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GEOINFORMATION TECHNOLOGY FOR SUPPORTING THE DECISIONS ON MINIMISATION OF CHORNOBYL ACCIDENT CONSIQUENCES IN AGRICULTURE

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Abstract

The radioecological information system on the base of GIS-technologies is offered. The complex analysis of the radioecological situation on the polluted agricultural territories of Ukrainian Polissya was carried out on the base of the Radiation Control System data during 1996-2000 with using information system, which was elaborated. The system allows selecting the critical territories for implementation of countermeasures for reduction of product radionuclides contamination level. The results of the statistical and spatial analysis of the data about product and soil contamination allowed elaborating the schedule of products monitoring.

1. The main goals and purposes of Radioecological Information System

The radioecological information system (RIS) of complex processing, analysis and storage of radioecological monitoring data was elaborated on integrated organized and programmed base. The system contains the reliable information about the radioecological situation on the polluted agricultural territories of Ukraine and provides decision on operative tasks of Ministry of Emergency.

The radioecological information system is formed from next subsystem:

- The subsystem for creating and keeping the thematic database (radioecological, agrochemical and soil data);
- The subsystem for creating and keeping the cartographic database;
- The subsystem for analysis, mapping and presentation of output data;
- The subsystem for GIS-modelling – optimisation of farm land use, simulation of product contamination level;
- The subsystem for ecological management using GIS and DBMS.

The GIS - MapInfo and Arc/Info are the program base for the RIS. Customized RIS carries out the following functions:

- Unification technologies of input and processing of radioecological information jointly with agrochemical and soil data;
- Connection between the cartographic and thematic database by using of land use structure elements and classifier of Ukrainian administrative division;
- Creation of unified cartographic and thematic data bases;
- Elaboration of computer-aided procedures for GIS-modelling of the assessment of radioecological situation and optimisation of land use on farm level.

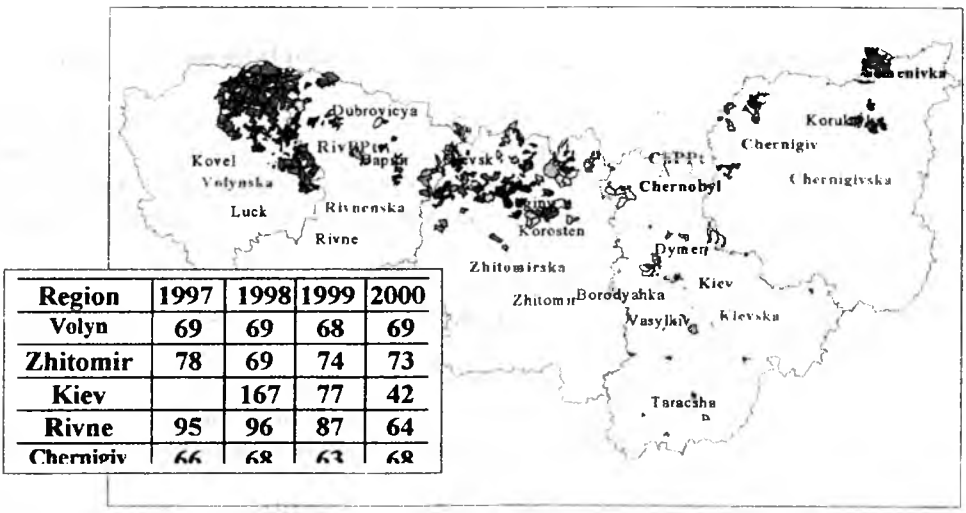
RIS is used for solution of radioecological monitoring problems of agricultural polluted territories in Ukraine (Figure 1):

1. presentation of complex analysis and actual state of radioecological situation to Ministry of emergency,
2. choosing of critical territories for implementation of countermeasures,
3. elaboration of product monitoring schedule.

2. The Complex analysis of the radioecological situation

The monitoring of the agricultural polluted territories of the Ukrainian Polissya was carried out up to 2000 at the level of the agricultural enterprises according to the National Program of the minimization of Chernobyl accident consequences. The complex geostatistical analysis was carried out on the data of the agricultural products monitoring:

- The cartographic data in scale 1:200 000 - digital farm's maps, soil maps and topographical maps of the 37 polluted districts in 5 regions.
- The annual average data per farm (near 400) about of products (14 -16 kinds) contamination level for the period 1996-2000,
- The original primary data (sample data) on 40 critical farms in 5 regions for the period 1997-2000



Region	1997	1998	1999	2000
Volyn	69	69	68	69
Zhitomir	78	69	74	73
Kiev		167	77	42
Rivne	95	96	87	64
Chernigiv	66	68	63	68

Figure 1 – Investigated territory with critical farms by product contamination level

The complex analysis was carried out using GIS Arc/Info, MapInfo and statistical package SPSS for Windows on the following algorithm:

- Analysis of the product contamination level changes dynamic of the basic products: milk, meat and potatoes.
- Statistical analysis of average levels of pollution of milk and meat.
- The multiobjective estimation and classification of the polluted territory with selection regions for monitoring and critical areas for implementation of countermeasures.

3. The products contamination analysis

The radioecological situation on the agricultural territories of Ukraine during the latest years has changed essentially. The radioactivity-polluted territories have decreased. The levels of the product pollution have stabilized. In 1997 the new acceptable levels of radionuclides contents in the products were approbated in the product quality control system. The levels of milk contamination in the collective sector were decreased noticeably as a result of implementation of countermeasures. In Chernigov, Volyn and Kiev regions average levels of the milk contamination in 95% of cases do not exceed 50 Bq/l. The most contaminated milk have watched in Rivne and Zhitomir regions, where in 80% of cases the farms produced the milk with contamination level below 100 Bq/l. In private sector the levels of the milk and meat contamination also have decreased, but they continue to remain higher, than in collective sector and in separate villages the contamination levels of milk reaches 800 Bq/l.

For the researched period the amount of controlled farms was approximately 400 and number of controlled products (14-16) are practically have not changed up to 2000. But the volume of monitoring has changed. As a whole, it had decreased in comparison with 1997 on 45%. Mainly, the milk (35 %) and green grass (20%) was controlled. It is provided the control of the migration of radionuclides in system "soil – plant – product". The value of the annual tendency of the contamination change fluctuated in borders 20 Bq/l (Bq/kg) per year. The analysis of the product contamination levels changes dynamic in the most critical farms of Chernigov and Volyn regions demonstrated the steady reduction of pollution and can be approximated by exponential function (Figure 2). It's shown that up to 2005 the average levels of pollution of milk in these areas will be in borders of the minimal activity, what can be fixed on used devices.

The statistical data received as a result of data monitoring process at the critical farms are generalised. The spatial and temporary variability of average means of contamination for separate kinds of products were investigated (Figure 3).

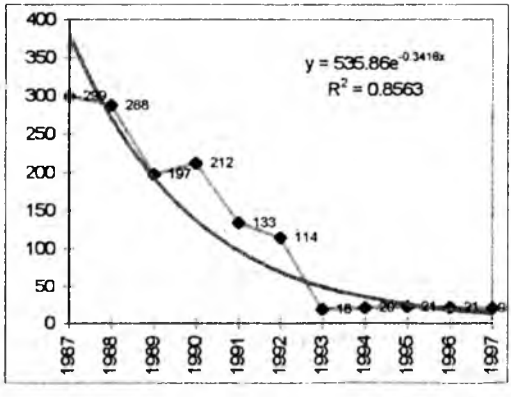


Figure 2 – Dynamic of the average data of milk contamination by per farm

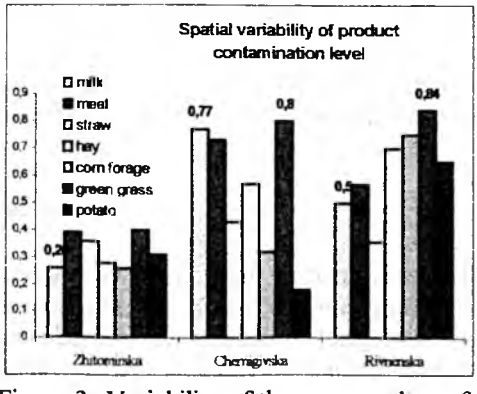


Figure 3- Variability of the average data of contamination products (1997-1999) by the regions

The Figure 3 shows the large variability of product contamination level for foodstuff in comparison to the data of milk and meat pollution. The average variability of the activity ^{137}Cs in products have change from 1.2 in 1991 up to 0.30-0.40 in 1994-1997. Such variability in time is depends on volumes of countermeasures and areas of theirs implementation in agriculture.

4. Classification of territory

The classification of farm's territories was carried out on the data of radioecological monitoring of agricultural territories and the populated places with using of multiobjective estimation methodology and GIS. The following parameters were used: vegetables, animal milk & meat contamination levels (the agricultural enterprises and private farms), soil contamination and human doses.

The following algorithm of the selection of the critical farms is used:

1) Calculation of average data for the basic kinds of products (milk, meat, vegetables, feedstuffs) for farms and villages for each region and for specific year.

2) Comparison of the received average data with acceptable levels of product contamination and choose rateable criteria for comparison with the data of monitoring for each region.

3) The matrix of criteria with critical attributes was prepared on the basis of the calculated accounts for each region. If the average data of product contamination level is higher then chosen criteria – the farm is determinate as critical and it gets the criterion, equal 1 for the chosen kind of product. Otherwise - 0. The populated places with human doses above 1.0 mlSv per year were considered separately. The following parameters are used in critical analyses: milk contamination by ^{137}Cs, meat contamination by ^{137}Cs, vegetables contamination by ^{137}Cs, soil contamination by ^{90}Sr and ^{137}Cs, human doses.

4) The selection of the critical farms was tested using comparison results of monitoring data and rateable criteria for each region.

The selected farms were formed in the uniform table with criterion of dangerous like matrixes (n_i*m_j), n_i - name of critical farm or farm with critical village and m_j - critical parameters. The thematic map of critical territories grouped on separate parameters or on a compound code of "emergency" of territory was constructed. The spatial distribution of critical farms with joint critical villages on map and typical soil of territory allows planning countermeasures taking account with the basic natural and ecological features of territory.

5. Schedule of products monitoring

The representative analysis for an estimation of adequacy of sampling amount of the products control to calculated average data of product contamination levels on the data of radioecological monitoring was carried out [1]. It was estimated the dependence the relative mistake calculated average levels of contamination for different products from number of control samplings and the variability of average meaning. The original data (primary data) of the products control on critical farms for 1997-2000 were used. The example of the comparative estimation of variability, amount of samplings and milk contamination level is given in table 1.

Table 1 - Comparative characterisation for calculated average milk contamination level by data monitoring

Region	Average quantity of samples per year	Variability of average data	Average relative error of mean calculation
Rivnenska	100	0.50	5
Volynska	70	0.71	10
Zhitomirska.	45	0.26	10
Chernigivska	20	0.77	26

The results of the statistical analysis of the monitoring data were used for formalisation of the monitoring schedule, which includes definition of monitoring territory, objects of supervision, the control parameters, periodicity and frequency of the control [2]. The requirements to the selection of territory, objects of supervision, the control parameters and an amount of sampling of supervision were formulated in the rules. The common formulas to calculate the numbers of sampling for the basic kinds of products were received. The results of accounts are placed in tab. 2.

Table 2 – Period and frequency of investigation for basic product kinds

Product	Period of investigation	Number of sampling according of variability from 0,3 to 1,1
Milk, meat	During year	10 - 70
Vegetable, Potato	After harvest	10 - 120
Green grassing	05-10 month	10 – 100
Hay, straw	07-09 month	10 - 200
Fodder crops	09-10 month	10 - 100
Crop, crop forage	07-08 month.	10 – 80

Selection of monitoring territory was executed for each region with selection of critical and conditionally qualitative farms for product contamination level control. Territory with selected farms was mapped in scale 1:200 000 and prepared report with map, diagram and table data on different administrative levels: region, district and farm.

Reviewer: dr. eng. Stanislaw Mularz (University of Mining and Metallurgy, Cracow, Poland)

References

1. Mahonko K.P., Silantev A.N., Shkuratov I.G. Control for radioactive contamination environment near PPn – (In Russian). GoskomHydromet. 1985. -136 p.

2. L. Tabachny, T. Lev, V.Voytzchehovich. . To a problem of organization and planning of radioecological monitoring agricultural territories in a late stage of radiation accident on Ukraine – (In Ukraine). Proceeding of Symposium "Geomonitoring-99", Morshin, Ukraine. 13-16 November 1999 p.63-67.