Evaluation of Radioactive Air Contamination due to a Forest Fire within the Exclusion Zone on June 5–8, 2018

**Introduction**

The highly contaminated territories of Ukraine and Belarus after the Chornobyl accident still remain potential sources of radioactive contamination due to forest fires there, first of all within the Ukrainian Chornobyl Exclusion zone and the Belarus Polesie Reserve. The radionuclides in the vegetation and soil would be emitted to the atmosphere during vegetation fires, which could represent a risk for firefighters and other personnel of these zones. In addition, a population could be affected by radioactive smoke particles transported over long distances. So, an assessment of the possible influence of forest fires in radioactively contaminated territories on the radioecological situation in the Exclusion zone and beyond is of particular interest. Unfortunately, data of direct measurements of additional air contamination and fallout on the underlying surface during fires are usually quite scarce (both in spatial and in temporal resolution). Therefore, methods of mathematical modeling of the atmospheric transport of radioactive aerosols — products of vegetation burning — are an important tool for a comprehensive assessment of the effects of forest fires.

The article presents a comparison of the results of calculations performed using the model complex developed in the Institute for Safety Problems of Nuclear Power Plants (ISP NPP) with direct measurements of the effects of the wildland fires in the Exclusion zone during June 5–7, 2018.

**Radionuclide emission due to wildland fires at radioactively contaminated territory (observation and modeling)**

The main source of radionuclide emission after wildland fires in the contaminated territories is the Chornobyl exclusion zone (ChEZ) with an area of 2,600 km². The forests covered 53 % of the area before the disaster. After 1986, economic activity stopped and the forest area extended. Now about 38 % of the territory is Scots pine forests, 30 % is broadleaf forests, and the other 32 % is deforested and former agriculture areas [1]. The lack of fire management allowed the vegetation to overgrow, creating conditions favorable for fires to ignite and spread. The radionuclides $^{137}$Cs, $^{90}$Sr, $^{238}$Pu, and $^{239} + ^{240}$Pu are concentrated mostly in litter and the top layer of soil in the forests and grasslands in ChEZ [2].

According to [3], from 1993 to 2013 more than 1,250 wildland fires of different types occurred in the ChEZ. Approximately 55 % of the fires occurred in former agricultural lands and about 33 % occurred in forested land. Although these fires consumed only 3,300 ha of vegetation, larger fires have occurred in the region. The largest fires were observed in July–August, 1992 (a total area of 17,000 ha of agricultural and forest land including crown fire over an area of 5,000 ha during a two week period) and in April 2015 (6,250 ha of grass fires at meadows, 2,737 ha of forest ground fires and 1,140 ha of forest crown fires). According to the measurement data within the ChEZ, the activity concentration in the surface air increased up to 7.6 mBq m$^{-3}$ of $^{137}$Cs and 10 mBq m$^{-3}$ of $^{90}$Sr [4].

Besides the ChEZ itself, the wildland fires could impact the radiological situation outside it. The long-range transport of smoke plumes after the forest fires in the ChEZ and near it was observed by the satellites [5]. Increasing the $^{137}$Cs activity concentration in the air was reported in Sweden [6] and Lithuania [7] during extensive forest fires in the radioactive contaminated territory of Ukraine and Belarus in 1987–2003. According to [8], several fires

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Emission fraction</th>
<th>Source</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{137}$Cs, $^{90}$Sr</td>
<td>5 % of deposited</td>
<td>[10]</td>
<td>Grassland fires (comparison of modeling and experimental data)</td>
</tr>
<tr>
<td>$^{137}$Cs, $^{90}$Sr</td>
<td>up to some%</td>
<td>[10]</td>
<td>Forest fire (comparison of modeling and experimental data)</td>
</tr>
<tr>
<td>$^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Am</td>
<td>1 % of totally available within the burnt area, or ~10 % of available in the biomass</td>
<td>[20]</td>
<td>Estimation for modeling of inter- and intra-continental transport of cesium released by boreal forest fires</td>
</tr>
<tr>
<td>$^{137}$Cs</td>
<td>40 % of deposited</td>
<td>[13]</td>
<td>Conservative estimation for modeling of redistribution over Europe</td>
</tr>
<tr>
<td>$^{137}$Cs, $^{90}$Sr</td>
<td>20 %</td>
<td>[11]</td>
<td>Conservative estimation for modeling</td>
</tr>
<tr>
<td>$^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Am</td>
<td>10 %</td>
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<td>Estimation value has been obtained after the natural forest fire in the ChEZ in July, 1992</td>
</tr>
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<td>$^{137}$Cs</td>
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<td>$^{137}$Cs</td>
<td>4 % of deposited</td>
<td>[2]</td>
<td>Fire experiments in the ChEZ</td>
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<td>up to 3 –4 %</td>
<td>[10]</td>
<td>Grassland fires (comparison of modeling and experimental data)</td>
</tr>
<tr>
<td>$^{137}$Cs</td>
<td>40–70 %</td>
<td>[18]</td>
<td>Straw and wood burning experiments in field and laboratory conditions. Biomass were combusted with temperatures varying from 160 to 1,000 °C</td>
</tr>
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in 2002 resulted in $^{137}$Cs transport over Europe. The highest release occurred at the end of July, with $^{137}$Cs fallout reaching Sweden, Finland, and Central Europe.

Wildland fires may result in additional contamination of the air both in the immediate vicinity of the fire territory and over long distances, including long-range atmospheric transport of fine aerosol. Therefore, different types of models of emission, following atmospheric transport and deposition of fire products are developed for the local area around the fire (up to 10 km) [9, 10] and mesoscale and long-range atmospheric transport [8, 11–15]. The main features of the radionuclide atmospheric transport models for different spatial and temporal scales are determined primarily by the nature of the diffusion processes of pollutants in the atmosphere, and they are similar for both models of emissions from point sources — e.g., from a nuclear power plant (NPP) stack — and for the re-suspension models during forest fires. The main problem for models of forest fires is the correct description of the radioactive aerosol source parameters (duration and area of the fire, emission intensity for the different phases of the fire, the initial raising height of smoke plume, activity size distribution of radioactive particles). In general, a model of atmospheric transport of smoke particles must be a part of a more general model of wildland fire evolution [16, 17]. Using a number of simplifying assumptions a sub-task of assessment of radioactive contamination of the atmosphere by combustion products can be singled out of the general picture describing the development of the fire and its consequences. Then this problem can be solved by relatively simple methods. The price of such simplification is the introduction into used models a number of constants whose values have to be determined empirically.

One of the main problems of radionuclide atmospheric transport models due to forest fires is the parameterization of the emission fraction of radionuclide after a fire event, namely the fraction that will be emitted compared to what is present on the ground or in the biomass. Evidence from laboratory experiments and field studies are quite contradictory (Tab. 1).

Therefore, any available information about the consequences of past fires is an important material for the validation of models of atmospheric transport of forest fire products, as well as for their further improvement.

**General description of the forest fire on June 5—7, 2018**

During the period from June 5 to June 8, 2018, several areas of grass and forest were burned on the territory of the 10-kilometer zone of the Chornobyl NPP. The most intense fires took place in two forest areas located near the Interim Spent Nuclear Fuel Dry Storage Facility (ISF-2) (Figs. 1, 2), where the seats of fire were detected about 11:00 on June 5, 2018 [22]. In total, according to the State Emergency Service of Ukraine, a fire covered about 15 hectares. At 17:50 on June 7 a fire in the forest area in the Exclusion zone was liquidated. During the fire, the personnel of the State Specialized Enterprise (SSE)”Ecocenter“ made an air sampling at the fire line using the mobile aspiration facility, in particular, in the 16th quarter of the Korohod forestry. The $^{137}$Cs activity concentration in this sample was about $9.8 \times 10^{-2}$ Bq/m$^3$ that exceeds the reference level by 9.8 times, and the $^{90}$Sr activity concentration was obtained to be $1.6 \times 10^{-1}$ Bq/m$^3$ that by 53 times exceeds the reference level ($3 \times 10^{-3}$ Bq/m$^3$) established by health and safety standards.
According to the measurements of the atmospheric surface layer contamination by radioactive aerosols conducted at stationary sites of the SSE "Ecocenter" automatic radiation monitoring system (ASKRO), the $^{137}$Cs and $^{90}$Sr volumetric activity concentration at the Chornobyl site exceeded the established control levels ($8.0 \times 10^{-5}$ Bq/m$^3$ and $4.0 \times 10^{-5}$ Bq/m$^3$, respectively). The $^{137}$Cs volumetric activity concentration was obtained to be $2.2 \times 10^{-4}$ Bq/m$^3$ (at 1:40 06.06.18), $3.8 \times 10^{-4}$ Bq/m$^3$ (at 15:00 06.06.18) and $4.7 \times 10^{-3}$ Bq/m$^3$ (sampling was made using a mobile aspiration facility from 15:00 to 18:00 06.06.18). The corresponding values for the $^{90}$Sr volumetric activity concentration were $2.4 \times 10^{-4}$, $2.5 \times 10^{-4}$ and $2.3 \times 10^{-3}$ Bq/m$^3$.

At the exclusion zone border (Dytyatky site), the $^{137}$Cs volumetric activity concentration on June 6 was $2.7 \times 10^{-5}$ Bq/m$^3$ which didn’t exceed the reference level ($2.1 \times 10^{-4}$ Bq/m$^3$).
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Meteorological conditions during the fire

The territory of the Exclusion zone on June 5, 2018, was in the low pressure area, in the trough of the north-western cyclone (Fig. 3). At night, a surface temperature inversion and an increase in the wind speed (from 1 to 9 m/s) in the air layer up to 280 m were observed (Fig. 4). Over the course of the day, a cold front passed over this area resulted in a temperature drop of 27.6 °C to 17.8 °C in the afternoon. During the next 3 days there was an increase in atmospheric pressure, which led to the formation of an anticyclone with a centre over the territory of Ukraine and Belarus with the prevailing northern and northwest atmospheric circulation. On June 6–7, 2018, the typical for the summer period vertical profiles of wind have been replaced by a weak wind (2–3 m/s) at altitudes up to 1,500 m and near-surface temperature inversions. It should be noted, that the weak wind or calm with a near-surface temperature inversion contributes to the increased pollution of atmospheric the near-ground air.

Survey of burnt forest areas

Measurement of the exposure dose rate and sampling of forest litter and top layer of soil was performed on August 22, 2018, to estimate the value of radioactive contamination in 2 burned forest areas (Fig 5). In Fig. 6 54 points of exposure dose measuring in site no. 1 (located 300–400 m from the ISF-2) are shown and 10 points in site no. 2. The sites are separated by the Chornobyl — Pripyat road. Measurement of gamma dose rate values was performed in accordance with the approved method using the dosimeter-radiometer DRG-01T. At each point, measurements were made at heights of 0.1 m and 1.0 m. The distance between measurement points was chosen taking into account the uniformity of contamination and dimensions of the surveyed sites: through every 100 m, starting from the western border of the site and reaching its eastern boundary. After that, the same route was shifted 100 m to the north until reaching the northern boundaries of the surveyed site.

Measured values of the exposure dose rate in burned areas range from 0.058 to 0.660 mR/h at a height of 1 m and from 0.080 to 0.800 mR/h at a height of 0.1 m above the ground resulting in the average values of 0.359 and 0.526 mR/h, respectively.

In these areas, in October 2018, sampling of forest litter (ash) and topsoil in 6 points at Site no. 1 and in 10 points in Site no. 2 were carried out. In addition, sampling of soil and litter on a non-burned forest area near the fire territory has been carried out (see Fig. 6). Simultaneously with soil sampling, at each point the gamma dose rate measurement at heights of 0.1 and 1 m was made. The geographic coordinates of sampling points were determined with using GPS. Soil sampling was carried out according to a unified method to a depth of 3 cm using a cylindrical sampler with a diameter of 80 mm.

The measurements of the selected samples were carried out using the γ-spectrometric complex Canberra, consisting of a GL2020R semiconductor detector made of ultra pure germanium with a beryllium window 500 μm thick and a multichannel analyzer (16 K). The minimum measurable activity for the geometry of measurements for the γ-line 59 keV of $^{241}$Am is 0.03 Bq/sample, and for $^{137}$Cs (661.6 keV) is 0.4 Bq/sample.
According to measurements of 14 samples, the average value of the density of cesium-137 surface contamination at burned sites was about 2.85 MBq/m² (with variability of values from 1.02 to 5.40 MBq/m²). The value of the exposure dose rate at burned areas varies from 0.245 to 0.845 mR/h at a height of 1 m above the ground and from 0.288 to 1.38 mR/h at a height of 0.1 m.

In Fig. 7 the dependence of the gamma dose rate \( H \) (mR/h) on the density of soil top layer \( D \) (MBq/m²) at 14 measurement points in two sites of burned forest is presented. The correlation between them for the measurement height of \( h = 0.1 \) m is sufficiently well described by the linear dependence of \( H = 0.248 \cdot D \) with the accuracy of approximation \( R^2 = 0.707 \). For the measurement height of \( h = 1 \) m this dependence is less distinct (\( R^2 = 0.270 \)) and is given by \( H = 0.149 \cdot D \).

For 6 samples (Tab. 2, four of which were selected at Site no. 2 and two at an adjacent non-burned area), spectrometric measurements of the gamma-emitting \(^{154}\text{Eu}\) and \(^{241}\text{Am}\) nuclides content were additionally conducted. The ratio of \(^{137}\text{Cs}/^{154}\text{Eu}\) activity in these samples varies almost in 2 times — from 240 to 450. The ratio of \(^{137}\text{Cs}/^{241}\text{Am}\) varies from 22 to 40, and the \(^{241}\text{Am}/^{154}\text{Eu}\) ratio — from 8.9 to 12.4.

**Modeling resuspension and following atmospheric transport of radioactive aerosols due to the forest fire**

To assess the effects of the fire on June 5–7, 2018, a set of models of the ISP NPP was used, which includes: 1) the mesoscale numerical weather forecast model WRF-ARW; 2) the model for the formation of a convective plume over the fire area — for estimation of the maximum lifting height of radionuclides in the atmosphere at the initial stage of their transport; 3) the Lagrangian-Eulerian diffusion model LEDI of the radionuclide atmospheric transport and their deposition on the surface — for calculating the atmospheric transport of radioactive aerosol particles products at distances up to 100 km.

The results of the WRF-ARW numerical weather forecast model (current version of model V3.9.1) \[23\] were used as input meteorological information for modeling of radionuclides dispersion released into the atmosphere due to the fire. A numerical grid covering the territory of Ukraine with the center in the vicinity of the Chornobyl NPP was chosen with the number of nodes on the horizontal plane of 144×120 and the grid step of 5 km. The number of levels in height was set as 35. Calculations using the WRF-ARW model were performed using the results of the project of data re-analysis from the international meteorological network ERA-40 (global atmospheric reanalysis) performed in European Center for Medium-Range Weather Forecasts (ECMWF) \[24\].

For the subsequent modeling of atmospheric transport of radioactive aerosol, calculated 3-dimensional fields of wind and air temperature were used, as well as the

**Table 2. Data on radionuclide contamination measurement of top soil samples**

<table>
<thead>
<tr>
<th>Sample code</th>
<th>Nuclide</th>
<th>Top soil contamination density, kBq/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2–2 (Site no. 2)</td>
<td>(^{137}\text{Cs})</td>
<td>457</td>
</tr>
<tr>
<td></td>
<td>(^{154}\text{Eu})</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>(^{241}\text{Am})</td>
<td>15.2</td>
</tr>
<tr>
<td>P2–4 (Site no. 2)</td>
<td>(^{137}\text{Cs})</td>
<td>341</td>
</tr>
<tr>
<td></td>
<td>(^{154}\text{Eu})</td>
<td>0.802</td>
</tr>
<tr>
<td></td>
<td>(^{241}\text{Am})</td>
<td>9.97</td>
</tr>
<tr>
<td>P2–5 (Site no. 2)</td>
<td>(^{137}\text{Cs})</td>
<td>346</td>
</tr>
<tr>
<td></td>
<td>(^{154}\text{Eu})</td>
<td>1.44</td>
</tr>
<tr>
<td></td>
<td>(^{241}\text{Am})</td>
<td>15.4</td>
</tr>
<tr>
<td>P2–8 (Site no. 2)</td>
<td>(^{137}\text{Cs})</td>
<td>176</td>
</tr>
<tr>
<td></td>
<td>(^{154}\text{Eu})</td>
<td>0.564</td>
</tr>
<tr>
<td></td>
<td>(^{241}\text{Am})</td>
<td>4.99</td>
</tr>
<tr>
<td>L-2 (non-burning area)</td>
<td>(^{137}\text{Cs})</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>(^{154}\text{Eu})</td>
<td>0.454</td>
</tr>
<tr>
<td></td>
<td>(^{241}\text{Am})</td>
<td>4.59</td>
</tr>
<tr>
<td>L-4 (non-burning area)</td>
<td>(^{137}\text{Cs})</td>
<td>127</td>
</tr>
<tr>
<td></td>
<td>(^{154}\text{Eu})</td>
<td>0.281</td>
</tr>
<tr>
<td></td>
<td>(^{241}\text{Am})</td>
<td>3.22</td>
</tr>
</tbody>
</table>
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values of characteristics of the atmospheric boundary layer (the atmospheric boundary layer height and the dynamic velocity $u_*$), obtained with a time step of 1 hour for the period from 00 h June 5 to 00 h June 8, 2018.

In the simulations, the fire area is considered as a constant area source of radionuclide emission in the atmosphere. According to the obtained data, the total $^{137}\text{Cs}$ activity in the burning areas was estimated as about $5.5\times10^{11}$ Bq. According to previous studies, the part of activity entering in the air of the forest area was set equal to 5% of this value. The height of the rise of the smoke plume formed over the fire area was estimated to be about 300–500 m (depending on meteorological conditions during the fire period) with using the above-mentioned model of a convective plume over
the fire area. The radioactive aerosol particle size formed due to the fire was set constant and equal to 1 μm.

The fields of instantaneous and integral (for the whole period of the fire) of the $^{137}$Cs volume activity in the surface air (Fig. 8) and the $^{137}$Cs deposition density on the earth’s surface were calculated using the atmospheric transport model LEDI.

Additionally, $^{137}$Cs activity in the air was calculated for 4 settlements: Kyiv, Chornobyl, Dytyatky and Mila (105 km to the south from the Chornobyl NPP). The last settlement was chosen for the calculation because the personnel of the State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS) made a special measurement during the fire with using a mobile laboratory [25]. The $^{137}$Cs activity in the air in the period from 13:15 to 14:25 on June 6, 2018, was measured to be 0.6 mBq/m$^3$.

According to our calculations, the maximum activity of $^{137}$Cs (averaged over a 1-hour period) in the surface air in Kyiv reached 0.82 mBq/m$^3$ at 23 h on June 5 and 1.22 mBq/m$^3$ at 02 h on June 7, 2018. For Chornobyl city the estimated maximum $^{137}$Cs activity in the air was about 10 mBq/m$^3$ (in the afternoon on June 5 and at 18 h. on June 6, 2018, when the radioactive aerosols transport was directed to the city), and for Dytyatky — it could reach up to 1 mBq/m$^3$. In general, the obtained results are in agreement with the measurements of the cesium-137 activity in the air carried out by the ASKRO networks of the “Ecocenter”, as well as the data of SSTC NRS (Fig. 9).

Conclusions

According to the both direct measurement data and modeling results an increase in the activity concentration in the air during forest fires in the ChEZ is quite low. It does not lead to a significant increase in the dose of the population of Ukraine and other countries. However, the problem of assessing the forest fires danger in the contaminated territories in the ChEZ remains relevant. Each event of a forest fire in the ChEZ attracts the attention of the media and the population living near the ChEZ, including the residents of Kyiv and other major cities. In the case of particularly large and prolonged fires, radioactive aerosols can spread over long distances outside Ukraine, including the countries of Western Europe. Therefore it is necessary to have a reliable means for rapid assessment and prediction of atmospheric transport of radioactive aerosols rising into the air as a result of forest fires. To date, the main problem that requires further research is the development of methods for operational determining the parameters of the forest fire territory as an area non-stationary source of radioactive aerosols. Among them are the following:

1. **Rapid assessment and prediction of the territory size covered by a forest fire, including the temporal dynamics of the spread of the fire front.** In general, it is necessary to use a special surface fire spread models for the calculation of fire spread over the area taking into account the properties...
of the area and weather conditions. However, these models require detailed information on the characteristics of the forest, which is not always available. These values can be set according to the observations and by expert estimates.

2. **Estimations of the value of the radionuclide emission fraction during forest fires** are differed considerably — from a few percent to 70% according to the reviewed experimental and modeling works. The most valid are the results of field experiments and model estimates of the radionuclide emission fraction, carried out for the fires in the ChEZ, which give values 3–5% of $^{137}$Cs and $^{90}$Sr and up to 1% of the Pu isotopes. Conditions of experiments for biomass burning, for which estimates are obtained from 20% and above, as a rule, don't fully correspond to the real conditions of the wood burning in a forest fire. In addition, it's necessary to note that in the second year after the deposition the bulk of radionuclides migrates to the forest litter and soil. As a result, the proportion of radionuclides that could potentially be raised to the atmosphere from forest fires, in their total stock in the contaminated area is steadily decreasing over time. Thus, the model estimates of the effects of forest fires on the territory of Ukraine and neighboring countries, obtained using the emission fraction value of 10% or more, can be considered as very conservative.

3. **Effective height of the smoke plume lifting over a forest fire.** Its value is determined primarily by the ratio between the kinetic energy of the rising air flow (determined by the intensity of heat release in the fire zone) and the wind kinetic energy.

4. **The size distribution of particulate matter formed during burning.** The large particles (more than 20 microns) that are formed in a fire, deposited near the burning territory up to 100 meters). Ignoring this factor in the simulation could lead to an overestimation of the long-range transport of radionuclide’s, and simultaneously to an underestimation of the value of the additional deposition in the near (up to 100–1000 m) fire zone.

Clarification of these parameters values and methods for their reliable estimation will enable to improve models of atmospheric transport of radioactive aerosols rising into the air as a result of forest fires, for a variety of spatial scales.

**References**

24. *European Centre for Medium-Range Weather Forecasts (ECMWF)*. Available at: http://apps.ecmwf.int/datasets/data/era40-daily/levttype=pl.

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Оцінка радіоактивного забруднення повітря внаслідок пожеж в Чорнобильській зоні відчуження 5–8 червня 2018 р.

Наведено результати моделювання розповсюдження радіоактивних аерозолів, які потрапили в атмосферу в результаті пожежі на ділянках лісу в Чорнобильській зоні відчуження (у районі СВЯП-2) у період 5–8 червня 2018 р. Для оцінки її наслідків було використано комплекс моделей Інституту проблем безпеки АЕС НАН України, який включає мезомасштабну модель прогнозу погоди WRF, модель формування конвективного струму над площею пожежі та лагранжово-єйлерову дифузійну модель LEDI атмосферного перенесення радіонуклідів та їхнього осадження на підстилку поверхні. Модельні розрахунки розповсюдження радіоактивних продуктів горіння виконано на відстані до 100 км від району пожежі. Наведено результати пробовідбору зразків лісової підстилки, що вигоріла, та верхнього шару грунту, виконаних з метою оцінки запасів активності на двох ділянках пожежі. Середнє значення щільності забруднення поверхні 137Cs становило близько 2,85 МБк/м² (за варіабельність значень від 1,02 до 5,40 МБк/м²). Потужність експозиційної дози на ділянках, що вигоріли, варіювала від 0,288 до 1,38 мР/год. Згідно з розрахунками максимальне значення активності 137Cs у приземному повітрі в Києві в окремі періоди пожежі могло досягати близько 1 МБк/м², у Чорнобиль – більш 10 МБк/м². Отримані результати в цілому узгоджуються з даними вимірювань активності 137Cs у повітрі, що проводились мережею постів автоматизованої системи контролю радіаційної обстановки (АСКРО) ДП «Екоцентр», а також даними пробовідбору повітря в с. Міла Київської області (результати Державного науково-технічного центру з ядерної та радіаційної безпеки). Виділено основні проблеми моде-
оценивание вторичного загрязнения воздуха радиоактивными аэрозолями в результате пожаров лесов на радиоактивно забруженной территории, что требует подобного уточнения при удосконаленных видах моделей, а самое: а) интеграция моделей атмосферного переноса радионуклидов с моделями розповсюдження фронту пожежи на территории, что горит; б) оценка частки активности, что падает в воздухе при пожаре, в) загрязнение запасов радионуклидов в лесной атмосферный перенос и др.; г) оценка эффективной высоты падения дымового струй на территорию пожежи; г) параметризация розподілу аерозольних часток — продуктов горения за розмірами.

Ключевые слова: пожарные пожары, радиоактивные, атмосферные загрязнения, моделирование, Зона отчуждения.

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Оценка радиоактивного загрязнения воздуха в результате лесного пожара в Чернобыльской зоне отчуждения 5–8 июня 2018 г.

Приведены результаты моделирования распространения радиоактивных аэрозолей, попавших в атмосферу в результате пожара на участках леса в Чернобыльской зоне отчуждения (в районе ХОЯТ-2) в период 5–8 июня 2018 г. Для оценки этих последствий был использован комплекс моделей Института проблем безопасности АЭС НАН Украины, который включает модель прогноза погоды WRF, модель формирования конвективной струи над площадью пожара и лагранжево-эйлерову диффузионную модель LEDI атмосферного переноса радионуклидов и их осаждения на подстилающей поверхности. Модельные расчеты распространения радиоактивных продуктов горения выполнены на расстоянии до 100 км от района пожара. Приведены результаты пробоотбора образцов выгоревшей лесной подстилки и верхнего слоя почвы, выполненных с целью оценки запасов активности на двух участках пожара. Среднее значение плотности загрязнения поверхности 137Cs составило около 2,85 МБк/м² (при вариабельности этой величины от 1,02 до 5,40 МБк/м²). Согласно расчетам, максимальное значение активности 137Cs в атмосфере в Киеве в отдельные периоды пожара могло достигать значений около 1 МБк/м³, в Чернобыль — около 10 МБк/м³. Полученные результаты в целом согласуются с данными измерений активности 137Cs в воздухе, проведенных съемкой постов автоматизированной системы контроля радиационных обстановок (АСКРО) ПГ "Экоконтроль", а также данными пробоотбора воздуха в с. Мила Киевской области (результаты Государственного научно-технического центра по ядерной и радиационной безопасности).

Ключевые слова: лесные пожары, радиоактивные, атмосферные загрязнения, моделирование, Зона отчуждения.

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