DEPENDENCE OF RADIOCAESIUM BIOLOGICAL HALF-LIFE IN FRESHWATER FISH ON WATER POTASSIUM CONCENTRATION AND TEMPERATURE

M.C.V. Carreiro and J. A.G. Corisco

DGA / DPSR, E N n° 10, 2686 Lisboa Codex, Portugal

Abstract: The main purpose of this study is to search for the influence of environmental potassium concentration and temperature on the elimination of radiocaesium by a freshwater fish. Results from short term experiments (35 to 49 days) showed that the elimination rate increases with potassium increase in water, decreasing the biological half-life, but only from 0.35 to 3.5 ppm of K^+; higher K^+ concentration in water seems not to affect the elimination rate. With decreasing water temperature (experiments were carried out at 20, 12 and 5°C), there is a tendency to lower elimination rates, therefore to higher biological half-lives. It is suggested that in water bodies of low K^+ concentrations, up to 2 ppm, potassium addition might increase the elimination rate, lowering the biological half-life, what is more effective at higher temperatures.

1. Introduction

Radiocaesium bioaccumulation shows a large variability in nature being affected by environmental parameters such as water chemical composition and temperature. As caesium and potassium are chemically analogues, potassium concentration in water is of the utmost importance on radiocaesium accumulation. Generally in oligotrophic lakes with low potassium concentration the bioaccumulation is higher than in fresh waters with high potassium content [1]. Radiocaesium concentration in fish is directly proportional to the radiocaesium content in water and is inversely related to potassium concentration in water [2, 3]; this inverse correlation was found over the range 0.8 to 3.6 ppm K^+, [3], and between 0.35 and 3.5 ppm K^+, [4, 5]. A significant inverse correlation between ^{137}Cs concentration in fish and K^+ concentration in water was reported by other authors [6, 7, 8].

Radiocaesium biological half-life in freshwater fish shows a range of values, reported in the literature [6], [7], [9], [10]. It is referred that generally biological half-life increases with decreasing temperature.

There are several studies on fish behaviour according to the environmental temperature [11] to [15]. Some authors, [16, 17, 18], also observed a decreasing elimination rate of radiocaesium with decreasing water temperature.

A series of experiments was programmed to study the role of potassium concentration and temperature on ^{134}Cs accumulation and elimination by fish. This study was done under the framework of a EU Contract.

2. Materials and methods

Experiments were carried out in small aquaria filled with 5 liters of an artificial freshwater medium. Artificial water was prepared keeping the main cation concentrations and changing K^+ concentration, which mean value, in the natural environment (Fratel Reservoire in Tejo River) is 3.3±0.3 mg l^{-1}.The artificial medium was composed of distilled water to which some salts were added, in order to get a basic cationic composition similar to that of the Fratel Reservoir: Ca^{2+}, Mg^{2+} and Na^+ concentrations were, respectively, 36, 11 and 25 mg l^{-1}. ^{134}Cs was added to aquaria in a solution 0.1 M of chloridric acid with a concentration of 2μg Cs^+ml^{-1}. Radioactivity in each aquarium water was approximately 20 Bq ml^{-1}.

The aquaria had no water filtration system. Aeration was maintained by aquarium air compressors and artificial light by fluorescent tubes was added to natural sunlight, during 8 hours a day, except for

weekends. Three temperatures were selected to carry out the experiments: 20 ± 2°C, 12 ± 2°C and 5±1°C.

Juvenile fish specimens of the Cyprinid *Chondrostoma polylepis polylepis*, aged less than one year, were 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 weight. Fish growth rate was evaluated for each experimental group; rates were low varying from 0 to 0.0018 day^{-1}. Each group of fish was previously acclimatized to the artificial medium and temperature, for 10 days, before contamination with radiocesium (direct uptake from water), which lasted for 4 weeks, followed by a decontamination period of 6-7 weeks.

^{134}Cs radioactivity was measured using a NaI(Tl) well-type detector with a multichannel analyser. Radioactivity measurements were made on pre-weighed live fish, anaesthetized in an aqueous solution of 0.3 g l^{-1} of MS-222 (Sandoz). Fish were kept in inactive water while being counted.

Data are expressed in Bq g^{-1} fresh weight of fish along with the 0.95 confidence interval. Retention, R_t, represent the percentage of the initial radioactivity of fish during the elimination phase. Biological half-life Tb is the time needed for a retention compartment to loose 50% of its radioactive content.

Uptake and loss kinetic curves are based on a model described by Garnier- Laplace [19] and Badie *et al.*[20], which is based upon a multicompartmental analysis of retention.

3. Results and discussion

For this short term experiments (35 to 49 days) radiocaesium elimination by fish seems to be affected by the external potassium concentration in water. Actually, from Fig. 1, 2, 3 and Table it is observed that the elimination rate increases, although slightly, with the potassium concentration in water, specially at the temperature of 20°C, because at 12 and 5°C the elimination rate is similar for the concentrations of 3.5 and 35 ppm of potassium. Therefore, the biological half-life decreases with potassium concentration.

Fig. 1. ^{134}Cs elimination by a freshwater fish at different [K^+] and temperature 20°C

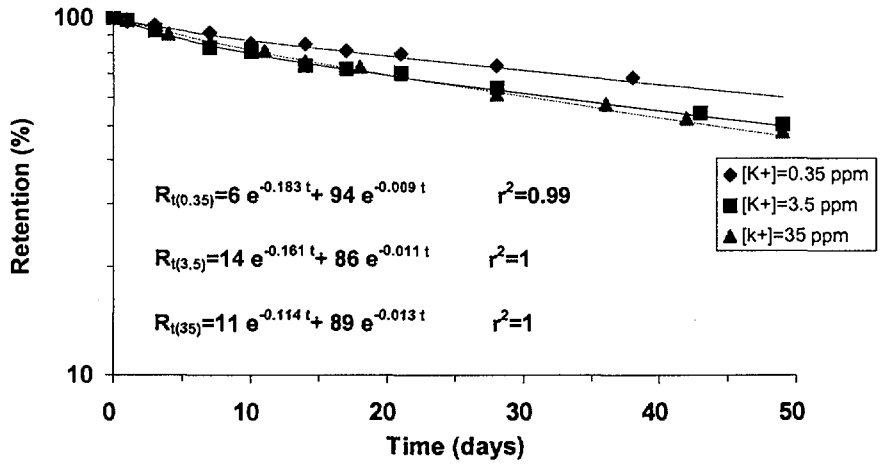


Table. Radiocaesium excretion parameters

Parameters	20°C			12°C			5°C		
	K^+ppm			K^+ppm			K^+ppm		
	0.35	3.5	35	0.35	3.5	35	0.35	3.5	35
Tb_2 (days)	86	67	57	157	119	100	220	119	115
Elim. rate	0.009	0.011	0.013	0.004	0.006	0.007	0.004	0.007	0.007

Fig. 2. ^{134}Cs elimination by a freshwater fish at different $[K^+]$ and temperature 12°C

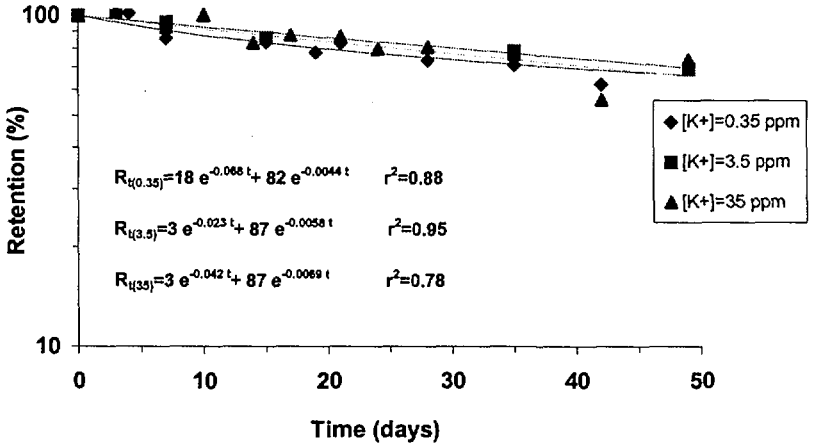
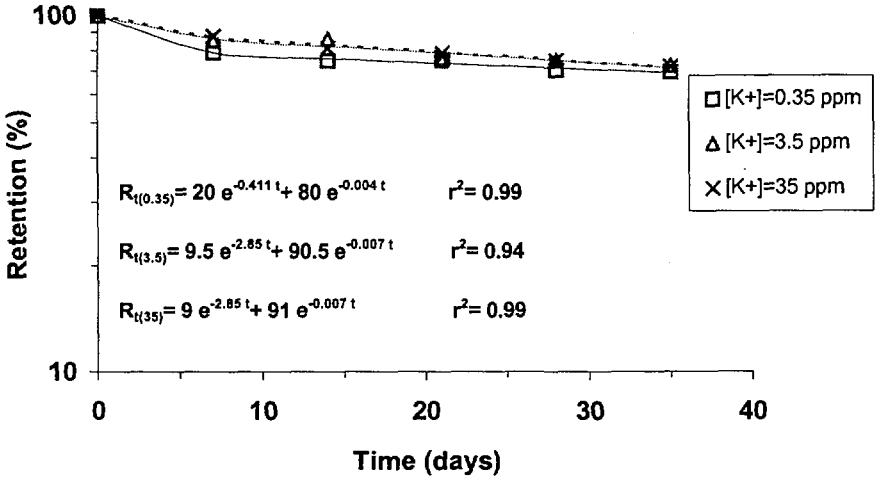


Fig. 3. ^{134}Cs elimination by a freshwater fish at different $[K^+]$ and temperature 5°C



As the effect of water potassium concentration on radiocaesium accumulation by freshwater fish is stronger below a value of about 2 ppm [2] and [4], it may be expected that the elimination rate might be influenced in a similar way.

The elimination rate also increases with the temperature for the three potassium concentrations studied, however, the effect is more marked at 20°C. The biological half-life decreases with the temperature increase, specially for 0.35 ppm of potassium in water.

4. Conclusions

The excretion rates decrease with the temperature, therefore biological half-life of the longer component increase at lower temperatures.

For the three temperatures studied, increasing potassium concentrations in water increase fish excretion rate and consequently biological half-life of the longer component decreases.

These experiments suggest that in water bodies of low K^+ concentrations, up to 2-3 ppm, potassium addition might increase the elimination rate, lowering the biological half-life, what is more effective at higher temperatures.

5. References

1. G. Blaylock, *in* R.O.Chester and C.T.Garten, Jr. (Ed.), Environmental Effects, (1982), 427-438.
2. G. Fleishman, *in* D. Greenberg (Ed.), Radioecology, John Wiley & Sons, New York, (1973), 347-370.
3. Preston, D. F. Jefferies and J. W. R. Dutton, *Water Research*, vol.1, (1967), 475-496.
4. A. G. Corisco and M. C. V. Carreiro, *in* Proceedings of International Congress on Radiation Protection, Vienna, Austria, April 14-19, 1996, vol.3, (1996), 271-273.
5. A. G. Corisco and M. C. V. Carreiro, (Int. Sem. on Freshwater and Estuarine Radioecology, Lisbon, 21-25 March 1994). *In publication.*
6. R. Kevern and S. A. Spigarelli, *in* D. J. Nelson (Ed.), Radionuclides in Ecosystems, Oak Ridge, Tennessee, (1971), vol. 1, 354-360.
7. D. Lebedeva, *Radiobiologiya*, 6, (1966), 556-559.
8. Srivastava, H. O. Denschlag, O. Kelgerg and K. Urich, *Journal of Radioanalytical and Nuclear Chemistry, Articles*, vol. 138, n° 1, (1990), 165-170.
9. Foulquier, CEA-BIB-231 (2), (1979), p. 360.
10. A. G. Corisco and M. C. V. Carreiro, LNETI/DPSR-A-n° 2 (III série), (1991), p. 16.
11. McCauley, N. Huggins, *in* G. W. Esch and R. W. McFarlane (Ed.), Thermal Ecology II, (1976), 171-175.
12. L. Beitinger, *in* G. W. Esch and R. W. McFarlane (Ed.), Thermal Ecology II, (1976), 176-179.
13. Carlsson, *Health Physics*, vol. 35, (1978), 549-554.
14. Descamps, *Verh. Internat. Verein. Limnol.*, vol. 22, (1985), 2611-2614.
15. Nakahara, T. Koyanagi and M. Saiki, *J. Radiat. Res.*, vol. 18, (1977), 122-131.
16. Ugedal, B. Jonsson, O. Njastad and R. Naemann, *Freshwater Biology*, vol. 28, (1992), 165-171.
17. R. Kevern, *Transactions of the American Fisheries Society*, vol. 95, (1966), 363-371.
18. Hasanen, S. Kolehmainen and J. K. Miettinen,, *in* B. Aberg& F. P. Hungate (Ed.), Radioecological Concentration Processes, Pergamon Press, Oxford, (1969), 921-924.
19. Garnier-Laplace, (PhD. Theses, Univérsité Montpellier II), Rapport CEA-R-5549, (1991), p. 198.
20. Badie, M. Belluau, J. M. Fernandez and G. Gontier, Rapport CEA/EDF, (1985), p. 122.