WATER TREATMENT PLANTS AND NORM - CZECH EXPERIENCE

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Legal basis

Water technology producing NORM

Uranium removal

NORM resulting in the removal of other substances

Handling of NORM
from water treatment plants

Conclusions

Legal basis

The Czech approach to limitation of exposures to natural radiation is based on the rules given by the Atomic Act (Act No. 18/1997 Coll., as amended) **and by the Decree of SONS on radiation protection** (Decree No. 3007/2002 Coll., as amended).

Workplaces where underground water is handled by pumping, collecting or by other methods, namely pumping stations, spa facilities, filling rooms and water treatment plants are considered as workplaces with potential risk of increased exposure to natural sources (§ 87 letter c, Decree on radiation protection).

Legal basis

If the raw water from an underground source contains natural radionuclides (usually higher concentrations of uranium or radium), the treatment of such water may lead to the production of NORM.

Workplaces performing treatment of underground water supply sediments and/or treatment of materials, in which the content of natural radionuclides exceeds clearance levels, or causes an increase of photon dose equivalent rate higher than 0.5 μSv/h, are thus classified in the same category (§ 87 letter e, Decree on radiation protection).

Legal basis

The owners of properties, in which the above mentioned workplaces are located, or the workplaces owners are obliged to ensure the measurements of natural radioactivity and the determination of effective doses of workers.

The exposure evaluation consists of three steps and it is based on the measurement of the average radon concentration in air during work activity of persons and on the determination of their effective dose above natural background caused by external gamma irradiation, by inhalation of natural radionuclides and by skin contamination.

Neznal M., Ženatá I. Evaluation of Occupational Exposures to Natural Radiation in the Czech Republic, 5th Conference on Protection against Radon at Home and at Work, Radiation Protection Dosimetry 2008; 130 (1): 30-33

Legal basis

Radiation protection of the population is ensured by limiting the release of radionuclides from NORM workplaces. A release of natural radionuclides from such workplaces into the environment is permitted only if clearance levels are not exceeded (§ 91 Decree on radiation protection) **or under the terms specified in a licence issued by SONS.**

In connection with the operation of water treatment plants, in particular the following materials are monitored: waste waters, used filter materials, sediments from sedimentation tanks.

Legal basis

Clearance levels

(materials, where a significant disturbance of radioactive equilibrium is expected)

Solid materials

Sum of shares of average mass activities of individual radionuclides and clearance levels of these radionuclides lower than 2

$$\sum_i \left(a_{m,i} / CL_i \right) \leq 2$$

Izotope	Radiotoxicity class	Clearance level [kBq.kg^{-1}]
^{238}U+	2	3
^{235}U+	1	0.3
^{230}Th	2	3
^{234}Th+	3	30
^{227}Th	2	3
^{228}Th+	1	0.3
^{223}Ra+	1	0.3
^{226}Ra+	1	0.3
^{228}Ra+	1	0.3
^{210}Pb+	2	3
^{231}Pa	1	0.3
^{227}Ac	1	0.3

Legal basis

Clearance levels

(materials, where a significant disturbance of radioactive equilibrium is expected)

Waste water released into surface water

Gross alpha activity lower than 0.5 Bq/l and gross beta activity after deduction of ^{40}K lower than 1 Bq/l

Waste water released into public sewerage system

Gross alpha activity lower than 50 Bq/l and gross beta activity after deduction of ^{40}K lower than 100 Bq/l

Solid materials deposited in the landfill

Increase of photon dose equivalent rate after deduction of natural background at a distance of 1 m from the surface of the landfill lower than 0.2 μSv/h

Water technology producing NORM

CR: about 60% of drinking water from surface water sources
about 40% from groundwater sources

The cause of exceeding the guideline values for drinking water:
usually an increased concentration of natural uranium and of isotopes of radium in the underground source
(presence of higher concentrations of other radionuclides less common)

Control activities of SONS: capturing of uranium or radium in filter materials can occur, when water cleaning is not targeted to remove natural radionuclides
- technologies for removal of other substances, particularly iron and manganese, arsenic or heavy metals.

Uranium removal

Limit of the concentration of natural uranium in drinking water : ***15 μg/l*** *(Chief Health Officer of the CR, 2007)*

Uranium in groundwater occurs generally as cations and selective ion exchange resins are used for its capturing (e.g. Lewatit). Selectivity is important to ensure sufficient sorption capacity. Selectivity also ensures that the mineral composition of the original groundwater is not modified. As a final result, the uranyl complex in groundwater is replaced by bicarbonates. Uranium is captured by ion exchange.

An increase of the uranium concentration in ion exchange cartridges is relatively fast (even after a short operation time the uranium content exceeds the clearance level for solid materials)**. On the other hand, when the ion exchangers are used, there is no need to perform washing and no waste waters are released from the water treatment plant.**

The spent ion exchangers are disposed in the state enterprise DIAMO, which is engaged in production of uranium concentrate.

NORM resulting in the removal of other substances

The accumulation of radionuclides occurs mainly in the filter media in open and in pressure filters, but also in sludge and in wash water.

Filter cartridges contain modified water-supply sand, or other sorbents (unmodified silica sand itself almost does not absorb radionuclides).

Water supply sands coated with oxides of iron and manganese (e.g. Greensand) are effective for capture of uranium or radium radioisotopes from 30 to 70%.

Also different types of sorbents - for example sorbent based on iron hydroxide with trade name GEH, used for the separation of arsenic, antimony, beryllium, chromium, molybdenum, aluminum, nickel and other materials - have high filtration efficiency for natural radionuclides, especially for uranium.

NORM resulting in the removal of other substances

Moreover, filters containing these materials require rinsing - in some cases frequent and intensive (intensive counterflow washing is required for loosening of the filter content). During the process, bound radionuclides are released into the waste water.

In some cases, concentrations of radionuclides are higher in the waste water than in the original underground water.

When the waste water is released into public sewerage system, the gross alpha activity is usually lower than the clearance level of 50 Bq/l.

Problems may arise from the discharge of waste water into surface waters due to the significantly lower clearance level (0,5 Bq/l).

NORM resulting in the removal of other substances

Example of water treatment plants, where the clearance level of 0.5 Bq/l was exceeded

Filter	Gross alpha activity (Bq/l)	
	Underground water	Waste water
Water treatment plant No. 1 (technology: removal of U)		
GEH	1.45	3.17
Water treatment plant No. 2 (technology: removal of U, As)		
GEH	0.66	2.13
Water treatment plant No. 3 (technology: removal of Fe, Mn)		
Greensand	2.87	1.31

Solution:

Water treatment plants No. 1 and No. 2: The original filter media GEH was replaced with Lewatit ion exchange resin, which does not require washing. These water treatment plants currently do not produce any waste water.

Water treatment plant No. 3: Waste water will be discharged into the public sewerage system.

Handling of NORM from water treatment plants

(Handling of spent ion exchangers, which are used for removal of uranium, has been already described.)

Options for further use or disposal of solid waste materials (filter materials, compacted sludge) with higher concentrations of radium and its decay products are intensively examined.

An appropriate way is to use this type of NORM for the remediation of tailings ponds, which originated in the past in the processing of uranium ore. These remediation activities currently underway in South Bohemia, on the site of the former chemical treatment plant of uranium ore MAPE Mydlovary. The condition for this use are appropriate physical and chemical properties of the material (low leachability).

Sludge and waste water from water treatment plants are often discharged into public sewerage system. They are mixed with a large volume of other, natural radionuclides uncontaminated waste water, including surface water and thus diluted are discharged to the wastewater treatment plant.

Handling of NORM from water treatment plants

Conclusions

NORM release into the environment is subject to strict rules. A release of natural radionuclides from NORM workplaces is permitted only in the scope not exceeding clearance levels or in the scope and under the terms specified in a licence issued by the state authority responsible for radiation protection.

Options for further beneficial use of some types of these materials are available. The disadvantage of these methods is their time limitation. For example: Remediation of tailings after processing of uranium ore is likely to be completed within a few years. Due to the decline of mining and processing of uranium ore in the Czech Republic, the future of the last chemical treatment plant of uranium ore is also uncertain.

It is therefore necessary to pay close attention to further development of appropriate methods and procedures, how to handle with NORM.

Thank you