*2024 International Nuclear Atlantic Conference – INAC 2024*
*Escola de Guerra Naval, Rio de Janeiro, RJ, May 6 - 10, 2024*

ISBN: 978-65-594-1256-3

# Dose Rate in Corvina (Micropogonias furnieri) due to the intake of natural radionuclides in Espírito Santo, Brazil

W. S. Pereira[1], A. Kelecom[2], J. M. Lopes[3], A. S. Carmo[4],
R. F. Vieira, E. L. C. Campelo[1], M. Charles_Pierre, A. X. Silva[1]

[1] *pereiraws@gmail.com, Programa de Engenharia Nuclear, Universidade Federal do Rio de Janeiro (COPPE/UFRJ), Rio de Janeiro, 21941-914, Brasil*
[2] *akelecom@id.uff.br, Instituto de Biologia, Universidade Federal Fluminense - UFF, 24.001-970, Niterói, Brasil*
[3] *joseml@ufba.br, Universidade Federal da Bahia (UFBA), Salvador, 40170-290, Brasil*
[4]*acarmo@cbpf.br, Centro Brasileiro de Pesquisas Físicas – CBPF/MCTI, 22.290-180, Rio de Janeiro, RJ, Br.*
[5]ronaldofurtado@inb.gov.br, COMAP, Indústrias nucleares do Brasil

## 1. Introduction

The fish is a source of protein and microelements for humans. Because of this, it is part of the diet, especially in coastal areas like Sepetiba Bay. However, it can also pose health problems with its deterioration and translocate radionuclides into the human diet. The assessment of fish translocation has never been a focus of attention. The reason for this is that radiation has focused on humans: 'if humans are protected, biota will be.' [1; 2] until publication 60 [3]. The institution that asserted this statement in the 1977 publication number 27 [2] and reinforced it in the 1991 publication 60 [1], first raised doubts in [3] and was later discarded in publication [4]. Now, the protection of biota must be explicit. Starting with publication 103 in 2007 [4], a framework supported by various publications [4; 5; 6; 7; 8; 9] has been created, accompanied by the IAEA [10; 11; 12], along with many guides, forming a framework for biota protection that has not reached the complexity of human radioprotection but has evolved more rapidly than human radioprotection.

## 2. Methodology

### *2.1. Sampled area*

The collections were conducted in Espírito Santo, a state in southeastern Brazil. Fish were captured using a 4 cm mesh gillnet during a 2-hour collection effort. They were thoroughly washed with water from the collection site, kept refrigerated, and transported to the environmental laboratory. In the laboratory, the fish were weighed in fresh weight and then dried in an 80°C oven until reaching a constant weight, i.e., with the fish at room temperature, weighed, and measurements with a variation of less than 5%. Subsequently, they were ashed, starting at 80 degrees with automatic increments of 50°C up to a maximum of 450°C. The ashes should be white; if not, they are re-ashed with 2 ml of nitric acid.

### *2.2. Radionuclides Analysis*

The radionuclides $^{238}$U, $^{235}$U, $^{234}$U, $^{232}$Th, $^{230}$Th, $^{228}$Th were analyzed by taking an aliquot of the material, solubilizing it in an acidic solution, and then plated on silver plates. Subsequently, the material was contacted with a surface barrier device under vacuum [12]. The remaining samples were extracted with a top and precipitation filter method, followed by total alpha counting ($^{226}$Ra) and total beta counting ($^{210}$Pb and $^{228}$Ra).

### *2.3. Dose assessment*

The dose rate was evaluated according to Equation 1. The conversion factors used are shown in Table 1 [13].

$$D_{ing} = \sum_{j} AC_j \cdot DoCo_{ing}^{j} \quad (1)$$

where:

| | |
|---|---|
| $D_{ing}$ | is the dose rate ($Gy \cdot d^{-1}$); |
| $AC_j$ | Is the activity concentration of radionuclide j in the fish |
| $DoCo_{ing}^{j}$ | is the dose conversion coefficient for natural radionuclides |

Table 1. Conversion factors for analyzed radionuclides [13]

| Radionuclides | $^{210}Pb$ | $^{226}Ra$ | $^{228}Ra$ | $^{228}Th$ | $^{230}Th$ | $^{232}Th$ | $^{234}U$ | $^{235}U$ | $^{238}U$ |
|---|---|---|---|---|---|---|---|---|---|
| FCD ($\mu Gy\ d^{-1}$) | $5.9 \cdot 10^{-3}$ | $3.5 \cdot 10^{-1}$ | $8.4 \cdot 10^{-3}$ | $4.6 \cdot 10^{-1}$ | $6.5 \cdot 10^{-2}$ | $5.6 \cdot 10^{-2}$ | $6.6 \cdot 10^{-2}$ | $6.4 \cdot 10^{-2}$ | $5.8 \cdot 10^{-2}$ |
| F1 | 0 | 95 | 0 | 97 | 100 | 100 | 100 | 95 | 100 |
| F2 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| F3 | 98 | 5 | 97 | 3 | 0 | 0 | 0 | 5 | 0 |

The expected effects for absorbed doses are expressed in Table 2, according to [13], for the reference fish, with averages based on 6 samples.

Table 2. Relationship between dose effects in reference fish [13].

| | |
|---|---|
| Fish | • LD50 ranges from 0.3 to 18.7 Gy for salmonids, depending on the embryonic stage at which irradiation occurred.<br>• 2 Gy had no effect on the survival of trout embryos with eyes.<br>• Doses between 3-12 Gy for three-month-old trout had little effect on mortality.<br>• 4.8 $mGy \cdot d^{-1}$ (up to a dose of 0.4 Gy) in salmon had no effect on survival up to one year of age.<br>• 5.1 $mGy \cdot d^{-1}$ led to an almost threefold increase in roach mortality.<br>• 304.8 $mGy \cdot d^{-1}$ (up to 8.4 mGy) had no effect on the survival of 3-month-old guppy embryos.<br>• The influence of temperature on radiation-induced lethal effects is significant, as seen with different doses in medaka and goldfish.<br>• For example, 28 Gy caused 100% mortality at 23 ºC but had no effect at 4 ºC in medaka.<br>• 80 Gy caused 100% mortality at 22 ºC but had no effect at 4 ºC in goldfish.<br>• A dose of 1.3 $Gy \cdot d^{-1}$ (50 Gy) had no effect on mosquito fish mortality at 15 ºC or 25 ºC. |

## 3. Results and Discussion

The dose rates are expressed in table 3, corresponding to the average of 7 collected specimens. The values presented there depict rates considered insignificant, well below the levels that induce measurable biological effects ($1.37 \cdot 10^{-4}\ mGy \cdot d^{-1} \ll 1.3\ Gy \cdot d^{-1}$), with a difference of 7 orders of magnitude between the values. Therefore, they can be deemed as insignificant (see Table 02), and the appearance of biological effects is not expected within this dose range.

Table 3. Dose rate for corvina fish in Espirito Santo

| $^{238}U$ | $^{235}U$ | $^{234}U$ | $^{232}Th$ | $^{230}Th$ | $^{228}Th$ | $^{226}Ra$ | $^{228}Ra$ | $^{210}Pb$ | Total | N |
|---|---|---|---|---|---|---|---|---|---|---|
| $2,2\ 10^{-06}$ | $1,3\ 10^{-07}$ | $3,4\ 10^{-06}$ | $2,0\ 10^{-06}$ | $2,5\ 10^{-06}$ | $3,7\ 10^{-06}$ | $8,5\ 10^{-05}$ | $1,6\ 10^{-06}$ | $7,1\ 10^{-07}$ | $1,0\ 10^{-04}$ | 7 |

## 4. Conclusions

The average data from the analysis of the 7 corvina fishes do not represent radiological problems, considering their carnivorous feeding habits. Low results were expected, but not with a difference of 7 orders of magnitude. With the found dose rate ranges, no deleterious effects are anticipated for this fish [14; 15; 16]

## References

[1] ICRP, ICRP, 1959. Recommendations of the International Commission on Radiological Protection. Now known as ICRP Publication 1. Pergamon Press, New York, New York: ICRP, 1959.

[2] ICRP, Recommendations of the International Commission on Radiological Protection 1990. ICRP Publication 60 (user edition). New York: ICRP, 1991.

[3] ICRP, Recommendations of the International Commission on Radiological Protection 2007. ICRP Publication 103. Ann. ICRP 37 (2-4). New York: Sage, 2007.

[4] IAEA, Modeling of the effects of Biota dose. VIENNA: IAEA, 2012A.

[5] IAEA, Guidelines on Soil and Vegetation Sampling for Radiological Monitoring. VIENNA: IAEA, 2023.

[6] IAEA, Worldwide Laboratory Comparison in the Determination of Trace Elements in IAEA-452 Biota Sample. VIENNA: IAEA, 2012.

[7] IAEA, INTERNATIONAL ATOMIC ENERGY AGENCY. Vienna: IAEA, 2024.

[8] IAEA, New CRP: Improving External Dosimetry for Terrestrial Animals and Plants (K41023). Vienna: IAEA, 2022.

[9] ICRP, Ethical Foundations of the Radiological Protection System. ICRP Publication 138. Ann. ICRP 47(1). New York: SAGE, 2018.

[10] ICRP, Environmental Protection: Transfer Parameters for Reference Animals and Plants. ICRP Publication 114. Ann. ICRP 39(6). New York: SAGE, 2009.

[11] IAEA, Worldwide Interlaboratory Comparison in the Determination of Trace Elements in IAEA-470 Oyster Biota Sample. NEW YORK: SAGE, 2014.

[12] J. M. Godoy, D. C. Lauria, M. L. Godoy, and R. P. Cunha, "Development of a sequential method for the determination of 238U, 234U, 232Th, 230Th, 228Th, 228Ra, 226Ra, and 210Pb in environmental samples," Journal of Radioanalytical and Nuclear Chemistry, pp. 165-169, January 20, 1994.

[13] ICRP, Dose Coefficients for Non-Human Biota Exposed to Environmental Radiation. ICRP Publication 136. Ann. ICRP 46(2). New York: SAGE, 2017.

[14] E. B. J., R. J. S., R. Saxén, H. Thorring, and J. ViVes i Batlle, "Radiation dose to aquatic organisms from natural radionuclides. 24(4A): A63-A77," Journal of Radiological Protection, 2004.

[15] W. S. Pereira, The Calculation of Dose as a Tool for Environmental Radioprotection, Niteroi: UFF, 2010.

[16] ICRP, "ICRP, 1977. Recommendations of the ICRP. ICRP Publication 26. Ann. ICRP 1 (3)," New York, ICRP, 1977.