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Artikova, Aziza; Egamberdiev, Bekhzod; Khamidov, Imomjon; Primov, Abdulla

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# **Industrial Pollution and PM2.5 analyses in Oskemen**

### Aziza Artikova\*, Bekhzod Egamberdiev\*\*, Imomjon Khamidov\*\*\*, and Abdulla Primov\*\*\*\*

\* International Agriculture University (IAU), Tashkent, Uzbekistan, <u>Aziza.Artikova@student.rau.ac.uk</u>

\*\* Center for Policy Research and Outreach, Westminster International University in Tashkent (WIUT), 12 Istiqbol street, 100047 Tashkent, Uzbekistan, <u>begamberdiev@wiut.uz</u>

\*\*\* German-Uzbek Chair on Central Asian Agricultural Economics (GUCAE), International Agriculture University (IAU), Tashkent, Uzbekistan, Imomjon.Khamidov@student.rau.ac.uk

\*\*\*\* German-Uzbek Chair on Central Asian Agricultural Economics (GUCAE), International Agriculture University (IAU), Tashkent, Uzbekistan, <u>Abdulla.Primov@iau.uz</u>

### Abstract

Kazakhstan represents one of the largest economies in the Central Asian region. Over recent years, Kazakhstan has experienced a rise in temperature and pollution levels due to its overreliance on fossil fuels in energy industries. The rise in temperature and pollution levels has contributed to the rise of extreme weather conditions, including floods, and the increase in health issues and mortality rates. This working paper analyses the current condition in the Oskemen region of Kazakhstan in terms of air pollution indicators. The manuscript also provides related consequences and solutions to the current environmental problems in the region.

### Introduction

Kazakhstan represents one of the largest economies in the Central Asian region. Over recent years, Kazakhstan has experienced a rise in temperature and pollution levels due to its overreliance on fossil fuels in energy industries. The rise in temperature and pollution levels has contributed to the rise of extreme weather conditions, including floods, and the increase in health issues and mortality rates.

Kazakhstan is one of the largest emitters of carbon dioxide and other greenhouse gases in Central Asia. This is because the energy industry of Kazakhstan uses fossil fuels such as oil and coal. That trend stems from the past when Kazakhstan, as a part of post-Soviet, built coalfired plants to meet the demand of heavy industries and operated coal mines in several regions (Assanov, Zapasnyi et al. 2021). Still, the country heavily relies on oil exports and generates energy from coal reserves. Burning of fossil fuels accounted for carbon dioxide emissions when Kazakhstan was ranked 14th in the world in 2019 for carbon dioxide emissions and 1st in Central Asia (Oladejo, Balogun et al. 2023). Globalization, energy and economic growth can all account for the current environmental problems in Kazakhstan (Oladejo, Balogun et al. 2023).

The pollution levels have an adverse impact with the rise of respiratory disease, coronary diseases, urinary tract diseases, heart attacks, strokes and many others. The same is true for the breast cancer risk in the Aktobe region, which is strongly correlated with the pollution levels (Oladejo, Balogun et al. 2023). It was estimated that the highest mortality rates are in the cities with metallurgical plants such as Balkhash, Temirtau, and Zhezkazgan. Changes in the climate have also accounted for the forest fires in recent years. For instance, in 2022, Kazakhstan faced 800 forest and 111 steppe fires, which is approximately two times more compared to previous years (Oladejo, Balogun et al. 2023). Climate change is a contentious issue in Kazakhstan. The rise in temperature and pollution levels and the increase in the occurrence of extreme natural events such as droughts and floods have not only an impact on population health but also wide-ranging economic activity. Kazakhstan did adopt transition plans, but further actions are also required.

### **Industrial Pollution in Oskemen**

Kazakhstan underwent considerable growth in manufacturing throughout the Soviet era, emphasizing boosting production at the expense of environmental deterioration. Because of the lax environment, industries could not control and stop hazardous waste contamination (WB 2007). Underground and lake waters became contaminated, creating health risks due to inadequate storage for dangerous substances and a shortage of incentives to limit trash creation.

One of Kazakhstan's most significant industrial hubs, Oskemen is home to 300,000 people and is well-known for its massive businesses in nonferrous metallurgy, nuclear power, gold and rare metal factories, heat-generating plants, engineering for mechanical construction, and the agricultural sector. There are 476 manufacturing companies (DB 2025), Lead, iron, zinc, copper, silver, gold, tantalum, niobium, cadmium, antimony, selenium, indium, tellurium, fuel from uranium pellets, titanium as metal beryllium, thallium, magnesium, sulfuric acid, mining machinery, and paints are among the primary goods that can be sold locally. The vast manufacturing sector of Oskemenhas resulted in widespread contamination with dangerous components, such as heavy metals and organic substances, due to negligent environmental laws.

Metallic substances pose an imminent danger to the health of people through respiration and food consumption, particularly toxic non-essential metals such as Pb, Cd, Hg, and Al, as well as necessary elements such as Cu, Ni, and Zn (Boluspayeva, Jakubus et al. 2023). The contaminants originate from a variety of sources, such as mineral extraction, smelting, the steel and iron industries, the chemical sector, and transportation. Wastewater and soil investigations in the proposed region indicate mixed toxins in the aquifer under the town's Central Industrial Complex, threatening the city's primary water consumption wells and living quarters. The existing water on the Ulba and Irtysh waters is unsafe, restricting the city's capacity to obtain safe water for consumption.

According to the experiment of Atanbaeva, Tuleuhanov et al. (2017) on rats in Oskmen, heavy metallic substances in rats' blood may destroy blood cells, decrease immunity, and cause immunological depression, neurological conditions, and bleeding. Leukograms reveal severe alterations to rats' well-being and behavior, all of them dying in 5-6 days. Animals infected with 75-100 times the highest allowable dosage of poisonous metal salts died. Throughout neutrophilia and lymphopenia, rats' blood showed leukopenia with granular toxicity and a gipersigmatich core. The findings revealed severe surface water contamination, notably in the Oskemen region, which is associated with manufacturing residuals and emissions to water outflow.



Map-1: Industrial and waste sites in Oskemen

Source: WB (2008)

The map illustrates the location of industrial complexes. There are many industrial facilities with various factories and plants for zinc production, a metallurgical plant, magnesium and titanium plants, and a sewage tank for a condenser plant. Nevertheless, there are thermal power plants, drinking water intake facilities and a waste disposal area (16). The most important point is that all industrial zones are located between two rivers, the Irtysh and Ulba, which is the main reason for concerns about water pollution in both rivers. Residuals from manufacturing facilities pollute water and soil with hazardous chemical contaminations and air. As a result, people and animals may face health problems.

### Statistics on PM2.5 analyses between March 2024 and February 2025

Because of the large number manufacturing enterprises that pollute the air with residuals, the PM2.5 index is high in Oskemen. PM2.5 is a matter that has a diameter of 2.5 or even can be smaller (Victoria, Trine et al. 2023). Breathing PM2.5 particles can negatively affect human health.

Variable	Obs.	Mean	Std. Dev.	Min	Max
March	31	280.6	26.12	183	289
April	30	287.8	0.698	285	289
May	31	262.7	49.46	56	288
June	17	252.4	39.45	121	288
July	31	242.5	50.89	65	288
August	20	255.8	71.33	55	289
September	5	199.6	127.71	8	288
October	6	106.3	102.97	18	272
November	6	207	96.30	77	288
December	31	284.7	10.89	240	288
January	25	249.2	68.33	35	288
February	28	269.7	49.95	43	288

Table 1. Annual Averaged PM2.5 Concentrations in the Oskemen Region, 2024

Source: AQICN (2025)

According to the statistics on daily indexes of PM2.5 in Oskemen for the last year, for September, October, November and June, there are some missing days without an index of PM2.5. However, it can be seen that in April 2024, Oskemen faced the most polluted air; on average in April, the index of PM2.5 was 287,8. During September, the city witnessed the lowest index, which was, on average, 106.3, but this index is low; as for August, September, October and November, there are missing days without controlling the PM2.5 index. On average, the city had the lowest index in July (all indexes by days are available). A glance at the statistics reveals that on the 22nd of September, Oskemen witnessed the lowest index of PM2.5, which is 8, and the highest index was on the 29<sup>th</sup> of April, 2024.



Figure 1. Monthly Averaged PM2.5 Concentrations by Season in the Oskemen Region, 2024 Source: AQICN (2025)

Last year, Oskemen witnessed 183 days of the highest index of PM2.5, which fluctuated between 280 and 314, an extremely unhealthy (hazardous) environment for everyone. However, the Air Pollution Index (AQI) was around 0-34 only for four days, with no risks to human and animal health. Around 10 days for the last year, AQI was acceptable with fluctuations between 51-100, but still, this index has influences on children and adults who have respiratory issues (asthma, allergy and others). On other days, Oskemen experienced an unhealthy environment, and people might begin to feel health problems, but a group of sensitive people could get serious health issues.



Figure 2. Monthly Averaged PM2.5 Concentrations in the Oskemen Region for 2024

Source: AQICN (2025)

### **Implementing Pollution Control**

Set up emission standards for manufacturing companies. Pollutant emissions into the atmosphere must be reduced in order to preserve the environment and enhance human wellbeing. To deal with the current levels of pollution and lower the emissions of pollutants from different sources, efficient oversight techniques must be created. The creation and implementation of air pollution control technologies are required to lower the pollutants prior to their release into the atmosphere, in addition to control measures including restricting emissions at the source and strengthening air pollution regulations. The term "emissions requirements for stationary sources" refers to specific regulations that restricting or lowering the quantity of pollutants that manufacturing enterprises discharge into the atmosphere. The following should be subcategories of the Oskemen regulations on emissions standards for industries:

#### **Emission standards for power plants.**

For power plants, the emission limit should include concentration limits and monitoring requirements of air pollutants (SO<sub>2</sub>, NOx, PM, CO<sub>2</sub>) from power plants. The standard should be used in managing existing thermal power plant emissions, environmental development of construction projects, design of environmental protection projects, environmental protection checks and acceptance of the completed projects, and post-operation management of air pollution emissions.

#### Emission standards for industrial processes chemical manufacturing.

Closed loop systems and catalytic oxidation technologies are meant to reduce VOC emissions in accordance to standards. Ammonia emissions should be 0.5-1.5 g/m<sup>3</sup> and particulate matter emissions 20-40 mg/m<sup>3</sup>. National air quality laws must be met and latest available technologies are to be applied to reduce emissions for chemical plants.

### Emission standards for waste management and disposal.

Air pollutants such as methane, dioxins, furans, and particulate matter are generated at waste management facilities such as landfills, incinerators, and recycling plants. Landfills can install gas collection systems and flare systems in order to reduce methane emissions. Prominent amongst them are the dioxins, furans and particulate matter, to which regulatory limits are set at 0.1 mg/m<sup>3</sup> and 30–50 mg/m<sup>3</sup>. Particulate matter and VOC emissions from the waste processing plants may be limited by the use of filters and advanced combustion technologies.

### Penalties for refusing to comply with emissions standards.

Emissions would come under acceptable levels as per emission standards for which regulators would conduct periodic inspections to enforce the same. They would be forced to keep continuous emissions monitoring data about power plants, chemical manufacturers, cement producers, and waste management facilities to be inspected in case of violations. Also, for penalties, the government should implement auditing and monthly reporting of the manufacturing volumes and emission level. For hiding and ignoring policies of auditing, enterprises should be legally responsible.

### **Economic Solution**

By fostering economic flexibility and preventing the failure of the markets, Pigouvian taxation seeks to maximize resource utilization. A tax equivalent to the marginal pollution harm at an efficient volume of manufacturing is imposed on each unit of polluting produced by an organization (Nesheva-Kiosseva 2020). They impose this charge on the person who creates "negative externalities." The goal of taxation is to make the polluter's private costs include a societal cost. Its economic value must match the quantity required to raise private expenses for pollutants compared to the marginal costs to society.

The government levies Pigouvian taxes on products that produce externalities that are detrimental to society, such as tobacco sales and environmental degradation. When the personal management cost (PMC), which reduces because of higher expenses, matches the social marginal benefit (SMB), the market equilibrium is ineffective within free market conditions (Wittman 1985). The state should impose the Pigouvian tax at a rate equivalent to the expenses associated with the adverse impact in order to increase market efficiency. The following will result in an improved environmentally effective market equilibrium by reducing the amount of supply of the good or service, raising consumer demand, and lowering the marketplace price. As a consequence, demand for what is being sold would increase, and supply would decline.



Figure 3. Theoretical Representation of Pigovian Tax

The graph provides information on how the Pigouvian tax intervenes to reduce harmful pollution in a free market by considering private sector costs and social costs. Assume this graph will be implemented in the chemical manufacturing plant. Clearly, an enterprise produces more at a lower price (Q1, P1). However, after implementing the Pigouvian tax, the price rises, and the quantity of supplied products decreases since the enterprise must pay according to the production volume. As a result, after implementing the Pigouvian tax, the quantity of supplied goods will start to fall since higher production equals higher tax; the tax also helps prevent overproduction; pollution levels will reduce, and enterprises will shift to cleaner technology, positively influencing social welfare.

For example, we can assume a manufacturing company that produces goods using chemicals causes hazardous pollution in Ust-Kamenogorsk and poisons the ground and surface water. Nevertheless, the enterprise emitted 130.000 units of emissions. The government levied a \$1 million fine for the production volumes in the past. Moreover, the government implemented a Pigouvian tax of \$40 per unit of emission to account for the negative externality in the city, aiming to protect social welfare and reduce emission levels.

### Conclusion

According to the analyzed amount of industrial pollution and PM2.5 concentrations in Oskemen, the city has major environmental problems because of numerous production firms. High levels of PM2.5, especially in a few months, indicate that there is an urgent need for effective pollution control measures. Heavy metal contamination and poor air quality has a very bad impact on human and animal population health. Limiting emissions from power plants, chemical manufacturing and the waste facilities will be a crucial solution to all these problems. Specific limits should be set for pollutants such as SO<sub>2</sub>, NOx, PM and CO<sub>2</sub>, and a good use of advanced technologies should also be a requirement to minimize emissions. Furthermore, penalties for non-compliance with the regulations must be imposed to ensure compliance. The problem of pollution could also be mitigated by economic solutions, including the adoption of Pigouvian taxes. These taxes will help by encouraging industries to incorporate cleaner technologies into their business by internalizing the external costs of pollution. Implementation of regulatory measures and economic incentives will make Oskemen environment more sustainable and healthy for living. It has been once again reiterated that a full walled strategy to combat pollution is needed, on an equal footing of economic and regulatory measures. Through tackling the root causes of pollution and encouraging sustainable methods Oskemen can lower its air quality, defend open wellbeing and accomplish a superior quality of life for its residents.

### References

AQICN.
(2025).
"Kazakhstan
Air
Pollution,
Oskemen."
from

https://aqicn.org/station/kazakhstan-oskemen .
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Assanov, D., V. Zapasnyi and A. Kerimray (2021). "Air Quality and Industrial Emissions in the Cities of Kazakhstan." **12**(3): 314.

Atanbaeva, G. K., S. T. Tuleuhanov, G. Daulet, M. Molsadykkyzy, S. O. Ossikbayeva and Z. S. Orynbayeva (2017). "Study of the effect of cadmium, lead, zinc salts on the rat blood cells." <u>International Journal of Biology and Chemistry</u> **10**(1): 9-14.

Boluspayeva, L., M. Jakubus, W. Spychalski, A. Abzhalelov and Y. Bitmanov (2023). "Health Risk of Heavy Metals Related to Consumption of Vegetables in Areas of Industrial Impact in the Republic of Kazakhstan—Case Study for Oskemen." **20**(1): 275.

DB. (2025). "Manufacturing Companies in Ust-kamenogorsk, Kazakhstan." from <a href="https://www.dnb.com/business-directory/company-information.manufacturing.kz.na.ust-kamenogorsk.html?page=2">https://www.dnb.com/business-directory/company-information.manufacturing.kz.na.ust-kamenogorsk.html?page=2</a>.

Nesheva-Kiosseva, N. (2020). Pigouvian Taxation. <u>Encyclopedia of Sustainable Management</u>. S. Idowu, R. Schmidpeter, N. Capaldi et al. Cham, Springer International Publishing: 1-5.

Oladejo, T. O., F. O. Balogun, U. A. Haruna, H. O. Alaka, J. Almazan, M. S. Shuaibu, I. S. Adedayo, Z. Ermakhan, A. Sarria-Santamerra and D. L.-P. Eliseo (2023). "Climate change in Kazakhstan: implications to population health." <u>Bulletin of the National Research Centre</u> **47**(1): 144.

Victoria, S., L. Trine, P. Hystad and C. Roper (2023). "Indoor and Personal PM2.5 Samples Differ in Chemical Composition and Alter Zebrafish Behavior Based on Primary Fuel Source." <u>Environmental Science & Technology</u> **57**(50): 21260-21271.

WB (2007). Kazakhstan - Ust-Kamenogorsk Environmental Remediation Project, The World Bank Group.

WB (2008). Kazakhstan - Ust-Kamenogorsk Environmental Remediation Project, The World Bank.

Wittman, D. (1985). "Pigovian taxes which work in the small-number case." Journal of Environmental Economics and Management **12**(2): 144-154.