purifier, the NuWave OxyPure. Relying on proven technology that is built to last, the OxyPure is proven to be able to handle particle pollutants, allergens, pathogens, chemical fumes, VOCs, smoke, odors and more, and do it with a very low cost of ownership since the filters are long lasting and the unit uses very little power.

THE PROBLEM
According to the U.S. Environmental Protection Agency (EPA), indoor air pollution in homes, schools, and offices can be 2 to 5 times greater than outdoor air pollution. This is due, to a great extent, to the nature of modern construction techniques aimed at increasing energy efficiency with less natural ventilation and more synthetic, chemically treated building materials, as well as the usual array of chemical fumes and tobacco smoke, cooking exhaust, pathogens and allergens, molds, heavy metals like lead that we've been living with for decades[1]. This creates a real problem in schools[2] since poor air quality can, according to the EPA[3]:

- Accelerate deterioration and reduce efficiency of the school's physical plant and equipment.
- Affect student comfort, the learning environment and attendance.
- Increase the likelihood that schools will have to be closed temporarily (for repairs) or permanently.
- Lead to costly repairs if maintenance and proactive measures are deferred. Preventative measures will save money over time.
- Reduce the productivity of teachers and staff due to discomfort, sickness or absenteeism.
- Increase the potential for long-term health problems among students and staff.
- Strain the relationship between administrators and facilities staff.

One solution to the problem of poor indoor air quality in schools is the addition of air purifiers. However, as reported by MSN News[4], in these days of Covid-19, school administrators going after ion- or hydroxyl-blasting air purifiers, which use ionization, plasma, and dry hydrogen peroxide, units that often emit harmful negative ions and ozone into the air, may not be getting what they think they are buying.

According to Marwa Zaatari, a member of the American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) Epidemic Task Force, "We're going to live in a world where the air quality in schools is worse after the pandemic, after all of this money. It's really sickening."[4]

This is the problem: that school administrators are often not familiar enough with air cleaning technology to avoid things with space-age-sounding names that promise clean and hygienic air but instead deliver new health concerns of their own.

BACKGROUND

The problem of air purification goes back as far as the industrial revolution, when coal-powered factories belched black smoke into the air to meet the demand for cheap goods, settling a foul-smelling smog over cities and causing a number of respiratory issues. 1830 saw the first portable air filter, a helmet that looked more like a heavy diving helmet than anything else. Made for firefighters, this device had hoses that trailed back away from the smoke and air was fed to the wearer by a bellows system. In the ensuing years, cotton batting was used as a filter medium in masks, but it wasn't until 1940 that scientists attached to the Manhattan Project came up with a filter that we still use today: the HEPA filter.

Large and expensive, this piece of military-industrial technology was designed to protect lab workers from radioactive dust, but it was not suitable for home use in spite of clearly capturing other pollutants as well, including pollen, mold, pet dander and smoke particles until 1963, when the Hammes brothers in Germany, the founders of IQAir, created the first home air purifying system. After that, it didn't take too long for competition to begin heating up. By the 1980s, the Association of Home Appliance Manufacturers (AHAM) had developed a standard for performance, the Clean Air Delivery Rate (CADR), which is still the standard today.

Today, air purifier manufacturers have sought to develop new technologies to either supplement or replace the tried-and-true HEPA filter. Right now, there are seven primary types of technology in use, all of which have their benefits and their drawbacks.[5]

1. **Fibrous Media Filter**. This is the HEPA filter, and it works by capturing particles within its fibrous mesh structure. It is efficient and safe, but it is also expensive due to replacement costs, will not handle odors, and if mishandled during replacement it can release the captured pollutants back into the air.[6]

2. **Absorbent Media Filter**. The most popular version of this is activated carbon, and it absorbs odors, gasses, and volatile organic compounds like formaldehyde and benzene. On the other hand, the filters are expensive to replace, must be used in conjunction with other filters such as HEPA filters, and their effectiveness depends on what they are absorbing.[7]

3. **Ion Generators (Ionizers)**. These generate large amounts of negative ions, which attach to airborne particles and weigh them down, sometimes onto charged collection plates within the unit itself, sometimes on your carpet, tabletops, or any other flat surface in the room where the ionizer is operating. They work and don't draw much power, but they are slow, and they often generate ozone in addition to their negative ions, and that can lead to a number of respiratory problems. Also, there is still much debate over whether exposure to that high a concentration of man-made negative ions is good for you.[8]

Plasma refers to a type of ionizer that destroys pathogens as well as the chemical bonds of gases and VOCs. However, these units often produce ozone, carbon monoxide and VOCs of their own, and they do not remove particle pollutants. They have shown great promise in laboratory settings, but there is very little data to show real world effectiveness.[9]

4. **Ultraviolet Germicidal Irradiation (UVGI)**. This technology uses ultraviolet light (UV-C) to destroy airborne pathogens and such lights are often seen in hospital settings, where they do seem to work. However, they work there because the air is not being rushed past the UV-C lights as it is in an air purifier, so there is time for it to do its work. Within an air purifier, however, the UV light is often too weak, or the pathogens are not in contact with the light long enough to be eliminated entirely, making this a slow process that requires a number of passes to work properly. It can also produce ozone and, if the light is uncovered, damage the human eye.[10]

5. **Photocatalytic Oxidation (PCO)**. This technology is for gasses and volatile organic compounds and uses titanium oxide and UV light to chemically transform them into harmless compounds like water and carbon dioxide. It is energy efficient and works on a number of different gases, but it is also slow and will produce byproducts such as formaldehyde and ozone.[11]

6. **Electrostatic Precipitation (ESP)**. First seen in large industrial applications, this technology has been coming down both in size and price. It uses a coronal discharge process to create negatively charged ions within the filter itself. These attach to passing particles and together they are drawn to the positively charged plates. It's a high-efficiency, low maintenance technology that, at higher power levels, can generate ozone and nitrogen oxide as byproducts.[12]

7. **Ozone Generators**. As the name implies, these release ozone into the room to effectively break down the chemical bonds of a wide variety gases and VOCs. However, they release ozone, which is harmful to both humans and their home appliances and as such they have no place in a residential setting.[13]

No single air purification technology can handle everything, which is why we see air purifiers with a combination of these filtering technologies, like a HEPA filter for particles and activated carbon for odors combined with an ionizer to handle pathogens, and while those units sound appealing, they can be very expensive, sometimes to buy but far more often to own since they require filter replacement at frequent intervals, and they don't do much about the ozone, negative ions, and other byproducts they emit into the air.

So, knowing this, educators are faced with a problem. Each room has its own, sometimes unique, needs. In a high school, a Chemistry classroom, for example, has different air purification needs from an Art classroom, which is different from an English or History classroom. Each should have its own air purifier that can handle those specific needs. However, it would also help that these air purifiers were standardized. That way if one unit failed another could quickly and easily take its place. This standardization would also allow the units to be linked, so that they can all be monitored and operated remotely from a central location. Beyond all that, there is also the initial cost and the ongoing cost of ownership that need to be considered.

SOLUTION

The answer is an air purifier that takes the best of the various technologies and combines them in a meaningful way to handle whatever air quality issue might arise without emitting dangerous byproducts. Such an ideal air purifier would combine filters to eliminate larger contaminants like pollen, pathogens and particles, fumes and odors, and ground-level ozone. It would also have Wi-Fi connectivity and air quality sensors so it can run independently, maintaining excellent air quality automatically. Regarding the financial questions, the initial cost should not break the bank, nor should it be so low as to make people question the quality of the unit. As for the ongoing cost of ownership, that needs to be low enough to justify using the machine for the entirety of its projected lifespan.

Such a unit does exist, and it won the 2021 National Parenting Product Awards! Powered by a quiet, six-speed DC fan and triggered by air quality and odor sensors tied to the unit's autonomous operating modes, the NuWave OxyPure uses a comprehensive 5-filter system that has been proven[14] to eliminate dust and smoke; allergens like pollen and dust mites; pathogens including bacteria, viruses, molds, and mold spores; chemical fumes, volatile organic compounds like formaldehyde and benzene, exhausts and odors. This system consists of:

- **The Never-Rust Stainless-Steel Prefilter.** The Prefilter captures larger particles, pollutants, and allergens such as pollen, pet hair, and dander. It is washable, will never rust, and will last for 20 years.
- **The Patented Bio-Guard Filter.** This filter uses electrostatic precipitation to capture 100% of airborne particle pollutants as small as 0.09 microns, 99.99% of airborne bacteria, and 99.96% of airborne viruses and molds. It is also washable and will last for 20 years, and at 8,000 volts, the Bio-Guard is specifically designed and powered to be effective while no negative ions escape the filter.
- **The Ozone Emission Removal Filter.** This filter not only eliminates any ozone (O_3) that might be generated by the OxyPure itself, it also lowers the ozone concentration of any space in which it is operating to less than 1 ppb, which is 70 times less than the EPA's clean air standard of 70 ppb and has earned the OxyPure UL's Ozone Free Certification. It can be cleaned, though not washed, and will last for 20 years.
- **The HEPA/Carbon Combo Filter.** This filter not only traps any remaining particles and allergens such as pollen, dust mites, molds and spores; it also absorbs industrial, household, and vehicle fumes and emissions; VOCs such as formaldehyde, benzene and other cleaning chemicals; and household and cooking odors. While other HEPA filters have to be replaced monthly, or quarterly, the NuWave HEPA/Carbon Combo Filter will last for up to a year, depending on its operating environment.

That means no filter-related costs for up to a year, but that's not the only savings available. Depending on where you live, on fan level one, you can run the unit all day, every day, all year, for less than $10 (based on 2020 Illinois electric rates)! That, however, is not the only energy-saving feature. The OxyPure boasts several autonomous operating modes that will either run the fan only if poor air quality or odor is detected or adjust the fan speed to best handle any emerging air quality or odor problem. This way there is no wasted energy. Unlike other air purifiers, power is used only when necessary and always in the amounts required. What's more, the OxyPure's Wi-Fi capabilities allow you to monitor air quality and operate one or more units remotely through your smart device using the NuWave Connect App.

Taken together, these savings on filters and electricity make the NuWave OxyPure a real winner for schools looking for long-term air quality solutions that can fit within their budgets, while the OxyPure's Wi-Fi capabilities make it easy for busy staff members to stay on top of the school's air quality.

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