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TECHNOGENIC AND ECOLOGICAL CONSEQUENCES OF TRITIUM CONTAMINATION OF THE SURROUNDING ENVIRONMENT CAUSED BY EMISSIONS FROM NEAR SURFACE STORAGE OF RADIOACTIVE WASTE

Poliakova I.[1], Denisenko I.[2],
[1]State Scientific and Technical Centre for Nuclear and Radiation Safety, Kyiv, Ukraine,
polyakova_ira@ukr.net
[2]State Ecological Academy of Postgraduate Education and Management,
emaa.dea@ukr.net

The analysis of the causes of radiation accidents at surface radioactive waste storage facilities with emissions of tritium (^{3}H) to the surrounding environment. It is defined the dynamics of change ^{3}H concentration in observation boreholes of near surface radioactive waste storages. The possible ways to prevent the occurrence of radiation accidents and response. **Key words:** radiation accident, emissions of tritium, surface storage of radioactive waste, radioactive waste, ways of migration, security, engineering barriers, containers for storage of radioactive waste, containing tritium.

Проведено аналіз причин виникнення радіаційних аварій на приповерхневих сховищах радіоактивних відходів (РАВ) з емісією тритію (^{3}H) в оточуюче природне середовище. Визначено динаміку зміни концентрації ^{3}H у свердловинах спостереження приповерхневих сховищ РАВ. Запропоновано можливі шляхи попередження виникнення радіаційних аварій та ліквідації їх наслідків. **Ключові слова:** радіаційна аварія, емісія тритію, приповерхневе сховище РАВ, радіоактивні відходи, шляхи міграції, безпека, інженерні бар'єри, контейнери для зберігання РАВ, що вміщують тритій.

Проведен анализ причин возникновения радиационных аварий на приповерхностных хранилищах радиоактивных отходов (РАО) с эмиссией трития (^{3}H) в окружающую среду. Установлена динамика изменения концентрации ^{3}H в скважинах наблюдения приповерхностных хранилищ РАО. Предложено пути предупреждения возникновения радиационных аварий и ликвидации их последствий. **Ключевые слова:** радиационная авария, эмиссия трития, приповерхностное хранилище РАО, радиоактивные отходы, пути миграции, безопасность, инженерные барьеры, контейнеры для хранения РАО, содержащие тритий.

Revenues of tritium in the environment surrounding from sources is caused by natural and artificial processes. In this article the author examines the of reasons tritium emissions during storage of radioactive waste (RW) in near-surface storage facility.

Tritium is dangerous to humans and surrounding environment through its ability to be involved in biogeochemical processes and substitute protium (^{1}H) on

tritium (^{3}H), that prolonged admission into the body (for absorbed doses around 1 Gy) causes morphological changes and disorders of the endocrine system and blood-forming organs, cardiovascular system, liver, etc., but does not accumulate significant doses [1].

Tritium migration paths from storage can be used as an indicator of the possible release of other radionuclides in the geological environment.

During conducting research the consequence of radiation accidents near-surface storage facility of ^{3}H emissions to the surrounding environment, there was determined the following causes of accidents:

1. No pre-treatment and conditioning of radioactive wastes which contain tritium, in the presence of necessary amount of knowledge, research and practical developments on the physicochemical properties of tritium.

2. Lack of additional engineering barriers and specially designed and tested containers [2] for storage of this type of wastes. Constructional material of near-surface storages from concrete is a single engineering barrier on the way of migration of ^{3}H.

Concrete as a structural material for the storages of radioactive waste, found its application in many enterprises around the world. Its using is justified in the case of «many-of-barrier» protection in the storage of radioactive wastes, including waste pre-treatment technology and conditioning them in special containers. The use of concrete as a structural material of a single of engineering barrier, the author declared as unfitted for storage radioactive wastes which contain tritium. This is confirmed also by experience of Canadian, American, French, Hungarian, Latvian, Russian and other researchers [1].

Scientific researching and developments of Ukrainian scientists of the pollution the surrounding environment ^{3}H partly be based on an analysis of the consequences of radiation accidents at the storage of radioactive waste Kharkov and Kiev State Interregional Specialized Enterprises State Corporation "Ukrainian State Association "Radon" (Kharkiv SISE and Kyiv SISE). Scenario of occurrence and progression accidents at storage facilities of Ukraine like a similar surface storage facility for other countries.

Dates of radiation accidents since the beginning of operation of storages as in Ukraine, as in France, Hungary and Latvia - 33÷36 years. Project operating period of surface storages of radioactive wastes to the moment of closure is 30 years.

In particular, groundwater storage facility zone of influence Center de la Manche (city Cherbourg, France) the tritium concentration reached $(17\div20)\times 10^3$Bq/l (1997-2002 years) followed whith reduction to $(7\div13)\times10^3$kBq/l (2008 year) [3].

The concentration of tritium in the groundwater zone of influence of near-surface storage facility of Hungary reached 2×10^4Bq/l (2008) (Fig.1) [4].

During work on the conservation of near-surface storages of radioactive waste at Baldone (Latvia) (held concreting RAW which contain ^{3}H) in 1997 observed increased to $2{,}0 \times 10^5$Bq/l levels of tritium contamination of groundwater. For 11 years, the pollution decreased to $(7 \div 8) \times 10^3$Bq/l [5] (Fig.2).

Fig. 1. Tritium contamination of groundwater in the area of the impact near-surface repository of Hungary [4].

It should be noted that neither in Hungary nor in Latvia the pre-treatment and conditioning of radioactive wastes, which contain 3H, were not performed. Waste storage facility compartments were placed in bulk. There was no separation provided by RW nuclide composition and half-life period.

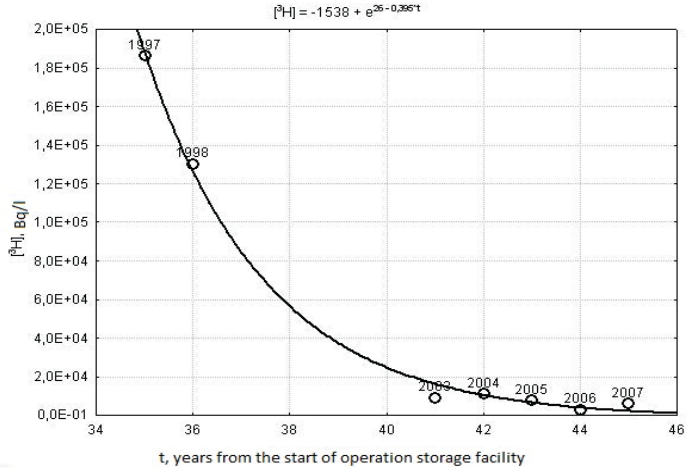

Fig. 2. Dynamics of tritium contents in observation wells (with maximum concentration) of near-surface storage facility in Latvia built according BAPA (Latvia).

Analysis of the causes of emissions of ^{3}H from near surface storage of radioactive wastes of Ukraine.

In Kharkov SISE at the beginning of1997 the network of observation wells were found significant excess (about 100 times) the specific activity of ^{3}H in comparing with the limit values for drinking water (PC_B^{ingest}). The situation was classified as a local communal radiation accident [5].

Water form of tritium (HTO) is the most active as biological form. HTO in the aquifer fell from the storage of solid radioactive wastes №№ 19 and 20 of the volume of 400 m^3 each, which operated in the period from 1962 to 1995. Now in these storage facility are stored radioactive wastes, such as hundreds of static neutralizers containing ^{3}H total activity in 1995 - $2,7\times10^{14}$Bq, and in 2015 - $1,69\times10^{14}$Bq. In 1995these storages were conserved. RW were cemented and there was completed an additional storage layer covering the ground. However, the emission of tritium were always took place after conservation.

Radiation monitoring of water samples first aquifer from 23 observation wells was carried on a quarterly basis by Radiation Safety Service of the Kharkiv SISP.

According to the monitoring researches the content of ^{3}H from samples of observation wells in 4-8 times was higher than the norms for drinking water (3×10^{4}Bq/l).

During 17 years of observation, tritium specific activity were decreased. At the beginning of 1998, activity of ^{3}H in the samples reached up to $1,26\times10^{6}$Bq/l, but in 2014 this value amounted to $0,16\times10^{6}$Bq/l. There were slight seasonal variations of measured values associated with different power supply aeration zone in different seasons.

Dynamics of tritium in observation well number 31H of near-surface repository Kharkiv SISP is shown in Fig. 3. The dependence is based on statistics from monitoring researches of the service of radiation protection of enterprise.

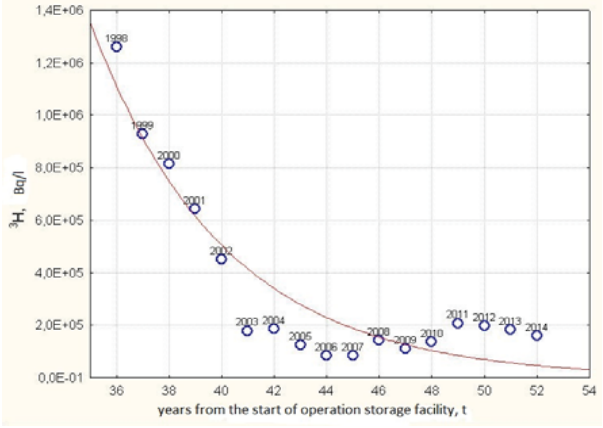

Fig. 3. Dynamics of tritium contamination of water well number 31H Kharkiv SISP.

On 10.19.2015, the aeration zone area during storage of radioactive wastes had almost reached the level of standards fixed for drinking water [6], the peak of tritium contamination of the aquifer passed in 2008 had changed to decline. The revenues of ^{3}H into aquifer offset by its radioactive decay and eventually pollution of the environment will only be decreasing.

In water observation wells in Kyiv SISE in the early 90-ies of last century of upper quaternary aquifer was recorded increasing in the content of tritium concentration which had reached tens of millions of Becquerel per liter [7]. As a result of depressurization of solid radioactive waste storage, infiltration of precipitation into the storage facilities and their contact with the solid radioactive wastesit is ^{3}H leaching with water in the geological environment, i.e. the formation of HTO and steam-gas emissions into the atmosphere (HT).

Fig. 4 (a, b) shows the specific activity of tritium in water wells number $6H_2$ and $5H_3$ located near storage of solid radioactive wastes №№ 5, 6, 7 (dynamics from the first year of operation).

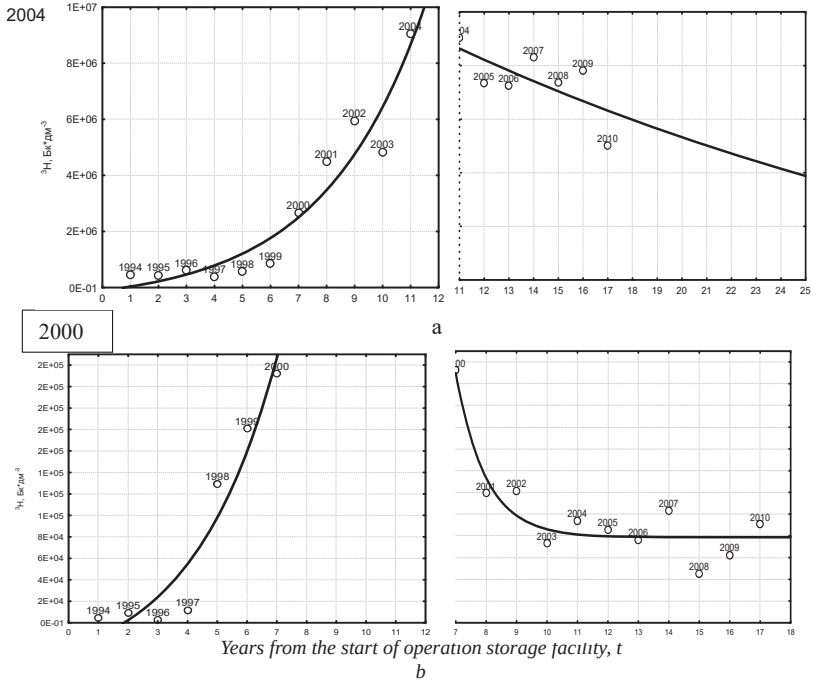

Fig.4. Dynamics of tritium contamination of water wells number $6H_2$ (a) and number $5H_3$ (b) on the industrial site of Kyiv SISE.

The data shown in Fig.4, enable to estimate the time of occurrence radiation accident and its course, radiation resistance artificial barrier and possible consequences.

The total release of gaseous tritium into the atmosphere from the storage of solid radioactive wastes Kyiv SISE in the conditions of radiation accident during last 20 years can be estimated at an average of about 4×10^{12}Bq.

The total amount of tritium outside storage №№ 5, 6 and 7 Kyiv SISP is estimated at about 1×10^{13}Bq, representing 0.5% of the estimated current activity of disposed waste containing ^{3}H.

To avoid the danger radiation accidents involving the emission of ^{3}H in the environment, to storage facilities that are operated and RW which has been placed on technology "disposal" without pretreatment and conditioning which is possible under preventing ingress of atmospheric precipitation to the storage of solid RW containing tritium, or the work on pumping water with tritium from these storage facility, if there is water there.

The complex of works to remove radioactive wastes from the "emergency" storages containing ^{3}H, their conditioning and carrying them in special containers will create additional engineering barrier to the spreading of radionuclides.

Analysis of the dynamics of content of tritium in observation wells in Fig.2, Fig.3 and Fig.4 the dynamics and content of tritium in observation well in Hungary storage facility [1] for the first time the author put forward the hypothesis that all radiation accidents were happened after the 33-36 years from the start of operation of near surface storage RW, in the post-project operation period of storage facility.

Conclusion

The existing near-surface radioactive waste storage facilities accordingly to the construction project, were defined as storage of dumping of radioactive wastes. The use of construction materials storage made of concrete is forced by the operating conditions of existing storages. However, its using as a single artificial barrier is inadmissible because of concrete filtration properties to water that condenses in the normal operation of the repository, without pre-processing technologies and conditioning RW of ^{3}H specifically designed and tested containers for storage of such type of radioactive wastes.

Researching and analysis of regularities of radiation accidents caused by emissions of tritium from near surface storage of radioactive wastes:

-enables assessment and forecast the approximate time of the accident and the potential radiation consequences;

-to prevent them and eliminating; conduct complex operations under "National Target Environmental Program of Radioactive Waste Management" in the part of containerization of RW;

-to develop the technology for removal, conditioning RW containing^{3}H, create a separated storage of ^{3}H RW, improving monitoring and dosimetry control of staff;

-to develop a methodology for early detection of tritium threats and dangers in order to effectively making impossible and prevent them.

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ВИКОРИСТАННЯ ФОСФОГІПСУ В СТВОРЕННІ СКЛАДНИХ КОМПОСТІВ ДЛЯ СІЛЬСЬКОГОСПОДАРСЬКОГО ВИРОБНИЦТВА

Іващенко Т.Г., Новосельська Л.П.
Державна екологічна академія післядипломної освіти та управління,
вул. Митрополита Липківського, 35, 03035, Київ,
http://dea.gov.ua/

Створення складного компосту з використанням фосфогіпсу передбачає поліпшення багатьох позицій ґрунтового процесу - фізичних, хімічних і біологічних особливостей: утворенням сульфату амонію, формуванням активних еколого-трофічних груп мікроорганізмів, що підсилюють ферментативну активність у плані формування всього ґрунтового процесу. Фосфогіпс, при внесенні в складний компост, а потім в ґрунт, сприяє утворенню малорозчинних сполук із важкими металами виконує природоохоронну роль.

Аналізуючи досвід господарювання та трансформації земельних відносин за останні двадцять років на Україні, вчені дійшли висновку [1], що всі економічні, технологічні, юридичні механізми, що застосовувалися для збереження родючості земель, не були достатньо ефективними. Втрата родючості земель в Україні набула і продовжує набувати глобального характеру.

Із проведених розрахунків [1] балансу поживних речовин та гумусу в ґрунтах України, можна зробити висновок, що сільгоспвиробниками із кожним роком не дотримується основний закон землеробства – винесення поживних речовин повинно компенсуватися шляхом їх повернення в ґрунт. Як наслідок, маємо від'ємний баланс поживних речовин та від'ємний баланс гумусу в ґрунтах.

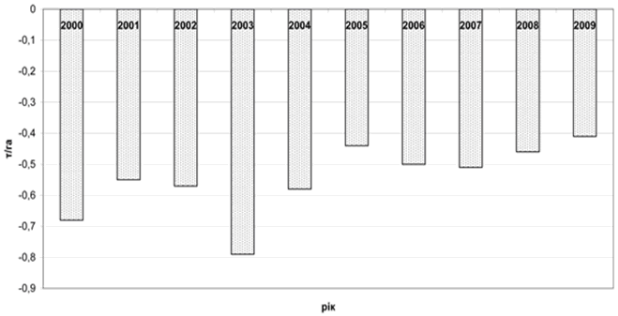

Рис.1. Баланс гумусу в ґрунтах України у 2000—2009 роках [1].