Review

of the scientific advisor on the dissertation work of Madina Orazgazievna Tursumbayeva on the topic «Effect of meteorological parameters on air quality in large cities of Kazakhstan», presented for the Ph.D. degree defense on educational program "8D050204-Meteorology"

Fine particulate ($PM_{2.5}$) pollution poses a serious concern in most cities in Kazakhstan and is a leading cause of premature mortality worldwide. According to estimates from the World Bank, exposure to $PM_{2.5}$ particles is responsible for over 10 thousand premature deaths in Kazakhstan. In 2021, Kazakhstan was ranked 23rd in the international IQAir anti-rating of the most polluted countries in the world, with Almaty and Astana consistently featuring in the top ten polluted cities, especially in the winter months. Despite the severity of this issue, there is a dearth of studies investigating the influence of meteorological conditions on air pollution, particularly $PM_{2.5}$. Addressing this research gap is crucial for developing effective strategies to mitigate the adverse effects of $PM_{2.5}$ pollution and improve public health in Kazakhstan.

Madina Tursumbayeva's Ph.D. dissertation aims to study the relationships between meteorological conditions and pollutant concentrations, with a specific focus on $PM_{2.5}$ in major cities of Kazakhstan and Central Asia. Within the framework of this dissertation, the temporal variations of $PM_{2.5}$ concentrations were examined. The findings revealed that in large cities in Central Asia, the annual $PM_{2.5}$ concentrations exceeded annual WHO standards (5 $\mu g/m^3$) by 4.3-12.6 times. On more than in 42% of all days in a year, the $PM_{2.5}$ concentrations exceeded the WHO daily limit of 15 $\mu g/m^3$. The work also explored the relationships of meteorological parameters such as temperature, wind speed and direction, relative humidity, and precipitation on the $PM_{2.5}$ concentrations.

High $PM_{2.5}$ pollution episodes (20% of highest hourly $PM_{2.5}$ concentrations) were also analyzed for the origin of air masses using the NOAA Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model. The result showed that slow-moving air masses were typical in Almaty (67%), Bishkek (77%), Dushanbe (50%), and Tashkent (70%) for $PM_{2.5}$ pollution episodes. Ashgabat and Astana showed different results with no prevailing back trajectories. Thus, these cities may be potentially susceptible to regional transport of air pollutants, for example, from intensive industrial cities such as Karaganda and Pavlodar.

The study involves an analysis of the impact of planetary boundary layer height (PBLH) on $PM_{2.5}$ concentrations using radiosonde data in Almaty. The findings showed revealed a distinct negative relationship between the daily average $PM_{2.5}$ concentrations and PBLH at 12.00 UTC. For instance, high $PM_{2.5}$ concentrations in winter months (94.0 $\mu g/m^3$) corresponded to a lower PBLH (393 m), and low $PM_{2.5}$ concentrations in summer months (9.9 $\mu g/m^3$) corresponded to a higher PBLH (1970 m). During the colder half of the year, the top 20% of $PM_{2.5}$ concentrations were associated with a lower PBLH (less than 500 m AGL) and calm wind conditions (lower average wind speeds within the PBL and a lower ventilation coefficient). A clear anti-

correlation was also revealed between the concentrations of $PM_{2.5}$ and PBLH in the cities of Almaty, Astana, Ashgabat, Bishkek, Dushanbe, and Tashkent using reanalysis data (ERA5).

The dissertation work also involves a discussion of the current emission inventory estimations used in Kazakhstan as well as in other post-Soviet countries. The $PM_{2.5}$ concentrations in major cities of Kazakhstan as well as in Central Asia are not proportional to their population as it is in other parts of the world. However, the government reports the transportation sector as the major pollution source, which is based on incorrect inventory methodology where air pollutant emissions (PM, SO_2, NO_2, CO, and others) are summed up without consideration of the toxicity of each pollutant. In more developed countries such as the US, Canada, China, and the EU, the share of air pollutant emissions by the source is presented separately for each pollutant. For instance, when the sources in Almaty are presented individually for each pollutant, the results show that 89.5% of CO emissions are emitted from transportation, while almost 90% of PM is emitted by private sector and power plants. Therefore, it is important to separate the sources and pollutants to avoid misleading representation of pollution sources and to implement effective measures to combat air pollution.

During the Ph.D. program, Madina Tursumbayeva demonstrated herself as a qualified, hardworking, and purposeful young scientist, capable of independently conducting research and proposing hypotheses to solve complex scientific tasks. She successfully completed part of her research during an internship between November 2022 and January 2023 at the Institute for Atmospheric and Earth System Research (INAR) at the University of Helsinki (Finland) under the supervision of Ph.D. Professor Tom Kokkonen. Madina Tursumbayeva presented the results of her dissertation research at four conferences: Farabi Alemi, 2021 (Almaty, Kazakhstan); Asian Aerosol Conference, 2022 (Taipei, Taiwan); Second Central Asian Air Quality Conference, 2023 (Astana, Kazakhstan); and 5th International Environmental Chemistry Congress, 2023 (Antalya, Turkey).

In 2023, Madina Tursumbayeva was awarded with the diploma for "Best Young Scientist of Al-Farabi KazNU-2023" and was also included in the list of "Top 10 best young scientists of Al-Farabi KazNU" for the same year.

Research by Madina Tursumbayeva was carried out within the framework of the projects AP09260359 "Comprehensive assessment of air pollution in Almaty: source-apportionment, spatiotemporal assessment" (2021-2023), and BR10965258, "Development of a research program to improve air quality in Nur-Sultan and Almaty using state-of-the-art analytic methods and modeling tools" (2021-2023), funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan.

During her studies, Madina Tursumbayeva published three articles in international peer-reviewed journals included in the Scopus and Web of Science databases: Atmospheric Environment (Q1 WoS, IF – 5.0), Urban Climate (Q1 WoS, IF – 6.4,), Aerosol and Air Quality Research (Q2 WoS, IF = 4.0,) and Environmental Processes, (Q3 WoS, IF = 4.4) focusing on the topic of her dissertation work. All requirements for Ph.D. defense regarding the publications were met.

Considering the significance of the work, scientific novelty, practical value, and volume of the research conducted, Madina Tursumbayeva's dissertation titled: "Effect of meteorological parameters on air quality in large cities of Kazakhstan" meets all the requirements for dissertations of the Ministry of Science and Higher Education of the Republic of Kazakhstan, and Madina Tursumbayeva deserves to be awarded a Ph.D. degree in the specialty "8D050204 - Meteorology".

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