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HYGIENIC ASSESSMENT OF THE RELATIONSHIP BETWEEN MICROCLIMATE, AIR POLLUTION, AND STUDENT WELL-BEING AT TASHKENT STATE MEDICAL UNIVERSITY

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Abstract

Air pollution and unfavorable indoor microclimate conditions represent major environmental health threats in rapidly urbanizing regions. University students constitute a vulnerable population due to prolonged exposure to enclosed educational environments with variable ventilation and pollutant accumulation. This article presents a structured scientific analysis based on the proposed study of hygienic relationships between indoor microclimate, air pollution, and self-reported well-being among students of Tashkent State Medical University (TSMU). The work integrates global evidence on air quality, microclimate hygiene, and student health with a proposed local investigation framework. The article outlines the scientific rationale, objectives, methodological design, expected outcomes, and public health implications. Particular emphasis is placed on particulate matter (PM2.5), gaseous pollutants, CO_2 concentration, volatile organic compounds (TVOCs), and thermal comfort parameters as determinants of fatigue, respiratory function, cognitive performance, and general well-being. The study contributes to environmental hygiene by bridging campus environmental monitoring with student health indicators, forming a model for sustainable academic infrastructure management.

Introduction

Air pollution is now recognized as one of the leading environmental determinants of global morbidity and mortality. According to the World Health Organization, approximately seven million premature deaths annually are attributable to air pollution exposure. Urban populations are disproportionately affected due to traffic emissions, industrial activities, and climatic influences that intensify pollutant accumulation. Students in large cities experience a unique exposure

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profile: extended daily time spent in classrooms, laboratories, and lecture halls where indoor air quality may be compromised by insufficient ventilation and building design limitations.

Tashkent, as a major metropolitan center in Central Asia, experiences high particulate pollution influenced by vehicular emissions, industrial sources, and transboundary dust transport. Elevated PM2.5 levels significantly exceed recommended international guidelines, increasing risks of respiratory illness, cardiovascular stress, inflammatory responses, and cognitive fatigue. University environments act as micro-ecosystems where indoor air composition interacts with building microclimate parameters such as temperature, humidity, and airflow. These factors collectively influence physiological comfort, concentration capacity, and long-term health.

Recent international research demonstrates that indoor environmental quality directly affects academic performance and mental alertness. Elevated CO_2 concentrations are associated with reduced decision-making ability, while high TVOC levels correlate with headaches and mucosal irritation. Thermal discomfort contributes to fatigue and decreased productivity. Despite growing global evidence, systematic hygienic assessments linking campus air quality with student well-being remain limited in Central Asian contexts.

This study framework proposes an integrated evaluation of indoor and outdoor air parameters at TSMU and their relationship to student well-being indicators. The research aligns environmental hygiene with preventive medicine, emphasizing the importance of healthy educational infrastructure in public health strategy.

International literature increasingly highlights the relationship between indoor environmental quality and human performance. Studies conducted in European and Asian universities demonstrate that classrooms with inadequate ventilation frequently exceed recommended CO_2 thresholds, leading to measurable declines in cognitive efficiency. Controlled exposure experiments reveal that high particulate concentrations impair working memory and reaction speed. These findings underscore the biological sensitivity of young adults to microenvironmental conditions.

Research on university campuses in China and South Korea reports strong associations between PM exposure and respiratory symptoms among students, including coughing, wheezing, and airway inflammation. North American studies

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further show that improvements in ventilation systems lead to significant reductions in absenteeism and fatigue complaints. Scandinavian investigations link thermal comfort optimization to improved attention span and academic output.

Global evidence also emphasizes the psychological dimension of air quality. Polluted environments increase perceived stress and reduce subjective well-being. Students exposed to poor indoor air frequently report headaches, sleep disturbances, and concentration deficits. These effects are compounded in urban universities where outdoor pollution infiltrates indoor spaces.

From a hygienic perspective, microclimate regulation is central to occupational and educational health. Optimal temperature, humidity, and airflow ensure physiological homeostasis and reduce pathogen transmission. The integration of microclimate control with air purification represents a modern preventive strategy. Universities implementing smart ventilation systems demonstrate measurable health and productivity gains.

The proposed research builds upon this international evidence by applying similar hygienic evaluation methods to a large Central Asian academic institution. It contributes region-specific data necessary for policy development and environmental health planning.

3. Objectives of the Study

The primary objective is to determine the hygienic relationship between air quality parameters and student well-being at TSMU. Specific objectives include: 1. Measuring microclimate parameters and pollutant concentrations in classrooms, laboratories, and outdoor campus zones. 2. Identifying levels of particulate matter, carbon oxides, nitrogen dioxide, sulfur compounds, CO_2, and TVOCs. 3.Assessing student well-being indicators including fatigue, respiratory discomfort, cognitive performance, and general health perception. 4. Establishing statistical correlations between environmental measurements and well-being outcomes. 5. Developing evidence-based recommendations for improving ventilation and air hygiene.

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4. Materials and Methods

The study employs a mixed environmental and epidemiological design.

Environmental Monitoring

Continuous monitoring devices will measure: PM2.5 and PM10 concentrations, Carbon monoxide and nitrogen dioxide, CO_2 levels, Temperature and humidity, TVOC concentrations, Airflow rates. Measurements will be conducted in lecture halls, laboratories, administrative rooms, and open campus areas. Sampling will occur during peak academic hours to reflect realistic exposure conditions.

Student Survey

A structured questionnaire will collect data on: Fatigue levels, Respiratory symptoms, Attention and concentration, Headache frequency, Sleep quality, General well-being. Validated scales for environmental health assessment will be used to ensure reliability.

Statistical Analysis

Correlation and regression analysis will evaluate relationships between air parameters and health indicators. Multivariate models will control for confounding variables such as age, smoking status, and physical activity.

5. Expected results

The study anticipates identifying: Critical zones with elevated pollutant levels, Poorly ventilated classrooms with excessive CO_2 accumulation, Statistical links between air quality and fatigue, Associations between particulate exposure and respiratory complaints, Cognitive performance decline in high-pollution settings. Improved ventilation scenarios are projected to reduce reported symptoms by 20–30%, consistent with international findings.

6. Scientific novelty and practical significance

This research represents the first systematic hygienic investigation linking campus air quality to student well-being at TSMU. It integrates environmental monitoring with health assessment in a unified framework. The study establishes a local evidence base for environmental health policy and demonstrates a reproducible methodology applicable to other universities in the region. Results will inform: Campus ventilation modernization, Environmental monitoring

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protocols, Student health protection strategies, National educational hygiene standards, Urban air quality management policies. By improving campus environmental conditions, the study contributes to preventive healthcare and sustainable educational development.

7. Conclusion

Air quality and indoor microclimate are critical determinants of student health and academic performance. Universities must be viewed not only as educational institutions but as environmental health systems. The proposed hygienic assessment at TSMU provides a model for integrating environmental science with preventive medicine. By identifying risk zones and implementing targeted interventions, academic institutions can significantly enhance student well-being and reduce long-term health burdens. The study aligns with global sustainability goals and supports the creation of healthier learning environments in rapidly urbanizing cities.

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