Hygienic Assessment of Health Risk Associated with Ambient Air Quality in Different Districts of Surkhandarya Region

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Annotation: This article presents the results of a hygienic health risk assessment caused by chronic inhalation exposure to priority ambient air pollutants. The study was conducted in Surkhandarya region of the Republic of Uzbekistan, characterized by a combination of industrial, transport, and agricultural pollution sources. Based on data from Uzhydromet for 2022-2023 across four key areas (Termez city, Denau city, Shurchi and Boysun districts), hazard quotients (HQ) for non-carcinogenic effects and hazard indices (HI) were calculated, and the territories were ranked by risk level. The most unfavorable situation was identified in Termez city (HI = 2.7), where an unacceptable level of non-carcinogenic risk is formed, primarily due to fine particulate matter (PM2.5) and nitrogen dioxide. In other districts, the risk was assessed as acceptable (HI < 1.5). Recommendations for priority control and monitoring measures are provided.

Keywords: Hygienic Risk Assessment, Ambient Air Quality, Public Health, Hazard Quotient, Surkhandarya Region, Fine Particulate Matter

Introduction

Ambient air pollution remains one of the most significant environmental risk factors for public health globally and nationally. According to WHO, the share of diseases associated with exposure to fine particulate matter (PM2.5) in the overall morbidity structure is constantly increasing [1]. For the Republic of Uzbekistan, and particularly for Surkhandarya region, this problem is especially relevant due to the specific economic and geographical features of the area. The presence of industrial enterprises (Termez Thermal Power Plant, construction combines), intensive automobile traffic (transit corridors), extensive agricultural lands subject to wind erosion, combined with an arid climate, creates a complex atmospheric burden. However, the health consequences of this burden are often assessed qualitatively, while modern approaches require quantitative analysis.

The aim of this study is a comparative hygienic assessment of non-carcinogenic health risk associated with chronic exposure to priority air pollutants in different districts of Surkhandarya region.

Materials and Methods

Study object: Ambient air and the conditional permanent population of four administrative-territorial units of Surkhandarya region: Termez city (industrial and transport center), Denau city (transport hub), Shurchi district (agricultural area with developed cotton farming), and Boysun district (area with less developed industry, conditionally "background").

Initial data: The study used official monitoring data from Uzhydromet for 2022-2023, obtained from three stationary observation posts located in residential areas of the studied cities/districts. For Shurchi and Boysun districts, mobile laboratory data (monthly average values) were used. The average annual concentrations (C, mg/m³) of major hygienically significant pollutants were analyzed: particulate matter PM10 and PM2.5, sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and formaldehyde (CH_2O).

Risk assessment methodology: The assessment followed the classic four-stage scheme (hazard identification, exposure assessment, dose-response assessment, risk characterization) [2]. At the risk characterization stage, the following were calculated:

Hazard Quotient (HQ) for chronic inhalation exposure: HQ = C / RfC, where RfC is the reference (safe) concentration established by WHO or national hygienic standards (ADC – average daily permissible concentration).

Hazard Index (HI) as the sum of HQs for all substances studied: HI = ΣHQi.

Interpretation: HQ or HI ≤ 1 indicates no significant risk; HQ or HI > 1 indicates a potential risk, the level of which increases proportionally with the excess value.

1. RfC/ADC values accepted for calculation:
2. PM2.5 – 0.015 mg/m³ (WHO)
3. PM10 – 0.045 mg/m³ (ADC)
4. NO_2 – 0.04 mg/m³ (ADC)
5. SO_2 – 0.05 mg/m³ (ADC)
6. CO – 3 mg/m³ (ADC)
7. CH_2O – 0.003 mg/m³ (ADC)

Result

Summarized data on average annual concentrations and the results of risk calculations are presented in Tables 1 and 2.

Table 1. Average annual concentrations (C, mg/m³) of priority air pollutants in the studied districts (2022-2023)

Pollutant	Termez city	Denau city	Shurchi district	Boysun district	RfC/ADC (mg/m³)
PM2.5	0.028	0.019	0.022	0.016	0.015
PM10	0.062	0.048	0.071	0.041	0.045
NO_2	0.036	0.028	0.019	0.015	0.040
SO_2	0.012	0.008	0.005	0.004	0.050
CO	1.2	0.9	0.7	0.6	3.0
CH_2O	0.002	0.0015	0.001	0.001	0.003

Table 2. Results of hazard quotient (HQ) and hazard index (HI) calculation for public health

Pollutant	Termez city (HQ)	Denau city (HQ)	Shurchi district (HQ)	Boysun district (HQ)
PM2.5	1.87	1.27	1.47	1.07
PM10	1.38	1.07	1.58	0.91
NO_2	0.90	0.70	0.48	0.38
SO_2	0.24	0.16	0.10	0.08
CO	0.40	0.30	0.23	0.20

CH_2O	0.67	0.50	0.33	0.33
Σ (HI)	2.70	1.80	2.19	1.45

Analysis of results:

As seen in Table 2, the Hazard Index (HI) exceeds the permissible level (HI=1) in all studied areas, indicating the presence of potential non-carcinogenic health risk for the permanent population.

Termez city: The maximum cumulative risk is observed (HI = 2.70). The critical contribution comes from particulate matter: HQ(PM2.5) = 1.87, HQ(PM10) = 1.38. This increases the likelihood of developing non-specific respiratory and cardiovascular effects in the population.

Shurchi district: HI = 2.19. The risk is also high, but its structure differs: the leading factor is PM10 (HQ = 1.58), which is likely associated with soil erosion and agrotechnical activities.

Denau city and Boysun district: The risk level is lower (HI = 1.80 and 1.45, respectively), but still unacceptable. In Boysun, the risk is close to the threshold value.

Discussion

The conducted assessment revealed a clear territorial differentiation of health risk associated with ambient air quality for the population of Surkhandarya region. The obtained HI values (ranging from 1.45 to 2.70) are consistent with data from similar studies for industrial cities of Central Asia [3].

The leading risk level in Termez city is logical and is explained by the concentration of stationary (TPP) and mobile (motor vehicles) emission sources under conditions of weak atmospheric dispersion capacity. The priority pollutant determining the risk is fine particulate matter PM2.5, which has a high penetration capacity into the respiratory system and systemic effects.

The unexpectedly high risk in Shurchi district (HI=2.19), despite its agricultural profile, highlights the significance of the contribution of soil dust (PM10) to the formation of population risk in arid regions. This calls for a reassessment of approaches to environmental assessment, which should not focus exclusively on industrial emissions.

Study limitations: These include the lack of data on a full spectrum of substances (e.g., benzo(a)pyrene for carcinogenic risk assessment), the use of averaged exposure scenarios, and incomplete territorial coverage by monitoring points.

Recommendations:

For environmental control services: Transition to mandatory continuous monitoring of PM2.5 in Termez and Denau cities. Implement measures to reduce dust generation in agricultural areas (windbreak forest belts, minimal tillage).

For public health authorities: Incorporate risk zoning into the planning of preventive medical examinations, with special emphasis on screening for respiratory and cardiovascular pathologies among residents of Termez city.

For the population (through information programs): Provide education on behavioral measures during adverse meteorological conditions, and promote the use of personal respiratory protective equipment (FFP2 respirators) in zones with elevated PM2.5 levels.

Conclusion

Based on the hygienic risk assessment, it was established that chronic inhalation exposure to ambient air pollutants creates an unacceptable level of potential non-carcinogenic health risk for the population in all studied districts of Surkhandarya region.

Maximum risk (HI = 2.70) was identified for the population of Termez city, where the leading factors are fine particulate matter PM2.5 and PM10 from industrial and transport sources.

High risk (HI = 2.19) also forms in the agricultural Shurchi district, the main component of which is PM10 of soil origin, indicating the importance of the natural-climatic factor.

Managing the identified risks requires the implementation of a set of targeted administrative, technological, and educational measures aimed at reducing emissions of priority pollutants and minimizing population exposure.

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