SORPTION AND RETENTION OF CERTAIN RADIONUCLIDES BY SOME FRESH WATER BIOTA
PART I : BIOMPHALARIA ALEXANDRINA.

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ABSTRACT

The uptake of ^{134}Cs, ^{89}Sr and ^{60}Co from contaminated water by the fresh water snail **Biomphalaria alexandrina** as well as the release of these radionuclides from the contaminated snail were studied. It was found that the uptake of the radionuclides increased with contact time up to 4 days, and the rate of uptake was $^{60}Co > ^{89}Sr > ^{134}Cs$.

Retention of these radionuclides by the snail was found to decrease with the increase of contact time in fresh water and the percentage release followed the order $^{134}Cs > ^{89}Sr > ^{60}Co$.

INTRODUCTION

Radionuclides introduced into an environment of freshwater ecosystem can either remain in solution, precipitate on the suspended material, settle on bottom sediments and/or taken up by aquatic organisms. The distribution and transport of radionuclides between various parameters is subject to complex purification factors wich are difficult to evaluate. The behaviour or radionuclides in the aquatic ecosystem is of great interest in order to evaluate the hazards that may occur to man due to the movement of such radionuclides via food chains (Foster & Davis 1955; Davis & Foster 1958; Davis et al, 1958).

The accumulation of radionuclides within the aquatic biota has been studied by several investigators (Bealsrud, 1962, Bendleton, 1968; Abdel Malik et al 1973; Ishak et al 1977; El-Shinawy & Abdel Malik 1980; Reed et al 1968; Alkholy et al 1970). Studies on the uptake of some radionuclides in the aquatic environment of Ismailia Canal, Egypt, may help to develop the safe limits for the disposal of low level radioactive wastes in this canal. It may thus be possible to evaluate the possible hazards underlying accidental release of large amounts of these radionuclides in the canal (IAEA Safety series No. 9, 1967).

In the present work, investigations were carried out on the uptake and release ^{134}Cs, ^{89}Sr and ^{60}Co isotopes by the fresh water snail **Biomphalaria**

alexandrina.

MATERIAL AND METHODS

The fresh water snails **Biomphalaria alexandrina** were brought to the laboratory and kept in a large aquarium containing well aerated tap water for acclimatization under laboratory conditions. The water in the aquriuum was changed three times a week and aeration was frequently made. The snails were fed daily on fresh lettuce leaves. The individual weight of the experimental snails ranged between 0.12 to 0.30 g with an average of 0.20 g/snail. Their size (shell-length) ranged between 8 to 15 mm.

For uptake studies, solution of ^{134}Cs, ^{89}Sr and ^{60}Co in well aerated tap water were prepared to give a final concentration of 8-10 uCi/l for each radionuclide under investigation. The experimental snails were placed in test solutions at a rate of 25 snail/l. The snails were starved for 244 hours before being transferred to the radioactive solutions. Throughout the experimental period, the snails were not fed. Aeration of the test solutions was frequently made. At intervals, samples of the snails were removed in triplicates, blotted on filter paper, weighed, dried and radioassayed. At the same time intervals, 1 ml samples of the experimental solutions were taken for radioassay.

For release studies, snails were kept in radioactive solutions for at least 2 days depending on their maximum uptake for the particular isotope. Thereafter, the snails were transferred to aquaria containing fresh non-radioactive tap water to follow their release of radioactivity. The water was continuously replaced. At intervals, samples of snails were taken in triplicates, blotted on filter paper, weighed dried and radioassayed.

The experimental radionuclides used were carrier free ^{134}Cs, ^{89}Sr and ^{60}Co supplied in their chloride forms from Amersham Radiochemical Centre. Radioassay was performed by drying the samples carefully, grinded then placed in tubes for the γ -emitters (^{134}Cs and ^{60}Co) and counted using a well-type scintillation detector connected to a preamplifier and decade scaler. The B -emitter (^{89}Sr) dried grinded samples were counted in planchettes by the use of G.M. detector and scaler. Solutions samples of either γ -Or B -emitters were counted in tubes or planchettes respectively. Corrections were made for decay and self absorption whenever necessary.

RESULTS AND DISCUSSION

Uptake of Radionuclides:

Fig.(1) shows the data on the accumulation of the investigated radionuclides by the fresh water snail, **Biomphalaria alexandrina.** From Fig.(1), it is clear that the maximum uptake of ^{134}Cs amounted 0.022

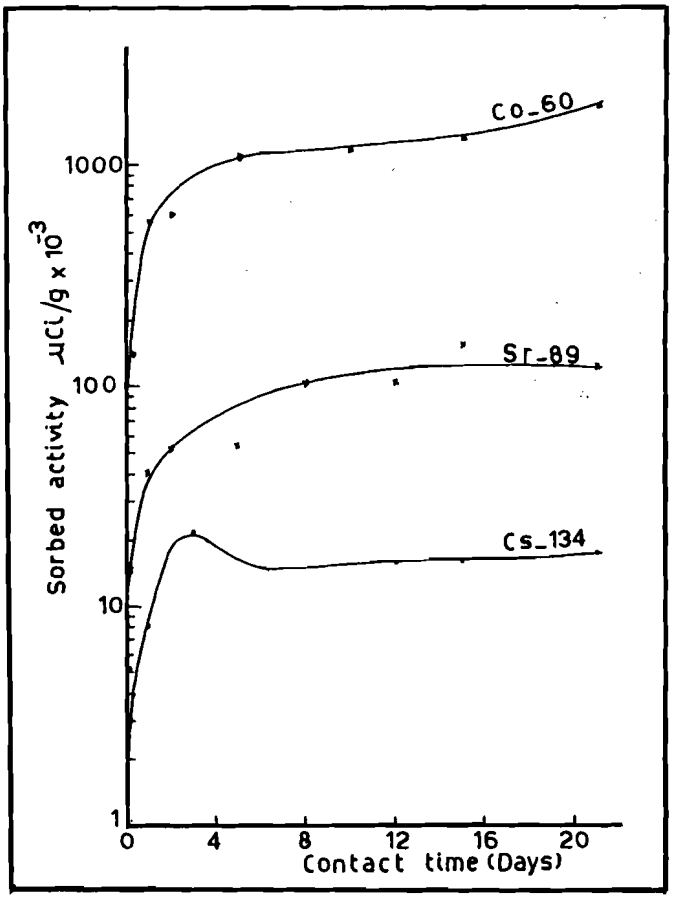

Fig. 1. Sorption of radionuclides by the snail **Biomphalaria alexandrina** in radioactive tap water.

uCi/g wet weight of snail has been reached after three days contact time in radioactive solution. This maximum uptake was noticed to decrease very slightly by increasing contact time reaching a value of 0.0175 uCi/g after 3 weeks.

In Case of ^{89}Sr and ^{60}Co uptake, it was found that the investigated snails accumulated the radioactive substances continuously with increasing contact time as shown in Fig.(1). After a period of three weeks uptake, ^{89}Sr reached 0.120 uCi/g wet weight snail, while for ^{60}Co it was about 1.94 uCi/g wet weight of snail. The uptake of ^{60}Co increased after 21 days contact (1.94 uCi/g) to reach about 14 times as compared with the uptake after 3 hours (0.141 uCi/g). In case of ^{89}Sr the uptake after 21

days (0.120 uCi/g) increased about 9 folds as compared with the uptake after 3 hours (0.013 uCi/g). While in case of ^{134}Cs, of lower sorption affinity by the snail, the uptake after 21 days (0.0175 uCi/g) increased about 3.5 times than that after 3 hours, while at its maximum after 3 days (0.022 uCi/g) the increase was about 4.35 times than that of 3 hours.

For the studied radionuclides, it was found that the rate of accumulation decreased with contact time increase as shown in Table (1). ^{60}Co showed highestt sorption rate as compared with ^{89}Sr and ^{134}Cs.

The concentration factors which were calculated as the ratio:

$$\frac{\text{activity / g wet weight of snail}}{\text{activity / ml of solution}}$$

were obtained from the given data. The concentration factors were plotted against contact time as shown in Fig.(2). In case of ^{134}Cs the concentration factors reached their maximum of 16 after 3 days of contact time and declined slightly thereafter. For the continuous increase of uptake of both ^{89}Sr & ^{69}Co isotopes, the maximum concentration factors 15 and

TABLE 1
RATE OF UPTAKE OF RADIONUCLIDES BY THE
SNAIL **Biomphalaria alexandrina**

Contact time (days)	Isotope		
	Cesium - 134 μ Ci/g/day	Strontium - 89 μ Ci/g/day	Cobalt - 60 μ Ci/g/day
1	40.80	109.60	1128
2	8.19	40.80	557
3	7.40	---	---
5	---	10.70	223
8	2.26	12.75	---
10	---	---	120
12	1.13	8.67	---
15	1.08	10.20	89.53
21	0.83	5.76	92.33

N.B. Activities are given in μ Ci / g / 10^{-3}.

percentage of ^{89}Sr is adsorbed to the snail shells. After 21 days of contact time with fresh water, the snails showed higher fixation of ^{60}Co (30 %

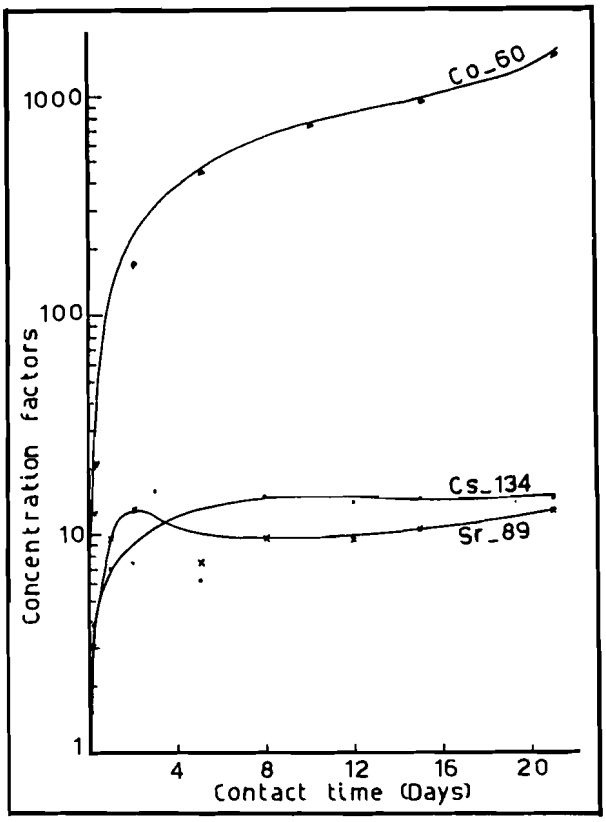

Fig. 2. Cgange of concentration factors of radionuclides in solution by the snail **Biomphalaria alexandrina** with time.

of activity was retained) than ^{89}Sr (20 % of activity was retained) and lower fixation of ^{134}Cs since only 5 % of activity was retained. The retention data suggests that ^{60}Co is metabolized by the snail tissues. Further investigations are needed to specify its role.

Release of Radionuclides

Fig.3 shows change of the released radionuclides, ^{134}Cs, ^{89}Sr and ^{60}Co from the contaminated snails transferred to the frequently changed tap water, with contact time. It is worth to notice that in the first 15 minutes contact time in fresh tap water, bout 10 % of the initially accumulated radioactive cesium and cobalt were removed, while 20 % of strontium

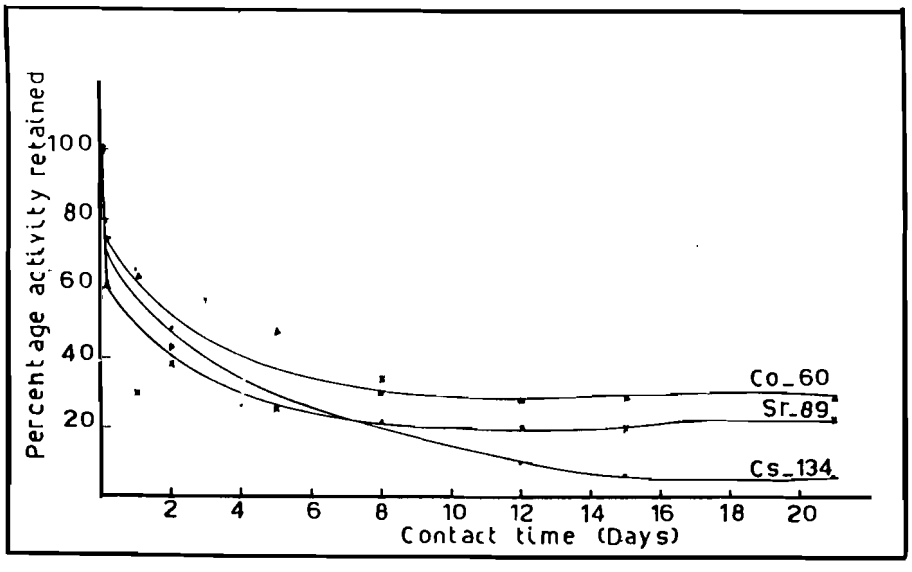

Fig. 3. Release of activity from contaminated snail **Biomphalaria alexandrina** using frequently changed tap water.

activity were released. After one day, the release of radioactivity continued in the same order reaching a value of 35 % for ^{134}Cs & ^{60}Co and 70 % for ^{89}Sr.

Table (2) shows the activity retained and released from the snails with contact time. The activity of ^{134}Cs accumulated by the snail was gradually released with time and reached about 95 % release of initial value after 3 weeks contact time.

The sorbed cobalt-60 was also released gradually to reach about 70 % released from the snail of the initially accumulated activity after a period of 8 days where it remained almost contant for the next two weeks of the experiment.

It was also obvious that the strontium-89 activity sorbed by the snail **Biomphalaria alexandrina,** was rapidly released through the first day. The amount of ^{89}Sr retained after one day in contact with fresh tap water reached 30 % of the total initial accumulated activity while it decreased very slightly through the next three weeks to reach about 20 % retained activity.

Concentration of the radionuclides by the aquatic organisms in ecosystems occurs mainly due to sorption from water and or assimilation through food chains (Davis & Foster, 1958; Davis et al, 1958; Foster & Davis 1955;

TABLE 2
RELEASE OF SORBED RADIONUCLIDES FROM BIOMPHALARIA ALEXANDRIA SNAILS
KEPT IN FREQUENTLY CHANGED TAP WATER

	Cesium - 134			Strontium - 89			Cobalt - 60		
Contact Time	Sorbed Activity* µCi/g	% Remained	% Released	Sorbed Activity µCi/g	% Remained	% Released	Sorbed Activity µCi/g	% Remained	% Released
Zero time	7.44	100.	0.00	52.2	100	0.00	327	100	0.00
5 min	7.27	97.60	2.40	---	---	---	---	---	---
10 min	6.26	90.80	9.20	41.80	80	20	288	88.70	11.30
30 min	5.75	77.20	22.80	---	---	---	---	---	---
1 hour	5.13	68.90	31.10	25.40	48.60	51.40	252	77.00	23.00
3 hour	4.98	66.80	23.20	32.20	61.60	38.40	239	73.00	27.00
1 day	4.85	65.10	34.90	15.50	29.60	70.40	211	64.40	35.60
2 days	3.63	48.80	51.20	20.60	39.40	60.60	142	43.30	56.70
4 days	1.98	26.50	73.50	---	---	---	---	---	---
5 days	---	---	---	13.40	25.60	47.40	161	49.30	50.70
8 days	1.64	22.00	78.00	17.90	34.20	65.80	101	30.70	69.30
12 days	0.72	9.70	90.30	10.60	20.20	79.80	96.80	29.20	70.80
15 days	0.44	5.90	94.10	10.80	20.40	79.80	98.60	29.90	70.10
21 days	0.39	5.30	94.70	11.80	22.6	77.40	96.20	29.20	70.80

* Activities are given in µ Ci / g X 10^{-3}.

Krumholz, 1956). The amount of radionuclides concentrated on the different organisms fluctuate according to their different modes of uptake and to environmental seasonal factors.

As the rapid release of ^{89}Sr activity (70 % released after one day) compared with these of ^{134}Cs and ^{60}Co (35 %), suggests that a high percentage of ^{89}Sr is adsorbed to the snail shells. Afterr 21 days of contact time with fresh water, the snails showed higher fixation of ^{60}Co (30 % of activity were retained) than ^{89}Sr (20 % of activity were retained) and lower fixation of ^{134}Cs since only 5 % of activity were retained. The retention data suggests that ^{60}Co is metabolized by the snail tissues. Further investigations are needed to specify its role.

REFERENCES

Foster R.F. & Davis J.J., 1955. The Accumulation of Radioactive substances in Aquatic Forms, **Int. Coaf. on the Peaceful uses of Atomic Energy,** A/Corf. 8,280 USA.

Davis J.J. and Foster R.F., 1958. Bioaccumulation of Radioisotopes Trough Aquatic Food chain, **Ecology,** 39: 530-535.

Davis, J.J. et al, 1958. Radioactive materials and terrestial organisms exposed to reactor effluent water, **second U.N. Int. Conf. on Peaceful Uses of Atomic Energy A/Conf.** 15/P/393, USA.

Bealsrud, K., 1962. The influence of radioactive wastes on biological conditions in a river, **research Contract Rep. No. 37 submitted to IAEA from 14 Dec.** 1959 to 15 Dec. 1962.

Bendleton R.C., 1968. Absorption of ^{137}Cs by an aquatic community in Hanford, Hanford atomic Energy products operation. **Cerneal Electric Co. USAEC Report HW-53500.**

Abdel Malik W.E.Y., El-Shhinawy R.M.K., Ishak M.M. & Mahmoud, K.A., 1973. Uptake of Radionuclides by some Aquatic Macrophytes of Ismailia Canal, Egypt. **Hydrobiologia,** 42, 1: 3-12.

Ishak M.M., Khalil S.R. and Abdel Malik W.E.Y., 1977. Distribution and Tissue Retantion of Cesium-134 and Cobalt-60 in the Nile cathish **Clarias lazera** (Cuv. & Val.), **Hydrobiologia,** 54, 1: 41-48.

El-Shinawy, R.M.Y., Abdel Malik, W.E.Y., 1980. Retention of Radionuclides by some aquaticfresh water plants, **Hydrobiologia,** 69, 1-2 : 126-129.

Read Jr J.R., Griffith, N.A. & Courtney C.H., 1968. Uptake and fixation on cobalt-60 by Black Bullheeds (**Ictalurus males**) ORNL- 4316, 118-122.

Al-Kholy, A., Ishak M.M. Yousef Y.A. & Khalil S.R., 1970. Phosphorus uptake from water by **Tilapia zillii** (Gervais) **Hydrobiologia,** 36, 3-4: 471-478.

IAEA, 1967. **Badic safety Standards,** Sefety series No. 9, revised edition, Vienna.

Moloukhia, M.K.M., 1970. **Studies on Strontium-90 Kinetics in the Marine Molluse Following Possible Release of Radioactive Waste in Sea Water,** Ph.D. Dissertation, Karl-Marx-Universitate Leipzig Sektion Chemie.

Moloukhia, M.K.M., 1970. **Studies on Strontium-90 Kinetics in the Marine Mollusc Following Possible Release of Radioactive Waste in Sea Water,** Ph.D.

Dissertation, Karl-Marx-Universitate Leipzig Sektion Chemie.
Krumholz, L.A., 1956. Observations on the fish population of a lake contaminated by Radioactive wastes, Bull, **Amer Mus, Nat. Hist.**, 110, 227-368.