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Iryna Matveeva

DIAPYCNOSIS MODEL APPLIANCE FOR ESTIMATION OF RADIATION FACTOR IN A LAKE ECOSYSTEM

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Research to creation of an ecological standardization system is offered. Such system is a hygienic standardization system. Basing on the radiation capacity model and theory of defining of critical biota condition on an example of a lake ecosystem is offered. The level of a critical radiation dose on the given biota, through radiocapacity models the pollution of the ecosystem's components are determined. The levels of permissible radiation doses are defined as such, at which radiation dose on the critical biota of the lake may not exceed the radiation doses on the biota; radiocapacity of ecosystems.

Ecological standardization of ecosystems in case of radionuclides release is an important, because there is a need to regulate these processes not only in the situations which dominate in modern ecological standardization. The approach of modern ecology concerning the biota in case of observing radiation is not always true, is not always supported by modern researches and in all it is connected with the facts of radiation to avoid negative influence of radionuclides usually cannot do this.

1. List of publications

Ecological paradigm, when the safety of the biota is defined by norms of people's activity, doesn't stand up to the requirements, why the International Commission on Radiological Protection in publication №80 set a need to create a system of ecological standardization based on reaction of the biota on radiation doses. [2, 4]. The variants are considered in this article, when the radiological standardization on the biota is estimated in terms of reaction of the critical (the most sensitive) kinds of organisms. But it is to be noted that the critical kind for one ecosystem may be critical for other types of ecosystems [2, 4]. Therefore it became necessary to develop other approaches. The substantiation of this need follows from this article.

The objective of the work: to build the approaches to principles of substantiation and creation of ecological norms on permissible levels of radiative effect on the ecosystems' biota, which differs from the current hygienic rating system. The thing is that in the situations of hygienic standards adherence the dose effects on the ecosystems' biota may be critical.

3. Results of the research

In the most radiological situations the biota in the environment where it grows is exposed to external (from the exposure sources outside the biota) and internal irradiation (from incorporated in the tissues radionuclides). In the irradiation biocenosis for the experimental organisms the exposure sources may become incorporated (accumulated) radionuclides, contained in contiguous organisms. For certain organs of plants and animals external are also those sources, which are contained in other parts of this plant or animal.

In case of biocenosis contamination by artificial radionuclides initially the radioactive substances are contained on the ground and water surface contacting with plants or animals. Only after a certain time period under influence of wind, downfalls, biomass increase radionuclides are being reallocated within the abiotic constituent of the ecosystem and as result of migration processes or anthropogenic measures shift into the depth of the ground and body of water.

In case of radionuclide emissions in the environment the need arises to define the boundary values of radionuclides intake into the ecosystem,

used significant changes in the... for evaluating the maximum... release into the ecosystem... the annual exposure rate. In the... and V.G. Tsytuginoy [2]... on ecosystems in the form... introduced (Table 1). ... that the actual dose limit for... and "storage" in ecosystems... may be dose rate that does not... year when visible ecological... on the scale. According to the... ground exposure rate of 0.4-4.0... to the concentration of ¹³⁷Cs... kBq/kg in the ecosystem or its... and aquatic plants) and about... ecosystem including terrestrials,... kBq/kg in average. Calculations... of dose factors developed by... in Table 2 [1].

Table 1. Scale of radiation doses and zones in ecosystems

Number of dose limit	Zone	Exposure rate, Gy/year
1	Zone of radiation safety	< 0,001 — 0,005
2	Zone of physiological masking	> 0,005 — 0,05
3	Zone of ecological masking:	
3.1	terrestrials	> 0,05 — 0,4
3.2	hydrobionts and terrestrials	> 0,05 — 4
4	Zone of visible ecological effects:	
4.1	dramatic for terrestrials	≥ 0,4
4.2	dramatic for hydrobionts and terrestrials	≥ 4
4.3	disastrous for animals and plants	≥ 100

Table 2. Dose factors for the biota ecosystems on some radionuclides

	Internal irradiation, Gy/year/Bq/kg	External irradiation			
		Water, Gy/year/Bq/m ³	Air, Gy/year/Bq/m ³	Ground, Gy/year/Bq/kg	Vegetation, Gy/year/Bq/kg
	4,1 10 ⁻⁶	2,7 10 ⁻⁹	1,72 10 ⁻⁶	4,02 10 ⁻⁶	1,72 10 ⁻⁶
	2,88 10 ⁻⁸	0	0	0	0
	3,44 10 ⁻⁶	1,76 10 ⁻⁹	1,43 10 ⁻⁶	2,64 10 ⁻⁶	1,43 10 ⁻⁶
	3,52 10 ⁻⁶	1,57 10 ⁻⁹	1,43 10 ⁻⁶	2,36 10 ⁻⁶	1,43 10 ⁻⁶
	2,86 10 ⁻⁵	1,48 10 ⁻¹⁰	7,73 10 ⁻⁸	2,22 10 ⁻⁷	7,73 10 ⁻⁸
	2,64 10 ⁻⁵	3,72 10 ⁻¹²	2,35 10 ⁻⁹	5,58 10 ⁻⁹	2,35 10 ⁻⁹
	9,92 10 ⁻⁷	3,07 10 ⁻¹⁰	2,83 10 ⁻⁷	4,61 10 ⁻⁷	2,83 10 ⁻⁷
	1,12 10 ⁻⁴	8,91 10 ⁻⁹	6 10 ⁻⁶	1,43 10 ⁻⁵	6 10 ⁻⁶
	2,5 10 ⁻⁷	6,51 10 ⁻¹²	6,01 10 ⁻⁹	9,77 10 ⁻⁹	6,01 10 ⁻⁹

data in Table 2 allow us to calculate the... doses of the wild biota in different types of... systems. ... ecological standardization in the lake... system. The simulation results of permissible... in lake ecosystem [3] ... According to the estimation of the maximum... permissible radionuclides ¹³⁷Cs concentration in the... of the ecosystem the critical releases and... into ecosystems can be estimated (we will... with an example — the lake). Based on the model... radiocapacity of the lake ecosystem [3] we showed... for benthos of benthical deposits of a freshwater

basin maximum permissible radionuclides release into the pond (N_k) shall not exceed the following value:

$$N_k < \frac{LHS}{kF}$$

where L — calculated based on the dose limit of 4 Gy/year (limit) of ¹³⁷Cs radionuclides concentration in aquatic biota (600 kBq/kg);

S — area of the basin;

H — the average depth of the basin;

k — coefficient of radionuclides accumulation from water by benthical deposits;

F — radiocapacity factor of benthical deposits of the basin.

in the water column the
radionuclides release shall

^{137}Cs accumulation
of the water column.

in basin where $S = 2 \text{ km}^2$,
= 0.7 critical value of

going to the calculations
than. $N_0 < 10 \text{ TBq}$ into

a critical value of
the basin for its benthos is
< 110 GBq.

less than the permissible
water of this lake, which is
of the water column of the

we give a specific example
model to the lake ecosystem.

calculation of permissible
into the lake.

into the lake area of 1 km^2
MBq of ^{137}Cs .

5 m. the thickness of the layer
— 10 cm, the sludge

Factor (AC) — 200 and into account
then AC of the biota, living in the

changes from 1 to 100000.

what amount of radionuclides can
to the lake, so that the dose for the
does not exceed the critical limit AC

above mentioned formula we will
able ^{137}Cs releases (Table 3).

was performed as follows.

the consistent pattern of radionuclides
through the components of the lake

can define the radioactivity levels in
its.

using a Table of dose values or
(Table 2), we can calculate the partial

the biota from different components of the
system for different values of AC for the
biota.

adding up the dose of the relevant columns
3, we calculate the summary dose on the

at the value of the initial radionuclides
only 1 MBq ^{137}Cs .

Then we take, for example, the summary dose in
the last column, which is equal to $4,7 \cdot 10^{-3} \text{ Gy/year}$
when the release is 1 MBq.

And if the permissible dose to the seabed biota,
as we have defined, should not exceed 4 Gy/year,
then dividing the value of 4 Gy/year by the
estimated value of $4,7 \cdot 10^{-3} \text{ Gy/year}$ we become the
estimation of the quantity — Bq in permissible
release, which makes — $8,5 \cdot 10^8 \text{ Bq/year}$ or
0,023 Cu/year.

Thus, it should be noted that at very high values
of AC of the biota (100 000 units) annual
permissible radionuclides release in the researched
lake can make a very small value, only
0,023 Cu/year on only 1 km^2 area of the lake.

A similar calculation was made for another
biogenous radionuclide — ^{90}Sr .

It can be seen that, depending on the AC of the
biota permissible releases into this lake make for
 ^{137}Cs from 0,023 to 2100 Cu per year, and for ^{90}Sr
— from 0.1 to 7800 Cu per year, if releases take
place for only one year, as it was after the
Chernobyl disaster.

If it is a working nuclear power plant, it is clear
that the permissible releases per year will be
significantly less, so that they do not lead to
exceeding the dose limits.

That is, for real values of AC for the seabed
biota fairly strict limits on permissible levels of
releases into such lake ecosystem can be applied.

In most cases the levels of water pollution, for
which there are hygienic standards (2 Bq/L for
 ^{137}Cs), will be estimated as significantly smaller
than the given hygienic standards.

Thus, the analysis shows that actually in this
case of the lake ecosystem the ecological norm can
be estimated as much tighter than the known
hygienic standard.

4. Conclusions

Generally in ecology and radioecology in
ecological standardization, environmental dominates
such paradigm. If for human it is comfortable to live
in the ecological situation, all the more nothing will
damage the biota.

The analysis, which we conducted shows that
this is not really so.

That is a safe situation for human can turn into
high doses for the biota due to redistribution of
radionuclides and high values of AC, which are
peculiar to biota.

Table 3. Calculation of the dose on the components of the lake ecosystem and the permissible annual ¹³⁷Cs release depending on the values of AC for the benthos biota

Components of the lake in effect the biota	K_H of the biota of benthic deposits of the lake (benthos)					
	1	10	100	1000	10000	100000
	5,4-9	5,4-9	5,4-9	5,4-9	5,4-9	5,4-9
	3,2-8	3,2-8	3,2-8	3,2-8	3,2-8	3,2-8
of the lake	1,4-8	1,4-7	1,4-6	1,4-5	1,4-4	1,4-3
	3,3-8	3,3-7	3,3-6	3,3-5	3,3-4	3,3-3
biota	5,2-8	4,8-7	4,7-6	4,7-5	4,7-4	4,7-3
release into the lake:						
	7,7+13 Bq 2100 Cu	8,4+12 Bq 220 Cu	8,4+11 Bq 22 Cu	8,5+10 Bq 2,3 Cu	8,5+9 Bq 0,23 Cu	8,5+8 Bq 0,023 Cu
	2,9+14 Bq 7800 Cu	3,8+13 Bq 1020 Cu	3,9+12 Bq 105 Cu	3,9+11 Bq 10,5 Cu	3,9+10 Bq 1 Cu	3,9+9 Bq 0,1 Cu

the lake when hygienic standards for can be easily fulfilled and the limits for the biota of the lake can be should be emphasized that the these limits on the biota of benthic lead to death of a part of the biota, and will lead to acidification of the (pH may drop to values 5-6) , return can cause desorption of accumulated in the benthic deposits. mean a significant increase of water will also obviously exceed hygienic

that the establishment of actually ecological standards for Ukraine and other very complicated task.

is that it is nearly impossible to ecological standards for permissible releases in different ecosystems.

generally any ecosystem will require ment of a specific model and evaluation value of ecological standard.

problem remains, and it is necessary to [2].

These same problems arise for other types of ecosystems as well.

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радіємності для нормування радіаційного фактора в озерній

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радиоёмкости для нормирования радиационного фактора в

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системы экологического нормирования. Показано, что такая система не гигиенического нормирования. Опираясь на модели радиационной ёмкости предложен метод установления критического состояния биоты на примере и контроль критической дозовой нагрузки на исследуемую биоту, через уровни допустимого загрязнения радионуклидами компонентов экосистемы. загрязнение оценены как такие, при которых дозовая нагрузка на превышать предельно допустимую норму — 4 Гр/год. биоту; радиоёмкость экосистем; экологический норматив.

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and application of the radiation capacity model for normalization of radiation factor in