PLANNED NEAR-SURFACE RADIOACTIVE WASTE REPOSITORY IMPACT ON PRODUCTIVE AQUIFER SYSTEM – CASE OF IGNALINA NPP

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Introduction. IAEA safety documents recommend assessing the safety margins of groundwater supply in the areas next to nuclear facilities. The main task of the present study is applying computer code FEFLOW to substantiate the water protection zones (WPZ) limitation of existing Visaginas wellfield with the maximal predicted (and permitted) wellfield pumpage rate of 31 000 m^3/day and to answer whether the planned near-surface repository (NSR) for radioactive waste and Ignalina NPP site is out of WPZ of Visaginas wellfield. The predicted doses obtained by human due to ^{14}C and ^{129}I in drinking water after 100 years from NSR closure should be below the dose constraint (0.2 mSv/y).

Methods. To implement the finite-element model based on FEFLOW 5.0, the study territory of 1300 km^2 was divided into a finite-element grid. The model was vertically divided into 7 active layers as was derived from the regional hydrogeological features (**Fig. 1**). The Visaginas town wellfield operates the very productive Upper-Middle Devonian multi-aquifer system. The calibrated model of Visaginas wellfield area simulated the groundwater flow in the Quaternary and Upper-Middle Devonian multi-aquifer systems for the modeling period 1978-2009. In the first modeling stage, the groundwater flow in steady-state conditions was recovered. In the second stage, potentiometric surface of productive Upper-Midle Devonian multi-aquifer system for 1987, when actual pumpage rate from the wellfield was maximal (~ 26 000 m^3/day), was restored. Model predictions of groundwater flow were fulfilled for the one Visaginas wellfield operation case, when wellfield is operated with the pumpage rate of 31 000 m^3/day.

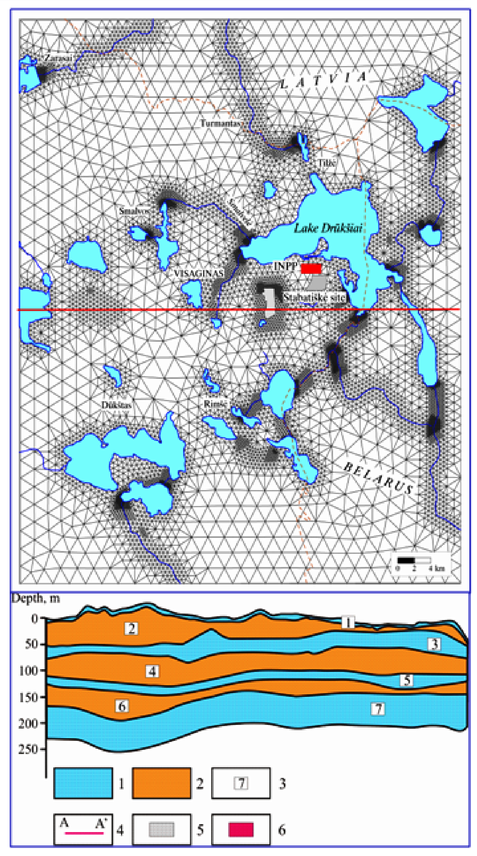

Fig. 1. Finite-element grid and simulated layers used for the model domain of Visaginas wellfield area: 1 – aquifers (in cross-section); 2 – low permeable layers (in cross-section); 3 – number of model layer; 4 – cross-section line; 5 - wellfield area; 6 – Ignalina NPP site.

Results. The groundwater level in the Upper-Middle Devonian multi-aquifer system in wellfield, in case of the pumpage rate of 31 000 m^3/day, will decrease till the altitude of 120-110 m a. s. l. The backward tracking endpoint analysis based on potentiometric surfaces of simulated aquifers is a routine tool implemented in FEFLOW 5.0 software and it was used for wellfield capture areas mapping. After 25 years operation of the wellfield with the pumpage rate of 31 000 m^3/day, its catchment boundary for productive Upper-Middle Devonian multi-aquifer system will be located at a distance of about 420-640 m. After 50 years operation of the wellfield with the same pumpage rate – 800-1140 m from the wellfield (**Fig. 2**). Catchment's boundary of Visaginas wellfield can reach the NSR site only in case when wellfied is operated with the pumpage rate more then 70 000 m^3/day (**Table 1**).

For the radionuclide analysis were selected two non-sorbed radionuclide ^{14}C and ^{129}I. The radionuclide distribution was simulated based on the assumption that the dispersion of radionuclides from radioactive waste repository begins straight after its closure. Visaginas wellfield is operated with the pumpage rate of 31 000 m^3/day. The maximal activity concentration of these radionuclides can reach the drinking water after 500-700 years after the closure repository, but activity concentration values in the productive multi-aquifer system water should be negligible (**Fig. 3**).

The maximum activity concentration of ^{14}C in the Visaginas wellfield expected after 700 years and should be below 10 Bq/m^3. The maximum volumetric activity of ^{129}I in the water will be after 500 years (~ 22 Bq/m^3). The effective dose caused by ^{14}C obtained by a human using a water from the Visaginas wellfield, would reach $4 \cdot 10^{-6}$ mSv/ year and $1.8 \cdot 10^{-3}$ mSv/year caused by ^{129}I.

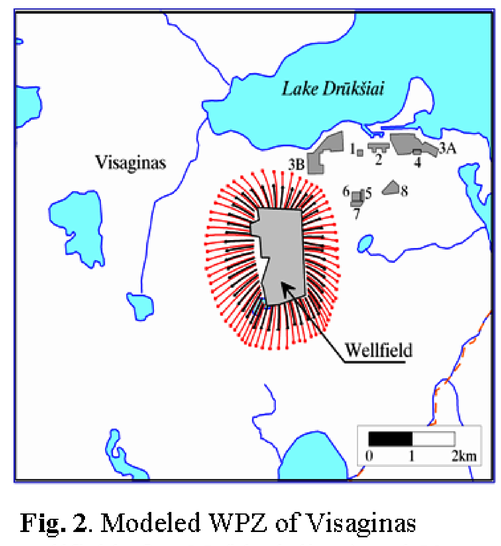

Fig. 2. Modeled WPZ of Visaginas wellfield after 25 (black lines) and 50 years (red lines) operation (1 – existing operational RW storage facilities; 2 – Ignalina NPP; 3A, 3B – sites for the planed new NPP; 4 – existing SNF storage facility; 5 – planned SNF storage facility; 6 – planned facilities for the solid waste management and storage; 7 – planned landfill facility for short-lived very low-activity RW; 8 - planned NSR in the Ignalina NPP industrial site).

Table 1. Predicted distance from wellfield capture zone boundary to the site for planned NSR for radioactive waste site assuming hypothetical yield implemented after 50 years operation period.

Wellfield yield, m^3/day	Distance from capture zone boundary to NSR site, m
31 000	1 310
40 000	1 080
45 000	765
50 000	600
55 000	465
60 000	315
65 000	180
70 000	60
75 000	0

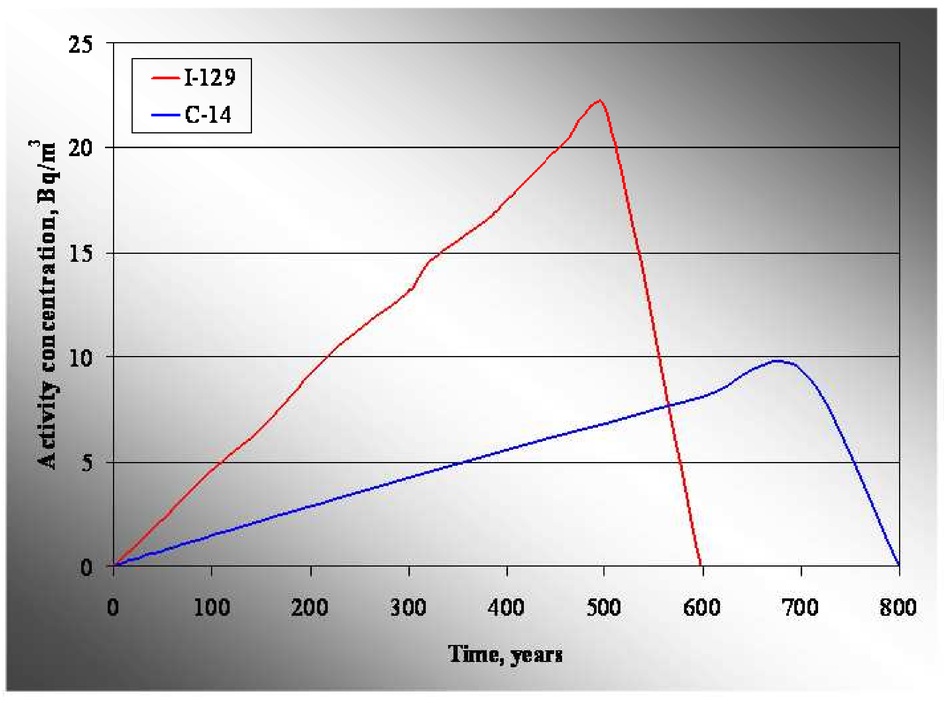

Fig. 3. ^{14}C and ^{129}I activity concentration variability in the Visaginas wellfield water when wellfield pumpage rate is 31 000 m^3/day

Conclusions. Using computer code FEFLOW 5.0 the groundwater formation sources were specified and dimensions of water protection zones were established and radionuclides distribution in the productive Upper-Middle Devonian multi-aquifer system modeled. The results show that Visaginas wellfield capture zone after 50 years operation period would reach the site for a NSR for radioactive waste in case of hypothetical very high wellfield pumpage rate more than 70 000 m^3/day. ^{14}C and ^{129}I activity concentration distribution in drinking water would be negligible and the effective dose caused by a ^{14}C and ^{129}I , would be respectively $4 \cdot 10^{-6}$ mSv/year and $1.8 \cdot 10^{-3}$ mSv/year, which does not exceed the dose limit (0.2 mSv/year).