INVESTIGATIONS OF SOIL RADIOACTIVITY LEVELS IN YEREVAN CITY FROM 1990 TO 2002.

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ABSTRACT

Radioecology is an interdisciplinary product of several scientific disciplines which is ultimately intended to provide forecasts of radionuclide impacts on the environment. Such forecasts must be based on an understanding of past and present observations. In Armenia, radioecological investigations have been conducted since 1958. The study object is the capital of Armenia – Yerevan city. This paper presents the results of radioecological investigation of Yerevan soils from 1990 to 2002. In 1990, a large number of soil samples (about 760) taken from different sites of Yerevan were analyzed. The analyses were done in the radioecological laboratory of the CENS. We used a method of gross β-activity measurement as an indicator of radioactive pollution of the environment. Based on these results, we produced the Yerevan soil radioactivity distribution maps (1:10000) with the application of Surfer 6.04 GIS program. Using the gamma-spectrometric analysis, we determined the radionuclide composition of samples. In 2002, 74 soil samples were taken from the same sites as in 1990 and analyzed. Our studies show that the soil radioactivity in Yerevan has definitely decreased in 2002 vs. 1990. Currently, we also study the radioactivity of vegetation in Yerevan. So, radioactivity levels tend to change in time and the systematic surveys of concentrations and flows of radionuclides are essential.

INTRODUCTION

Radioecology is an interdisciplinary product of several scientific disciplines which is ultimately intended to forecast the radionuclide impacts on the environment. Such forecasts should be based on an understanding of past and present situations. Radioactivity levels tend to change in time and the systematic surveys of concentrations and flows of radionuclides are essential (radioecological monitoring).

The global contamination of the Earth's surface by radioactive substances makes the soils cover to function as a powerful natural adsorbent accumulating the depositing radioactive fission products. The urban areas are known to hold high levels of chemical and radioactive contamination of the environment, including soils, that results from energy- and industrial production induced emissions, traffic, garbage combustion and others [1].

Our study area is Yerevan - the capital of Armenia. The city is located in north-eastern part of the Ararat Valley and occupies about 220 km^2. The following landscape belts have been recognized in Yerevan: semi-desert (800 –1200 m a.s.l.) and dry grassland (1200-1400 m). The climate is dry continental. Mean annual precipitation makes 300-400 mm. The soils are mainly brown carbonic, somewhere the multicolor salt lands occur.

Yerevan – a densily populated city (population - over 1 mln) with heavy traffic - holds many industrial enterprises and a heat - producing station. The Armenian nuclear power plant is situated 30 km to the north - west from Yerevan.

MATERIAL AND METHODS

The natural radioactivity level serves a criterion of relative radiation purity or pollution level of soils. In our studies we used one of the kinds of measurement monitoring – a method of gross β-radioactivity measurement as an indicator of radioactive pollution of the environment. The measurements of β-radioactivity of different soils sampled in Armenia in 1943 - 1950, when there was no pollution at all, have shown that the natural level of soil β-radioactivity varied from 489 to 562 Bq/kg. The gross natural radionuclides (U, Ra, Th, K, Rb) averaged 522 Bq/kg. Potassium made 68% of the gross radionuclides [2]. So, as a standard for natural radioactive background of soils a β-radioactivity value equal to 500-600 Bq/kg, mean 550 Bq/kg is accepted. It should be noted that the same minimal threshold of 500 Bq/kg was accepted in a region faraway from Armenia – the Ukraine (the area of Zaporozhie RWDE) [3].

Our study material comprised the soil samples taken in Yerevan in 1999, 2000, and 2002. The urban territory was divided into the sampling plots. The samples were collected over the grid network at every 100 cm at depths 0-10-15 cm. The samples were dried, ground and sieved through a one - mm mesh. The β-radioactivity measurements were carried out by β-radiometer RKB4-1eM. KCL served a standard. The sample weight was 100 g.

Basing on these results, we produced the Yerevan soil gross β-radioactivity distribution maps (1:10000) applying Surfer 6.04 GIS program.

Using the gamma-spectrometric analysis we determined the radionuclide composition of soil samples, particularly, ^{137}Cs on gamma-spectrometer with semiconductor detector HpGe (Canberra). The analyses were done in the radioecological laboratory of the CENS.

RESULTS AND CONCLUSIONS.

As our studies show, radioactivity levels significantly change in years, hence systematic surveys of radionuclide contents and migration (i.e., radioecological monitoring) are essential.

In 1990, a large number of soil samples (about 760) taken from different sites of Yerevan were analyzed for Σβ-radioactivity. A significant patchiness was found in distribution of soil Σβ-radioactivity in Yerevan. Each plot contained the natural level and different patterns of radioactive pollution [4]. Wholly, min. and max. indices throughout the city varied in considerable limits: 538-919 Bq/kg. In 2002, 74 soil samples were taken from the same sites as in 1990 and analyzed for comparison. In 1990, 7% of total number of samples (74) had the Σβ-radioactivity from 550- to 650 Bq/kg. Majority of samples (41.5%) had 651-750 Bq/kg, and 31% had 751-800 Bq/kg. The radioactivity of 11% of samples was high - over 800 Bq/kg (Figs. 1, 2).

Figure 1. Distribution of sampling points throughout Yerevan city.

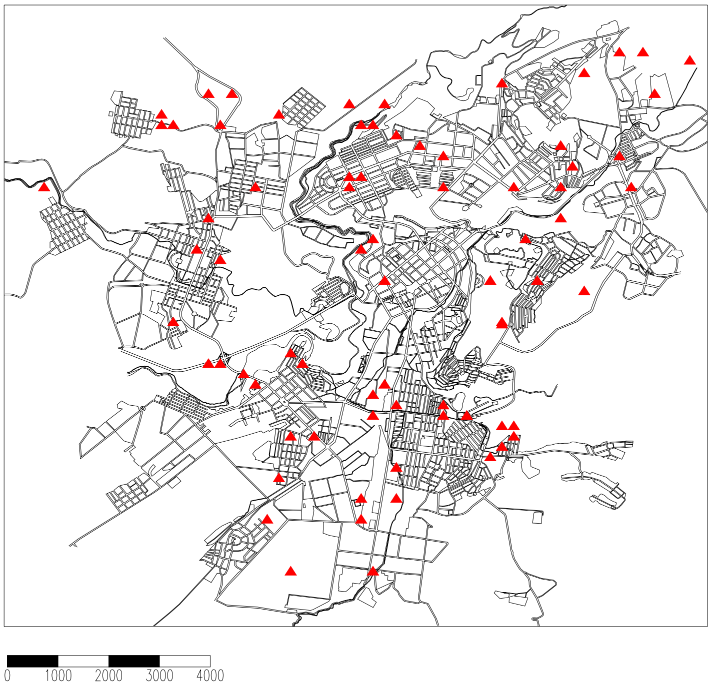
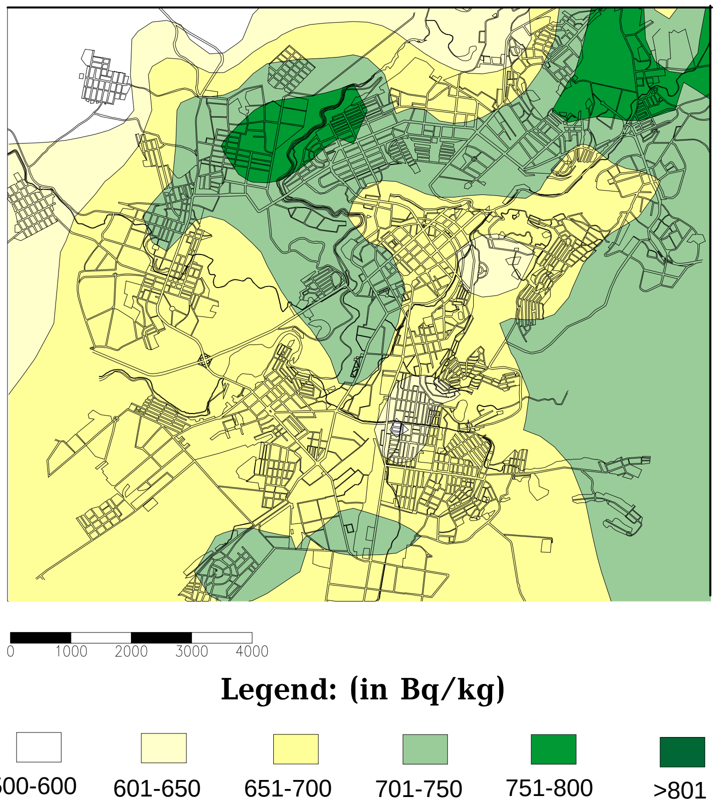
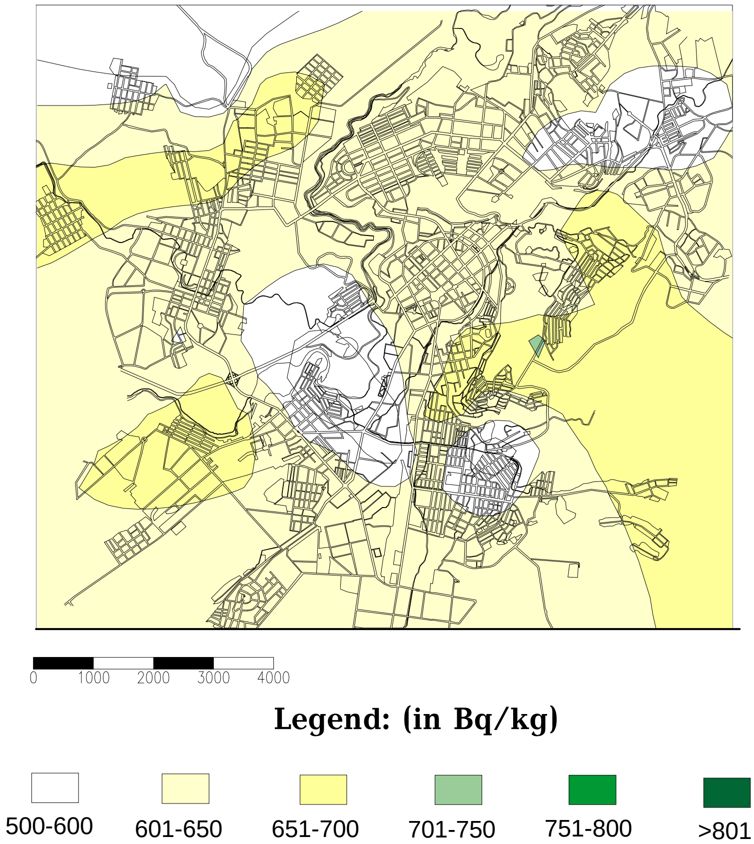


Figure 2. Gross β-radioactivity distribution in the soils of Yerevan city in 1990.



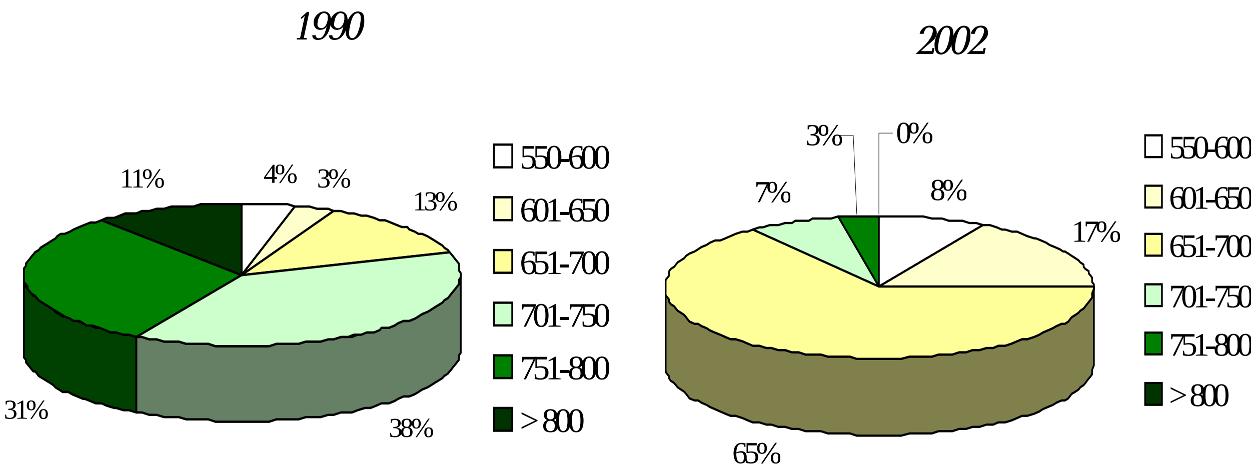
In 2002, 25% of total number of samples were close to background. Most samples (72%) had Σβ-radioactivity 601-700 Bq/kg. Seven samples had 701-800 Bq/kg, and no radioactivity exceeding 800 Bq/kg was determined in the samples (Fig. 3).

Figure 3. Gross β-radioactivity distribution in the soils of Yerevan city in 2002.



So, the comparison shows a decline in radioactive pollution over a twelve-year period: the number of samples with background levels has increased from 7% in 1990 to 25% in 2002. In 1990 Σβ-radioactivity 651-700 Bq/kg was determined in 13%, in 2002 – in 65% of samples. As for relatively high values - over 800 Bq/kg, they were determined in 11% of samples in 1990 and in no samples in 2002 (Fig. 4).

Figure 4. Distribution of Σβ-radioactivity in Yerevan soils in 1990 and 2002 (Bq/kg).



In 2000, the samples of vegetation and soils were taken in 10 sites. The Σβ-radioactivity and concentrations of ^{137}Cs (γ-spectrometric method) were measured in soils. Basing on this, we extrapolated ^{137}Cs for 1990 and have also calculated the percentage of ^{137}Cs in Σβ-radioactivity. In 1990 and 2002, the percentage of ^{137}Cs in Σβ-radioactivity varied within 2.5 - 4.2% and 2.0 - 3.4% respectively and actually did not play any significant role in radioactive pollution of the urban soils.

So, it should be concluded that basic radioactive urban pollution occurs at the expense of total man-made environmental contamination with heavy radioactive elements (U, Ra, Th and the products of their decay). Therefore, to obtain the full pattern of radioactivity distribution, it is essential to continue the radioecological monitoring aimed to investigation of soil α-radioactivity, too, and determination of concentrations of natural radionuclides.

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