UDC 504.05

APPLICATION OF RISK ASSESSMENT METHODS IN NUCLEAR ENERGY

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The potential environmental hazard of a number of pure metals assessed. A comparative analysis of hazard indicators established by various international organizations (WHO, ACGIH, etc.) and hazard factors regulated by the Globally Harmonized System of Classification and Labeling of Chemicals was conducted. The assessment was carried out for the following metals: aluminum, beryllium, vanadium, cadmium, manganese, arsenic, nickel, lead, titanium, zinc, zirconium.

INTRODUCTION

The metals founds in most types of waste, atmospheric emissions and discharges into water bodies from various industries, including nuclear facilities. They are common indicators of anthropogenic impact on the environment, most of them belonging to the first and second classes of danger. In addition to the physical hazards of some metals (explosion, fire, oxidation, etc.), the threat to humans and the environment is also directly affect by their high concentrations in different environmental sites. The maximum negative impact on the level of environmental safety as a rule manifests in the long-term consequences associated with the ability of many metals to accumulate in various objects of living and inanimate nature including in the human body. This leads to the fact that even small concentrations in the long term can lead to disturbance of ecological balance in the ecosystems and to the accumulation of critical doses of contaminants in the humans and other living things body.

Assessment of pollutants and directly pure metals potential hazard is the purpose of this paper.

RESEARCH METHODS

Currently, in the world practice, the main conceptual approaches to the implementation of the control and management of environmental safety is strict hygiene standardization, which is also applied in Ukraine, and the methodology of risk assessment, applied in the EU, USA, Canada and others. Their main differences are that the first system does not take into account the effect of the accumulation of pollutants in the human body and it is considered that compliance with the standard (ГДК, etc.) guarantees the absence of adverse effects. Permissible concentrations are set taking into account the limiting sign of harmfulness that is, the minimum concentration that causes either unpleasant organoleptic traits or an ecosystem imbalance or adverse health effects, etc., depending on the environment for which they are established. However, there is no mechanism to further determine the specific forms of these effects and their quantitative expression [1]. The second system makes it possible to determine the quantitative effect of a contaminant on the human body at different exposures and allows to establish the specificity of the negative effect of the agent on the body, the establishment of critical organs, systems and effects corresponding to the established reference concentrations [2]. The resulting risk indicators are also indicators of environmental impact.

Conducting a hazard analysis for each impact scenario using these methods requires the involvement of various resources (environmental monitoring results, international chemical hazard databases, specialized software, etc.) and a considerable amount of time.

For the preliminary assessment of the danger of a substance, it is worthwhile to carry out a comparative analysis of the hazard indicators already established by the various international institutions. They should also analyze their hazard factors governed by various global classification systems, such as the "Globally Harmonized System of Classification and Labelling of Chemicals" (GHS) and others.

In this paper we limited ourselves to analyzing the hazards of atmospheric air pollution with a number of pure metals and H-phrases which are unified warnings about the nature or degree of danger established under the GHS.

The following indicators were analyzed:

- MPC – the maximum permissible concentration in the air of populated cities regulated in Ukraine;
- MPC w.a. – MPC in the air of the work area regulated in Ukraine;
- RfC – inhalation reference concentration recommended by the World Health Organization (WHO);
- TLV – the maximum allowable concentration developed by the American Conference of Governmental Industrial Hygienists (ACGIH).

MPC is used for hazard assessment precisely within strict hygiene regulations, RfC is used in the methodology of risk assessment and involves the calculation of doses of contaminants into the human body over a period.

H-phrases are codes that encrypt messages about the nature and degree of danger of various substances and mixtures. Accordingly, the hazard is divided into physical, environmental and human health hazards with further subspecies of these hazards identified.

RESEARCH RESULTS AND DISCUSSION

The analysis was carried out for the following metals: aluminum (Al), beryllium (Be), vanadium (V), cadmium (Cd), manganese (Mn), arsenic (As), nickel (Ni), lead (Pb), titanium (Ti), zinc (Zn), zirconium (Zr). Its results are presented in Table 1.

Table 1

Hazard indicators

Item name	Al	Be	V	Cd	Mn	As	Ni	Pb	Ti	Zn	Zr
CAS	7429-90-5	7440-41-7	7440-62-2	7440-43-9	7439-96-5	7440-38-2	7440-02-0	7439-92-1	7440-32-6	7440-66-6	7440-67-7
MPC of the air of populated cities											
MPC, mg/m^3	0.01	-	0.002	0.0003	0.001	0.003	0.001	0.0003	-	0.05	0.01
C.H.	2	-	1	1	2	2	2	1	-	3	3
Reference concentrations (WHO)											
RfC, mg/m^3	0,005	0,00002	0,00007	0,00002	0,00005	0,00003	0,00005	0,0005	0,03	0,0009	-
Critical organs/sys-tems, (inhalation)	CNS	Respirat.immune.	Respirat.	Kidney, respirat., hormo-necan--cer.	CNS, nervous system, respirat.	Develop ment, nervous system, cardio-vas. system, respirat., cancer	Respirat. blood, immune, cancer, CNS	CNS, blood, develop.-reproduc-system, hormo-nekidney.	-	Respirat.-immune, blood.	-
MPC of the working area air											
MPC w.a., mg/m^3	2	0.001		0.01	0.2	0.01	0.05	0.05	10	0.5	6
C.H.	3	1	-	1	2	1	1	1	4	2	3
Features of influence on an organism	Fibro-genic action	Carcino-gen, allergen	-	Carcinogen	-	Carci-nogen	Carci-nogen, allergen	-	Fibro-genic action	-	-
TLV of the atmosphere (ACGIH)											
TLV, mg/m^3	1	0.00005	-	0.01	0.2	0.01	1.5	0.05	-	-	5
Marking system GHS											
Signal word	Danger	Danger	Warning	Danger	Warning	Danger	Danger	Danger	Danger	Danger	Danger
Hazard statement	H250,H261	H350, H372	H228, H315, H319, H335, H413	H250, H330, H341, H350, H361, H372, H400, H410	H228, H319, H411, H412	H301, H331, H400, H410	H317, H351, H372	H360FD, H362	H228, H250, H260, H315, H319, H335	H250, H260, H400, H410	H250, H260

MPC – maximum permissible concentration; MPC w.a. – MPC in the air of the work area; C.H. – hazard class; RfC – inhalation reference concentration; TLV – maximum permissible concentration developed by ACGIH.

As you can see, the permissible concentrations for each element are often quite different, especially with respect to the permissible air concentrations of populated cities (MPC and RfC). There are significantly stricter levels of security for WHO regulations. Almost all substances have differences in values of one (Al, Cd) or even two orders of magnitude (V, Mn, As, Ni, Zn). Only Pb MPC is slightly less than RfC. In this case the MPC for Be and Ti is not installed, and there is no RfC for Zr.

Indicators of hazardous air pollution in the work area (MPC w.a. and TLV) [3, 4] are more identical. A significant difference is observed for Be for which the MPC is 2 orders of magnitude greater than TLV, and for Ni for which the TLV is 2 orders of magnitude higher than the MPC.

Also for each substance are listed the organs and systems of influence that are critical in their inhalation route of entry into the human body. Some of these metals also have carcinogenic properties (Be, Cd, As, Ni).

The analysis of the H-phrases revealed both physical, and human and environmental hazards to the listed elements [5]. The transcripts of these phrases are given in Tables 2–4.

Physical danger is inherent in Al, V, Cd, Mn, Ti, Zn, Zr. Health hazards occur with contact with Be, V, Cd, Mn, As, Ni, Pb, Ti. Environmentally hazardous are V, Cd, Mn, As, Zn.

Table 2

Physical hazards

Phrase code	Deciphering the phrase
H228	Flammable solid
H250	Catches fire spontaneously if exposed to air
H260	In contact with water releases flammable gases which may ignite spontaneously
H261	In contact with water releases flammable gas

Table 3

Health hazards

Phrase code	Deciphering the phrase
H301	Toxic if swallowed
H315	Causes skin irritation
H316	Causes mild skin irritation
H317	May cause an allergic skin reaction
H319	Causes serious eye irritation
H320	Causes eye irritation
H330	Fatal if inhaled
H331	Toxic if inhaled
H335	May cause respiratory irritation
H341	Suspected of causing genetic defects
H350	May cause cancer
H351	Suspected of causing cancer
H360	May damage fertility or the unborn child
H361	Suspected of damaging fertility or the unborn child
H362	May cause harm to breast-fed children
H372	Causes damage to organs through prolonged or repeated exposure

Table 4

Environmental hazards

Phrase code	Deciphering the phrase
H400	Very toxic to aquatic life
H410	Very toxic to aquatic life with long-lasting effects
H411	Toxic to aquatic life with long-lasting effects
H412	Harmful to aquatic life with long-lasting effects
H413	May cause long-lasting harmful effects to aquatic life

CONCLUSIONS

As we can see, the hazard indicators obtained from different sources may differ significantly. For a comprehensive analysis of the potential environmental hazards both of pure metals and their compounds, it is worthwhile to apply different methodological approaches involving both domestic and worldwide assets.

Preliminary qualitative risk assessment can be performed on the basis of GHS data, and further quantitative analysis of tears can be performed using both hygiene regulation and risk assessment methods.

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Article received 04.10.2019

ПОТЕНЦИАЛЬНАЯ ЭКОЛОГИЧЕСКАЯ ОПАСНОСТЬ ЧИСТЫХ МЕТАЛЛОВ

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Осуществлена оценка потенциальной экологической опасности ряда чистых металлов на основе сравнительного анализа их показателей опасности, установленных различными международными организациями (WHO, ACGIH и др.), и факторов опасности, регламентированных согласованной на глобальном уровне «Системой классификации и маркировки химических веществ» (GHS). Оценка проведена для следующих металлов: алюминия, бериллия, ванадия, кадмия, марганца, мышьяка, никеля, свинца, титана, цинка, циркония.

ПОТЕНЦІЙНА ЕКОЛОГІЧНА НЕБЕЗПЕКА ЧИСТИХ МЕТАЛІВ

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Здійснено оцінку потенційної екологічної небезпеки ряду чистих металів на основі порівняльного аналізу їх показників небезпеки, встановлених різними міжнародними інституціями (WHO, ACGIH та ін.), та факторів небезпеки, регламентованих узгодженою на глобальному рівні «Системою класифікації та маркування хімічних речовин» (GHS). Оцінка проведена для наступних металів: алюмінію, берилію, ванадію, кадмію, марганцю, миш’яку, нікелю, свинцю, титану, цинку, цирконію.