Errors in the extrapolation of laboratory experiments to field conditions

by

JASMINE KANE, STJEPAN KEČKEŠ and ANDRÉ VEGLIA

Laboratory of marine radioactivity, I.A.E.A., Monaco

Introduction

The extent to which results of laboratory experiments can be interpreted to assess the outcome of similar experiments in nature, has always been open to question. Experimenters are continually trying to bring the more or less artificial laboratory conditions as near as possible to those existing in the natural environment. In some experiments, this may be easy, but in radioecological studies it is very difficult to bridge this gap, since for planned *in situ* experiments, radionuclides can only be used in restricted areas and on limited occasions; therefore most investigations on the mechanisms involved in their bioaccumulation depend on field observations and laboratory experiments. These experiments are often characterised by an oversimplified, empirical approach which neglects the complexity of the natural environment, where only the interaction of all components gives the finally observed effect.

Errors in the extrapolation of the results may be introduced by one of the following differences existing between the laboratory and field conditions : a. the physico-chemical form of the radionuclide; b. the carrier concentration; c. the physical conditions and d. the ionic composition.

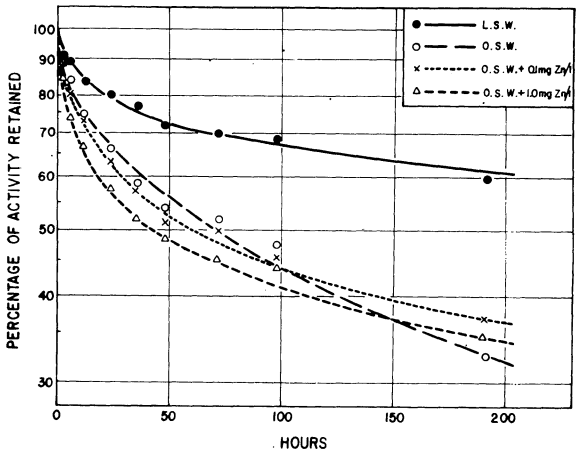

FIG. 1. — Relative biological loss of Zn^{65} from *Pachygrapsus* kept in running laboratory sea water (L.S.W.) and in running sea water from open sea (O.S.W.) with natural and increased zinc concentrations.

The biological fractionation of isotopes caused by their different masses can be neglected when the typical sea water trace elements are considered [BOWEN, 1960] but the fractionation caused by the possible physico-chemical forms of a particular element is not yet fully understood or taken into account

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[CHIPMAN, 1966; KEČKEŠ *et al.*, 1967]. Therefore, predictions of the highest possible bioaccumulation of radionuclides based on the specific activity concept — where only the overall concentrations of an element in the environment and in the organisms are considered — may lead to estimations which contradict experimentally found results [ROBERTSON *et al.*, 1968]. The importance of the carrier concentration is often neglected and various physical conditions, especially that of temperature, can considerably change the biological half-life of some radionuclides. The metabolism of a particular element and its physico-chemical form [HEYRAUD & KEČKEŠ, 1971] can be directly affected by the ionic composition of the environment, the importance of which, when determining the biological half-life of a radionuclide, is illustrated by the following experiment.

Experiment

20 shore crabs, *Pachygrapsus marmoratus* Fabricius (1 and 5 g size-range) were placed in the same basin containing 30 l of aerated sea water and radiozinc (about 1μCi of Zn^{65}/l). After 6 days the radioactivity accumulated was determined by total body counting using a one channel analyser (CEA) connected to a 3″ × 3″ NaI(Tl) well type crystal. The animals were then divided into 4 similar groups of 5 crabs, and put into running sea water (5 l/hour during the first 8 hours, 1.3 l/hour afterwards). The conditions for all 4 groups were identical except that the sea water supplied to each differed as follows : 1st group : sea water from normal laboratory supply (L.S.W.); 2nd group : sea water from open sea (O.S.W.); 3rd group : sea water from open sea (O.S.W.) with increased zinc concentration (0.1 mg/l added), and 4th group : sea water from open sea (O.S.W.) with increased zinc concentration (1.0 mg/l added). The running sea water temperature varied between 14.8°C and 17.2°C and the salinity of L.S.W. and of O.S.W. was 37.36 ‰ and 37.64 ‰, respectively. The zinc content of L.S.W. and O.S.W. was 20 μg/l and 22 μg/l, respectively, according to spectrophotometric analyses using dithizone as indicator.

The loss of Zn^{65} by the crabs was followed over a period of 8 days, the radioactivity of the animals being determined by whole body counting at frequent intervals, especially during the first 48 hours. The results, corrected for the background radiation and sensitivity shift of the counting equipment, were expressed as percentages of the crabs' initial activity before they were put in running sea water. Thus, at time zero, all crabs have 100 % radioactivity. The results obtained are illustrated in Fig. 1. where the average radioactivity of the 5 crabs in each group is plotted, at different time intervals.

It can be seen immediately that of the four experimental groups only the 1st group, to which L.S.W. was supplied, showed a very different and much slower rate of loss than the control O.S.W. group (2nd group). After 3, 12 and 24 hours, there was a difference of 3, 10 and 14 %, respectively, between the 2 groups, and towards the end of the experiment this difference gradually increased to 27 % In terms of the actual activity lost by the crabs, after only the first day the control O.S.W. group had lost 34 % of its initial activity, whereas the L.S.W. group had only lost 20 %. After the 2nd day, 45 % and 28 %, had been lost, respectively, and the loss rate in both groups continued to decrease so that by the 8th day, the O.S.W. group had lost 66 % but the L.S.W. group only 40 % of the initial activity. Thus the biological half-life of Zn^{65} is also different, being about 3 days in what may be taken as natural sea water (O.S.W.), but more in the order of 18 days in sea water normally used in the laboratory (L.S.W.)

A part from these appreciably different loss rates, the smaller difference between the O.S.W. group is also significant. It seems that the initial loss rate depends on the stable zinc concentration though towards the end of the experiment the overall loss was the highest in the group where the O.S.W. was not enriched with stable zinc.

Conclusions

The loss of Zn^{65} was quite comparable in all O.S.W. groups, although their stable zinc concentration was very different, but the loss was remarkably different in the natural O.S.W. and L.S.W., where the stable zinc concentration was practically the same. It seems that in this particular case the carrier concentration was far less important than some unknown factors, present only in L.S.W. and which were inhibiting or slowing down the exchange of zinc adsorbed on the surface of crabs and/or the metabolic processes concerned with the turn-over of zinc.

This experiment shows that the experimentally determined biological half-life of Zn^{65} in *Pachygrapsus* depends very much on the conditions maintained during the experiment. Thus it is evident that any predictions based on laboratory experiments concerning the metabolic rates of rationuclides in the natural environment, can only be tentative, unless field observations can prove that laboratory conditions do not alter the normal metabolic processes.

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