The Formaldehyde, TVOCs, PM2.5 and PM10 Concentrations at Outdoor Street Food in Kalasin, Thailand

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Received: 4 April 2024; Revised: 18 October 2024; Accepted: 22 October 2024; Available online: 24 October 2024

Abstract

Human health and well-being are directly impacted by air quality. Cardiovascular and respiratory problems have been linked to exposure to pollutants such as formaldehyde, total volatile organic compounds (TVOCs), and particulate matter 2.5 and 10 micrometers (PM2.5 and PM10). This study aimed to quantify formaldehyde, TVOCs, PM2.5, and PM10 levels in the outdoor air at street food vendors in Kalasin, Thailand. The study was conducted at street food vendors in the province of Kalasin. Formaldehyde values at the top five food stalls in Kalasin ranged from 0.58 to 1.41 mg/m^3. The PM2.5 values ranged from 2.29 to 9.43 ug/m3, and the TVOC values ranged from 2.91 to 7.02 ug/m3, with PM10 concentrations ranging from 2.86 to 7.29 ug/m3. Drawing on data about these pollutant concentrations across five distinct locations, the following recommendations can be put forth: Elevated levels of formaldehyde, TVOCs, PM2.5, and PM10 in certain areas can have detrimental effects on the environment and human well-being.

Keywords: Formaldehyde, street food, particulate matters, volatile organic compounds, environmental pollutants

Introduction

Human health and well-being are significantly influenced by air quality, especially in urban areas where pollution exposure is frequently higher. Particulates in the air such as formaldehyde, total volatile organic compounds (TVOCs), and particulate matter 2.5 and 10 micrometers (PM2.5 and PM10) have been the focus of much research due to their harmful effects on respiratory and cardiovascular health. Previous research has demonstrated that poor air quality in environments is a result of pollutants from industrial activities, cooking processes, and vehicle emissions (Manisalidis et al., 2020). Street food vendors play a big role in the daily lives and local economy of Kalasin, Thailand. Therefore, the air quality in these areas is a public health concern.

Microscopic particles suspended in water or air are referred to as particulate matter or PM. Aerosols are impermanent particles in the air (Shah & Mishra, 2020). PM2.5 contains particles smaller than 2.5 μm, while PM10 comprises particles smaller than 10 μm. Particles with a diameter of less than 10μm are primarily responsible for the toxicity of suspended particles. The two types of particulate matter that are most concerning from the standpoint of public health are PM2.5 and PM10. PM 2.5 particles increase the risk of dying from heart and lung disease, stroke, and cancer by penetrating deeply into the bloodstream and lungs. Air pollutant emission inventories are essential for understanding the development and transmission of air pollution at the local level as well as for guiding regional air quality management (Cichowicz & Dobrzański, 2021).

Human health and well-being directly depend on the quality of the surrounding air. Respiratory and cardiovascular problems have been linked to exposure to pollutants such as formaldehyde, TVOCs, PM2.5 and PM10 (Ankhy et al., 2021). Exposure to airborne contaminants such as formaldehyde, TVOCs, PM2.5 and

PM10 can have negative effects on human health (Suwanaruang, 2023). Numerous detrimental health impacts, such as cardiovascular diseases, respiratory conditions, and other systemic effects, have been connected to these pollutants. To accurately assess air quality and implement the necessary mitigation measures, understanding both indoors and outside concentrations of these pollutants is crucial (Li et al., 2019). Frequently observed indoor air pollution, formaldehyde is emitted during the burning of furniture, building materials, and other items. Formaldehyde can irritate the throat, eyes, and respiratory system in addition to being associated with a higher risk of developing specific cancers (Maity et al., 2020). Volatile organic compounds (VOCs) are a class of organic compounds found in paints, building supplies, cleaning products, and other products. Among these substances are benzene, toluene, xylene, and other volatile compounds (Bagaber & Kaafil, 2023). Exposure to VOCs has been linked to several health issues, including allergic responses and respiratory discomfort. Microscopic airborne particles suspended in the atmosphere are referred to as particulate matter (PM); PM2.5 and PM10 denote particles smaller than 2.5 and 10 micrometers (Lin et al., 2022). According to Sahu et al. (2023), these particles may originate from outside dust and pollen, automobile exhaust, industrial pollutants, and combustion. Respiratory and cardiovascular problems may arise from the deep entry of PM2.5 and PM10 particles into the respiratory system (Chen et al., 2019).

The purpose of this study is to measure formaldehyde, TVOCs, PM2.5, and PM10 levels near Kalasin's street food vendor vicinity. By understanding the environmental impact of these emissions on both vendors and customers, the potential health risks and advocating for targeted interventions can be identified.

Materials and Methods

Study areas

Formaldehyde, PM2.5, PM10, and TVOCs in the outdoor air at the top five street food vendors in the province of Kalasin (Fig.1) were measured in April 2023. The measurements of air samples were conducted from daylight to evening at the roadside food stands located in Mueang Kalasin District, Kalasin 46000.

Gas Detector Analysis

The JJ013127 gas detector equipped with formaldehyde, PM2.5, PM10, TVOCs, temperature, and humidity sensors, was used to ensure accurate measurements. Particle samplers were employed to measure the PM2.5 and PM10 concentrations at each station. To obtain representative data, the measurements were taken over a predefined period from daylight to evening. Although these samplers collected airborne particles of specific sizes, they were still effective in capturing and measuring PM2.5 and PM1. The formaldehyde and TVOC concentrations were determined using the formaldehyde and TVOC sensors integrated into the gas detector. Certain types of sensors can identify and quantify specific air pollutants. Additionally, the gas detector included a temperature and humidity sensor to gather additional environmental data (Palmisani et al., 2021). Measuring temperature and humidity aids in understanding the state of the air, as these variables influence the behavior and persistence of contaminants in the atmosphere (Laughlin et al., 2020).

Station 1 Grilled Chicken with Papaya Salad

Station 2 Noodles, made-to-order food

Station 3 Traditional grilled pork

Station 4 Red pork rice, chicken rice, and other types of food

Station 5 Tom Yum and Noodle Shop

Figure 1 Five study areas (station 1-5) for TVOCs, formaldehyde, PM2.5 and PM10 at the top five street food vendors in the province of Kalasin

Results

The top five food stands in Kalasin (stations 1-5) sell the following goods grilled chicken with papaya salad, noodles, made-to-order food, traditional grilled pork, red pork, chicken rice, Tom Yum, and other types of food (Fig.1).

Formaldehyde

The formaldehyde (HCOH) concentrations at these study station varied from 0.58 to 1.41 mg/m^3, with station 4 having the highest levels and station 5 having the lowest levels (Fig.2).

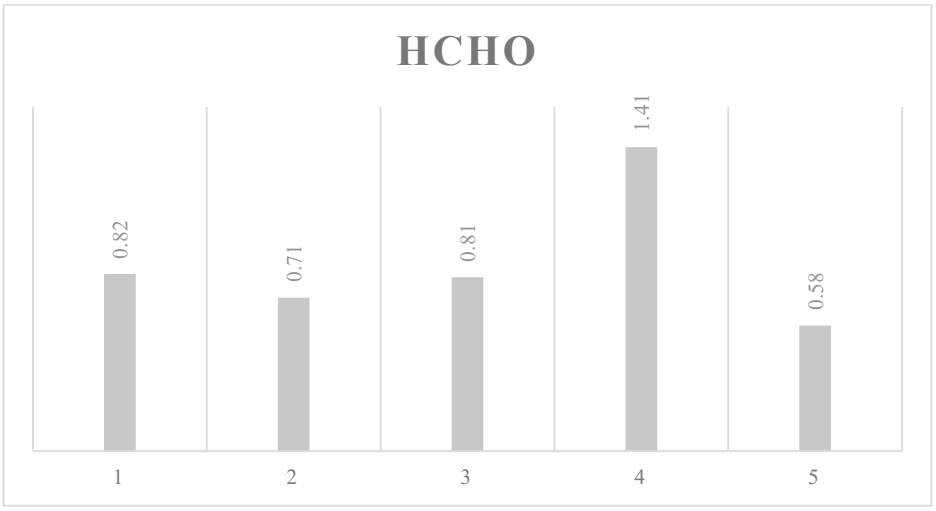

Figure 2 The amount of formaldehyde in the food stalls at all five stations

TVOCs

TVOC concentrations in the food stalls at each of the five sites, were 4.56, 3.88, 4.86, 7.02, and 2.90 ug/m^3 (Fig.3). The station 4 had the highest and station 5 had the lowest amounts.

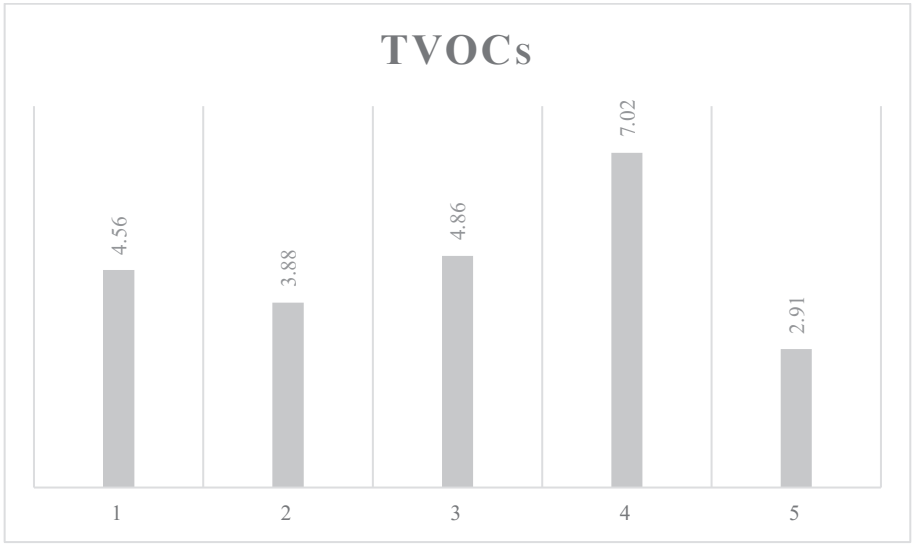

Figure 3 The amount of TVOCs in the food stalls at all five stations

PM 2.5

PM2.5 concentrations in food stalls at each of the five stations were as follows:3.43, 3.86, 9.43, 4.29 and 2.29 ug/m^3 (Fig.4). The result showed that station 3 had the highest concentration, while station 5 had the lowest PM2.5 concentration.

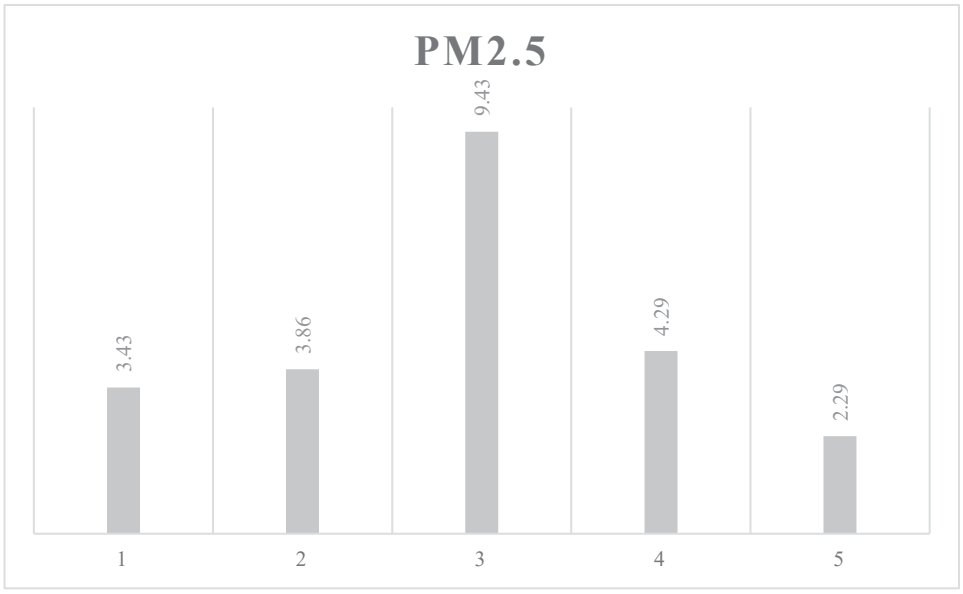

Figure 4 The amount of PM2.5 in food stalls at all five stations

PM 10

The results showed that the range of PM10 values was 2.86 to 7.29 ug/m^3 (Fig.5), with Station 3 having the highest concentration and station 2 and 5 having the lowest.

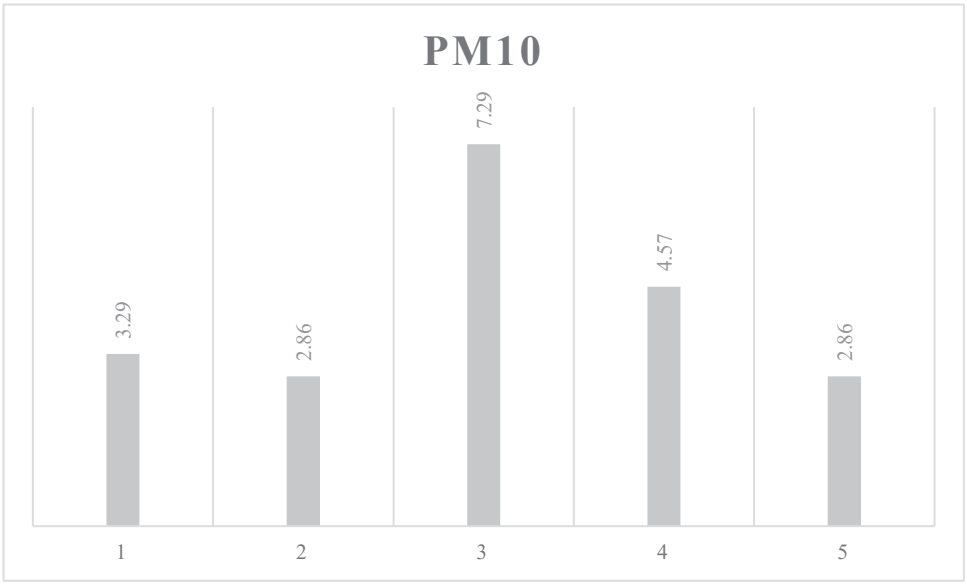

Figure 5 There are PM10 levels in food stalls at all five stations

Discussion

The study provides targeted insights into a region with a high population density and potential exposure to pollution by focusing on street food vendors. Several pollutants were measured to give a complete picture of air quality and health risks, including formaldehyde, TVOCs, PM2.5, and PM10. There are differences between five distinct food stall stations regarding formaldehyde, TVOCs, PM2.5 and PM10 concentrations, and other air quality metrics. These changes could substantially impact the comfort and health of both personnel and customers in food stalls. Here is a more thorough explanation of the results. The air quality research at street food vendors in Kalasin, Thailand, offers valuable information about the local levels of formaldehyde, volatile organic compounds (TVOCs), PM2.5, and PM10. It's critical to contrast these results with related studies conducted in other areas to put them in context.

The levels of formaldehyde in Kalasin varied from 0.58 to 1.41 mg/m³. The study's formaldehyde readings are much higher than the WHO's 30-minute exposure threshold of 0.1 mg/m³ (WHO, 2021). This suggests that formaldehyde levels in Kalasin could pose health risks, especially for prolonged or frequent exposure. The high levels may be possible as a result of various emission sources or environmental factors. A volatile chemical molecule, formaldehyde, can be hazardous to human health at large doses (Baldelli et al., 2020). It is often associated with indoor air pollution and can irritate the eyes and lungs (Yin et al., 2021). The highest formaldehyde levels at station 4 are concerning and investigating potential sources of formaldehyde emissions at this station, such as building materials or cleaning supplies, may be necessary (Bej et al., 2021). Formaldehyde emissions reduction strategies such as more ventilation or using formaldehyde-free materials may be essential (Shen et al., 2021).

The range of TVOC levels in Kalasin, 2.91 to 7.02 μg/m³, is significantly lower than those found in Gorakhpur, India, where outdoor TVOC levels at roadside locations ranged from 134.94 ppb to 163.88 ppb (Masih & Lall, 2016). This suggests that the TVOC levels in Kalasin, while relatively high, are still within a lower range compared to other environments. The proximity of street food vendors in Kalasin could contribute to the higher TVOC levels due to the cooking activities involved. TVOCs are a group of chemical compounds that can be harmful to human health (Cincinelli & Martellini, 2017). High TVOC concentrations can exacerbate indoor air pollution and lead to discomfort (Mozaffar et al., 2020). Similarly, station 4 had the highest TVOC readings, indicating the need for further investigation to identify and minimize the sources of TVOC emissions. This would help create a healthier environment for residents and visitors.

The present study's findings the PM2.5 range from 2.29 to 9.43 μg/m³, which is generally below the WHO's 24-hour mean guideline of 15 μg/m³ but above the more stringent annual mean guideline of 5 μg/m³ (WHO, 2021), indicating sporadic higher exposure that might be harmful over time. This implies occasionally high concentrations that could be detrimental to one's health if they persist. The present study's findings, which range from 2.86 to 7.29 μg/m³ for PM10, greatly exceed the 24-hour mean guideline of 45 μg/m³ (WHO, 2021), suggesting that PM10 levels in the study area are well within acceptable ranges based on WHO guidelines.

The range of PM2.5 concentrations was 2.29 to 9.43 μg/m³ and 2.86 to 7.29 μg/m³ for PM10. The World Health Organization (WHO, 2021) states that 15 μg/m³ is the recommended limit for PM2.5. In addition, average PM2.5 concentrations were found to be 26.7 μg/m³ and PM10 concentrations to be 39.0

μg/m³ in Bangkok, Thailand, according to a comparative study (WHO, 2021). The PM levels in the area of study in Kalasin are concerning even though they are lower than those in Bangkok (Chirasophon & Pochanart, 2020), especially in light of the limited influence of street food vendors.

Particulate matter, including PM2.5 and PM10, might worsen the air quality and lead to health problems (Tran & Thai, 2023). The prevalence of particulate pollution in indoor environments is attributed to various sources, including cooking activities, prolonged indoor exposure, and external pollution exposure (Ali et al., 2021; Baiturina et al., 2023). At station 3, the levels of PM2.5 and PM10 were consistently high. This suggests a higher concentration of particles, potentially stemming from factors such as cooking fumes or inadequate ventilation (Bagaber & Kaafil, 2023). All stations should prioritize maintaining acceptable indoor air quality by installing appropriate ventilation systems and carrying out routine maintenance (Sharma et al., 2019). By locating and addressing specific sources of pollution, such as using low-emission building materials, installing suitable ventilation systems, and controlling culinary emissions, air quality can be greatly improved (Zaporozhets et al., 2020). To enable prompt remedial action, it is critical to monitor changes in air quality parameters frequently (Canha et al., 2018). By teaching food stall personnel about the importance of air quality and suitable ventilation measures, it is possible to create a healthy workplace for both patrons and employees (Faour et al., 2023).

The findings of previous studies suggest that Indonesian children, especially those in Surabaya, are at a higher risk of adverse health effects due to exposure to elevated levels of air pollution. In Indonesia schools, formaldehyde, and PM2.5 concentrations were significantly higher than the WHO's guidelines, with formaldehyde levels ranging from 0.004 to 1.160 ppm and PM2.5 concentrations from 0.023 to 0.432 ppm (Prasasti et al., 2021). A Portuguese preschool study assessed the potential health risks associated with exposure to various PM fractions. While concentrations of PM10, PM2.5, carbon monoxide (CO), carbon dioxide (CO_2), and formaldehyde generally adhered to legal limits, TVOC levels exceeded permissible standards. The current study contributes to the understanding of indoor air quality in early childhood education settings, particularly focusing on the element composition of PM2.5 and PM10. The concentrations of formaldehyde, CO, fine and coarse PM, and CO_2 were found to comply with Portuguese regulations for indoor air quality in public buildings (Oliveira et al., 2016).

PM2.5 is the most prevalent form of air pollution in many countries, including China. PM2.5 contains numerous photoactive substances, but the process of photochemical aging caused by PM2.5 is not well understood. A recent study by Xia et al. (2020) investigated the photoaging of real PM2.5 samples collected in Beijing during 2017 and 2018. The study found that PM2.5 undergoes significant photochemical aging, leading to the formation of new and potentially more harmful pollutants.

The findings have immediate application to the local context, and Kalasin public health officials and policymakers will find the recommendations to be more relevant and helpful. Since the study only examines five locations, it may not be an accurate representation of Kalasin's overall state of air quality. Expanding the count of observation sites could potentially produce a more comprehensive image. The study is probably a snapshot in time. Long-term monitoring would help understand trends and seasonal variations in pollutant levels. While tracking pollution levels, the study does not identify the specific sources of emissions. Understanding the sources (car emissions and food preparation, for example) would help with targeted mitigation strategies.

To enhance the study's reliability, expand its duration and monitoring sites. Employ source apportionment to identify pollution sources and their contributions. Educate the public about air quality concerns and integrate findings into local policies. Encourage street vendors to adopt cleaner practices, and conduct health studies to assess the impact of pollutants on the local population.

Conclusion and Suggestions

The study measured formaldehyde, TVOCs, PM2.5, and PM10 levels at street food vendors in Kalasin, Thailand. Results showed elevated concentrations, particularly at Station 4, which had the highest levels of formaldehyde and TVOCs. Station 3 had the highest PM2.5 and PM10 levels due to grilling activities. These findings highlight potential health risks associated with prolonged exposure to these pollutants. The study suggests implementing air quality measures like monitoring, improving ventilation, and using cleaner cooking methods to reduce pollutant levels. Further research is needed to assess the impact of these pollutants on public health and develop targeted interventions.

Acknowledgments

We are grateful to the Pitchayabandit College Faculty of Science and Health Technology, the Faculty of Science and Technology College of Asian Scholars, and the Faculty of Science and Health Technology Faculty of Kalasin University for their support. We also thank our friends, family, and fellow students.

Author Contributions

Author 1 (Suwimol Dobut): Data collection, methodological design, data interpretation and analysis, manuscript editing and review

Author 2 (Sopon Buengbon): Data interpretation and analysis, manuscript review and editing

Author 3 (Theeranat Suwanaruang): Study conceptualization, methodological design, data interpretation and analysis, research, manuscript writing, review, and editing.

Conflict of Interests

The authors declare that he has no competing interests.

Funding

This study was not funded in any way.

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