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Impact of plant-based natural extracts on pollutants and pathogens in the air

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ABSTRACT:

Introduction: Air pollutants result in a number of health problems. These health setbacks may range from minor respiratory troubles to chronic effects on human health like asthmatic attacks. A product has been developed consisting of plant-based active nano extracts which is a simple, safe and effective solution to poor air quality by reducing pollutants and pathogens in the air. The aim of this paper is to study the impact of this product (in the form of the liquid solution - referred as 'spray') in improving the indoor air quality by reducing the PM, HCHO, and TVOC (Total Volatile Organic Compound) and pathogens.

Materials and methods: The study was conducted in three phases in indoor environments in India. Phase1 was conducted in a controlled environment in a laboratory to study the impact of spray on air pathogens. Phase2 was conducted indoors in multi-scenario simulations, and Phase3 was done in a school principal room with reception area.

Results: The study conducted in three phases supports the effectiveness of the spray to reduce air pathogens and the air pollutants viz., $PM_{2.5}$, PM_{10}, HCHO, and TVOC in indoor air environments.

Conclusion: The spray will be an effective, safe, environment friendly and economical solution to reduce indoor air pollution to safe guard human health.

Introduction

Air pollution is one of the key environmental risk factors to health [1]. It has been documented that exposure to $PM_{2.5}$ (particulate matter with an aerodynamic size less than 2.5 mm) and other pollutants in indoor air can primarily cause cardiovascular and respiratory diseases with many other problems like neural tube defects, lung cancer, strokes [2, 3, 4]. There is a significant socio-economic burden of childhood asthma associated with severity of asthma and socio-economic status of the families [5]. Keeping air pollution levels within required minimum limits, there is significant possibility to reduce the burden of diseases like stroke, heart ailments, lung cancer, and both chronic and acute respiratory diseases, including asthma. People will be able to keep overall good health with the lower levels of air pollution, not only in short-term but also in long-run.

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The Air quality guidelines of World Health Organization (WHO) provide an assessment of the health effects of air pollution and thresholds for health-harmful pollution levels [6]. It was identified that in 2014, approximately 92% of the world population was unable to live in places with good air quality according to WHO guidelines levels. Similarly, it was identified that major population in India resides in poor air quality conditions [7]. The fine particles in air pollution cause inflammation in one's body especially in lungs and liver. A recent study revealed that compounds in certain plant extracts/oils can reduce the inflammation caused by breathing in these pollutant fine particles [8]. These compounds, known as phenylpropanoids, act as antioxidants and have amazing anti-inflammatory powers. Researchers put these powers to the test by applying them to liver and lung cells damaged by fine particle air pollutants. They found that these compounds lowered levels of two pro-inflammatory cytokines (proteins that body releases when it's inflamed) by 87% and 96%. It's the first-time scientists have found evidence that compounds in natural essential oils can counteract inflammation from polluted air.

The author, using plant-based active nano extracts, has developed a technological breakthrough which is a simple, safe and effective solution (referred as 'spray' in the paper) to poor air quality by reducing pollutants and pathogens in air. The spray herbal contents act as neutralizing agents which float in the air to neutralize the pollutants and pathogens in the air. It is a 100% natural spray of herbal extracts that reduce $PM_{2.5}$, PM_{10}, volatile organic compound (VOC), Formaldehyde (HCHO), air-borne pathogens, carbon dioxide (CO_2), and spores and fungus.

The aim of this paper is to study the impact of the plants' extract solution (spray) in improving the indoor air quality by reducing the $PM_{2.5}$, PM_{10}, HCHO, and TVOC (Total Volatile Organic Compound) and pathogens.

Materials and methods

The study was conducted in three phases in indoor environments in India. Phase1 was conducted in a controlled laboratory set-up to study the impact of the spray on pathogens in air. It was conducted at Devansh testing and research laboratory private limited which is NABL (National Accreditation Board of Testing and Calibration of Laboratories) certified. Part of the tests on pathogens was done through the Four Plate test to map efficacy and anti-microbial action of the spray on the air microbes. The spray was also tested on total bacterial, yeast and mould count, E. Coli, Salmonella, Pseudomonas aeruginosa and Staphylococcus aureus.

Phase 2 was conducted with multi-scenario simulations. This second phase of the study was done with four control group simulations in the indoors day-to-day working environment. First simulation scenario was an empty room with no person occupation, the second was a cabin with single person occupation, third was a meeting room with 3-4 persons, and fourth was a large office area with 25-30 persons. $PM_{2.5}$ levels were studied, for each simulation, to assess the duration of effectiveness of the spray. Mann-Whitney Test and Confidence Interval (CI) were used to analyse the statistical valid reading of $PM_{2.5}$ levels during pre- and post-usage effect of the spray. An air quality monitor 'The Atlanta Healthare AirVisual Node' was employed to record the $PM_{2.5}$ levels.

Phase 3 was done in a school that is in the school principal room and associated reception area. It

was a setting where persons were moving in and out from the room and reception area. The spray was done in the room and the reception area, and at time intervals the existing $PM_{2.5}$, PM_{10}, HCHO, and TVOC measures have been recorded for three consecutive days. The air quality was measured with the help of 'Air Quality Detector'.

In all the three phases, the spray was done in all the corners of the room and towards the ceiling. The amount sprayed was approximately 1% of the room area. In other words, it can be said that for one square foot of area less than 1 ml of spray was used. The air monitor used in Phase 2 (measuring the only $PM_{2.5}$) and Phase 3 (measuring $PM_{2.5}$, PM_{10}, HCHO and TVOC) were different depending upon the availability of the monitor.

The spray was done with the help of slow release micro-fog atomizer (like the one - http://www.nozzle-network.com/products/microfog.html). The micro-fog system enables the neutralizing agents in the spray to float in the air to neutralize the air pollutants and pathogens.

Results and discussion

Phase 1

The air microbial monitoring was done within a controlled environment. Viable microbes were reported before spray and 4 h after spray in 3.6×2.4 m room (Table 1). There was a reduction of 68-93% microbes after spray in the controlled laboratory room. The test shows a significant change towards a low level of microbes with the application of the spray in the indoor environment. The spray was also tested satisfactorily on total bacterial count, yeast and mould count, E. Coli, Salmonella, Pseudomonas aeruginosa and Staphylococcus aureus (Table 2).

Table 1. Bacteria pathogen plate test in laboratory (report No. DTRLF-100118080)

Description	Microbial examination in 3.6×2.4 m room (in colony forming unit [cfu])		Percentage reduction in microbes after the spray
	Before Spray	After Spray	
Plate1 in LAF	18	2	88.88
Plate 2 in LAF Floor	25	8	68.00
Plate 3 in sterility section gate	23	5	78.26
Plate 4 in sterility mid-point	15	1	93.33

Table 2. Microbial contamination test in the laboratory (Report No. DTRLF-100118076)

Microbial Test for	Result
Total bacterial count	Less than 10 cfu/ml
Total yeast and mould count	Less than 10 cfu/ml
E. Coli	Absent in 1 ml
Salmonella	Absent in 10 ml
Pseudomonas aeruginosa	Absent in 1ml
Staphylococcus aureus	Absent in 1ml

Microbes are found in all indoor environments even in airplane cabins due to various sources including human bodies [9], and in households with unclean air conditioning and/or keeping the temperature-controlled air without ventilation [10]. It is studied that microbial pathogens in indoor environments may cause various infections and may lead to acute diseases [11]. The spray will be effective to control and reduce the microbes in indoor air and will help humans to safeguard their health from day-to-day air microbes in their living environments.

Phase 2

The second part of the study was conducted with four control group simulations (refer to Table 3). All four simulations have shown statistically significant improvement with a 95% confidence level. In an empty room with no occupant; there was an improvement of 44% in $PM_{2.5}$ post application of the spray and 20% improvement was seen in the first 30 min of post application. $PM_{2.5}$ levels had shown an upward shift only post 4 h.

In a cabin with single person occupation; there was an improvement of 52% in $PM_{2.5}$ post ap-

Table 3. Four control group simulations results

Simulation scenario	Mann-Whitney Test and CI: pre and post
Empty room with no occupation	Pre: N=277, Median = 95.300 Post: N=365, Median = 42.000 Point estimate for n1 – n2 = 53.300 95% CI for n1 – n2 (52.600, 54.100) W = 139608.0 Test of n1=n2 vs n1≠n2 significant at 0.0000
Cabin with single person occupation	Pre: N=182, Median = 115.10 Post: N=200, Median = 55.00 Point estimate for n1 – n2 = 61.00 95% CI for n1 – n2 (60.10, 61.90) W = 53053.0 Test of n1=n2 vs n1≠n2 significant at 0.0000
Meeting room with 3-4 persons	Pre: N=300, Median = 93.100 Post: N=300, Median = 52.000 Point estimate for n1 – n2 = 40.900 95% CI for n1 – n2 (40.099, 41.900) W = 135150.0 Test of n1=n2 vs n1≠n2 significant at 0.0000
Large office area with 25-30 persons	Pre: N=181, Median = 75.600 Post: N=210, Median = 33.000 Point estimate for n1 – n2 = 42.000 95% CI for n1 – n2 (41.000, 42.600) W = 54481.0 Test of n1=n2 vs n1≠n2 significant at 0.0000

plication of the spray and 20.4% improvement was seen in 30 min post application. There was a noticeable upward shift in $PM_{2.5}$ levels around post 3 h which was an outlier due to cooking in adjoining room. However, the $PM_{2.5}$ levels again came down significantly post 30 min and shown an upward shift only post 4.

In a meeting room with 3-4 persons; there was an improvement of 44% in $PM_{2.5}$ post application of the spray and 20% improvement was seen 45 min post application. $PM_{2.5}$ had shown an upward shift only post 3.5 h.

In a large office area; there was an improvement of 56.4% in $PM_{2.5}$ post application of the spray and 21% improvement was seen 30 min post application. $PM_{2.5}$ levels shown an upward shift only post 3 h.

In each category space or simulation, significant improvement has been observed. The improvement in $PM_{2.5}$ was in the range of 45-56%. The effect of the spray on air quality stayed for a duration of close to 6 h. Observed and recorded improvement was steady, and continued to improve progressively.

Indoor air quality becomes more harmful in comparison to outdoor air quality due to a build-up of air pollutants in closed inner spaces [12]. Various chemicals (like floor cleaners), fragrances (like perfumes), smoke (like, from cigarette smoking, while cooking, from candles) and other day-to-day indoor activities results in adding air pollutants to indoor environments [13]. Fine particulate matter $PM_{2.5}$, at initial stages with low levels, results in a number of health concerns including headaches, sneezing, low-order respiratory disorders; which used to result in more severe conditions over prolonged exposures [4]. The spray usage can help to keep the $PM_{2.5}$ levels in control for keeping good health. Some measures can be taken to manage indoor air pollutant like controlling cigarette smoking, heavy usage of perfumes and cleaning agents; and over and above keep circulating the indoor air. However, pollutants still are there due to daily activities for which spray can help keeping good human health in a natural way.

Phase 3

The air pollutants viz. $PM_{2.5}$, PM_{10}, HCHO, and TVOC were measured in the school environment within the principal room and the adjoining reception area. It was observed that on day1 the HCHO and TVOC levels were reduced by 80% and 76% respectively post the 4-h spray application. However, there was a steady and continuous decrease in the pollutants level. During the same time duration, the $PM_{2.5}$ and PM_{10} were reduced by 54% and 55% respectively (Table 4 – day 1).

On day 2, the levels of HCHO and TVOC were reduced by 90% and 89% respectively over a duration of around 4.5 h post-spray. During the same time period along with HCHO and TVOC, there was a drop in $PM_{2.5}$ and PM_{10} levels by 70% and 69% respectively. Level of $PM_{2.5}$ and PM_{10} were reduced in comparison to day1 by 16% and 14% respectively. On day 2, $PM_{2.5}$ and PM_{10} measures were high at the beginning of the day but still, the effective reduction was quite evident from the numbers. For example, PM_{10} decreased from 163 to 119 almost within half an hour time. Overall, there was a continuous reduction in pollutant levels over the period of time (Table 4 – day 2).

On day 3, the $PM_{2.5}$ and PM_{10} levels were on the lower side at the time of the spray application and each decreased by 24% during the next 4.5 h. It

can be assumed that there might be some effect of the continuous spray usage from the last two days in keeping the low levels of $PM_{2.5}$ and PM_{10} at the time of spray on day 3. Similarly, there was a reduction is HCHO and TVOC levels by 84% and 77% respectively during almost the same time period (Table 4 – day 3).

It can be interpreted that regular application of the spray will help to keep pollutants at low acceptable levels. In the identified school area, the air quality is likely to be varied as affected by frequent movement of people, and therefore, the spray application can help to protect from air pollutants.

Table 4. Measure of air pollutants in the school

Day 1					
Time (h)	HCHO	TVOC	Time (h)	$PM_{2.5}$	PM_{10}
09:38	0.080	0.585	09:38	39	66
10:10	0.068	0.527	10:10	35	60
10:41	0.054	0.390	10:41	25	41
11:38	0.019	0.200	11:38	21	35
12:45	0.013	0.110	12:45	19	34
13:41	0.009	0.076	13:41	18	30
Percentage reduction	80%	76%		54%	55%
Day 2					
Time (h)	HCHO	TVOC	Time (h)	$PM_{2.5}$	PM_{10}
09:53	0.075	0.555	09:53	89	163
10:26	0.096	0.693	10:25	57	119
10:53	0.051	0.38	10:53	39	70
11:05	0.018	0.15	11:04	31	53
12:02	0.013	0.084	12:02	30	51
13:11	0.015	0.069	13:11	27	51
14:29	0.008	0.064	14:25	27	51
Percentage reduction	90%	89%		70%	69%
Day 3					
Time (h)	HCHO	TVOC	Time (h)	$PM_{2.5}$	PM_{10}
09:57	0.055	0.389	09:55	30	51
10:27	0.019	0.070	10:26	25	43
10:55	0.017	0.157	10:55	32	54
11:57	0.009	0.095	11:57	23	39
13:15	0.012	0.094	13:18	24	43
14:33	0.009	0.090	14:33	23	39
Percentage reduction	84%	77%		24%	24%

It has been assessed that 90% of one's time is normally spent indoors like in homes, schools, work places. Poor indoor air quality is primarily affected by PM, TVOC, HCHO and microbes say pathogens, which are also more likely to affect children, older people, and persons already suffering from a respiratory illness [14]. HCHO is considered to be a troublesome indoor air pollutant. Besides a cause of a number of ailments like eye irritation, headaches and upper respiratory infections, it may cause cancer [15, 16].

The usage of spray can help to reduce air pollutants and pathogens within acceptable levels and will help in providing good health and well-being in general.

The spray is a natural product consisting of herbal extracts and no side effects were seen and recorded during any of the test conducted during all the three phases.

Conclusion

The study conducted in three phases supports the effectiveness of the spray to control the air pollutants and pathogens, and thus to improve the air quality. This will, in turn, result in effective breathing and in maintaining improved respiratory health. The reduction in microbes and air pollutants with the application of the spray will result in a reduction of respiration distress, the spread of diseases/ infections, and pathogens in the air. The spray can be used without any side effects in any indoor environments. The study can be further extended to determine the effectiveness of the spray in outdoor spaces. The future study can also collect the spray users' response in a structured manner to determine the user experience of air quality after the use of the spray.

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Competing interests

The author declares that there is no conflict of interest.

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Ethical considerations

This is an original article and has not previously been published by any other publication. Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy) have been completely observed by the author.

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