ROLE OF DIFFERENT POTASSIUM CONCENTRATIONS ON ACCUMULATION AND EXCRETION OF RADIOCAESIUM IN A FRESHWATER FISH

Maria Carolina Vaz Carreiro, José Alberto G. Corisco

DGA/DPSR, 2685 Sacavém, Portugal

ABSTRACT

The objective of this study is the role of different K^+ concentrations in water on radiocaesium accumulation and on the biological half-life, in a freshwater fish, in order of its possible use as a countermeasure.

At the temperature of 12°±2°C the accumulation kinetics at K^+ concentrations of 3.5 and 35 ppm are quite similar and CF's at steady state are one order of magnitude lower than with a K^+ concentration of 0.35 ppm. Therefore K^+ concentration in that range seems not to affect radiocaesium accumulation.

The retention experiment lasted for 130 to 260 days and showed increasing radiocaesium excretion rates at increasing K^+ concentrations.

It is suggested, at least for this temperature, that potassium might be used as a countermeasure in lakes of low potassium content.

INTRODUCTION

The transfer of radiocaesium into and outwards the freshwater biota, is affected by several environmental parameters. Out of the most importants are temperature and water chemical composition, mainly the K^+ concentration, as both elements are chemically analogues and K^+ is the non isotopic carrier of caesium.

It is known that in nature, the radiocaesium bioaccumulation shows a large variability, being higher in oligotrophic lakes with low potassium concentrations and lower in freshwater with high potassium content (1); but the influence of different K^+ concentrations in water on radiocaesium excretion is not very well known.

In different lakes it is possible to say that radiocaesium accumulation by fish is directly proportional to the radiocaesium content and inversely proportional to the potassium content in water (2), (3). Other authors obtained significant correlation between ^{137}Cs in fish and K^+ in water (3), (4). More recently, after the Chernobyl accident, very high ^{137}Cs concentrations in fishes were found, mainly in lakes in Northern Europe, with large differences from lake to lake (5), (6). However, it must be stressed that in these cases, the bioaccumulation occurs not only through the water, but mainly through the food webs. On the other hand, some authors stated the above relationship as being inverse, although not statistically significant (7); but they were mainly analysing temporal trends at several latitudes, dealing with a large variability of data.

The balances of radiocaesium and potassium in water have already been studied in laboratory by several authors and an inverse relation was quoted (8), (9), (10).

Concerning radiocaesium biological half-life in freshwater fishes, several values are reported in the literature (11), (12), (13). However, the influence of soluble K^+ on the ^{137}Cs excretion rate, only recently was studied (10), (14).

The objective or this work, was to study the effect of different Potassium concentrations in water (0.35, 3.5 and 35 ppm), on the radiocaesium biological half-life for a freshwater fish species (*Chondrostoma polylepis polylepis*), at the temperature of 12° C.

MATERIALS AND METHODS

All the experiments were performed in 5 litters aquaria, using an artificial freshwater, without water filtration system, but with aeration, artificial light during 8 hours a day, except for weekends (continuos lighting) and the temperature was kept at 12°±2°C. Artificial medium was prepared, in order to get a basic cationic composition similar to the Tejo River water at the site of Fratel dam. Ca^{2+}, Mg^{2+}, Na^+ and K^+ concentrations were, respectively, 36, 11, 25 and 3.3 mg l^{-1}. Only K^+ concentration was changed and the values used were 0.35, 3.5 and 35 mg l^{-1}. ^{134}Cs was in the chloride form, in a 0.1 M solution of hydrochloric acid, with a concentration of 2 μg Cs^+ml^{-1}. Water was changed once a week and the contaminated faecal pellets were daily separated by screening, to prevent their ingestion by fish.

Small specimens of the cyprinid fish *Chondrostoma polylepis polylepis*, aged about 1 year, with a mean weight of 1.8 g, were used and fed 5 days a week, with milled soft parts of bivalves containing 0.9 mg (K^+) g^{-1}, each meal representing about 5% of the total fish weigth. Each group was previously acclimatised to the artificial medium, for 2 weeks, before contamination with ^{134}Cs. Growth rates were evaluated separately for the three groups of fishes and within them, for uptake and elimination period; growth rates for the whole period were low, varying from 0.0011 to 0.0018 day^{-1}. During the uptake phase, fishes were fed in separated aquaria with uncontaminated water, to avoid any contact of food with radioactive caesium.

Radioactivity measurements were made on pre-weighed anaesthetised fishes. ^{134}Cs concentration in the liquid phase during the uptake, was measured in water samples filtered through membranes (0.45 µm). The measuring equipment was based in a well-type NaI(Tl) detector, associated with a multi-channel analyser.

RESULTS AND DISCUSSION

Concentration factor was computed considering the mean value of water radioactivity for all the uptake period. Elimination of the radioisotope was treated by multicompartmental analysis (15), (16).

^{134}Cs concentration in fish, during 4 weeks of direct uptake, has increased in all three groups without reaching a steady state. All the uptake kinetic curves were fitted according to the treatment described in (15), (16), where fish growth, bioelimination, and physical decay of ^{134}Cs are taken into account.

The higher the K^+ concentration in water, the lower the radioactive contamination of fishes **Fig.1**. The evaluated CFs at steady state for K^+ concentrations of 3.5 and 35 ppm are of the same order of magnitude; uptake curves are almost overlapped, as it happens at 20°C (10). As K^+ concentration in water of about 2 ppm seems to be critical (7), it is understandable that 3.5 or 35 ppm has no significant influence on the radiocaesium uptake.

Biological half-life means the time needed for a retention compartment to loose 50% of its radioactive content. Two compartments were evaluated, **Fig.2**, with the following Tb's: at 0.35ppm K^+, Tb_1=21 days and Tb_2=472 days; at 3.5ppm K^+, Tb_1=24 days and Tb_2=254 days; at 35ppm K^+, Tb_1=21 days and Tb_2=136 days.

The elimination of radiocaesium by fish seems to be affected by the external potassium concentration in water. The longer biological half-life (Tb_2) decreases as the K^+ concentration increases.

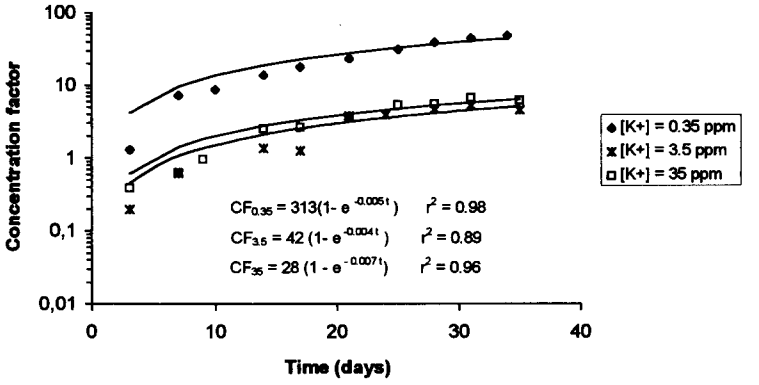

Fig. 1 ^{134}Cs uptake by a freshwater fish from water with different K^+ concentrations.
(CF is the ratio Bq g^{-1} (fish) / Bq ml^{-1} (water))

In (10) the conclusion seemed to be different, however, it needs to be enhanced that it concerned a short-term experiment (about 50 days), while the present one lasted more than 250 days. Retention analysis made at 50 days showed that, in this period, the retention curves exhibited parallel profiles and Tb_1 actually would not significantly differ, but Tb_2 would be very different. A question raises from this data, whether a long-term experiment influences the goodness of the results, although the growth rate will be lower.

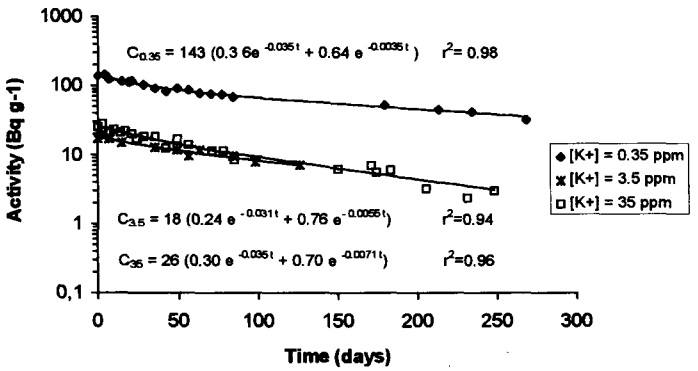

Fig. 2 ^{134}Cs retention by a freshwater fish at different K^+ concentrations in water, at 12°C.
(C is the radioactivity of fishes)

CONCLUSIONS

At 12°±2°C, a long-term retention experiment (more than 4 months), with *Chondrostoma polylepis polylepis*, revealed that at higher K^+ concentrations in water the elimination is faster, i. e., the excretion rate increases with K^+ concentration, therefore the biological half-life of the longer component is shorter.

Relating the interpretation of uptake and loss data, it seems that in water bodies of low K^+ concentration (below 2 ppm), the increase of K^+ concentration might increase the radiocaesium excretion.

REFERENCES

1. B. G. Blaylock, in R.O.Chester and C.T.Garten, Jr. (Ed.), Environmental Effects, 427-438 (1982).
2. D. G. Fleishman, in D. Greenberg (Ed.), Radioecology, John Wiley & Sons, New York, 347-370 (1973).
3. A. Preston, D. F. Jefferies and J. W. R. Dutton, *Water Research*, vol.1, 475-496 (1967).
4. N. R. Kevern and S. A. Spigarelli, in D. J. Nelson (Ed.), Radionuclides in Ecosystems, Oak Ridge, Tennessee, vol. 1, 354-360 (1971).
5. R. Saxén, Report STUK-A, Supplement 3 to Annual Report STUK-A74, pp. 59, (1990).
6. J. M. Elliot, J. Hilton, E. Rigg, P. A. Tullett, D. J. Swift and D. R. P. Leonard, *Journal of Applied Ecology*, 29, 108-119 (1992).
7. F. W. Whicker, W. C. Nelson and A. F. Gallegos, *Health Physics*, vol. 23, 519-527 (1972).
8. G. D. Lebedeva, *Radiobiologiya*, 6, 556-559 (1966).
9. A. Srivastava, H. O. Denschlag, O. Kelgerg and K. Urich, *Journal of Radioanalytical and Nuclear Chemistry, Articles*, vol. 138, n° 1, 165-170 (1990).
10. J. A. Corisco and M.C.V. Carreiro, (Int. Sem. on Freshwater and Estuarine Radioecology, Lisboa, 21-25 March 1994). *In publication.*
11. L.Foulquier, CEA-BIB-231 (2), pp. 360 (1979).
12. J. A. G. Corisco and M. C. V. Carreiro, LNETI/DPSR-A-n° 2 (III série), pp.16 (1991).
13. C. J. Hewett and D. F. Jefferies, *J. Fish Biol.*, 9, 479-489 (1976).
14. V. Romanenko, O. Nasvit, V. Solomatina, M.C.V. Carreiro and M. Fomovski, (Int. Sem. on Freshwater and Estuarine Radioecology, Lisboa, 21-25 March 1994). *In publication.*
15. J. Garnier-Laplace, Rapport CEA-R-5549, pp. 198 (1991).
16. C. Badie, M. Belluau, J. M. Fernandez and G. Gontier, Rapport CEA/EDF, pp.122 (1985).