Agroecological evaluation of radiocaesium pollution of sunflower products grown on irrigated land of Zaporizhia region

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SOILS: WHERE FOOD BEGINS

Global Symposium on Soils for Nutrition | 26-29 July 2022

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Among the many problems that have arisen in connection with the accident at the Chernobyl nuclear power plant, one of the most acute and large-scale is the possibility of agricultural activities on lands contaminated with radionuclides. The probable consequences of hostilities in the immediate vicinity of the Zaporizhzhya NPP can cause much more harm. Therefore, the organization of continuous monitoring, assessment and forecast of soil and vegetation cover pollution is especially relevant in order to obtain edible crop products.

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The aim of the work is modeling, assessment and forecast of radiocesium contamination of soils, irrigated waters, sunflower crops grown on agricultural lands of the Zaporizhia region, as well as food products that are obtained in the processes of cultivation and processing.

Main goals:

- Assess the radiocesium contamination of agricultural lands in the Zaporozhye region in 1986, 2021 and under the ChNPP-86 scenario.
- Assess radiocesium contamination of irrigated waters of the Dnieper and Kakhovka reservoirs in 1986, 2021 and under the ChNPP-86 scenario.
- Carry out calculations of radiocesium pollution of sunflower crops, its seeds and sunflower oil in 1986 and 2021.
- Conduct calculations of radiocesium contamination of sunflower crops, its seeds and sunflower oil according to the ChNPP-86 scenario.
- Assess the contamination of sunflower products with radiocesium and make a forecast of its contamination according to the ChNPP-86 scenario.

RADIOCESIUM CONTAMINATION OF AGRICULTURAL LANDS IN THE ZAPORIZHZHIA REGION, Ci/km2

District	Soil	Density of pollution, Ci/km2	
		1986	2021
Berdyansky subregion			
Berdyansky	1	0,04	0,02
Primorsky	4	0,05	0,09
Chernigovsky	3	0,10	0,04

District	Soil	Density of pollution, Ci/km2	
		1986	2021
Melitopolsky subregion			
Veselovsky	4	0,07	0,04
Melitopolsky	4	0,08	0,04
Yakimovsky	6	0,06	0,05
Pryazovsky	7	0,11	0,04

District	Soil	Density of pollution, Ci/km2	
		1986	2021
Vasilevsky subregion			
Vasilevsky	3	0,07	0,05
K.-Dneprovsky	4	0,04	0,03
Mikhailovsky	3	0,09	0,06
Tokmaksky/WP	3	0,16	0,12

District	Soil	Density of pollution, Ci/km2	
		1986	2021
Zaporozhye subregion			
Zaporozhye	2	0,06	0,03
Volnyansky	1	0,12	0,03
N- Nikolaevsky	1	0,06	0,05
Orekhovsky	2	0,04	0,04

District	Soil	Density of pollution, Ci/km2	
		1986	2021
Pologovsky subregion			
Pologovsky	2	0,10	0,14
Hulyaipolsky	2	0,05	0,09
Bylmaksky	2	0,05	0,16
Tokmaksky /EP	2	0,16	0,12

Soils: 1 – ordinary medium-loamy chernozems; 2 –ordinary low-loam chernozems; 3 –southern chernozems transitional to ordinary chernozems; 4 –southern black soils with low humus; 6 –dark chestnut weakly and moderately salty; 7 –chestnut medium and strongly salted.

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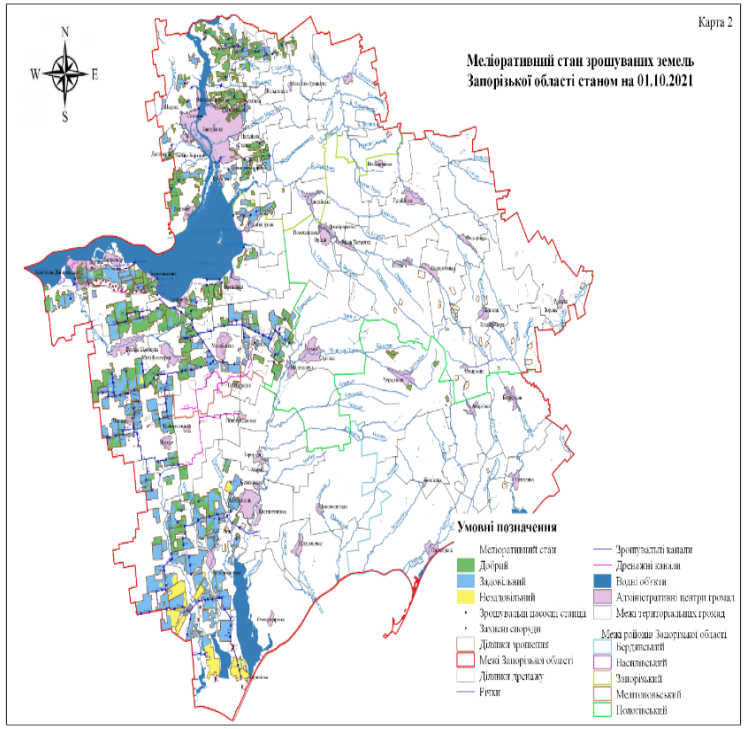
AGRICULTURAL LANDS IRRIGATED BY THE WATERS OF THE DNIPROV CASCADE

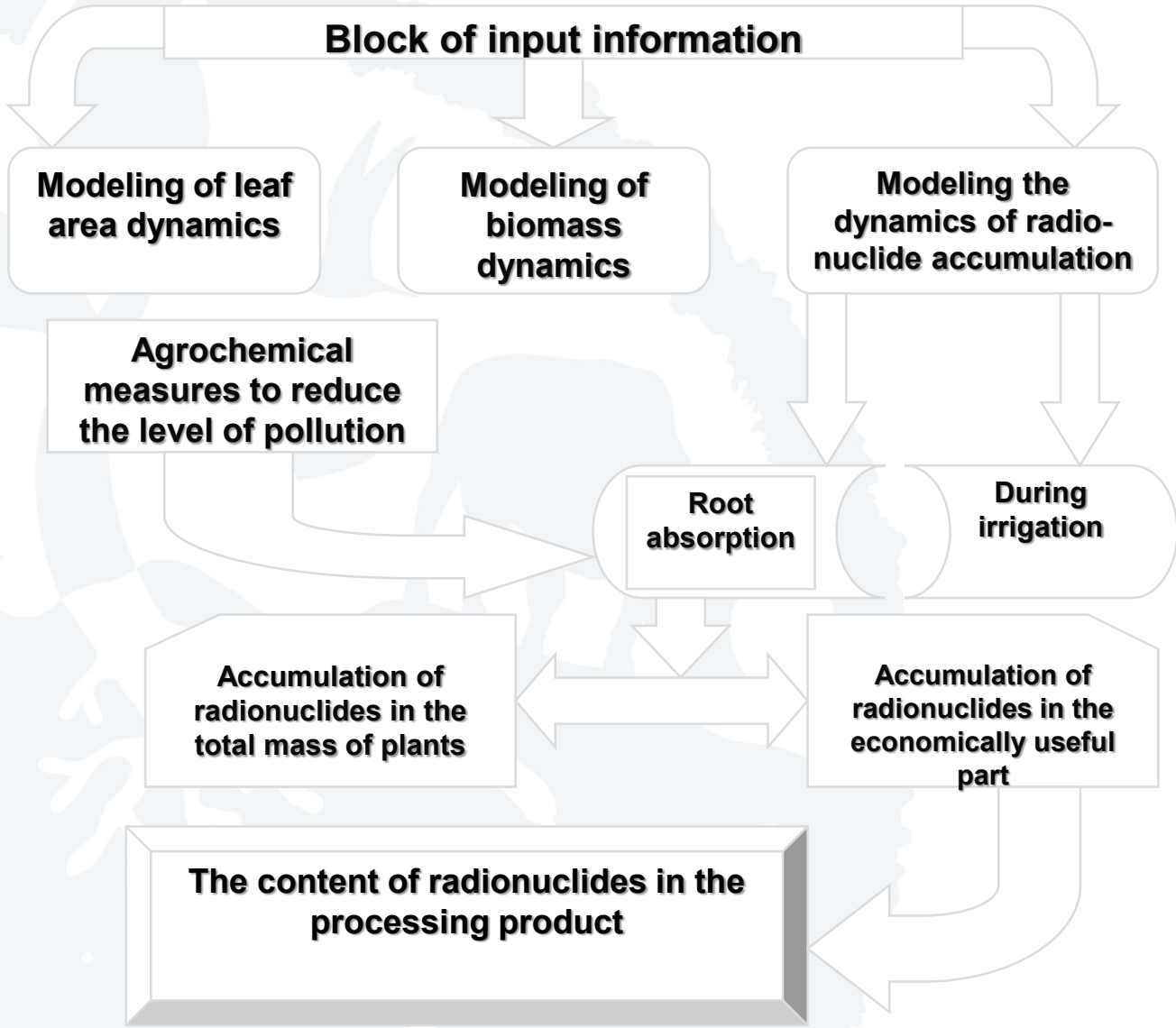


Nine irrigation systems supply water from the Kakhovsky Reservoir for irrigation of agricultural land.

The waters of the Dnipro Reservoir for irrigation of agricultural land are supplied by two irrigation systems.

Year	Water reservoir:	
	Dniprovske	Kakhovskoye
	Concentration of radiocesium, Bq/dm3	
1986	**0,37**	**0,20**
2021	**0,17**	**0,10**

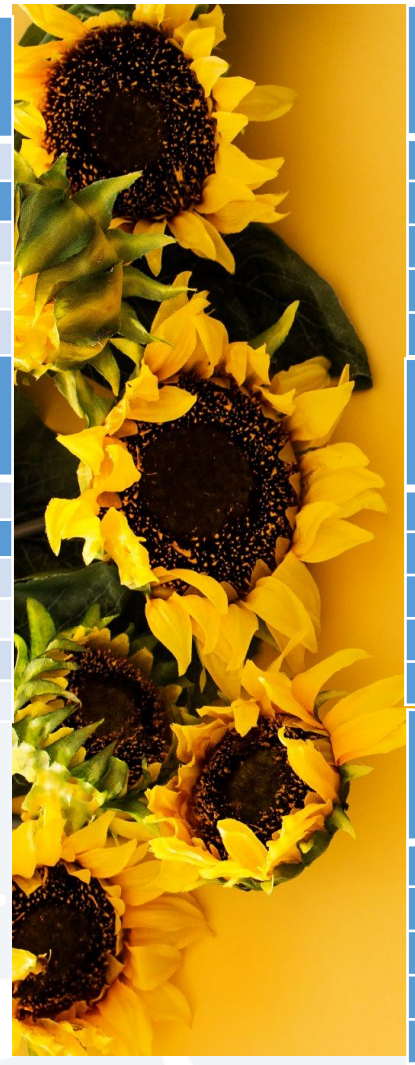
BLOCK DIAGRAM OF THE RADIONUCLIDE ACTIVITY FORMATION MODEL IN THE "IRRIGATED WATER - SOIL - PLANT - PRODUCT" SYSTEM ECOSYS-87



RADIOCESIUM CONTAMINATION OF SUNFLOWER CROPS IN 1986 and 2021, Bq/kg

District	Concentration of cesium-137 in total biomass, Bq/kg	
	1986	2021
Berdyansky subregion		
Berdyansky (WI)	0,35	0,26
Primorsky (WI)	0,78	1,64
Chernigovsky (WI)	1,28	0,63

District	Concentration of cesium-137 in total biomass, Bq/kg	
	1986	2021
Pologovsky subregion		
Pologovsky (WI)	1,63	2,96
Hulyaipolsky (WI)	1,19	2,17
Bylmaksky (WI)	1,19	3,27
Tokmaksky(WI)/ EP	2,81	2,64



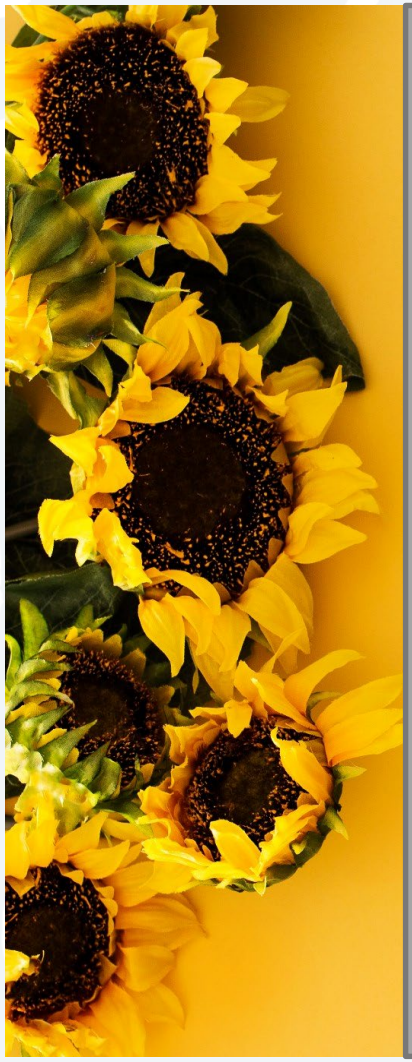
District	Concentration of cesium-137 in total biomass, Bq/kg	
	1986	2021
Vasilevsky subregion		
Vasilevsky (IK)	39,80	21,67
K.-Dneprovsky (IK)	41,65	22,33
Mikhailovsky (IK)	40,05	21,83
Tokmaksky (IK)/ WP	40,95	22,77

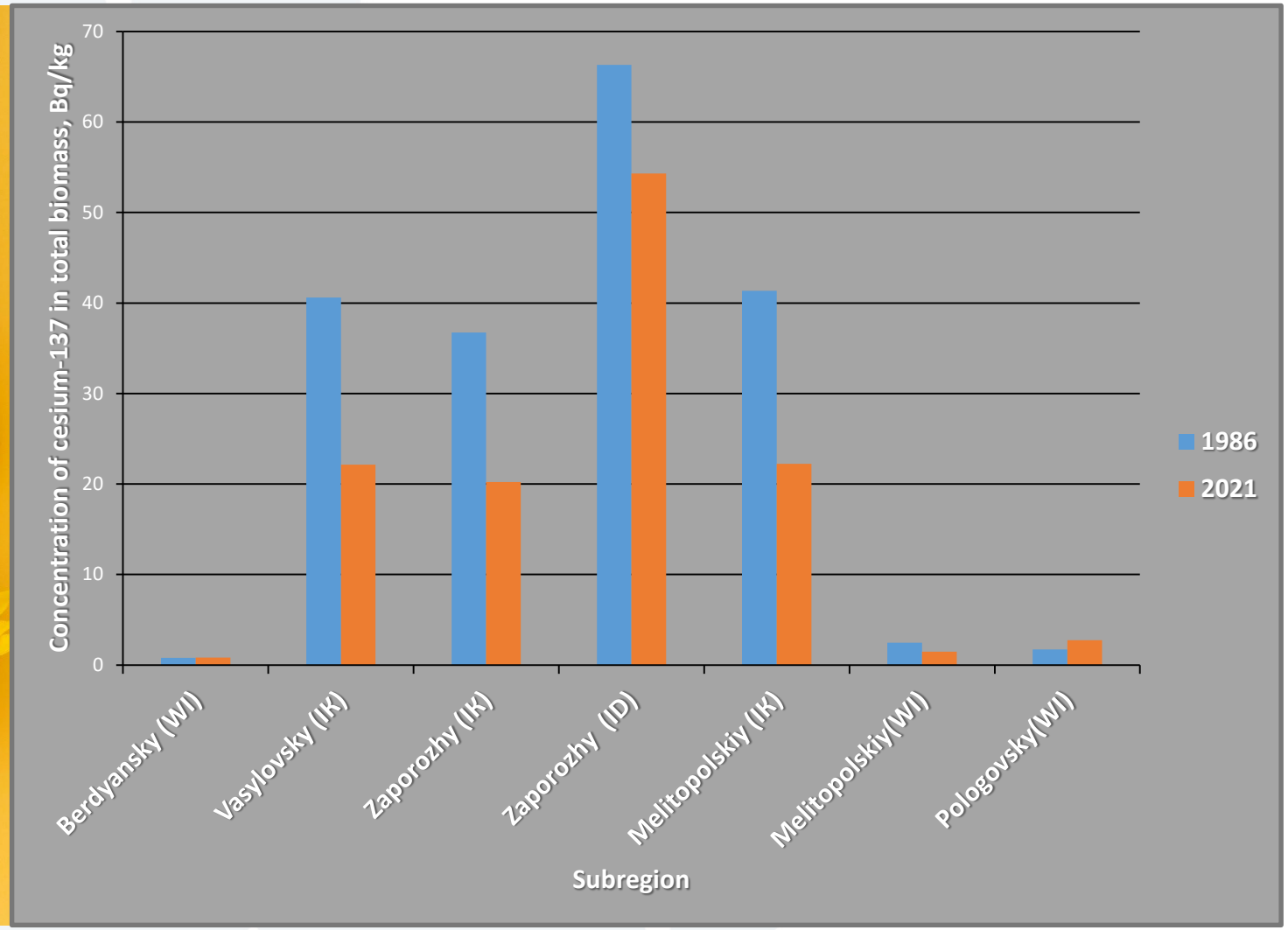
District	Concentration of cesium-137 in total biomass, Bq/kg	
	1986	2021
Zaporozhye subregion		
Zaporozhye (IK)	36,47	20,21
Volnyansky (IK)	36,99	20,21
N- Nikolaevsky (ID)	66,39	52,89
Orekhovsky (ID)	66,21	55,74

District	Concentration of cesium-137 in total biomass, Bq/kg	
	1986	2021
Melitopolsky subregion		
Veselovsky (IK)	42,12	22,52
Melitopolsky (IK)	42,28	22,52
Yakimovsky (IK)	39,67	21,67
Pryazovsky (WI)	2,48	1,48

WI –agricultural land without irrigation; IK –irrigation from the Kakhov reservoir; ID – irrigation from the Dnipro reservoir

DEPENDENCE OF Cs-137 CONTAMINATION OF SUNFLOWER CROPS (Bq/kg) ON SOIL CONTAMINATION (Ci/km2) AND IRRIGATION WATER (Bq/dm3)

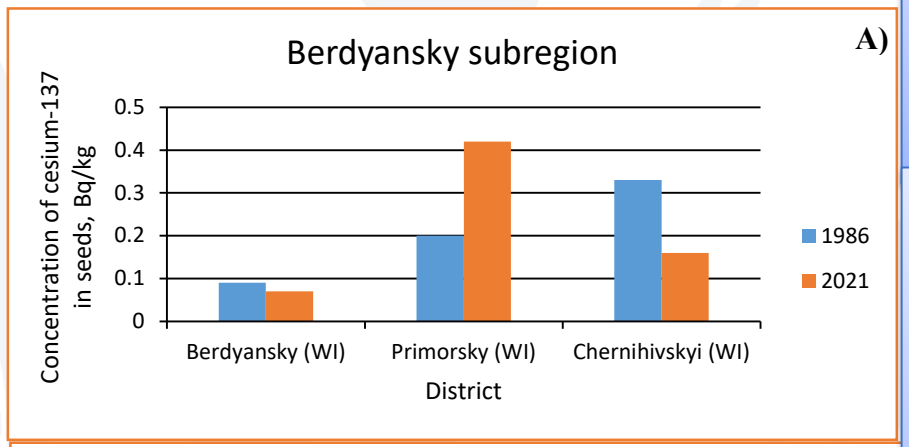


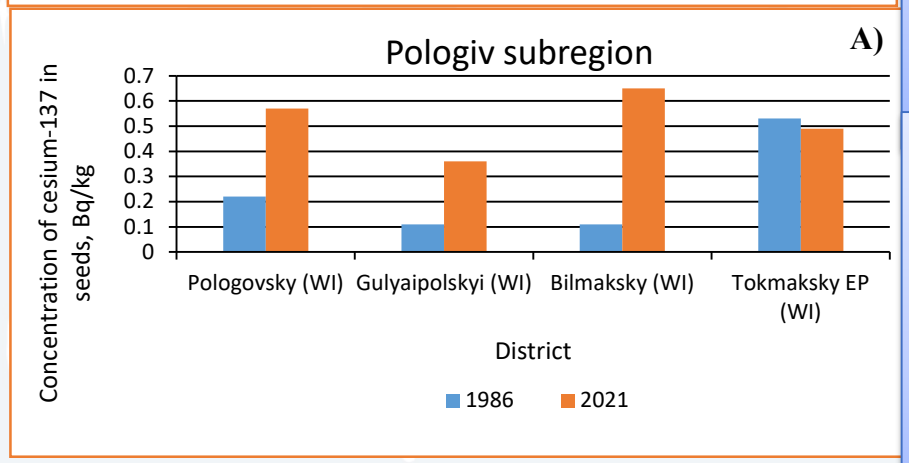


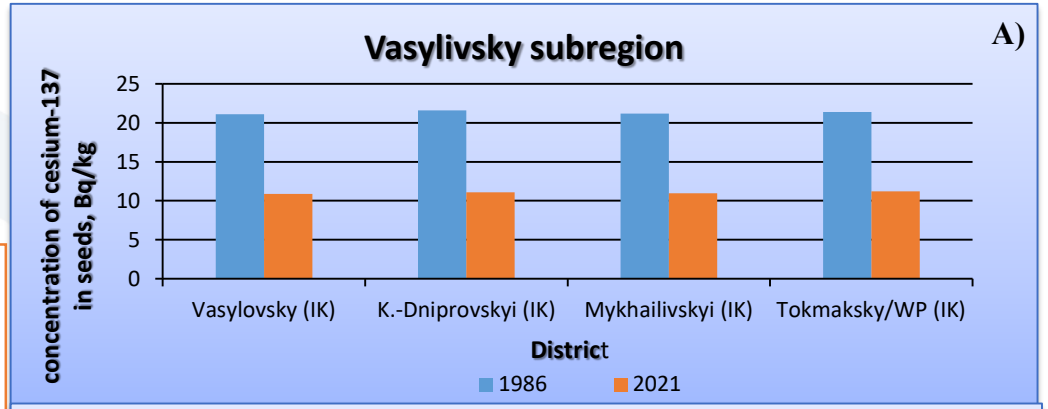
1986

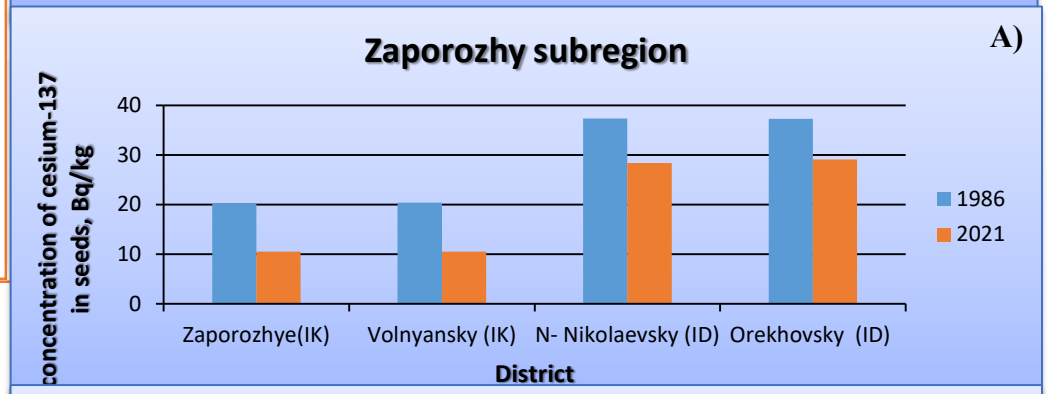
RADIOCESIUM CONTAMINATION OF SUNFLOWER SEEDS, Bq/kg

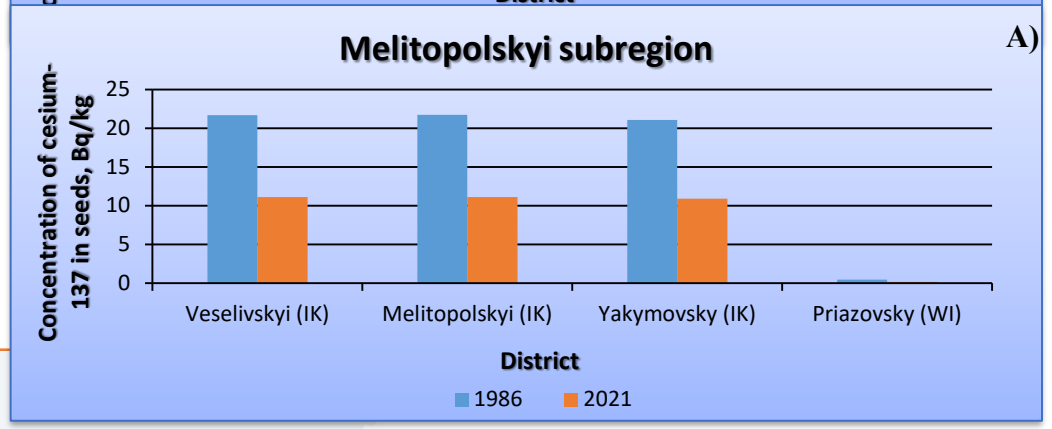
2021











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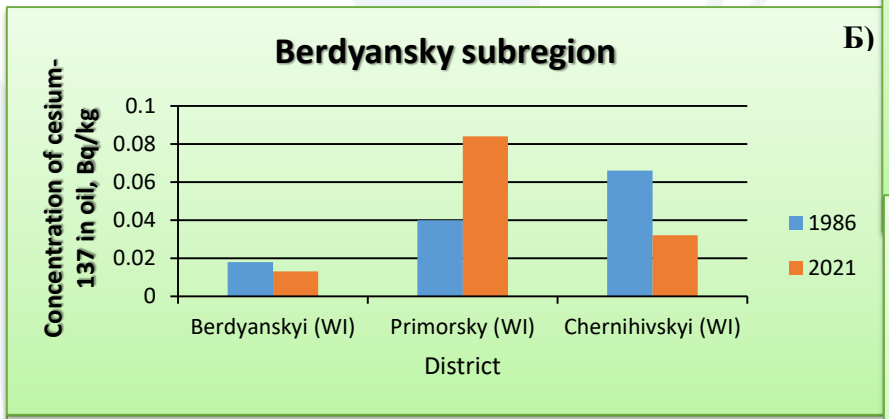
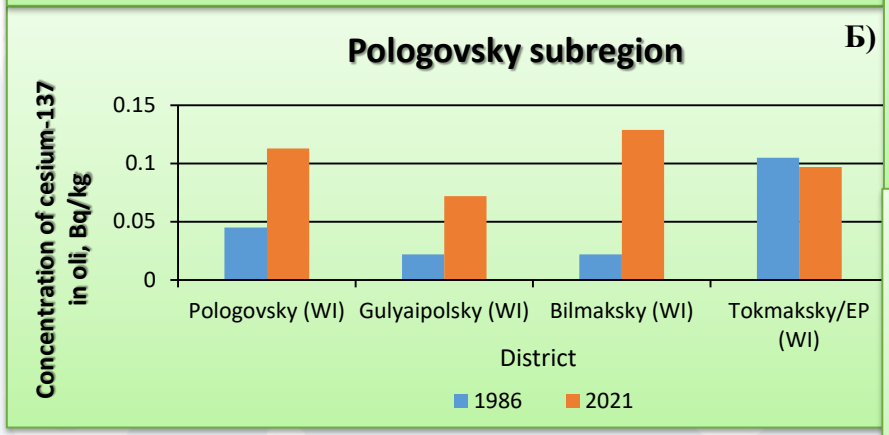
1986

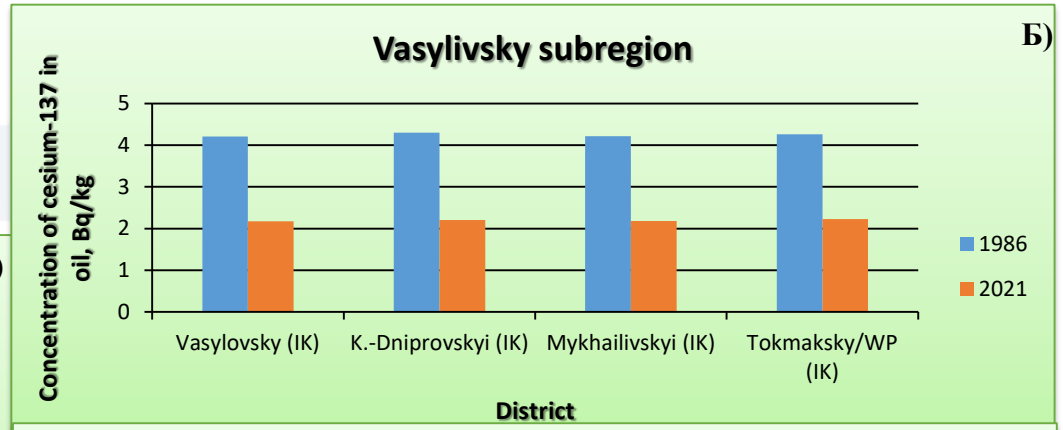
RADIOCESIUM CONTAMINATION OF SUNFLOWER OIL, Bq/kg

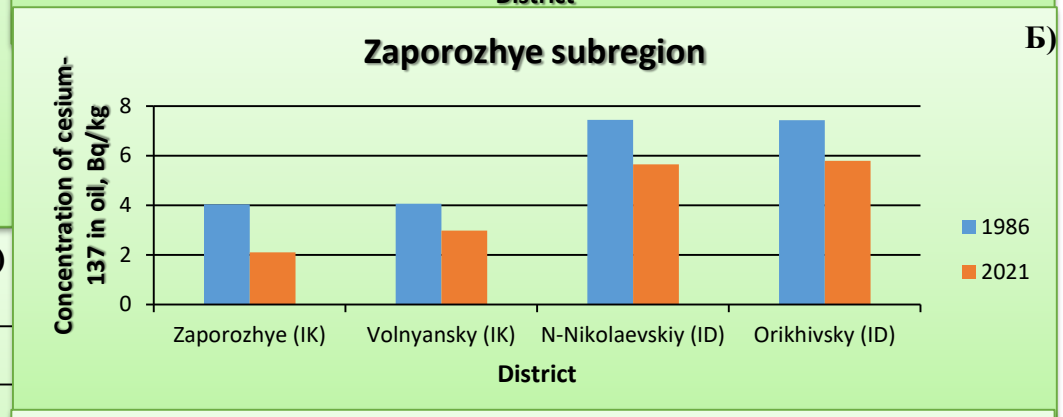
2021

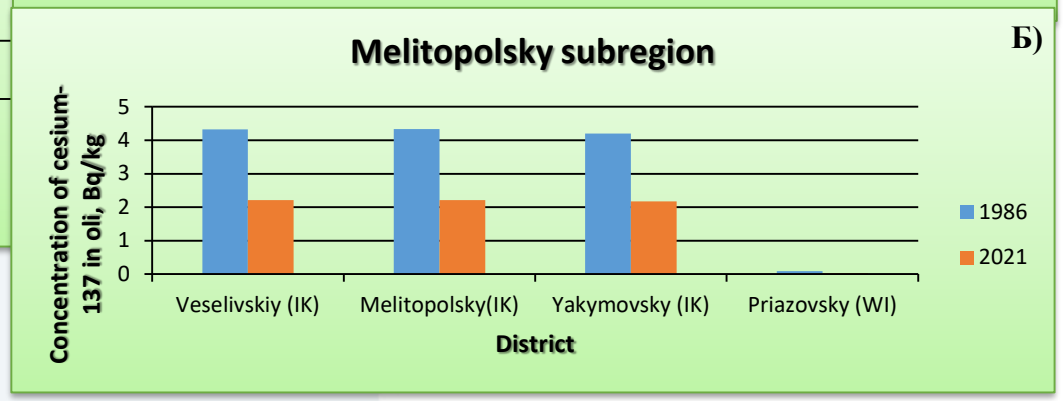
ZAPORIZHZHIA REGION











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RADIOCESIUM POLLUTION OF AGRICULTURAL LAND IN ZAPORIZHIA REGION IN 2021 AND ACCORDING TO THE ChNPP-86 SCENARIO

District	Soil	Density of pollution, Ci/km2	
		2021 p.	*ChNPP-86
Berdyansky subregion			
Berdyansky	1	0,02	0,51
Primorsky	4	0,09	0,22
Chernigovsky	3	0,04	0,44

District	Soil	Density of pollution, Ci/km2	
		2021 p.	*ChNPP-86
Pologovsky subregion			
Pologovsky	2	0,14	0,44
Hulyaipolsky	2	0,09	0,44
Bylmaksky	2	0,16	0,93
Tokmaksky /EP	2	0,12	5,12

District	Soil	Density of pollution, Ci/km2	
		2021 p.	*ChNPP-86
Vasilevsky subregion			
Vasilevsky	3	0,05	21,36
K.-Dneprovsky	4	0,03	> 40
Mikhailovsky	3	0,06	5,61
Tokmaksky/WP	3	0,12	5,12

District	Soil	Density of pollution, Ci/km2	
		2021 p.	*ChNPP-86
Zaporozhye subregion			
Zaporozhye	2	0,03	5,61
Volnyansky	1	0,03	2,11
N- Nikolaevsky	1	0,05	2,30
Orekhovsky	2	0,04	7,02

District	Soil	Density of pollution, Ci/km2	
		2021 p.	*ChNPP-86
Melitopolsky subregion			
Veselovsky	4	0,04	5,61
Melitopolsky	4	0,04	7,28
Yakimovsky	6	0,05	3,28
Pryazovsky	7	0,04	0,22

* ChNPP-86 – soil and irrigated water pollution scenario with the probability of an accident at the Zaporizhzhya NPP similar to that at the Chornobyl NPP

2021 RADIOCESIUM CONTAMINATION OF SUNFLOWER CROPS ChNPP-86

ZAPORIZHZHIA REGION

District	Concentration of cesium-137 in total biomass, Bq/kg	
	2021	ChNPP-86
Berdyansky subregion		
Berdyansky (WI)	0,26	8,04
Primorsky (WI)	1,64	3,47
Chernigovsky (WI)	0,63	9,94

District	Concentration of cesium-137 in total biomass, Bq/kg	
	2021	ChNPP-86
Pologovsky subregion		
Pologovsky (WI)	2,96	9,94
Hulyaipolsky (WI)	2,17	9,94
Bylmaksky (WI)	3,27	14,66
Tokmaksky (WI)/ EP	2,64	80,73

Year	Water reservoir:	
	Dniprovske	Kakhovskoye
	Concentration of radiocesium, Bq/dm3	
2021	0,17	0,10
ChNPP-86	2,0	2,0

District	Concentration of cesium-137 in total biomass, Bq/kg	
	2021	ChNPP-86
Vasilevsky subregion		
Vasilevsky (IK)	21,67	740
K.-Dneprovsky (IK)	22,33	not allowed
Mikhailovsky (IK)	21,83	492
Tokmaksky(IK)/WP	22,77	484

District	Concentration of cesium-137 in total biomass, Bq/kg	
	2021	ChNPP-86
Zaporozhye subregion		
Zaporozhye (IK)	20,21	491,85
Volnyansky (IK)	20,21	436,66
N- Nikolaevsky (ID)	52,89	455,42
Orekhovsky (ID)	55,74	514,08

District	Concentration of cesium-137 in total biomass, Bq/kg	
	2021	ChNPP-86
Melitopolsky subregion		
Veselovsky (IK)	22,52	491,85
Melitopolsky (IK)	22,52	514,08
Yakimovsky(IK)	21,67	455,11
Pryazovsky (WI)	1,48	3,47

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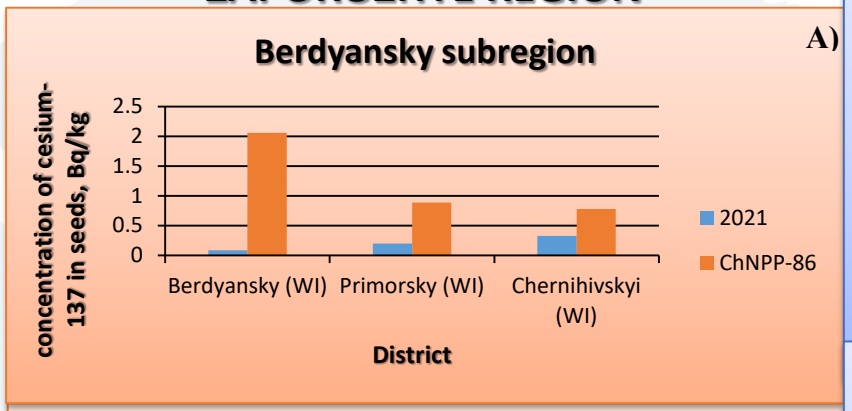
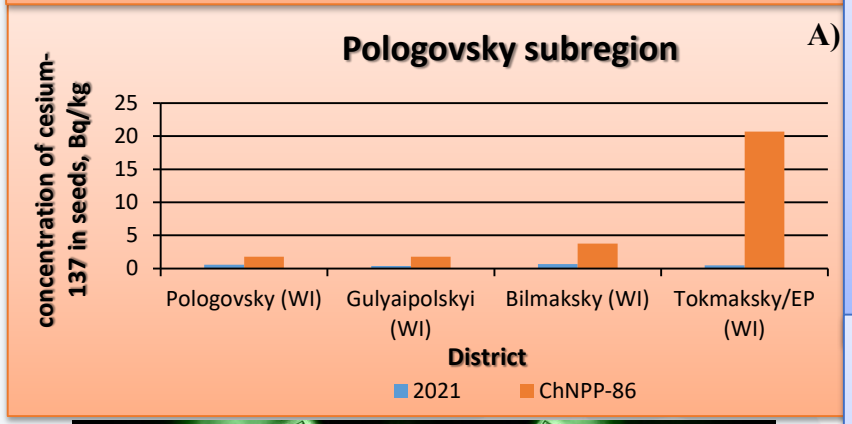
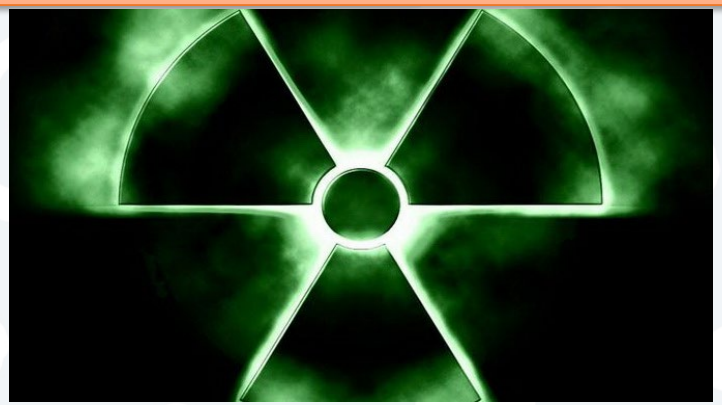
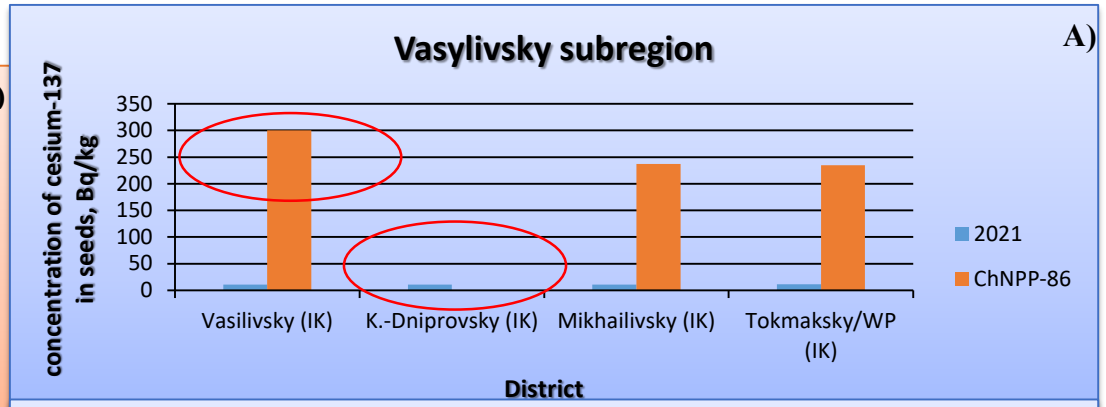
RADIOCAESIUM POLLUTION OF SUNFLOWER SEEDS IN 2021 AND ACCORDING TO THE ChNPP-86 SCENARIOS

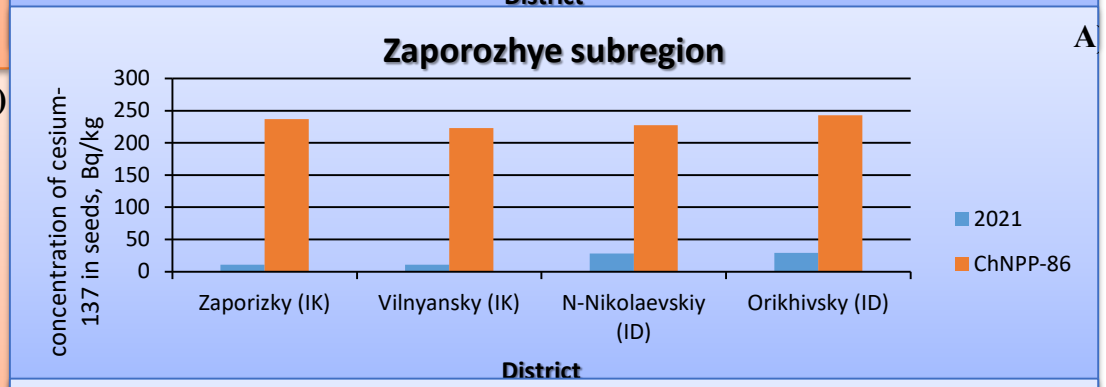
ZAPOROZHYE REGION

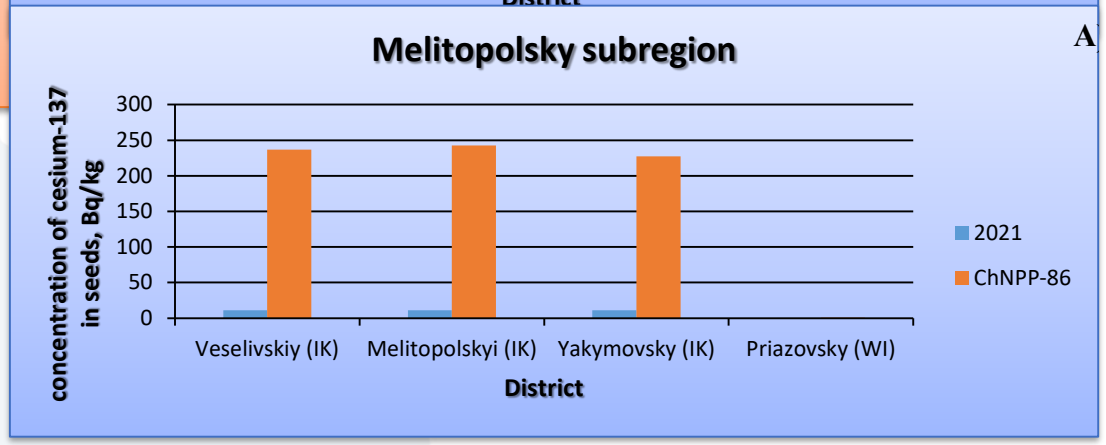








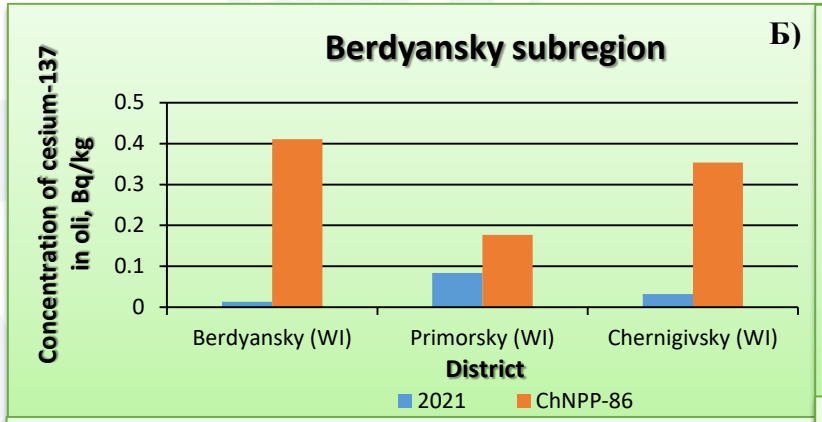


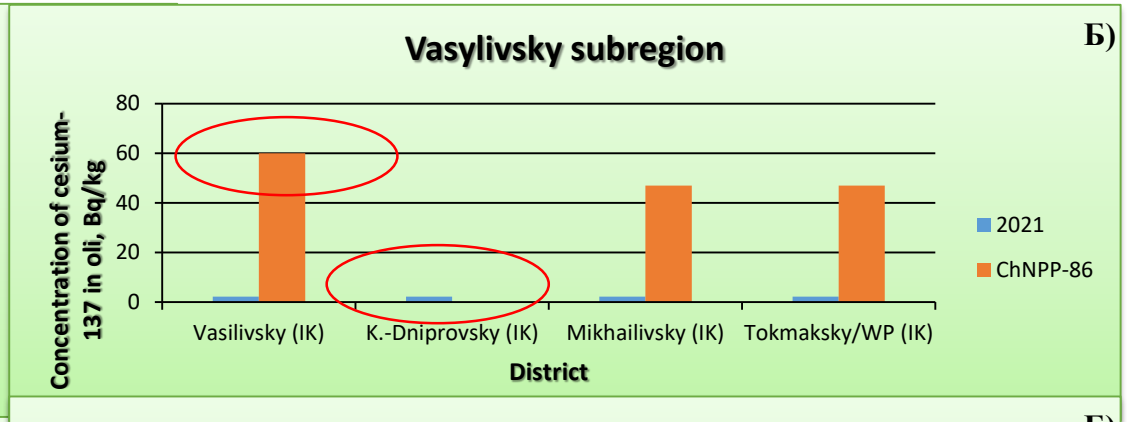


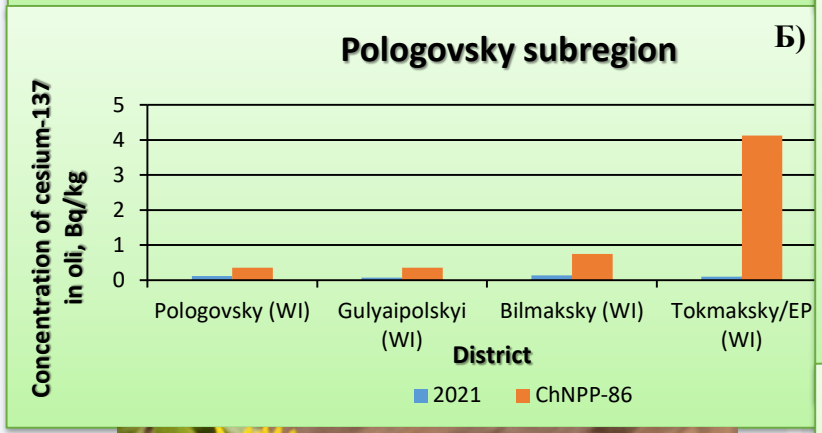
2021

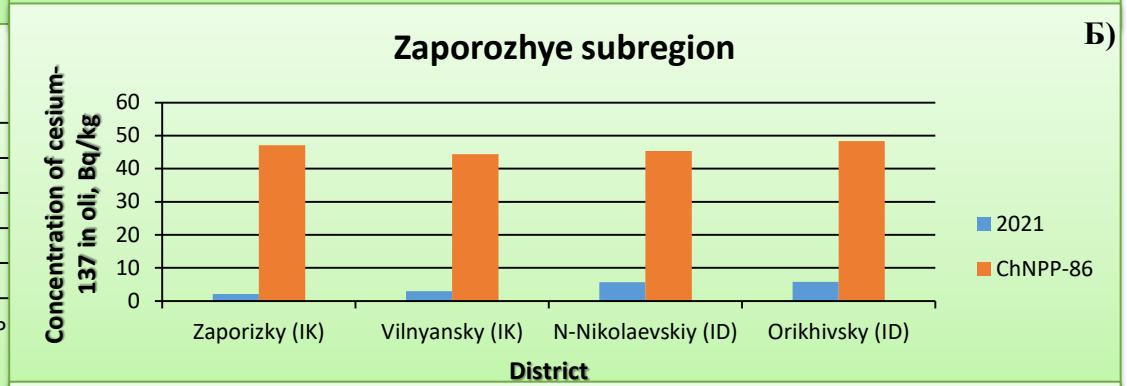
RADIOCAESIUM POLLUTION OF SUNFLOWER OIL

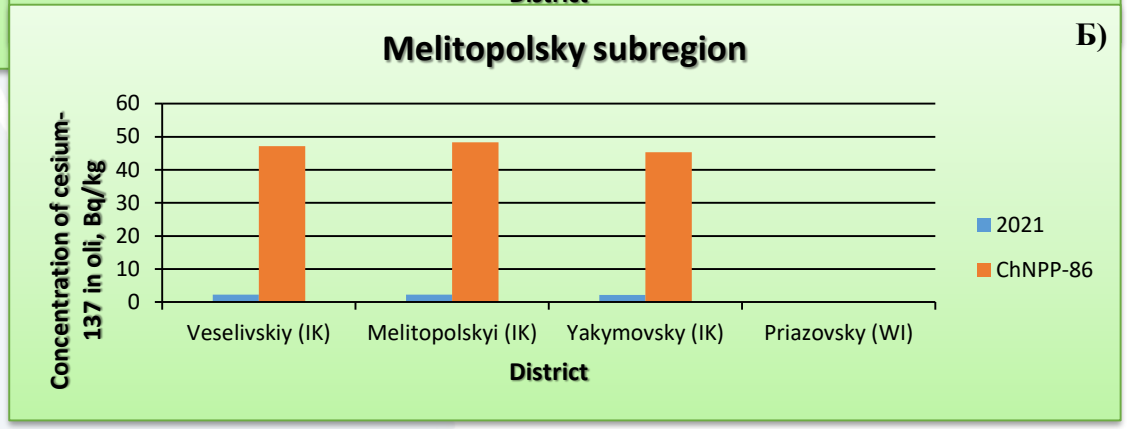
ChNPP-86











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CONCLUSIONS

1. Thus, if a catastrophe occurs, namely an explosion at the Zaporozhye NPP, then 100,000 hectares of agricultural land in the region will be taken out of agricultural production. Approximately 70% of them are arable land, a fifth (and in some farms a fourth) of which is allocated for sunflower. Consequently, sunflower crop losses in total, taking into account irrigated lands and rainfed lands, will amount to approximately 30,9 thousand tons per year.

2. According to our calculations, 1 143 000 hectares of agricultural land will be contaminated with radiocesium from 5 to 20 Ci/km2. The concentration of radiocesium in the waters of the Dnieper and its reservoirs will reach 2 or more Bq/dm3.

3. On agricultural lands, where radiocesium contamination of soils will be more than 5 Ci/km2, and the concentration in irrigated waters will reach 2 Bq/dm3, sunflower will need to be replaced with another crop, which will also lead to crop losses. According to preliminary estimates, crop losses will amount to 347,5 thousand tons per year.

4. Crop losses will lead to a decrease in the volume of sunflower oil. The losses will be 166,5 thousand tons per year.

5. It should also be taken into account that the purification of soil and water does not occur in one year. In at least 5 years, the situation will begin to improve.


Thank you !
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