LESLIE
LAND MANAGEMENT
ENVIRONMENT &
SOLID-WASTE

LAND MANAGEMENT, ENVIRONMENT & SOLID-WASTE: INSIDE EDUCATION AND BUSINESS IN CENTRAL ASIA
ERASMUS-EDU-2023-CBHE Project Number: 101129032

MICRO-CREDENTIAL

CLIMATE CHANGE FOR SUSTAINABLE LAND MANAGEMENT IN CENTRAL ASIA

7.- Cities, Air Quality and Human Health

Case Study

Air Pollution Episode in Almaty and Mitigation Measures

Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

1. Introduction

Almaty, the largest city in Kazakhstan, is widely recognized as one of the most air-polluted cities in Central Asia. Home to more than two million residents, the city serves as an important economic, cultural, and educational center. However, rapid urbanization, increasing energy demand, and growing vehicle ownership have contributed to persistent air quality challenges.

Air pollution has become a major concern because of its effects on human health, quality of life, and environmental sustainability. Although air pollution occurs throughout the year, the most severe episodes are typically observed during winter, when a combination of meteorological conditions and increased emissions creates dense smog that can cover the city for days or even weeks.

The experience of Almaty illustrates how urban development, energy systems, and environmental conditions influence air quality and public health.

2. Air Pollution in Almaty

Several factors contribute to air pollution in Almaty. One of the most important is the city's geographical location. Almaty lies in a basin at the foothills of the Trans-Ili Alatau Mountains. While this location provides attractive scenery and favorable living conditions, it also limits the dispersion of pollutants.

During winter, temperature inversions frequently occur. Under normal conditions, warmer air near the surface rises and allows pollutants to disperse. During an inversion, however, a layer of warm air traps colder air near the ground, preventing vertical mixing of the atmosphere. As a result, pollutants emitted by vehicles, industries, power plants, and residential heating systems accumulate close to the surface where people live and work.

The problem is intensified by increased energy consumption during the cold season. Many households rely on coal-based heating systems, while thermal power plants burn large quantities of fossil fuels to meet heating and electricity demands. At the same time, traffic congestion contributes to substantial emissions of nitrogen oxides, carbon monoxide, and particulate matter.

These combined sources often lead to elevated concentrations of $PM_{2.5}$ and PM_{10}, which are among the most harmful air pollutants due to their ability to penetrate deep into the respiratory system.

3. Human Health Impacts

Air pollution is closely linked to human health outcomes. Fine particulate matter can enter the lungs and, in some cases, pass into the bloodstream. Long-term exposure to elevated concentrations of particulate matter has been associated with increased risks of respiratory and cardiovascular diseases.

In Almaty, poor air quality has been linked to higher rates of respiratory symptoms, asthma exacerbations, chronic bronchitis, and reduced lung function. Vulnerable populations, including children, older adults, and individuals with pre-existing medical conditions, are particularly affected.

The health impacts are not limited to physical illness. Air pollution can also reduce outdoor activity, affect quality of life, and increase healthcare costs. During severe smog episodes, residents may limit outdoor exposure, schools may reduce outdoor activities, and public concern about environmental conditions often increases.

The World Health Organization recognizes air pollution as one of the leading environmental risks to human health worldwide, making urban air quality management an important public health priority.

4. Mitigation Measures

Recognizing the growing environmental and health challenges associated with air pollution, local authorities and national institutions have implemented several mitigation measures.

One important strategy has been the gradual transition from coal-based energy sources to cleaner fuels such as natural gas. Expanding gas infrastructure can reduce emissions from residential heating and industrial activities. Modernization of thermal power plants has also been proposed to improve energy efficiency and reduce pollutant emissions.

Transportation policies play a crucial role in improving urban air quality. Efforts to expand public transportation networks, encourage the use of cleaner vehicles, and improve traffic management can help reduce emissions from the transport sector. Investments in electric buses and low-emission technologies have been considered as part of broader urban sustainability initiatives.

Urban greening projects have also been promoted. Trees and green spaces can provide multiple environmental benefits, including improved urban microclimates, reduced dust levels, and enhanced quality of life. Although urban vegetation cannot solve air pollution problems on its own, it can contribute to a healthier urban environment when combined with emission reduction measures.

Another important component of mitigation is environmental monitoring. Air quality monitoring stations provide information on pollutant concentrations, allowing authorities to identify pollution hotspots, issue public health advisories, and evaluate the effectiveness of environmental policies.

5. Lessons Learned

The case of Almaty demonstrates that air pollution is not solely an environmental issue but also a challenge of public health and urban planning. The city's experience shows how geographical conditions can amplify the effects of human activities, leading to severe pollution episodes.

It also highlights the importance of adopting integrated solutions that address both emission sources and exposure risks. Cleaner energy systems, sustainable transportation, effective urban planning, and continuous monitoring are all necessary components of long-term air quality improvement.

As cities throughout Central Asia continue to grow, the lessons learned from Almaty can help guide future efforts to create healthier and more sustainable urban environments.

6. Discussion Questions

- Why do winter air pollution episodes occur more frequently in Almaty than in summer?
- How do temperature inversions influence pollutant concentrations?
- Which emission sources contribute most to poor air quality in the city?
- How can improving air quality benefit public health?
- Which mitigation measure do you think would have the greatest impact in Almaty and why?

7. References

Kerimray, A., Baimatova, N., Ibragimova, O. P., Bukenov, B., Kenessov, B., Plotitsyn, P., & Karaca, F. (2020). Spatiotemporal Variations and Contributing Factors of Air Pollutants in Almaty, Kazakhstan. Aerosol and Air Quality Research, 20, 1340–1352. https://doi.org/10.4209/aaqr.2019.09.0464

Asian Development Bank (ADB). (2023). Almaty Clean Air Action Plan. Asian Development Bank. Manila, Philippines.

World Health Organization (WHO). (2021). WHO Global Air Quality Guidelines: Particulate Matter ($PM_{2.5}$ and PM_{10}), Ozone, Nitrogen Dioxide, Sulfur Dioxide and Carbon Monoxide. Geneva, Switzerland.