Metabolism of Zn^{65} in mussels *(Mytilus galloprovincialis* Lam.). Uptake of Zn^{65}

by

STJEPAN KECKEŠ*, BARTOLO OZRETIĆ and MIRJANA KRAJNOVIĆ

Institute « Rudjer Boskovic », Rovinj and Zagreb (Yougoslavie)

**Present address : International Laboratory of Marine Radioactivity, Musée Océanographique, Monaco (Principauté)*

One of the most frequently found radiocontaminant is Zn^{65}, a neutron-induced radioisotope of zinc, originating from fallout and wastes of nuclear establisments, and which is especially quickly accumulated to a very high degree in various marine bivalves [BOROUGHS *et al.*, 1957; CHIPMAN *et al.*, 1958; ICHIKAWA, 1961; RICE, 1963; POLIKARPOV, 1964]. This is probably due to a high turnover of this essential biogenic microelement [VALLEE, 1959] and or/to a more or less irreversible type of its binding in their body. In a series of experiments these aspects of zinc metabolism were investigated using Mussels as experimental animals and ethylenediamine-tetraacetic-acid (EDTA) as a modifier.

Materials and method

Common mussels (*Mytilus galloprovincialis* Lam.) reared in commercial parks and adapted to the laboratory conditions were used.

Zn^{65} was produced as carrier free by the cyclotrone of Institute « Rudjer Boskovic » and used in chloride form (5 milliCi in 5 ml of 10^{-2}N HCl) Radiometric determinations were carried out using a well type gamma ray scintillation detector with a 2.5 $\times$ 2 inch NaI (Tl) crystal connected to a decade scaler The efficiency of the counting equipment for Zn^{65} was about 22 %.

The uptake of Zn^{65} by animals was studied in closed polyethylene basins containing natural sea water enriched by 1 microCi of Zn^{65}/1. During the experiment the basin was replaced daily by a fresh one so that the quantity of radiozinc, and concomitantly the amount of total zinc, were approximately at the same level. The concentration factors (CF), i.e. the ratios of Zn^{65} per unit weight of animal and the surrounding medium [ICHIKAWA, 1961; HELA, 1963; POLIKARPOV, 1964] were calculated according to the mean activity of the basin during the whole experiment.

The activities of soft tissues and shells were always measured separately. In some experiments the animals were dissected and the activity of various organs was established. EDTA was used as its dinatrium salt.

Results and discussions

The general pattern of Zn^{65} uptake by soft tissues and shells of mussels in normal sea water and in sea water containing 10 and 50 mg of EDTA per liter is shown in Figure 1. The activity was taken up much more by soft tissues than by the shells and after 10 days the equilibrium between the medium and the animals, regarding the Zn^{65} exchange, was not established. Due to the high ratio between the conc. of stable zinc in molluscs [VINOGRADOV, 1963; BROOKS & RUMSBY, 1965] and our sea water [PETEK & BRANICA, 1968] at the exchange equilibrium in normal sea water the concentration factor should be between 2 000 and 7 500. It can be mentioned that after 600 days of exposure in a natural environment containing Zn^{65}, the exchange equilibrium in oysters was not reached at a concentration factor roughly estimated as 3 600 [SEYMOUR, 1966].

Rapp. Comm. int. Mer Médit., **19**, 5, pp. 949-952, 3 fig. (1969).

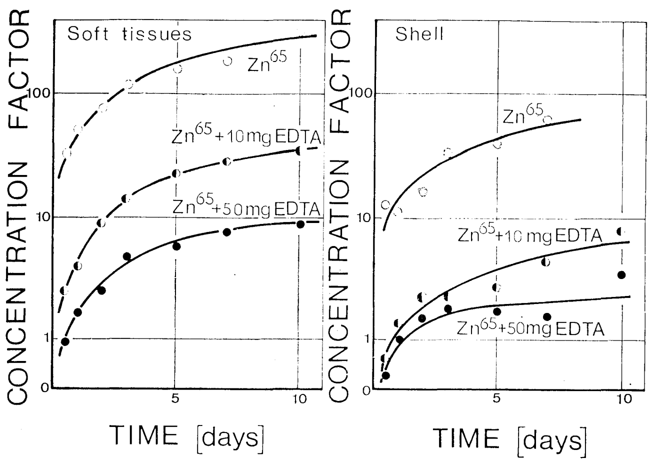

FIG. 1. — Uptake of Zn^{65} by soft tissues and shells of mussels influenced by various EDTA conc. Each mark represents the mean of at least 5 samples.

Using two basins in parallel experiments, one without and one with 50 mg of EDTA/1, the uptake of Zn^{65} by various organs of mussels was investigated. In general the overall uptake process was 20 times slower in EDTA group (Figure 2). The « remainder », which contained all what was not separately checked for radioactivity, showed the highest activity per unit weight in both groups, but the sequence of organs, arranged according to decreasing specific activity, was not the same in both groups, indicating that the effect of EDTA on the uptake of Zn^{65} was not the same in all organs.

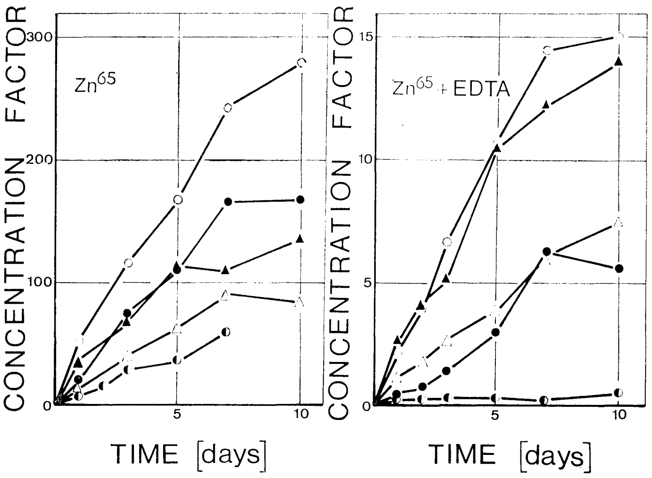

FIG. 2. — Uptake Zn^{65} of by organs and tissues of mussels influenced by 50 mg EDTA per litre of the experimental basin. Each mark represents the mean of 5 samples. (●-muscle, ▲-gills, △-mantle, ◐-shell, ○-remainder).

In experiments with much lower EDTA conc. the radioactivity taken up by animals was tested on the fifth day from the beginning of the experiment. The results were expressed as the « inhibition factors » (IF), i.e. as the differences of the incorporated activities (in terms of CF) between the control group and the groups treated with EDTA (CF_C-CF_{EDTA}) in % of the values for the control (1) :

$$IF = 100\ (CF_C - CF_{EDTA}) / CF_C \qquad (1)$$

The calculated IF, plotted against the EDTA conc. in the basin, showed a sigmoidal shape curve (Figure 3), and a clear dependence between the EDTA conc. in the basin and the uptake of Zn^{65}. Graphically it was estimated that at about 0.2 — 0.3 mg EDTA per litre the uptake of Zn^{65} is half of the normal uptake.

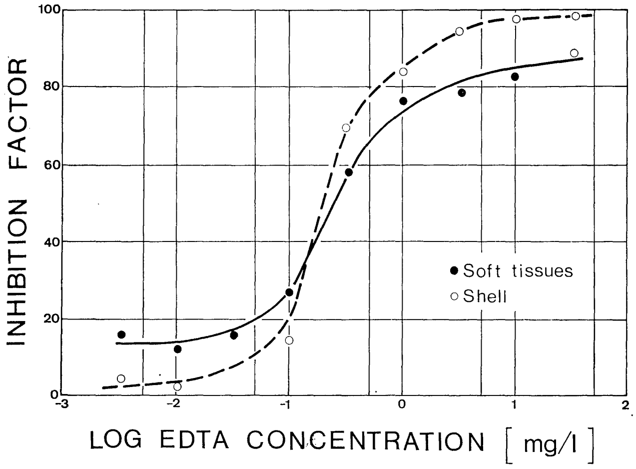

FIG. 3. — The dependence of the inhibition of the radiozinc uptake on the EDTA conc. in the experimental basins 5 days from the beginning of the experiment. Each dot represents the mean of eight samples.

Due to the complex composition of sea water the proportion of zinc actually bound in our experiment with EDTA can not be precisely calculated. However, some preliminary results of BRANICA (personal communication) indicate that the observed relation between the inhibition of Zn^{65} uptake and the EDTA concentration in the basins is directly correlated with the chelation of zinc.

In summary we could say that

a. The uptake of radiozinc in Mussels is rapid but equilibrium is reached only after a long period. The uptake is about ten times higher for the soft tissues than for the shells.

b. 0.01 to 50 mg EDTA per litre significantly depresses the uptake of radiozinc. The effect of EDTA depends on its concentration.

Acknowledgements

This work was supported by contracts with the International Atomic Energy Agency, Vienna (RB/201). The authors wish to express their gratitude, to Miss Maja BENETTA, Miss Marija MARECIĆ and Mr. Slavko DRAGIĆ for their valuable technical assistance.

Références

BOROUGHS (H.), CHIPMAN (W.A.) & RICE (T.R.), 1957. — Laboratory experiments on the uptake, accumulation, and loss of radionuclides by marine organisms, *in : The effects of atomic radiation on oceanography and fisheries*, **551**, pp. 80-87. — Washington, National academy of science, National Research Council.

BROOKS (R.R.) & RUMSBY (M.G.), 1965. — The biogeochemistry of trace element uptake by some New Zealand bivalves. *Limnol. & Oceanogr.*, **10**, 4, pp. 521-527.

CHIPMAN (W.A.), RICE (T.R.) & PRICE (T.J.), 1958. — Uptake and accumulation of radioactive zinc by marine plankton, fish, and shellfish. *Fish. Bull., U.S.*, **58**, 135, pp. 279-292.

HELA (I.), 1963. — Alternative ways of expressing the concentration factors for radioactive substances in aquatic organisms. *Bull. Inst. océanogr. Monaco*, **61**, nº 1280, 8 p.

ICHIKAWA (R.), 1961. — On the concentration factors of some important radionuclides in the marine food organisms. *Bull. Jap. Soc. sci. Fish.*, **27**, 1, pp. 66-74.

PETEK (M.) & BRANICA (M.), 1968, *in press.* — Hydrographic and biotical conditions in North Adriatic. III. Distribution of zinc and iodate. *Thalassia jugosl.*, **5**.

ПОЛИКАРПОВ (Г.Г.), 1964. – Радиоэкология морских организмов. – Москва, Атомиздат. 296 p. [POLIKARPOV (G.G.), 1964. — *Radioécologie des organismes marins.* — Moscou, Atomizdat. 296 p.]

RICE (T.R.), 1963. — Review of zinc in ecology, *in : Radioecology*, pp. 619-632. — New York, Reinhold.

SEYMOUR (A.H.), 1966. — Accumulation and loss of zinc-65 by oysters in a natural environment, *in : Disposal of radioactive wastes into seas, oceans and surface waters*, pp. 605-619. — Vienna, International Atomic Energy Agency.

VALLEE (B.L.), 1959. — Biochemistry, physiology and pathology of zinc. *Physiol. Rev.*, **39**, 3, pp. 443-490.

VINOGRADOV (A.P.), 1953. — *The elementary chemical composition of marine organisms.* — New Haven, Sears foundation for marine research, Yale university. XIV-647 p. [*Mem. Sears Fdn Mar. Res.*, **2**].