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EFFECT OF VAYU NIRVISHIKARANA YOGA IN REDUCING LABORATORY-INDUCED BTEX GAS EXPOSURE: AN ANALYTICAL STUDY

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ABSTRACT :

Introduction: Air pollution remains a critical environmental challenge due to rapid industrialization and urban growth. Indoor air pollution, in particular, poses a greater risk to professionals exposed to harmful substances for prolonged periods. Those working in chemical laboratories are highly vulnerable to volatile organic compounds (VOCs) like benzene, toluene, ethylene, and xylene, which are known carcinogens and pose severe health risks. While modern technologies exist to reduce indoor air pollution, Ayurvedic texts suggest traditional methods such as *Dhoopana Karma*, which involves fumigation with natural substances to purify the air and mitigate chemical hazards effectively. **Objective:** This study aims to evaluate the impact of *Vayu Nirvishikarana* yoga in reducing BTEX gases and compare its effectiveness with the conventional Exhaust Ventilation method. **Materials and Methods:** A comprehensive literature review was conducted from credible sources. *Vayu Nirvishikarana yoga* was formulated following traditional Ayurvedic principles, and preliminary analytical studies were performed. The protocol involved conducting *Dhoopana* twice daily for six days. Fume samples were collected using an automatic vacuum suction pump and condensed in distilled HPLC-grade diethyl ether and petroleum ether. Total of 24 samples were collected over a period of 6 days of the study. These samples were analysed using Gas Chromatography-Mass Spectroscopy (GC-MS) with the Shimadzu TQ 8050 Plus and HS-20. Descriptive statistical tests and t-test were employed. **Results:** The *Vayu Nirvishikarana yoga*, prepared in *churna* (powder) form, exhibited an aromatic odour, high water solubility, and contained phytochemicals such as steroids, flavonoids, alkaloids, tannins, carbohydrates, and reducing sugars. *Dhoopana* significantly reduced hazardous compounds like Bis(2-ethylhexyl) phthalate, Diethyl Phthalate, and Butylated Hydroxytoluene in BTEX samples. The exhaust ventilation method showed no substantial improvements. **Conclusion:** GC-MS analysis confirmed that *Dhoopana* with *Vayu Nirvishikarana yoga* may prove to be more effective than exhaust ventilation in eliminating toxic chemicals, enhancing workplace safety.

KEYWORDS: Indoor air pollution, *Vayu Nirvishikarana yoga*, BTEX, *Dhoopana.*

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1. INTRODUCTION

Environmental toxicity is caused by the bioaccumulation of hazardous substances that can be physical, chemical, or biological. The problem of hazardous material bioaccumulation grew more pronounced following industrialisation and modernisation. Though environmental toxicity didn't pose an important concern in the past, when we review the conventional texts of Ayurveda, we can see that these issues were studied and sufficient significance was given with the idea that only a healthy environment allows for a healthy life.[1]

The air quality index has deteriorated to the point where around 91% of the population lives in the regions with air quality that goes above World Health Organisation (WHO) limits. Every year, around 7 million people succumb as a result of air pollution, with lung cancer, stroke, and heart disease accounting for one-third of these deaths. Automobiles, industry, home sources, indoor pollutants, and so on are primary sources of air pollution.[2]

People spend a significant portion of their daily lives indoors, which is a crucial microenvironment. Indoor air pollution is more likely to affect the population than outdoor pollution because of longer exposure times. Gas exposure is a common hazard observed in the Research Laboratories. The laboratory air can contain a variety of gases released during chemical reactions, such as hydrogen sulphide, benzene, acetone, and ammonia. Prolonged exposure to these gases may result in short-term impacts such as mental disorientation and headaches, as well as long-term health effects such as carcinogenicity. The contemporary strategy employs "Exhaust Ventilation" to lower gas concentrations in laboratories. This mechanism, however, does not negate the impact of the gases discharged into the atmosphere.[3]

Chemical disinfectants have been used for sanitation and disinfection all over the world. However, microbial resistance is commonly found from their use during the transitional period. Furthermore, continuous exposure to these chemicals is detrimental to the environment and can cause a variety of respiratory, allergy, and skin issues in those who are exposed to them.[4]

As a consequence, an attempt is made to apply the traditional *Dhoopana* technique to minimise the consequences of indoor air pollution in laboratories, with the objective to enhance the air quality index and the quality of life of professionals working in such settings.

Air pollution:

The term "air pollution" refers to the substances, such as gases, mixtures of gases, and particulate matter, that are present in the ambient air. These are produced by human activity in quantities that are harmful to people's health, safety, and comfort.[3] Air pollution is defined as the contamination of the indoor and outdoor environment by a chemical, physical, or biological factor that alters the natural properties of the atmosphere.[5]

More than 90% of the global population resides in areas with air quality that is not suitable for breathing, resulting in approximately 4.2 million deaths annually as of 2016. [6,7] Air pollution has

been associated with various acute and chronic health conditions, such as lung cancer, chronic obstructive pulmonary disease (COPD), and cardiovascular disease. Statistical data indicates that ambient air pollution is responsible for approximately 16% of lung cancer deaths, 25% of deaths related to chronic obstructive pulmonary disease (COPD), 17% of deaths caused by ischemic heart disease and stroke, and around 26% of respiratory infection-related deaths worldwide. [8]

Indoor Laboratory Air pollution

A significant portion of daily lives are spent indoors, which is a crucial microenvironment. Because of the extended exposure, interior air pollution is more likely to have an impact on the populace than outdoor pollution.[3]

As organic gases are frequently utilised as reagents or released as byproducts of numerous chemical reactions, the atmosphere inside research laboratories frequently becomes overburdened with them. Many of them are odourless and hence go unnoticed.[9]

Factors influencing the amount of indoor air pollutants in laboratories: In chemical laboratories, ventilation rate and pollutant source strength are the two key determinants of indoor air quality (IAQ). Building characteristics including moisture damage, building supplies, furnitures and cleaning supplies are other variables that may be relevant.[10]

Number of variables, including the rate of emission at the source, the air exchange rate, the concentration of the pollutant, the amount of time spent inside, and the weather, affect the amount of time people are exposed to airborne pollutants.[11,12,13,14]

Volatile Organic Compounds

Human cancer has been linked to volatile organic chemicals such toluene, benzene, ethylbenzene, and xylene. [15,16] The quantities of volatile organic compounds (VOCs) have actually grown as a result of the use of new goods and materials. VOCs can negatively impact human health [17] and contaminate indoor air. [18] There are both immediate and long-term negative impacts on human health. VOCs are blamed for the smells that are perceived in indoor air. Eye, nose, throat, and mucosal membrane irritation are blamed on short-term exposure, while hazardous effects are linked to long-term exposure.[18] It is challenging to anticipate the hazardous consequences complex VOC combinations will have since these contaminants may have a synergistic, antagonistic, or neutral impact.[17,18,19,20].

***Dushita Vayu* in Classical texts**

The scriptures written by the *Acharyas* describe the idea of pollution in general and go into great detail on the health risks it poses as well as the process of purification.[21]

In *Kalpasthana, Acharya Sushruta* describes in great detail how to employ "*Vayu Nirvishikarana yoga*" to purify the air through the *Dhoopana* process and so improve the air quality index.[22]

The term "*Janapadodhvansa Rogas*" refers to the disease that spreads by way of epidemics when a large number of people become ill and desolate an area. The symptoms of *Samanya vayu* (Normal Air), *Vikruta vayu* (Polluted Air), and *Visha dushita vayu* (Poisoned Air) have also been explained by

Acharya Charaka in *Vimana Sthana* chapter 3 where *Desha* (Land), *Vayu* (Air), *Jala* (Water) and *Kala* (Season) are all affected.[23]

- *Vikruta Vayu Lakshana* – This type of air is known to cause illness by being excessively damp, quick, harsh, chilly, hot, rough, blocked, and horribly noisy; unduly conflicting with one another and influenced by an inappropriate odour, vapour, gravels, dust, and smoke.[24]
- Effects and Characteristics of polluted air – It is a sign that the wind and the smoke (of the atmosphere) are poisoned when birds descend from the sky in a fatigued state. Additionally, among those inhaling the same wind and smoke, an attack of cough, nasal discharge, headache, and serious eye disorders occurs.[25]
- Purification of polluted air – When the air is poisoned, burning the herbal remedies in the environment will help to purify the air. These medicated vapours clean the noxious air.[26]

Literature on *Dhoopana* (Fumigation)

The classics provide a remarkable discussion of the indications and symptoms of the effects of contaminated air, treatment, and steps to be taken to purify such an atmosphere. "*Dhoopana*" is one such measure that is referenced in the classical Ayurvedic texts. Modern medical research covers several ailments that are airborne and also recommends strategies for purifying dirty air.[27]

Dhoopa is a blend of medicinal substances that is burnt in a certain method to produce smoke.[28] The process of yielding fume through the slow incineration of different medicinal plants, herbo-minerals, and medication from animal origin for fumigation is known as *dhoopana*.[29] *Dhoopana* promotes an aseptic atmosphere by destroying germs, hence preventing infection. It solely uses natural substances that are safe for both the environment and humans.

For this technique, *Agni* and *Vayu Mahabhoota Pradhan Dravyas* are typically employed. These have the qualities of *Laghu, Sheeta, Ruksha, and Vishada*. These characteristics of the *dravyas* contribute to their swift spreadability and combustion. The majority of *dravyas* have volatile tendencies. Their volatility would be an apparent advantage in reducing microbial contamination on hard-to-reach surfaces and in the air. Additionally, data reveals that these oils have potent antioxidant characteristics, which are advantageous qualities to fend off organoleptic deterioration caused by free radicals. [30,31]

Ayurvedic fumigation is an instance of delivering medications via inhalation, which has multiple benefits such as ease of administration, effective bioavailability, and the capability to permeate the blood brain barrier. [32,33,34]

Proposed mode of action: It is considered to dilate blood vessels and aid in oxidation of blood. It results in appropriate tissue oxygenation and perfusion. Thus, removes infection, decreases inflammation and itching.[35] To an extent, the widespread utilisation of these *dhoopana dravyas* with their numerous characteristics will play a vital role in regulating microbial load, resulting in significant reduction in the pollution and its harmful effects.

According to *Ayurvedic* texts, *Dhoopana* is recommended for *Rakshoghna Karma*, which

implies the killing of pathogenic bacteria.[36] Therefore we can consider that there are no side effects reported during the *Dhoopana karma*.

In this formulation, the majority of drugs possess *Katu, Tikta Rasa, Ushna virya* and *Katu vipaka*. Drugs including *Haridra, Ativisha*, and *Vakra* have anti-poisonous characteristics. *Haridra, Ativisha, Kushta, and Tagara* are examples of drugs with antimicrobial properties.[37]

AIM AND OBJECTIVES

Aim of the study: To explore ancient air purification measures on BTEX Gases.

Objective of the study:

To analyse the effect of *Vayu Nirvishikarana yoga* in alleviating BTEX gases.

To compare the efficacy of *Vayu Nirvishikarana yoga* with the standard practiced protocol of "Exhaust Ventilation" method on BTEX gases.

2. MATERIALS AND METHODS

Sources of data:

- **Literature:** Classical text and conventional text books, journals and other books were referred from central library and digital data was obtained from related websites in digital library of Shri BMK Ayurveda Mahavidyalaya.
- **Materials:** Materials used in the *Vayu Nirvishikarana yoga*

1. Raw drugs for preparation
2. Analysis of *Vayu Nirvishikarana yoga*

Study Drug details:

Vayu Nirvishikarana yoga has been mentioned in *Sushruta Samhita, kalpa sthana; jangama visha vijnaniyam kalpa*: 3rd chapter, 17 sloka.[22]

Table 1. List of ingredients of *Vayu Nirvishikarana Yoga*, Botanical name with its official part used and Pharmacological actions.

Sl.no	Sanskrit name	Latin name	Family	Official part	Pharmacological Actions
1.	*Laksha* [38]	*Lacifera lacca* Kerr.	Lacciferidae (Coccideae)	*Niryasa* (Exudate)	Antiseptic.[5]
2.	*Haridra* [39]	*Curcuma longa* Linn.	Zingiberaceae	*Kanda* (Rhizome/Tuber)	Anti-bacterial, Anti-fungal, Insecticidal.
3.	*Ativisha* [40]	*Aconitum heterophyllum* Wall.	Ranunculaceae	*Mula* (Root Tuber)	Anti-bacterial, Psycho-stimulant, CNS-inhibitor.
4.	*Abhaya* [41]	*Terminalia chebula* Retz.	Combretaceae	*Phala majja* (Fruit rind)	Anti-septic, Anthelmintic, Anti-inflammatory.
5.	*Abda* [42]	*Cyprus rotundus* Linn.	Cyperaceae	*Mula* (Tuber)	Anti-microbial, Anthelmintic.
6.	*Harenuka* [43]	*Vitex agnus* Castus Linn.	Verbenaceae	*Patra, Mula, Beeja*	Anti-bacterial, Anti-microbial, Anti-filarial.
7.	*Ela* [44]	*Elettaria cardomomum* Maton.	Zingiberaceae	*Beeja* (Seeds)	Anti-microbial.

8.	*Dala* [45]	*Cinnamomum tamala* Nees.	Lauraceae	*Patra* (Leaf)	Anti-bacterial, Anti- microbial, Anti-viral, Anti-fungal
9.	*Vakra* [46]	*Valeriana wallichi* DC.	Valerianaceae	*Mula* (Root)	Antibiotic, Anti-amoebic, Anti-bacterial.
10.	*Kushta* [47]	*Saussurea lappa.*B.Clarke	Astraceae	*Mula* (Root)	Insecticidal, Anti-bacterial, Antiseptic.
11.	*Priyangu* [48]	*Callicarpa macrophylla* Vahl.	Verbenaceae	*Phala, Pushpa, Patra, Twak*	Anti-inflammatory.

Materials used in analytical study

- Collection of the samples using a glass funnel, bent glass tubes, Conical flask and an automatic Vacuum suction pump. Distilled HPLC grade Diethyl Ether and HPLC grade Hexane is used as solvents.
- Analysis performed by Gas Chromatography Mass Spectroscopy MS (GCMSMS) TQ 8050 Plus with HS-20 at Department of SAIF – DST Centre, Shivaji University, Kolhapur 416004.

Methodology

- Procurement, authentication and analysis of raw drugs
- 11 drugs were purchased KLE's Ayurveda Pharmacy, Khasbag Belagavi.
- All the procured drugs were authenticated at AYUSH Approved Drug Testing Laboratory for ASU Drugs, at KAHER's Shri B.M.Kankanawadi Ayurveda Mahavidyalaya, Post Graduate Studies and Research Center, Shahapur Belagavi.

Method of Preparation

A. Preparation of *Vayu Nirvishikarana yoga:*

- The required parts of the drugs are taken, cleaned and dried well in shade.
- The individual drugs are then pound into powder using a Pulveriser.
- The powder is collected and sieved through sieve of 20 mesh size to obtain moderately coarse *Churna*.
- Individual *churna* are mixed in the quantity of equal proportions and used for the purpose of *Dhoopana*.

Packaging and Storage – Stored in an Air tight container to avoid contact with moisture.

Gas sampling protocol for the study

- An indigenous sample collection technique was developed to meet the requirements. Basic setup was made using a glass funnel, bent glass tubes, conical flask and an automatic Vacuum suction pump. The conical flask was filled equally with required quantity of Distilled HPLC grade Diethyl Ether and HPLC grade Hexane as solvents and later plugged with the rubber cork with two openings.
- Ethical Clearance was obtained from the Institutional Review Board and the concerned authority of the Study site.
- *Dhoopana* with *Vayu Nirvishikarana Yoga* was done by sprinkling 200-250 grams of powder over the burning charcoal for 20-30 minutes.
- The aromatic fumes were collected by directing them into the funnel and by switching on the vacuum pump to create suction in the flask to

facilitate the absorption of the fumes into the solvent.

- The fumes are to be concentrated in the conical flask and the flask was to be shaked timely to promote dissolution of the fumes into the solvent. The flask was kept undisturbed for 10-15 minutes.
- The solvent was transferred to suitable conical flask, sealed properly and transported to the centre where the sample was subjected to gas chromatography analysis.
- Both BTEX and *Dhoopana* samples were collected through the procedure mentioned above.
- The procedure was repeated twice a day for 6 days. No blinding or randomization was done for sample collection as the data obtained by GC-MS needs to be tabulated day-wise.
- The air exhaust sample was collected in the similar way after exposure of BTEX gases and *Dhoopana*.
- The study did not include repeated trials in different environments or different laboratories and there was no control group.
- GCMS was carried out at Department of SAIF – DST Centre, Shivaji University, Kolhapur 416004, with the instrument Gas Chromatography Mass Spectroscopy MS (GCMSMS) TQ 8050 Plus with HS-20, under following specifications:

Column Oven Temp. : 50.0 °C; Injection Temp. : 250.00 °C; Injection Mode: Direct;

Flow Control Mode: Linear Velocity; Pressure: 54.4 kPa; Column Flow: 1.01 mL/min;

Linear Velocity: 36.5 cm/sec; Purge Flow: 3.0 mL/min;

Oven Temp. Program

Rate	Temperature (°C)	Hold Time(min)
-	50.0	4.00
6.00	150.0	4.00
6.00	200.0	4.00
6.00	250.0	4.00

Ion Source Temp: 200.00 °C; Interface Temp. : 270.00 °C; Solvent Cut Time: 6.00 min; Mode of Detector Gain: Relative to the Tuning Result; Detector Gain: 1.17 kV +0.00 kV; Threshold: 0

Statistical tests:

- Descriptive Statistics: For unmatched compounds, evaluated based on mean, max, and distribution.
- Independent Two-Sample t-Test: Applied to assess statistical differences in compound concentrations.

The tests were done using SPSS software.

3. OBSERVATIONS AND RESULTS:

Observations during Pilot Study: Pilot study was conducted to see the feasibility of the protocol and necessary changes were made. During the conductance of pilot study, it was observed that collection of air samples from the "Exhaust Ventilation" system was tedious and difficult due to the arrangement of the Gas collection setup. Initially, samples of the pilot study showed presence of Phthalates and other plastic components during the analysis because of the use of plastic laboratory equipment for collection and transportation of samples.

Observations during Sample Collection: During collection of *Dhoopana* samples, the bent tubes

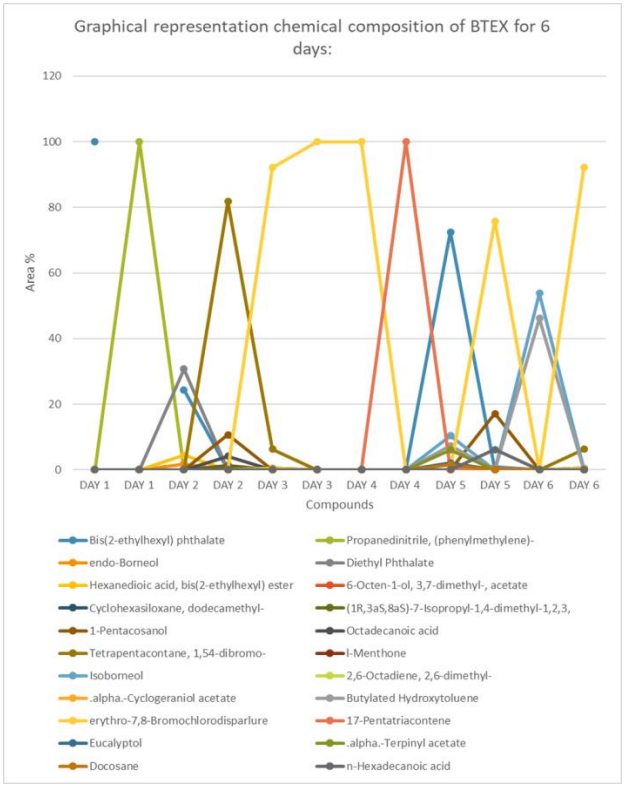
and the conical flask appeared foggy and hazy with whitish fumes. Strict protocols were followed while sampling to avoid contamination.

The experimental design did not include replication under varying environmental or laboratory conditions, nor did it incorporate a control group.

Interpretation of Gas Chromatography-Mass Spectrometry reports

Table 2. Principle compounds in BTEX samples:

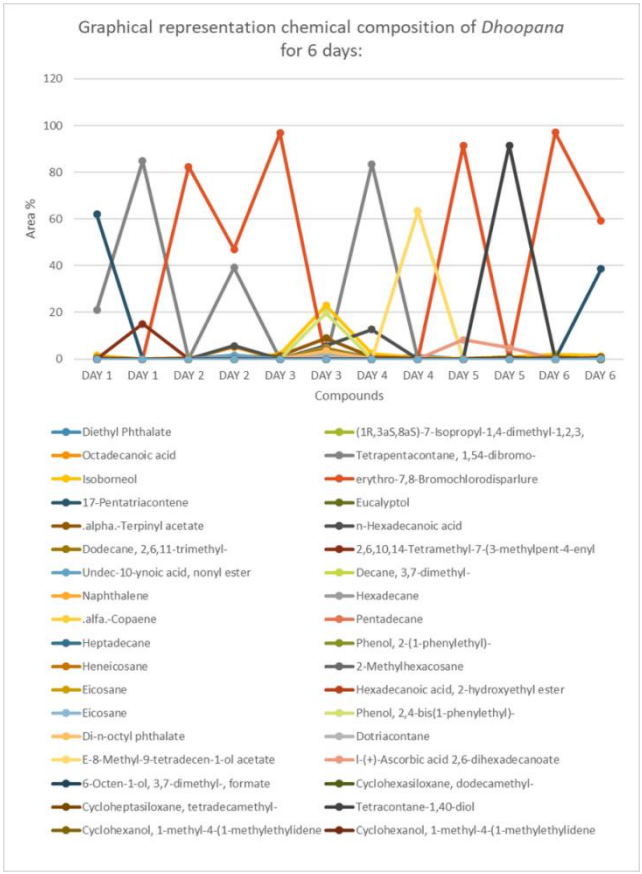
Sl.No	Principle compounds	Concentration in %
1.	Bis(2-ethylhexyl) phthalate	24.36% to 100.00%.
2.	Diethyl Phthalate	0.87% to 30.75%.
3.	(1R,3aS,8aS)-7-Isopropyl-1,4-dimethyl-1,2,3,	0.18% to 0.87%.
4.	1-Pentacosanol	10.64% to 17.10%.
5.	Tetrapentacontane, 1,54-dibromo-	6.25% to 81.81%.
6.	Isoborneol	0.29% to 53.83%.
7.	Butylated Hydroxytoluene	0.05% to 46.17%.
8.	erythro-7,8-Bromochlorodisparlure	75.83% to 100.00%.



Graph 1. Graphical representation chemical composition of BTEX for 6 days:

Table 3. Principle compounds in *Dhoopana* samples:

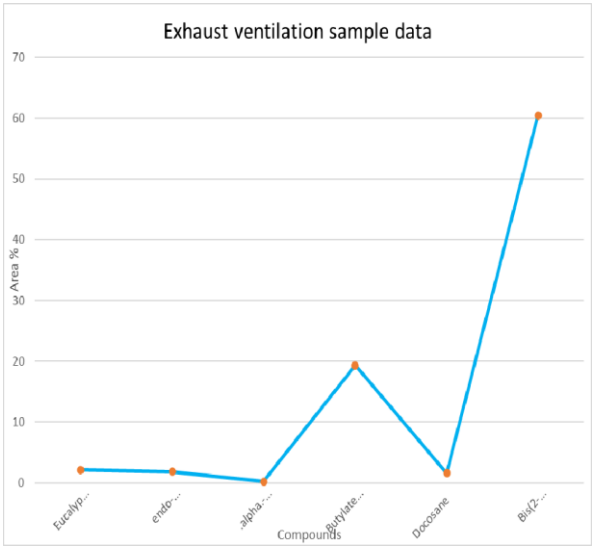
S.No	Principle compounds	Concentration in %
1.	Eucalyptol	0.39% to 3.83%.
2.	Isoborneol	0.38% to 22.89%.
3.	.alpha.-Terpinyl acetate	0.17% to 8.93%.
4.	Tetrapentacontane, 1,54-dibromo-	20.90% to 84.88%.
5.	17-Pentatriacontene	38.59% to 62.01%.
6.	erythro-7,8-Bromochlorodisparlure	46.97% to 97.05%.
7.	Diethyl Phthalate	0.64% to 4.67%
8.	n-Hexadecanoic acid	5.59% to 12.63%.
9.	l-(+)-Ascorbic acid 2,6-dihexadecanoate	4.74% to 8.18%.



Graph 2. Graphical representation chemical composition of *Dhoopana* for 6 days:

Table 4. Chemical composition of exhaust ventilation sample:

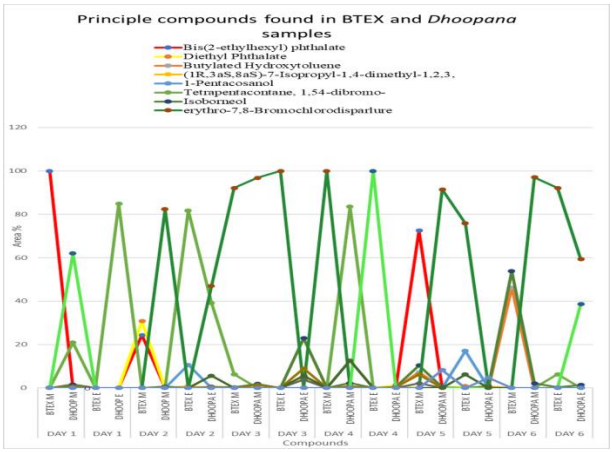
Compounds	M. Formula	M. Weight	Rt	Content %
Eucalyptol	$C_{10}H_{18}O$	154	9.970	2.12
endo-Borneol	$C_{10}H_{18}O$	154	14.018	1.82
.alpha.-Cyclogeraniol acetate	$C_{12}H_{20}O_2$	196	19.099	0.21
Butylated Hydroxytoluene	$C_{15}H_{24}O$	220	23.097	19.33
Docosane	$C_{22}H_{46}$	310	39.083	1.61
Bis(2-ethylhexyl) phthalate	$C_{24}H_{38}O_4$	390	44.885	60.47



Graph 3. Exhaust ventilation sample data

Table 5. Principle compounds and their concentration in BTEX and *dhoopana* samples

Compound Name	BTEX (%)	Dhoopana (%)	Comparison
Bis(2-ethylhexyl) phthalate	24.36 – 100.00	Absent	Present only in BTEX
Diethyl Phthalate	0.87 – 30.75	Absent	Present only in BTEX
1R,3aS,8aS)-7-Isopropyl-1,4-dimethyl-1,2,3,	0.18 – 0.87	Absent	Present only in BTEX
1-Pentacosanol	10.64 – 17.10	Absent	Present only in BTEX
Tetrapentacontane, 1,54-dibromo-	6.25 – 81.81	20.90 – 84.88	Present in both
Isoborneol	0.29 – 53.83	0.38 – 22.89	Present in both
Butylated Hydroxytoluene (BHT)	0.05 – 46.17	Absent	Present only in BTEX
erythro-7,8-Bromochlorodisparlure	75.83 – 100.00	46.97 – 97.05	Present in both
Eucalyptol	1.12	0.39 – 3.83	Present in both
α-Terpinyl acetate	6.12	0.17 – 8.93	Present in both
17-Pentatriacontene	Absent	38.59 – 62.01	Present only in Dhoopana
n-Hexadecanoic acid	2.60	5.59 – 12.63	Present in both
l-(+)-Ascorbic acid 2,6-dihexadecanoate	Absent	4.74 – 8.18	Present only in Dhoopana



Graph 4. Principle compounds found in BTEX and *Dhoopana* samples

Table 6. Summary of Principle compounds present in Dhoopana Sample (Using Mean of Concentration Ranges)

Compound	Min %	Max %	Mean %
Eucalyptol	0.39	3.83	2.11
Isoborneol	0.38	22.89	11.635
α-Terpinyl acetate	0.17	8.93	4.55

Tetrapentacontane, 1,54-dibromo-	20.90	84.88	52.89
17-Pentatriacontene	38.59	62.01	50.30
erythro-7,8-Bromochlorodisparlure	46.97	97.05	72.01
Diethyl Phthalate	0.64	4.67	2.655
n-Hexadecanoic acid	5.59	12.63	9.11
l-(+)-Ascorbic acid 2,6-dihexadecanoate	4.74	8.18	6.46

Table 7. Compounds of Exhaust ventilation sample

Compounds	Content %
Eucalyptol	2.12
endo-Borneol	1.82
.alpha.-Cyclogeraniol acetate	0.21
Butylated Hydroxytoluene	19.33
Docosane	1.61
Bis(2-ethylhexyl) phthalate	60.47

- Descriptive statistical analysis of the Dhoopana sample identified key compounds with considerable variation in their concentration ranges. As summarized in Table 6, the highest mean concentrations were observed for *erythro-7,8-bromochlorodisparlure* (72.01%), *tetrapentacontane, 1,54-dibromo-* (52.89%), and *17-pentatriacontene* (50.30%). Among the volatile constituents, eucalyptol (2.11%), isoborneol (11.64%), and α-terpinyl acetate (4.55%) were notable.
- In contrast, the exhaust ventilation sample (Table 7) revealed a markedly different chemical profile. The predominant compounds included *Bis(2-ethylhexyl) phthalate* (60.47%) and *butylated hydroxytoluene* (19.33%), neither of which was prominent in the original Dhoopana mixture. Eucalyptol (2.12%) appeared in both samples at similar concentrations.
- An independent two-sample t-test was performed to compare the mean concentrations of compounds shared between the two samples. Statistically significant differences ($p < 0.05$) were observed, indicating compositional changes during Dhoopana combustion and subsequent release into the environment.

4. DISCUSSION

Discussion on the quantity of *Vayu Nirvishikarana yoga* used for *Dhoopana*:

200 to 250 grams of *Vayu Nirvishikarana yoga* was used for performing *dhoopana*. The quantity was decided depending on the dimension of the room which was approximately 20x20 square feet. A thorough assessment of the literature was conducted to estimate the quantity.

Discussion on Chemical composition of BTEX and *Dhoopana* samples:

Bis(2-ethylhexyl) phthalate and Propanedinitrile, (phenylmethylene)- are the documented Plasticizers.[49]

17-Pentatriacontene, a proven anti-inflammatory, anticancer, antibacterial, and antiarthritic phytochemical [50] was found in the concentration of 62.01% during *Dhoopana*; persisted in the BTEX sample in maximum concentration. n-Hexadecanoic acid classified as palmitic acid with the properties like antioxidant, antifibrinolytic, hypocholesterolemic, anti-androgenic, 5-alpha reductase inhibitor [51] was persistently identified in the *Dhoopana* samples of Day 2, 3 and 4 in the

concentrations of 5.59%, 5.61% and 12.63% respectively. It was identified in BTEX sample of Day 5 at the rate of 6.2%. Tetrapentacontane, 1,54-dibromo- an effective antioxidant and with antibacterial activity [52,53] attained the concentrations of 20.09%, 84.88%, 81.81% and 83.55% consistently during *Dhoopana*. Presence of Isoborneol with properties of Antibacterial, analgesic, antiacetylcholine, antibronchitic, antiinflammatory, antipyretic, antispasmodic, CNS-stimulant, choleretic, hepatoprotective, inhalant, insect-repellent etc [54] was in concentration of 10.36% in BTEX sample of Day 5. erythro-7,8-Bromochlorodisparlure, an organochloride with the Antioxidant, analgesic property [55] was observed in highest concentration in the *Dhoopana* samples consecutively for 5 days and was also found in maximum level in BTEX samples. .alpha.-Terpinyl acetate demonstrating anti-cholinesterase, anti-oxidative, anti-amyloidogenic and neuroprotective potential [56] was identified in the *Dhoopana* sample in the concentration of 8.93% and it persisted in the BTEX sample of Day 5 in the level of 6.12%. Tetracontane-1,40-diol, a principle component of volatile oils was found maximum (91.57%) in *Dhoopana* sample of Day 5.

Most of the identified chemicals are Volatile compounds of the drugs used in the formulation. The Presence of Few Plant Phytochemicals in the BTEX Samples after the Day 1 And 2 can be comprehended that the plant components persist in the Indoor Environment due to continuous performance of *Dhoopana*. Presence of Saponins in *Vayu Nirvishikarana yoga* was justified by the presence of Heptadecane, Dodecane etc in GCMS report.[57]

According to Balkrishna A et al, the observed particle nature of the *Dhoopana* indicates that it might serve as a suitable substitute for chemical-based fumigation to expurgate locations that are hard to reach. *Vayu Nirvishikarana Yoga* fumes were found to be safe on actively growing A549 human lung epithelial cells when subjected to *Vayu Nirvishikarana Yoga* ventilated growth media for 24 h. This study was completed by following all the safety guidelines. The study concluded that *Vayu Nirvishikarana Yoga* satisfied a crucial standard of non-toxicity.[58]

Exhaust Ventilation sample contained trace amounts of Plant components when compared to the larger concentration of compounds like Butylated Hydroxytoluene (19.33%) and Bis(2-ethylhexyl) phthalate (60.47%). *Dhoopana* with *Vayu Nirvishikarana yoga* was considered preferable over the Exhaust ventilation method because with the Exhaust the gases are merely flushed out, but *Dhoopana* aids in chemical neutralisation.

The comparative analysis between Dhoopana and Exhaust ventilation samples highlights the superior efficacy of Dhoopana in enhancing indoor air chemistry. Notably, Dhoopana demonstrated greater chemical diversity, with both higher mean and peak concentrations of volatiles. Moreover, a larger number of bioactive agents were identified in Dhoopana-treated environments, suggesting its potential as a more effective intervention for air purification or bioactivity enhancement compared to traditional exhaust ventilation systems.

Laksha, Haridra, Ativisha, Abhaya, Abda, Harenuka, Ela, Dala, Vakra, Kushta, and *Priyangu* are medicinal products formulated as *Vayu Nirvishikarana yoga*. According to the classics, most of the medications used here are *Vishaghna* such as *Haridra, Ativisha, Abhaya, Abda, Vakra, Priyangu*, and *Krimighna* such as *Harenuka, Ativisha*, and *Haridra*. The presence of these medicinal products with anti-toxic characteristics can justify *Vayu Nirvishikarana yoga's* ability to mitigate the chemical components.

The risk of contamination was minimum during collection of the samples because the obtained samples were immediately transferred to the sampling container and sealed well. Minimum contamination was observed during performance of Gas Chromatography studies.

The limitation of the study lies in the methodology used for gas sample collection during *Dhoopana*, which needs to be improved and standardized.

CONCLUSION

Dhoopana with *Vayu Nirvishikarana yoga* was found effective in nullifying Bis(2-ethylhexyl) phthalate, Diethyl Phthalate and Butylated Hydroxytoluene. Plant components like erythro-7,8-Bromochlorodisparlure, 17-Pentatriacontene, n-Hexadecanoic acid, l-(+)-Ascorbic acid 2,6-dihexadecanoate etc were consistently present in both BTEX and Dhoopana samples; comparatively in higher concentrations in the *Dhoopana* samples. Presence of plant components substantiate that along with nullifying the synthetic chemicals, they persist for a longer time imparting the aroma and sustained action.

Data comparison between Dhoopana samples and Exhaust ventilation samples supports that Dhoopana was comparatively more effective in terms of Chemical diversity, Higher mean and peak concentrations and greater number of bioactive agents compared to Exhaust ventilation. To conclude *Dhoopana* with *Vayu Nirvishikarana yoga* can negate the hazardous chemicals in the indoor environment thus making it safer for the personals at the site.

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