American Journal of
Biomedical Science & Research

www.biomedgrid.com
ISSN: 2642-1747

Mini Review

The Absorbed Dose Rate of Internal Irradiation of Fish in the Water Bodies of the Chornobyl Exclusion Zone at the Present Stage

AE Kaglyan[1]*, DI Gudkov[1], LP Yurchuk[1], NA Pomortseva[1] and OO Gupalo[1]

1Institute of Hydrobiology of the National Academy of Sciences of Ukraine, Ukraine

***Corresponding author:** AE Kaglyan, Institute of Hydrobiology of the National Academy of Sciences of Ukraine, Kyiv, Ukraine.

To Cite This Article: *AE Kaglyan, DI Gudkov, LP Yurchuk, NA Pomortseva, OO Gupalo, The Absorbed Dose Rate of Internal Irradiation of Fish in the Water Bodies of the Chornobyl Exclusion Zone at the Present Stage. Am J Biomed Sci & Res.* DOI: 10.34297/AJBSR.2022.17.002303

Received: August 22, 2022; **Published:** August 29, 2022

Keywords: Chornobyl Exclusion Zone; Internal Dose Irradiation; Fish; Water Bodies; 90sr; 137cs

Introduction

Changes in the radioecological situation for representatives of the ichthyofauna in the reservoirs of the Chornobyl Exclusion Zone (ChEZ) are of significant scientific interest. We investigated aquatic bodys with different levels of radionuclide contamination and hydrological regime: Vershyna Lake and Hlyboke Lake, the conditionally non-flowing Yaniv backwater of the Pripyat River, one of the reservoirs that formed in the former north-western part of the water area of the ChNPP Cooling Pond (CP) after the water level decreased, as well as channel section of the Pripyat River (near Chornobyl town). The main objects of the study were fish species that differ in the type of nutrition: silver Prussian carp (Carassius gibelio Bloch), rudd (Scardinius erythrophthalmus L.), bleak (Alburnus alburnus L.), sanbleak (Leucaspius delineatus Heckel), perch (Perca fluviatilis L.) and pike (Esox luceus L.). The paper presents the results of calculating the power of the absorbed dose of ionizing radiation of fish due to radionuclides ^{90}Sr and ^{137}Cs incorporated in tissues as of 2021. The value of the power of the internal dose was determined using the ERICA Assessment Tool 1.0 software [1]. Averaged data for each type of fish were used for calculations. The age of the fish was 2–8 years. Absorbed radiation dose rate for fish was measured in μGy/h.

Results and Discussion

It was previously established that the specific activity of radionuclides in representatives of the ichthyofauna of the ChEZ reservoir differs significantly [2-5], which is reflected in the strength of the internal dose of fish irradiation. As can be seen from (Figure 1), the highest internal dose load is observed for the Vershyna Lake – 19.9–85.8 μGy/h. Hlyboke Lake, Yaniv backwater of the Pripyat River and the CP – respectively, 8.1–13.5, 0.96–2.89 and 0.62–0.96 μGy/h, and the smallest – for fish of the Pripyat River – 0.021– 0.052 μGy/h. It should be noted that, in contrast to the external irradiation of fish by ChEZ, formed primarily by ^{137}Cs, the internal dose of irradiation is due mainly to ^{90}Sr incorporated in the tissues. This is due to significantly higher indicators of the specific activity of ^{90}Sr in contrast to ^{137}Cs. The value of the ratio of ^{90}Sr/^{137}Cs for different types of fish in closed ponds of the ChEZ was 2.5–107.6. Among the water bodies of the ChEZ that we studied, the partial exception was the fish of the CP and the Pripyat River, in which the ratio of ^{90}Sr/^{137}Cs was 0.15–1.40.

For the majority of closed and conditionally non-flowing reservoirs, the contribution of the dose load for fish from incorporated ^{90}Sr to the internal radiation dose was 61–96% (for fish in the CP before and after the lowering of the water level as of 2021, respectively, 9–40 and 38–81%). For fish of the Vershyna Lake, internal exposure, due to significant values of the specific activity of ^{90}Sr in the tissues, for such species as Prussian carp, rudd and sanbleak, prevails even over the total dose, which is formed mainly by external exposure to ^{137}Cs (Figure 2). For all other studied ponds of the ChEZ, the absorbed dose rate due to external sources (with a predominance of 137Cs deposited in the bottom sediments) is significantly higher than the dose of internal irradiation of fish.

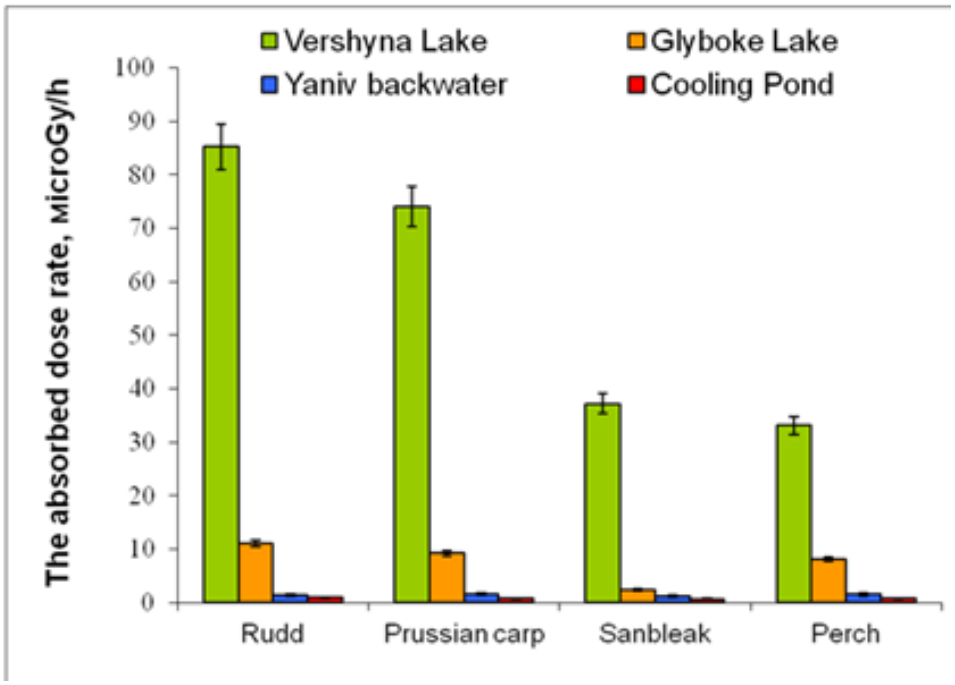

Figure 1: The absorbed dose rate of internal radiation of some fish species of the ChEZ in 2021, μGy/h
(*for Vershyna Lake and Hlyboke Lake, the analysis was taken to be sanbleak, and for the Yaniv backwaters of the Pripyat River and CP - bleak).

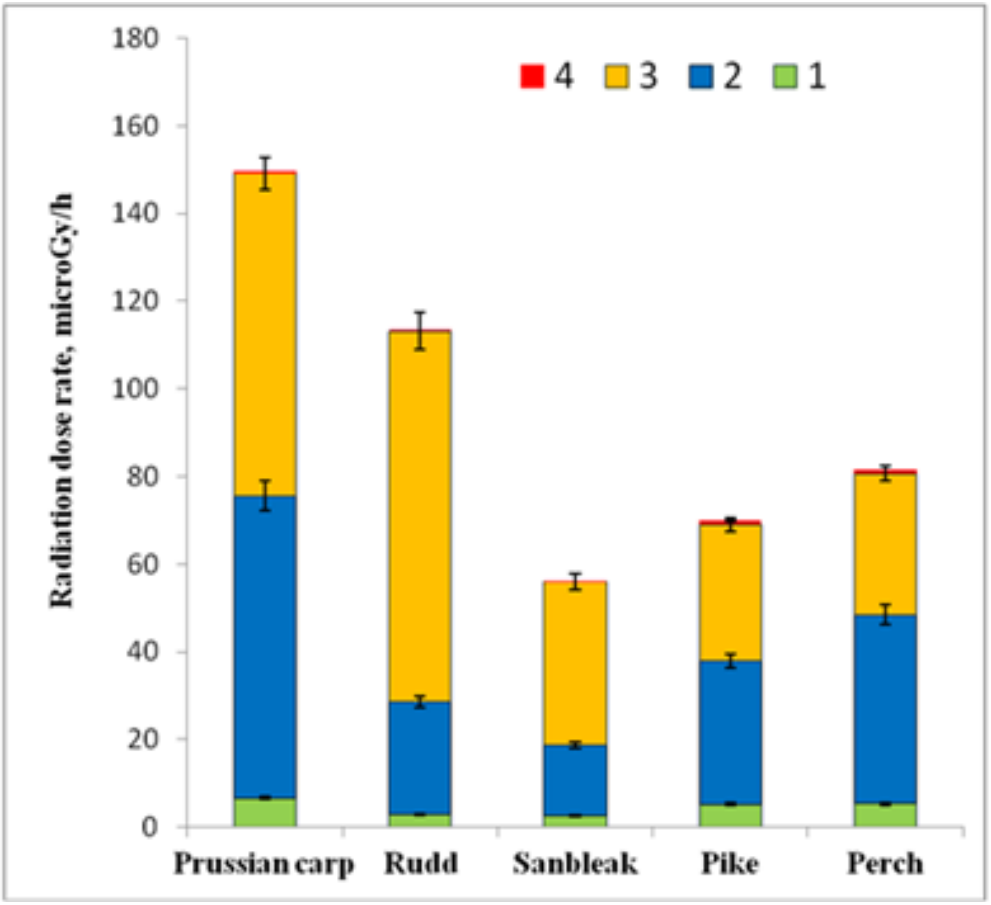

Figure 2: The absorbed dose rate of irradiation of fish in the Vershyna Lake, μGy/h: 1 – external irradiation from 90Sr; 2 – external irradiation from ^{137}Cs; 3 – internal irradiation from ^{90}Sr; 4 – internal irradiation from ^{137}Cs.

The Scientific Committee on the Effects of Atomic Radiation of the United Nations (UNSCEAR) and the independent organization of the International Commission on Radio-Environmental Protection (ICRP) suggest using the value of the power of the absorbed dose in the range of 40-400 μGy/h as a safe level of radiation exposure to biota [6]. Also, the dose load value of 40 μGy/h is accepted as a safe threshold level for vertebrates. At the same time, within the framework of the European Commission's PROTECT project, the value of the safe threshold of exposure to biota was estimated at 10 μGy/h [7]. As the limit (screening) the absorbed dose rate for vertebrates (therefore for fish as well), a value of 2 μGy/h was recommended, which is recommended for the initial assessment of the safety level of biota. Thus, if the power of dose irradiation for representatives of ichthyocenosis does not exceed 2 μGy/h, then the radiation situation is safe and does not require further consideration.

The work was partially carried out with the support of the National Research Fund of Ukraine (grant No. 2020.02/0264).

Conclusion

Thus, ^{90}Sr, which is incorporated mainly in bone tissues, plays a dominant role in the formation of the power of the internal radiation dose of fish in the investigated non-flowing water bodies of the ChEZ. It should be noted that for some fish species of the Vershyna Lake ^{90}Sr is dominant even for the total exposure dose.

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