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Toxicity of Radionuclides in Determining Harmful Effects on Humans and Environment

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1. Toxicity of Radionuclides

All chemical elements and nuclides consolidated in system of elements on a base of periodic law. Nuclides are similar in texture, have a charge and an atomic weight etc. But some of them inherent property of radioactivity. Such elements and nuclides called radionuclides. Chemical elements and their compounds (substances) can negative impact on living organisms and ecosystems. Science of toxicology studies poisonous substances and their potential dangerous, mechanism of action of toxic substations, methods of diagnosis, prevention and treatment. One aspect of development of this science, in context of dangerous of radionuclides, is radiotoxicology.

In conditions, personnel working at industries with combine chemical and radiation hazards there is a toxic load on humans and environment from chemical and radiation components of chemical elements and compounds.

The examples for such enterprises are:

- companies with extracting a mineral resource (iron ore, uranium and thorium ore, gravel, etc.);
- processing of ores (including hydrometallurgical plants);
- radioactive waste management (including reprocessing spent of nuclear fuel at chemical plants);
- processing of enrichment uranium and thorium ores;
- monitoring studies of tailings etc.

In this case radionuclides and their compounds have a double toxicity:

- Chemical toxicity is caused by chemical properties of elements and their compounds that the substance consists.
- Toxic of radioactive elements and nuclides is called radiotoxicity.

The overall impact on the human body will be expressed by the amount of chemical toxicity and radiation toxicity according to the formula:

$$\mathbf{T = Tc + Tr} \quad (1)$$

Tc – chemical toxicity, Tr - radiation toxicity.

In radiotoxicology all radionuclides consolidated in four groups of radiation danger (group of radiotoxicity): Group A, Group B, Group C, Group D (see Table 1), beginning from radionuclides of very high level of radiotoxicity to the low and the minimum [1-4].

Group of radiotoxicity	**Radionuclides**
Group A (Radionuclides have particularly high level of radiotoxicity)	**^{210}Pb, ^{210}Po, ^{226}Ra, ^{230}Th, ^{232}Th** (including natural),**^{232}U, ^{238}Pu, ^{237}Np, ^{241}Am** and others.
Group B (Radionuclides with high radiotoxicity)	**^{224}Ra,^{106}Ru, ^{130}I, ^{131}I, ^{152}Eu, ^{144}Ce, ^{210}Bi, ^{230}Th, ^{235}U,** **^{238}U, ^{234}U, ^{241}Pu, ^{90}Sr** and others.
Group C (Radionuclides with average radiotoxicity)	**^{22}Na, ^{32}P, ^{35}S, ^{36}Cl, ^{59}Fe, ^{60}Co, ^{89}Sr, ^{90}Y, ^{93}Mo, ^{125}Sn,** **^{140}Ba, ^{234}Th** and others.
Group D (Radionuclides with low and minimal radiotoxicity)	The group includes the following radionuclides: **^{7}Be, ^{14}C, ^{18}F, ^{40}K, ^{51}Cr,^{55}Fe, ^{64}Cu, ^{129}Te,** **^{131}Cs, ^{197}Pt, ^{197}Hg, ^{200}Tl, ^{210}Pb** and others. Also this group includes tritium (**^{3}H**) and its chemical compounds (oxides of tritium and heavy water).

Table 1: Group of radiotoxicity beginning from radionuclides of very high level of radiotoxicity to the low and the minimum.

In situations where we have radionuclides of several groups of radiation danger, their activity is equivalent to the Group A of radiotoxicity according with the formula [2]:

$$\mathbf{A = A_A + 0.1A_B + 0.01A_C + 0.001A_D} \quad (2)$$

A – total activity. A_A, A_B, A_C, A_D – activity of radionuclides of Groups A, B, C, D.

We should not forget that decaying radionuclides create daughter's decay products, which can be stable or radioactive.

As for nature radionuclides, which are consolidated in radioactive series, we should take into account the chemical and radiotoxicity impact of each radionuclide with these series (daughter's decay products). For example, the Series of Thorium:

$$ {}^{232}_{90}Th \rightarrow {}^{228}_{88}Ra \rightarrow {}^{228}_{89}Ac \rightarrow {}^{228}_{90}Th \rightarrow {}^{224}_{88}Ra \rightarrow {}^{220}_{86}Rn \rightarrow {}^{216}_{84}Po \rightarrow {}^{212}_{82}Pb \rightarrow {}^{212}_{83}Bi \begin{array}{c} \nearrow {}^{212}_{84}Po \searrow \\ \searrow {}^{208}_{81}Tl \nearrow \end{array} {}^{208}_{82}Pb \text{ (stable)} $$

In this case we should take into account the chemical and radiotoxicity impact (2) of ${}^{232}_{90}Th$, ${}^{228}_{88}Ra$ ${}^{228}_{89}Ac$, ${}^{228}_{90}Th$ ……… ${}^{212}_{84}Po$, ${}^{208}_{81}Tl$ and only chemical impact of stable ${}^{208}_{82}Pb$. During extracting a mineral resource and their processing there are waste which placed in the territories of the so-called tailing dumps.

According to research the territory of Ukraine, there are 344 tailing dumps. Total additional volume of waste in tailings of Ukraine – 1709 million of cubic meters. Plus there are 11 tailings of waste after the processing of uranium ores.

Such objects are identified on all parts of the territory of Ukraine except Crimea region, Zakarpatska region, Volynsck region, Ternopil region, Odesa and Khmelnytsk regions (Figure 1).

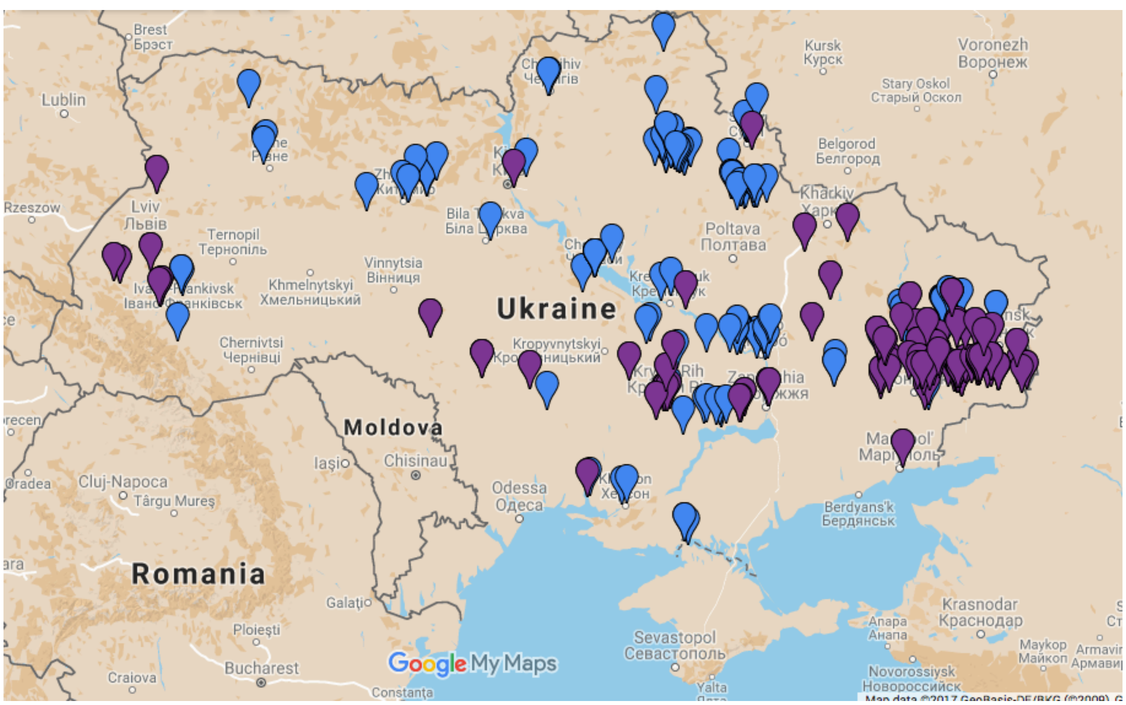

Figure 1: Tailing dumps on the territory of Ukraine (except tailings after uranium processing).

The information received from:

145 objects (Violet) – Scientific Research Institute of Micrograph State Archival Service of Ukraine (2014).

199 objects (Blue) - Register of Waste Disposal of Ukraine Ministry of Environmental Protection (2015).

Table 2 shows the brief data of states of Hydrometallurgical plant «Govti Wody» **(**GMP «Govti Wody», operating company) and State Enterprise «Prydniprovskyi Chemical Plant» (SE «Prydniprovskyi Chemical Plant», inactive company). In the tailes of these enterprises there are preserving chemical elements and there are compounds which are nature occurring radioactive materials (waste after processing of uranium ores).

GMP «Govti Wody» **(**operating company)	**SE «Prydniprovsky Chemical Plant»** (inactive company)
Stored wastage: 25 million of m^3	Stored wastage: 28 million of m^3
Total activity of chemical waste: 3,89 + 14 Bq	Total activity of chemical waste: 2,70E+15 Bq
Tailings area: 2,98 million square meters	Tailings area: 2,43 million square meters

Table 2: States of Hydrometallurgical plant.

For the goal of assessment of tails' potential danger for humans and environment we propose determine the potential danger index (IPNN). The scheme of forming of IPNN is shown in Figure 2 [7].

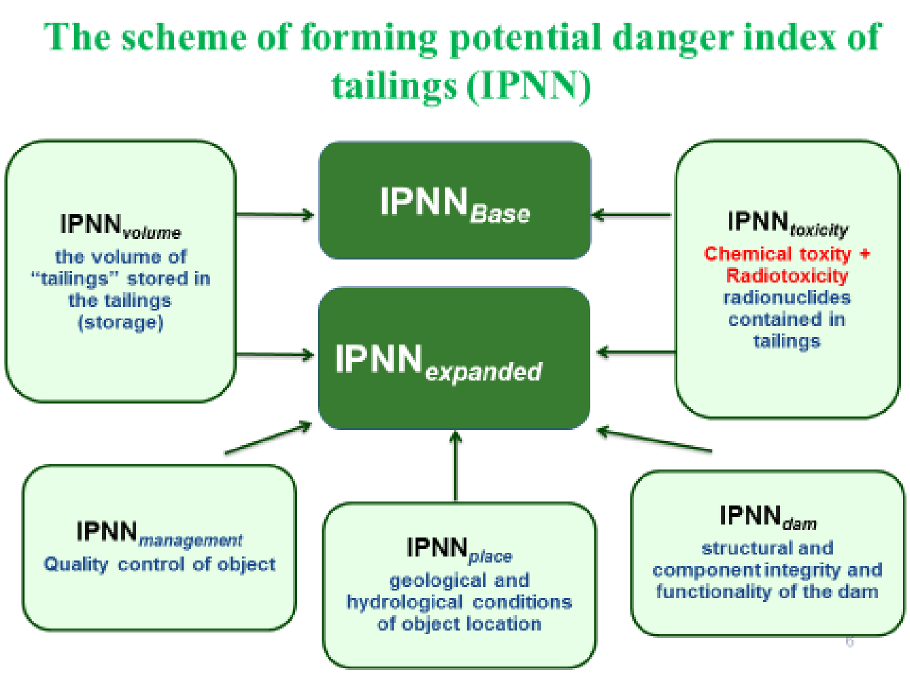

Figure 2: Parts of IPNN for calculating the base or expanded variants.

The higher the IPNN, the higher the level of danger of tailings for humans and environment. The maximum contribution to the level of IPNN creates IPNN, which is the index of the «toxicity», and IPNN which is the index of the «volume».

After the assessment of tailings of enterprises GMP «Govti Wody» and SE «Prydniprovsky Chemical Plant» we got the next results. The more dangerous influence has SE «Prydniprovskyi Chemical Plant». The database of $IPNN_{management}$ is absent and the information about the volume of «tailings» stored in the tailings (storage) ($IPNN_{volume}$) is absent partly.

2. Conclusions

When the extraction of mineral resources and preserving of waste after the processing of ores we get not only chemical influence for humans and environment. Many experts do not consider the radiation impact because they think that these mineral resources don't have radiation sources. It is false. In this case, we loose the significant part of dangerous factors that affect on people and environment. Thus, the results of assessing the impact of any tailing of industrial enterprises (not only uranium) is doubtful. Taking into accounting the radiotoxicity in $IPNN_{toxic}$ we can get more reliable information about the state of tailings and there are influence for humans and environment.

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