Accumulation of Radionuclides under Determined Conditions in Trouts and Carps

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1)Introduction

In the literature [1] the value of the biological half-life of the nuclides Co-60, Zn-65, Sr-85 and Cs-137in fish ranges from 10 to 1000 days. The object of this study was to determine the intake of radionuclides from water and contaminated food by trouts and carps, two important freshwater fishes, to estimate the biological and effective half-lives, to compare or verify the found values with in the literature and to estimate the transfer factors food/fish after feeding the fishes with contaminated food in aquarium experiments. This study also examines the effect of the salinity of the water an the accumulation of the radionuclides.

2)Results and Discussion

2.1 Accumulation of radionuclides from water:
The accumulation of the radionuclides is expressed by equation (1):

$$[R]_t = [R]_\infty\{1 - \exp(-kt)\} \qquad (1)$$

$[R]_t$. and $[R]_\infty$: concentration of radionuclide at time t and steady state concentration (Bq/kg fresh weight
k : excretion rate of 0,692/ t 1/2, t 1/2 being the biological half-live (days)

All radionuclides with the exception of Co-60 in carps were found in the two species. By fiiting the rapidly increasing part of model curve to measured points the steady state concentration $[R]_\infty$, the rate constant k and the biological half-live are obtained.. With the mathematical formula (2) the effective half-live can be estimated. The calculated values are shown in table 1. The sign "-" means: No determination

$$0.693/T(Eff.) = 0.693/T(Bio.) + 0.693/T(Phys.) \qquad (2)$$

Table 1: Biological and effective half-lives (days) after intake from water in carp and trout.

Nuclide	Carp		Trout	
	T(Bio.)	T(Eff.)	T(Bio.)	T(Eff.)
Mn-54	27.2 ± 2.0	25.2 ± 1.7	27.6 ± 10.1	25.4 ± 8.2
Co-60	-	-	14.5 ± 0.9	14.4 ± 0.9
Zn-65*	-	-	37.4 ± 2.8	32.2 ± 2.1
Sr-85	9.0 ± 4.6	7.9 ± 3.4	26.5 ± 3.9	18.8 ± 2.0
Cs-137	38.7 ± 6.0	38.6 ± 6.0	38.9 ± 4.4	38.7 ± 4.4

* A good fit for zinc to obtain was unavailable. The biological half-lives for Cs-137 agree very well with those determinated in field experiments. In the literature [2] half-lives of 55 days are reported for one-to-two-yeras old trouts and for two-years-old roaches, related to carps.

Potassium and calcium are non-isotopic carrier elements of cesium 137 and strontium 85. If the carrier elements are homeostatically controlled, the concentration factor AF(R) of the radionuclides will be given by the equation (3).

$$AF(R) = q\,[C]_i/[C]_w \qquad (3)$$

$[C]_i$ and. $[C]_w$: Concentration of non-isotopic carrier element in organism or tissue i (µg/kg FS) and concen tration in water (µg/l)
q : Discrimination factor
The disrimination factor is expressed by equation (4):

$$q = \frac{[R]_i/[C]_i}{[R]_w/[C]_w} \qquad (4)$$

$[R]_i$: Concentration of the radionuclide in organism i
$[C]_i$: Concentration of the non-isotopic carrier in organism i
$[R]_w$: Concentration of the radionuclide in water
$[C]_w$: Concentration of the non-isotopic carrier in water
As mentioned above calcium and potassium are non-isotopic carrier elements of Sr 85 and Cs137, i.e. the AF(R)

of these nuclides should decrease with increasing concentration of the carriers. Taking the natural logarithm of each side of equation (3), the equation (5) is obtained:

$$\log AF(R) = \log q\,[C]_i - \log [C]_w \qquad (5)$$

Sincee $[C]_i$ is a constant, a plot of log AF(R) versus log $[C]_w$ should have a slope of -1, if q is constant. The trouts were kept in water compartments with an average potassium concentration of 1 mg/l, 10 mg/l, 100 mg/l und 200 mg/l and an average calcium concentration of 80 mg/l and 160 mg/l and the carps in one with an average pozassium concentration of 1 mg/l, 100 mg/l and 200 mg/l and an average calcium concentration of 80 mg/l and 160 mg/l. An increase of the calcium concenztation is not possible because a higher calcium concentration may be poisonous [3].The figures 1 - 2 show the results in double logarithmic presentation.

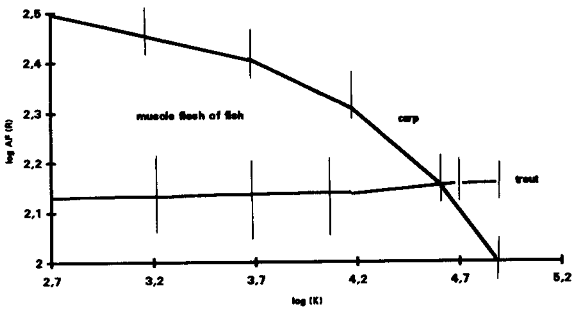

Fig 1: The dependence of the accumulation factors of cesium 137 in the muscle of carp and trout on the concentration of potassium in water.

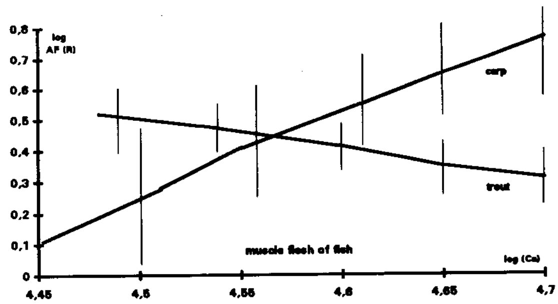

Fig .2: The dependence of the accumulation factors of strontium 85 in the muscle of carp and trout on the concentration of calcium in water.

In contrast to Vanderploeg et al [4], but in accordance with Whicker et al. [5], who examined trouts from mountain lakes in Colorado/USA the potassium concentration was of no effect on the intake of cesium in the muscle of trouts, kept in our compartment. The carps show a decrease of the accumulation factors by increasing potassium concentration from 1 mg/l to 200 mg/l..

The accumulation factor of strontium in the muscle of trout decreases with increasing calcium concentration, a phenomenon which was observed by Templeton et al [6], too. In contrast to the trouts the carps show an increase of the accumulation factor of strontium in muscle with increasing calcium concentration in water.

2.2. Intake of radionuclides from contaminated food:

All radionzclides in the food were found in both species. The accumulation of radionuclides may be described by the equation (1), too. By fiiting the fast ascent of model ,curve to measured points the steady state concentration R_{∞} and hence the biological and effective half-lives are obtained. The values are listed in table 2.

Table 2: **Biological and effective half-lives of the radionuclides (in days) after intake of contaminated food in carps and trouts.**

Nuclide	carp		trout	
	T(Bio.)	T(Eff.)	T(Bio.)	T(Eff.)
Mn- 54	41.3 ± 8.1	36.5 ± 6.5	15.2 ± 5.8	14.5 ± 5.2
Co- 60	26.5 ± 0.6	26.2 ± 0.6	10.3 ± 1.7	10.2 ± 1.7
Zn- 65	31.8 ± 2.5	28.1 ± 2.0	33.2 ± 5.6	29.2 ± 4.3
Sr- 85	8.0 ± 4.0	7.1 ± 3.6	12.4 ± 0.5	10.4 ± 0.4
Cs-137	39.0 ± 1.8	38.9 ± 1.8	46.7 ± 1.5	46.5 ± 1.5

The half-lives for cesium 137 agree well for the two species already quoted in the literature . There is reported a half-live of 47,2 days for the speckled trout [7] and a one of 35 days for carp[8], both determined after being fed with contaminated food.

The intake of contaminated food by fish is a two-comparment system. The transfer of the nuclides from the compartment food into the compartment muscle will be descibed by the formula (6).

$$T = [R]_{fish} / [R]_{food} \; 1/V \qquad (6)$$

T : **transfer factor**
$[R]_{fish}$: **concentartion of the radionuclide in fish (Bq/kg fresh weight)**
$[R]_{food}$: **concentration of the radionuclide in food (Bq/kg fresh weight)**
V : **amount of feed (kg/day)**

The calculated transfer factors (day/kg) are listed in table 3.

Table 3: Transfer factors (d/kg) of radionuclides for the pathway food/fish

Nuclide	carp	trout
Mn-54	$2x10^{-3}$	$3x10^{-3}$
Co-60	$2x10^{-3}$	$7x10^{-3}$
Zn-65	$2x10^{-2}$	$4x10^{-3}$
Sr-85	$2x10^{-2}$	$5x10^{-2}$
Cs-137	$6x10^{-2}$	$1x10^{-1}$

The transfer factors do not differ distinctly in the single nuclides in the two kinds of fish.

3) References

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The study was prepared within the scope of the project St.Sch. 959 sponsored by the Federal Minister of the Interior and the Federal Minister of the Environment, Natural Protection and Reactor Safety.