Dust Pollution in Urban Areas: Current Trends and Implications for Human Health and Outdoor Physical Activities

Nguyen Thi Tuyet*, Nguyen Thi Hong*
*Thai Nguyen University of Science, Viet Nam

DOI: 10.29322/IJSRP.14.05.2024.p14931
10.29322/IJSRP.14.05.2023.p14931

Paper Received Date: 20th April 2024
Paper Acceptance Date: 23rd May 2024
Paper Publication Date: 31st May 2024

Abstract- Dust pollution, particularly particulate matter (PM), is a prominent environmental concern in urban areas of Vietnam. This paper aims to provide an in-depth analysis of the current status of dust pollution, focusing on PM10 and PM2.5 and exploring the impact of PM on human health and physical activity based on a comprehensive review of the literature. The research delved into various aspects of air quality, including the sources of PM, health consequences, and the relationship between outdoor physical activities and exposure to air pollutants. Findings highlighted the adverse effects of high PM on human health and emphasized the importance of considering air quality in outdoor exercise settings. Additionally, the paper discussed the potential benefits of physical activity in low PM environments and suggested practical recommendations, such as choosing exercise locations with good air quality and monitoring air pollution indices for informed decision-making. The comprehensive review contributed valuable insights to the ongoing discourse on mitigating the health risks associated with air pollution, particularly for individuals engaging in outdoor physical activities.

Index Terms**:** *Dust pollution, Particulate matter, Human health**,** physical activities*

I. INTRODICTION

Currently, in major urban areas of Vietnam, the concerning issue of air pollution, particularly dust pollution, prevails. Monitoring data from the Ministry of Natural Resources and Environment for the period 2012 - 2016 indicates that the levels of dust pollution in urban areas remain high, with no signs of reduction over the past five years [1]. While outdoor physical activities are encouraged to promote a healthy lifestyle, engaging in such activities in a dust-polluted environment requires careful consideration. Particulate matter (PM) has diverse potential impacts on human health due to its size-related toxicity. Studies suggest that PM10 and PM2.5 particles are more crucial to human health compared to total suspended particles (TSP). PM10 tends to settle in the bronchi and lungs, while PM2.5 can easily enter the bloodstream, affecting the respiratory and cardiovascular systems and leading to various health issues [2]. This article presents the current status of dust pollution in urban areas of Vietnam, highlighting the effects of dust pollution on human health and outdoor sports and exercise activities.

II. METHODOLOGY

The information presented in the article is gathered and synthesized from secondary sources, including electronic databases and online scientific libraries such as Science Direct, Scopus, Google Scholar, and PubMed. The search process involved utilizing keywords and exploring recent titles of publications and abstracts. Scientific works published in domestic specialized journals, such as the Journal of Science of Hanoi National University, the Journal of Preventive Medicine, and the Journal of Science and Technology of Thai Nguyen, have also been referenced. Additionally, national environmental reports and information from the websites of various organizations and agencies have contributed to the compilation of data. Daily Air Quality Index (AQI) measurements from different localities were obtained from the iqair.com website. These selected databases were scrutinized for studies related to the current status of air pollution in urban areas, the impact of air pollution on health, and the influence on outdoor sports and exercise activities. The author specifically filtered data related to dust pollution to discuss its effects on human outdoor physical activities.

III. RESULTS AND DISCUSSION

3.1. Assessment of Dust Pollution and Its Impact on Human Health

Dust Pollution

This section aims to provide an understanding of the different particulate matter categories and their sources, emphasizing the contribution of PM2.5 and PM10 particles to urban dust pollution. These particles are associated with various human activities and industrial processes, posing a potential risk to public health. The subsequent section will delve into the health implications of exposure to these dust particles and their impact on outdoor physical activities.

Particulate matter (PM) refers to solid or liquid particles. Dust pollution is reflected through suspended particulate matter, including coarse dust (TSP and PM10), fine dust (PM2.5), and ultrafine dust (UFP).

PM2.5 denotes particles with a size equal to or smaller than 2.5 micrometers (μm). PM10 includes particles with a diameter equal to or smaller than 10 μm (but larger than PM2.5). Ultrafine particles (UFP) are dust particles with a size of <100 nm.

Various types of PM2.5 and PM10 particles are formed from substances such as carbon, sulfur, nitrogen, and other metallic compounds. In large cities, fine PM2.5 particles can originate from industrial activities such as fossil fuel combustion, dust from construction sites, street dust, waste incineration, wildfires, industrial smoke, deforestation, cigarette smoke, and, notably, vehicle emissions.

Assessment of Dust Pollution

To evaluate and control air pollution, international organizations, and many countries have established systems of standards and environmental quality regulations. Air quality is considered satisfactory when the environmental parameters meet the values specified in the standards or regulations and fall within permissible limits. In Vietnam, to assess the level of dust pollution in urban areas, the current standards, QCVN 05:2013/BTNMT (National Technical Regulation on Ambient Air Quality) can be applied, replacing QCVN 05:2009/BTNMT.

Assessing the impact of dust pollution on human health requires integrated studies combining environmental research and public health studies [3]. Research subjects may include children, the elderly, young adults, individuals living near traffic routes, industrial areas, or those with existing health conditions. Currently, such studies are more prevalent in various countries worldwide.

The simple Air Quality Index (AQI) is a daily air quality reporting index indicating whether the air is clean or polluted. The health risk for the community increases as the AQI value rises. AQI focuses on the health impact that people may experience within a few hours or days after inhaling polluted air. The U.S. Environmental Protection Agency (EPA) calculates the AQI based on five parameters (O3, PM10, PM2.5, CO, SO_2, and NO_2). This index converts pollutant concentrations into a color-coded scale ranging from 0 to 500, assigning a specific color to each AQI range for easy understanding of air pollution levels in their community (Table 1).

Table 1. Color-coded Scale for PM10, PM2.5 Parameters, and Associated Health Concern Levels

PM10 (μg/m3)	PM2.5 (μg/m3)	AQI Values	Level of Health Concern
0-54	0.0-15.4	0-50	Good
55-154	15.5-40.4	51-100	Moderate
155-254	40.5-65.4	101-150	Unhealthy for Sensitive Groups
255-354	65.5-150.4	151-200	Unhealthy
355-424	150.5-250.4	201-300	Very Unhealthy
425-504	250.5-350.4	301-400	Hazardous
504-604	350.5-500.4	401-500	Hazardous

[EPA's breakpoint and AQI index]

3.2. Current Status of Dust Pollution in Major Urban Areas of Vietnam

In 2010, a study conducted in Hanoi identified the primary source of suspended particulate matter as vehicular emissions, contributing to 86% of PM10 emissions [4]. The 2013 National Environmental Report presented monitoring data from 2008 to 2013, revealing significant differences in Total Suspended Particles (TSP, particles with a diameter <100 μm) concentrations in the ambient air across various urban types. Pollution was notably higher in cities with high traffic density, such as Hanoi and Ho Chi Minh City, and strong industrial activities. The peak pollution levels exceeded the QCVN 05:2013/BTNMT standard by 2-6 times. Dust pollution was also prominent along traffic routes and construction sites, with significantly lower pollution levels in residential areas. In industrial zones, dust concentrations often exceeded regulatory limits, reaching 3 - 4 times the standard at some points [5].

A study by Nguyen et al [6] on the air pollution status in Ho Chi Minh City collected 76 air samples, including 10 PM10 samples, over a week on working days, weekends, and nighttime. Results indicated that PM10 levels in Ho Chi Minh City exceeded permissible standards and those reported in other global studies, particularly on city roads, with a concentration of 177.0 ± 73.7 $\mu g/m^3$.

According to the 2016 National Environmental Report, in urban areas, the primary source of dust pollution was identified as transportation activities. TSP concentrations exceeded the QCVN 05:2013 standard by 2 to 3 times, particularly along major traffic routes. For PM10 and PM2.5, measurements at many traffic stations exceeded the annual average limit specified in QCVN 05:2013/BTNMT. Additionally, industrial production plants in urban areas had TSP concentrations surpassing QCVN limits by 1.5 to 2 times. Construction activities, including residential complexes, houses, bridges, shopping centers, and entertainment areas, also contributed to dust dispersion into the ambient air. Estimated TSP pollutant loads were 2.396 for the year 2020 and 3.632 for the year 2025 [1].

The study conducted by the research team led by Trinh et al [8] at Hanoi University of Natural Resources and Environment collected data on PM2.5 particulate matter levels at two continuous automatic air quality monitoring stations: one located at the Northern Environmental Monitoring Center (formerly the Environmental Monitoring Station), 556 Nguyen Van Cu Street (referred

to as Station TCMT), and the other at 7 Lang Ha Street, part of the U.S. Embassy in Vietnam (referred to as Station DSQ). The average annual PM2.5 levels at both monitoring stations exceeded the permissible limits stipulated in QCVN 05:2013/BTNMT on ambient air quality. Specifically, Station TCMT exceeded the PM2.5 limit by 1.02 times, and Station DSQ exceeded it by 1.7 times

In the World Air Quality Report 2019 [9], which ranks PM2.5 pollution levels in cities and regions, the results of air quality monitoring over the past four years (2016-2019) showed a reduction in average annual PM2.5 concentrations in Hanoi, Ho Chi Minh City, Hue, and Da Nang. The highest average concentration in 2019 was recorded in Hanoi at 46.9 μg/m³, followed by Hue (28.6 μg/m³), Da Nang (25.9 μg/m³), and Ho Chi Minh City (25.3 μg/m³). According to the EPA air quality index, Hanoi had a PM2.5 index in the "unhealthy" range, especially for sensitive individuals. In other cities, the PM2.5 levels were evaluated to have a moderate impact on human health. In 2019, countries and territories in East Asia, Southeast Asia, and South Asia faced the highest annual average PM2.5 concentrations per population. Vietnam ranked 15th globally in average PM2.5 emissions and stood in the second position in Southeast Asia. Hanoi surpassed Beijing in the global ranking and secured the 7th position among capitals worldwide (Table 2) [9].

Table 2. Ranking of Vietnam in terms of average PM2.5 index (μg/m³) globally and in the Southeast Asia region

Rank	World	PM2.5 Concentration (μg/m³)	Rank	Southeast Asia	PM2.5 Concentration (μg/m³)
1	Bangladesh	83.3	1	Indonesia	51.7
2	Pakistan	65.8	2	Vietnam	34.1
3	Mongolia	62.0	3	Myanmar	31.0
4	Afghanistan	58.8	4	Thailand	24.3
5	India	58.1	5	Laos	23.1
6	Indonesia	51.7	6	Cambodia	21.1
7	Bahrain	46.8	7	Malaysia	19.4
8	Nepal	44.5	8	Singapore	19.0
9	Uzbekistan	41.2	9	Philippines	17.6
10	Iraq	39.6	-	-	-
11	China	39.1	-	-	-
12	UAE	38.9	-	-	-
13	Kuwait	38.3	-	-	-
14	Bosnia & Herzegovina	34.6	-	-	-
15	Vietnam	34.1	-	-	-

3.3. Health Risks Associated with Outdoor Physical Activities in Polluted Air

Outdoor physical activities are commonly conducted in public areas, ecological zones, squares, residential areas, and school premises, especially activities like running, walking, and cycling on traffic routes. During physical activities, Individuals engage in intense metabolic exchanges with the environment through respiration, transitioning from nasal to oral breathing. This implies a reduction in the filtering function of the nose against pollutants, leading to increased inhalation of air. If individuals engage in physical activities in an air-polluted environment, are they exposed to dust particles? This question has been examined through various research studies by both domestic and international authors. However, domestic studies on this matter have not received much attention, likely due to limitations in data. collection and literature synthesis. The following are some pieces of evidence regarding the impact of dust pollution on human health and outdoor physical activities, as shown in Tables 3 and 4.

Table 3. Impact of Dust Pollution on Human Health

Reference	Pollutant(s)	Study Population	Associated Health Issues
Slaughter et al [10]	PM10	133 children	Asthma and respiratory conditions
Rückerl et al [11]	Fine particles (UFP, PM10, PM2.5)	57 male patients with heart disease	Inflammation, blood clotting, and coronary events
Chuang et al [12]	PM	76 healthy young university students	Autonomic dysfunction in young individuals
Basagaña et al [13]	PM2.5	2618 elementary school students (average age: 8.5 years)	Impaired cognitive function and decline
Vriens et al [14]	Ultrafine particles (UFP) <100 nm	80 children	Altered salivary microRNA (small RNA molecules) in children's saliva
Yang et al [15]	PM2.5	51 children aged 9-12 years	Impaired Lung function in schoolchildren

Qiu et al [16]	PM10, PM2.5	3892 residents in Wuhan (high air pollution area)	Liver enzymes and hepatic health
Nguyen & Le [3]	PM10	Individuals commuting on four main roads in Hanoi	Estimated personal exposure while commuting by motorbike, walking, car, and bus with dust concentration
Phung et al [18]	PM10	Personal exposure in Ho Chi Minh City	Hospital admissions for respiratory and cardiovascular diseases in Ho Chi Minh City
Ha [19]	Dust and other pollutants	Air pollution in Tan Long Ward, Thai Nguyen City	Quantification of respiratory-related healthcare costs (cough, sore throat, allergic rhinitis, sinusitis, etc.)

Table 4. The impact of dust pollution on physical activities.

Reference	Pollutant(s)	Physical Activity	Results
Slezakova et al [20]	Ultrafine Particles (UFP)	Aerobic activities in parks and streets of children (5-17 years) and adults (18-64 years)	Exposure to UFP during high-intensity exercise (running) is double compared to moderate intensity. Children and adolescents have a 203-267% higher inhalation dose. Inhalation dose in males is 1.1-2.8 times higher than in females. The inhalation dose when walking, commuting, or going to school is 1.6-1.75 times lower than when playing sports.
Endes et al [21]	PM2.5, PM10, Fine Particles	Physical activity of older adults aged 50-81	Physical activity in low-dust environments has no impact on health. However, in high-dust environments, the beneficial effects of exercise are lost.
Kubesch et al [22]	PM2.5, PM10, Fine Particles	Physical activity related to traffic-related pollution	2 hours of exposure to dust pollution from traffic increased white blood cell count.
Bisht et al [23]	PM2.5, PM10	Air quality during the 19th Commonwealth Games in Delhi, India	Average concentrations of PM2.5 and PM10 measured were 229.7 and 112.1 μg/m3, respectively, exceeding the annual average. PM2.5 concentration inside the stadium was 18% lower than outside. Concentrations were higher in the morning and late at night, and lower during the day.

IV. CONCLUSION

Particulate matter (PM) generated in urban areas primarily stems from transportation activities, affecting both human health and physical activity. In environments with low dust concentrations, physical activity has positive effects on preventing diseases. Conversely, in environments with high dust concentrations, intense and prolonged physical activity can impact the respiratory and cardiovascular systems, and induce inflammation, and affect liver enzymes, and cognitive abilities in humans. It is advisable to engage in outdoor physical activities in areas with good air quality, such as parks, eco-friendly zones, or residential areas away from traffic. Regularly monitoring the Air Quality Index (AQI) in the living area is essential to adopt suitable exercise measures and mitigating the adverse effects of pollution.

REFERENCES

1. Ministry of Natural Resources and Environment, *National Environmental Status Report: Air Environment*, 2017, pp. 25-45.
2. M. Krzyzanowski, *Health Impact Assessment of Air Pollution and Communication Strategy*. WHO Europe, 2005.
3. V. H. Nguyen, T.T.H Le, "Health Impacts of Air Pollution in Hanoi: Enhancing Scientific Research and Policies for Health Improvement", *Journal of Preventive Medicine*, 23(4), 2013, pp. 67-76.
4. T. H. Ngo, "Urban Air Quality Modelling and Management in Hanoi, Vietnam" (Doctoral dissertation, Aarhus University, National Environmental Research Institute, Denmark), 2010.
5. Ministry of Natural Resources and Environment, National Environmental Report: Air Environment, 2014.
6. T. Q. H. Nguyen et al., "Current Status of Air Pollution in Ho Chi Minh City", Vietnam, 2018.
7. V. G. Ngo, T. T. Tuyet, T. N. T. Nguyen, *Environmental Pollution*. Hanoi Agricultural Publishing House, 2017.
8. T. T. Trinh et al., "Study on the Impact of Inversion Phenomenon on PM2.5 Levels in the Air in Hanoi", *Journal of Earth and Environmental Sciences, Hanoi National University: Natural Sciences*, 34(3), 2018, pp.1-9.
9. L. Nguyen., D.H. Nguyen, "World Air Quality Report - PM2.5 Rankings of Cities and Regions", *Environmental Solutions*, 2020, pp. 1-35.
10. J. Slaughter et al., "Effects of Ambient Air Pollution on Symptom Severity and Medication Use in Children with Asthma", *Annals of Allergy, Asthma & Immunology*, 91(4), 2003, pp. 346–353.
11. R. Rückerl et al., "Air Pollution and Markers of Inflammation and Coagulation in Patients with Coronary Heart Disease." *American Journal of Respiratory and Critical Care Medicine*, 173(4), 2006, pp. 432–441.
12. K. Chuang et al., "The Effect of Urban Air Pollution on Inflammation, Oxidative Stress, Coagulation, and Autonomic Dysfunction in Young Adults." *American Journal of Respiratory and Critical Care Medicine*, 176(2), 2007, pp. 370–376.
13. X. Basagaña et al., "Neurodevelopmental Deceleration by Urban Fine Particles from Different Emission Sources: A Longitudinal Observational Study", *Environmental Health Perspectives*, 124(10), 2016, pp. 1630-1636.
14. A. Vriens et al., "Recent Exposure to Ultrafine Particles in School Children Alters miR-222 Expression in the Extracellular Fraction of Saliva", *Environmental Health*, 2016, pp. 15, 1-9.
15. X. Y. Yang et al., "Acute Effects of Individual Exposure to Fine Particulate Matter on Pulmonary Function in Schoolchildren", *Biomedical and Environmental Sciences*, 33(9), 2020, pp. 647-659.
16. W. Qiu et al., "Short-term Effects of Air Pollution on Liver Function among Urban Adults in China" *Atmospheric Environment*, 245, 2020. Pp. 118-120.
17. N, T. H., Ketzel et al., "Air Pollution Modeling at Road Sides Using the Operational Street Pollution Model - A Case Study in Hanoi, Vietnam", *Journal of the Air & Waste Management Association*, 60(11), 2012, pp. 1315-1326.
18. D. Phung et al., "Air Pollution and Risk of Respiratory and Cardiovascular Hospitalizations in the Most Populous City in Vietnam", *Science of the Total Environment*, 557, 2016, pp. 322–330.
19. T. Q. Ha, "Quantification of Community Health Care Costs Due to Air Pollution in Tan Long Ward, Thai Nguyen City", *Journal of Science and Technology*, 164(04), 2017, pp. 207 – 213.
20. K. Slezakova, et al "Ultrafine Particles: Levels in Ambient Air During Outdoor Sports Activities", *Environmental Pollution*, 258, 2020.
21. S. Endes et al., "Associations of Novel and Traditional Vascular Biomarkers of Arterial Stiffness: Results of the SAPALDIA 3 Cohort Study", *International Journal of Hygiene and Environmental Health*, 220(6), 2017, pp. 1030-2038.
22. N. J. Kubesch et al., "Respiratory and Inflammatory Responses to Short-term Exposure to Traffic-related Air Pollution with and without Moderate Physical Activity", *Occupational and Environmental Medicine*, 72(4), 2015, pp. 284-293.
23. D. Bisht, et al., "Assessment of Air Quality During 19th Commonwealth Games at Delhi, India." *Natural Hazards*, 66, 2013, pp. 141-154.

AUTHORS

First Author – Thi Tuyet Nguyen, Thai Nguyen University of Science, Viet Nam
Second Author – Thi Hong Nguyen, Thai Nguyen University of Science, Viet Nam
Correspondence Author – Thi Tuyet Nguyen, Thai Nguyen University of Science, Viet Nam
tuyetnt@tnus.edu.vn