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Transformational Learning Network for Resilience

Enabling Ukrainian higher education to ensure a sustainable and robust reconstruction of (post-war) Ukraine

Course. ***Sustainable pathways and risk management in times of crises***

Topic. ***Assessment of non-carcinogenic risk to public health based on air pollution levels***

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Plan:

1. General Provisions.
2. Determination of Non-Carcinogenic Health Risk from Chemical Air Pollution.
3. Tasks for Practical Work Execution.
4. Initial Data.

Assessment of non-carcinogenic risk to public health based on air pollution levels

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According to Order No. 1811 of the Ministry of Health of Ukraine, dated October 18, 2023, the methodology "Assessment of Carcinogenic and Non-Carcinogenic Risk to Public Health from Chemical Air Pollution" (hereinafter referred to as the Methodology) was approved. These methodological guidelines serve as a tool for the primary and secondary prevention of oncological diseases in the population.

Human health is determined by the complex interaction of several factors, including:

- ✔ Heredity;
- ✔ Socio-economic and psychological well-being;
- ✔ Availability and quality of medical care;
- ✔ Lifestyle and presence of harmful habits;
- ✔ Living conditions and the quality of the natural environment.

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Assessment of non-carcinogenic risk to public health based on air pollution levels

The ***risk assessment methodology*** involves selecting the most optimal ways to eliminate or reduce risk in a given situation. It consists of three interrelated components:

1. Risk assessment;
2. Risk management;
3. Risk communication.

According to international risk assessment methodology:

- For non-carcinogenic substances and non-genotoxic carcinogens, threshold levels are assumed, below which no harmful effects occur;
- Carcinogenic effects caused by the action of genotoxic carcinogens can occur at any dose that leads to genetic material damage; therefore, no threshold levels exist for such compounds.

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Assessment of non-carcinogenic risk to public health based on air pollution levels

To characterize the risk of developing non-carcinogenic effects, two key indicators are most commonly used: the ***maximum no-effect dose*** and the ***minimum dose*** that induces a threshold effect. These indicators serve as the basis for establishing minimal risk levels, such as ***reference doses (RfD)*** and ***reference concentrations (RfC)***.

The ***reference concentration (RfC)*** is defined as the concentration of a substance that, when inhaled continuously on a daily basis over a lifetime, is unlikely to cause adverse non-cancer health effects in the general population, including sensitive groups.

The final characteristics of exposure assessment based on reference doses and concentrations are expressed through ***hazard quotients (HQ)*** and ***hazard indices (HI)***.

Hazard Quotient (HQ): The ratio of the actual exposure dose or concentration of a chemical to its safe (reference) level of exposure.

Hazard Index (HI): The sum of hazard quotients for substances with a similar mechanism of action or the sum of hazard quotients for different exposure pathways of a chemical substance.

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Assessment of non-carcinogenic risk to public health based on air pollution levels

The assessment of non-carcinogenic effects is carried out by calculating hazard quotients (*HQ*), which involve comparing actual exposure levels of substances to their safe (reference) levels:

$$HQ = C / RfC, \quad (1)$$

HQ – Hazard Quotient;
C – Exposure level of the substance, mg/m³;
RfC – Safe exposure level (Reference Concentration), mg/m³.

Classification of Non-Carcinogenic Risk Levels

Hazard Quotient (*HQ*) for Individual Compounds	Hazard Index (*HI*) for Groups of Compounds with the Same Mechanism of Action	Risk Level
> 3	> 6	High
1,1 – 3	3,1 – 6	Concerning
0,11 – 1,0	1,1 – 3,0	Acceptable
0,1 or less	1,0 or less	Minimal (Target)

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Assessment of non-carcinogenic risk to public health based on air pollution levels

The assessment of non-carcinogenic risk from combined exposure to chemical substances is conducted by calculating the hazard index (*HI*) using the following formula:

$$HI = \sum_{i=1}^{n} HQ, \quad (2)$$

HQ represents the hazard quotients of the individual components within the chemical mixture that contribute to the overall effect.

In cases where reference (safe) dose (*Rf*) information is unavailable, proposed using the following formula:

$$HQ = Ci / C_{MPC}. \quad (3)$$

Classification of Non-Carcinogenic Risk Levels for Public Health

Risk Characterization	Hazard Quotient (*HQ*)
The risk of adverse effects is considered negligibly small	< 1
Threshold value that does not require immediate measures, but cannot be considered entirely acceptable	1
The probability of adverse effects increases proportionally with the increase in HQ	> 1

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Tasks for Practical Work Execution

1. Carefully study the theoretical part of the practical work.
2. Assess the risk of non-carcinogenic effects according to the assigned individual case by calculating hazard quotients (*HQ*) and the total non-carcinogenic risk (*HI*) for critical organs and body systems using reference concentration (*RfC*) values.
3. Evaluate the risk of non-carcinogenic effects by determining *HQ* and *HI* using maximum permissible concentration (*MPC*) values.
4. Analyze the obtained results and formulate a conclusion based on the findings.

Assessment of non-carcinogenic risk to public health based on air pollution levels

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Initial Data

Average Annual Pollutant Concentrations in Zaporizhzhia (mg/m³)

Pollutant	2019	2020	2021	2022	2023
Dust	0,12	0,105	0,135	0,105	0,105
Sulfur dioxide	0,005	0,005	0,01	0,005	0,005
Nitrogen dioxide	0,08	0,072	0,072	0,048	0,06
Carbon monoxide	1,2	1,2	1,2	1,2	1,2
Nitric oxide	0,048	0,048	0,048	0,042	0,042
Phenol	0,006	0,006	0,006	0,0051	0,0051
Hydrogen fluoride	0,001	0,001	0,001	0	0
Hydrogen chloride	0,04	0,04	0,04	0,04	0,04
Formaldehyde	0,0051	0,0051	0,0051	0,0051	0,006

Average Annual Pollutant Concentrations in Uzhhorod (mg/m³)

Pollutant	2019	2020	2021	2022	2023
Dust	0,081	0,0885	0,0705	0,0705	0,096
Sulfur dioxide	0,005	0,011	0,013	0,013	0,014
Nitrogen dioxide	0,0652	0,054	0,05	0,0512	0,06
Carbon monoxide	1,11	1,08	0,99	0,9	0,87
Sulfuric acid	0,01	0,006	0,004	0,009	0,01
Nitric oxide	0,0366	0,0348	0,0198	0,0282	0,03
Formaldehyde	0,00714	0,006	0,006	0,006	0,0069

Assessment of non-carcinogenic risk to public health based on air pollution levels

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Initial Data

Average Annual Pollutant Concentrations in Dnipro (mg/m^3)

Pollutant	2019	2020	2021	2022	2023
Dust	0,405	0,3	0,195	0,25	0,25
Sulfur dioxide	0,01	0,012	0,011	0,012	0,012
Nitrogen dioxide	0,092	0,1	0,092	0,07	0,072
Carbon monoxide	2,1	2,1	2,1	2,17	2,17
Nitric oxide	0,048	0,048	0,048	0,04	-
Formaldehyde	0,011	0,015	0,014	0,013	0,014
Ammonia	0,04	0,04	0,04	0,04	0,035
Phenol	0,003	0,003	0,003	0,002	0,002

Average Annual Pollutant Concentrations in Kharkiv (mg/m^3)

Pollutant	2019	2020	2021	2022	2023
Dust	0,09	0,09	0,06	0,043	0,043
Sulfur dioxide	0,007	0,007	0,007	0,011	0,014
Nitrogen dioxide	0,028	0,028	0,028	0,029	0,028
Carbon monoxide	2,7	1,2	1,2	1,3	1,27
Nitric oxide	0,018	0,018	0,018	0,02	0,03
Formaldehyde	0,0018	0,0018	0,003	0,0017	0,0023
Phenol	0,0018	0,0018	0,0018	0,002	0,002
Soot	0,03	0,02	0,03	0,05	0,02

Assessment of non-carcinogenic risk to public health based on air pollution levels

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Initial Data

Average Annual Pollutant Concentrations in Mykolaiv (mg/m^3)

Pollutant	2019	2020	2021	2022	2023
Dust	0,08	0,08	0,08	0,08	0,1
Sulfur dioxide	0,006	0,005	0,005	0,007	0,006
Nitrogen dioxide	0,05	0,04	0,04	0,04	0,03
Carbon monoxide	2,0	1,0	1,0	2,0	1,0
Nitric oxide	0,02	0,02	0,02	0,02	0,02
Formaldehyde	0,019	0,013	0,012	0,014	0,015
Hydrogen fluoride	0,001	0,001	0,002	0,002	0,002