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UPTAKE OF COBALT BY GOLDFISH (*Carassius auratus*)

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금붕어(*Carassius auratus*)에 의한 코발트 흡수

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Radiocobalt was used as tracer to study the uptake of cobalt by fish either from water or food source, respectively. Four groups of goldfish were exposed to ^{57}Co-labelled water under 4 different temperatures, while another four groups were fed labelled feed pellets at 15℃. Results indicate that water temperature has no significant effect on the uptake of cobalt from water. The uptake from water is quite a slow process since the cobalt uptaken from water reached 0.0006% of available activity at best on the 13th day of exposure. The uptake from a labelled feed source showed a linear increase with time over the period of ninety days. On the 90th day of experiment the percentage of available activity consumed seemed to be approaching an equilibrium point at roughly 12% of the total activity fed to the goldfish.

INTRODUCTION

Cobalt, as a constituent of the vitamin cyanocobalamin (B-12) and an enzymatic cofactor associated with basic cellular processes, is an important trace element for living organisms. And also, cobalt has been received increasing concerns since it frequently occurs as a toxic pollutant in aquatic environments. Uptake of cobalt by different aquatic organisms has been documented mostly in response to concerns about bioaccumulation of the material from the environment where various forms of cobalt can be introduced into via industrial activities including operation of nuclear power plants cooled by river or sea water (Koyanagi *et al.*, 1979 ; Carvalho, 1987). Radioisotopes have various advantages when used in experiments, which, among others, are the relative easiness in detection of their pathways and dynamics by means of radioactivity counting and the same behavioral characteristics as their stable counterparts.

Radioecological studies showed that bioaccumulation processes can be affected by environmental factors such as temperature, pH, and salinity, therefore the experimental results often depend upon local or expe-

rimental conditions. And also the results show wide variation depending upon the species of organism, and physico-chemical form of radionuclide. Nevertheless, short-term experiments with radioisotopes are considered acceptable for evaluating certain parameters regarding environmental pollution when exposure periods to contaminants did not allow the radionuclides to reach an equilibrium state. Radiocobalt was used in this experiment to study the uptake of cobalt from water and that through feed source and to determine the possible effect of water temperature on the uptake from water.

MATERIALS AND METHODS

The radiocoblt which was used for this experiment was a solution of chloride form ($^{57}CoCl_2$). Four 4.5ℓ tanks were set up and water temperatures of were maintained at 5℃, 10℃, 15℃, and 20℃, respectively. Eight goldfish (*Carassius auratus*) were stocked in each tank and acclimatized prior to the beginning of the experiment. The initial activity level of cobalt in water was about 50Bq/ml-water (Carvalho, 1987). This initially labelled water was maintained throughout the experiment except for the 20℃ tank.

The water in the 20℃ tank was changed daily and the water labelled again to prevent the possible formation of bacterial colonies on the tank wall and the subsequent consumption of Co-57 by bacteria from the water.

Cobelt-labelled feed pellets were used to study the uptake of cobalt from the feed source. Sixty goldfish were used for the experiment. Fifteen fish were stocked in a lucite cage which was suspended in each of 4 tanks. This cage had small holes drilled up its sides enabling water to flow out of the cage but preventing fish from escaping. The labelled feed source was based on a commercially available fish feed in pellet form. These pellets were ground to a power-like consistency, to which were added a gelling agent and liquid Co-57 in controlled amounts. The feed was remade into pellets of the same size as those of the original commercial feed and then allowed to dry. The fish were fed a maintenance diet of 80mg of labelled feed per day, and countings of the feed' s radioactivity were taken before each feeding. The fish were acclimatized to the test conditions of well water at 15℃ for a week. A periodic culling of the schools and the subsequent gutting were done in order to measure the actual bioaccumulation in the flesh and bone of the fish.

Activity measurements were taken of each fish using a whole body counter(Nuclear Chicago Tobor Counter) connected to a multichannel analyzer(Davidson Co. Model 1056C). For the study of uptake from labelled water each fish was counted live by heat-sealing it in a plastic sleeve with 4mℓ of water. For the experiment, the fish was counted after gutting.

To eliminate unnecessary noises in counting data due to the nature of radioactive decay and the counting statistics and find a overall trend, a three-point moving average was used as a nonbiased technique (Halfon and Bargmann, 1975). Data were smoothed by three-point moving average through the first three points. The middle point was then replaced by the value predicted by moving average. The same procedure was followed with the other points (2,3,4 ; 3,4,5 ; etc.) until the last three points were analyzed.

RESULTS AND DISCUSSION

Effect of water temperature on the uptake of cobalt-57 by goldfish from the labelled water

Counting data (Fig. 1) indicated that the rates of Co-57 uptakes were generally low, and the expected funtion of increasing consumption with temperature was not found. Instead, fish from the 5℃, 10℃ and

NOTE : 1Bq=1 disintegration per second=2.7×10^{-11} Ci

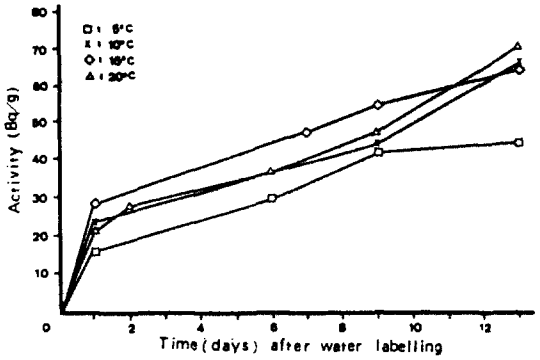

Figure 1. Uptake of Co-57 by goldfish from labelled water at four different temperatures.

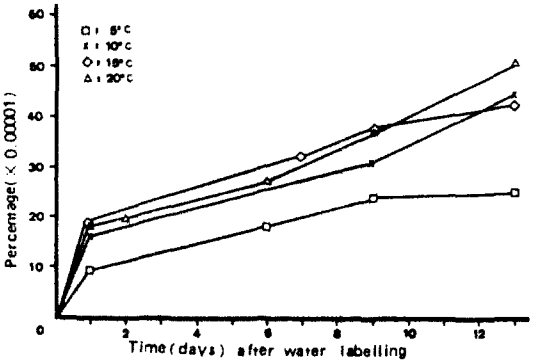

Figure 2. Percentage of Co-57 activity consumed by goldfish from labelled water.

15℃ tanks had very similar activity levels, but the activity of the fish from the 20℃ tank far surpassed these. Water samples revealed a much lower Co-57 activity in the 20℃ tank, and this result suggested that bacteria were forming in the warmer water and they consumed the Co-57 from the water. The fish in the 20℃ tank would then feed on the labelled bacteria and could thus take up more of the Co-57. It was demonstrated that bacteria were forming on the inside surfaces of the 20℃ tank. However, this formation was not noticeable until at least 24 hours after the Co-57 labelling (unpublished data).

Results(Fig.1) indicate that the uptake rates do not seem to increase with temperature. The data from all tanks are grouped together for the most part except for a sudden divergence of the 5℃ tank value after 13 days. The goldfish from the 20℃ tank were no longer much more radioactive than the others. Since the activity levels in the water were roughly 50Bq/ml (i.e. the water activity is, per se, high enough), it is likely that the major contribution of fish activity levels was from labelled water clinging to the goldfish as they were removed from the tanks and prepared to be counted. This explains the sudden activity fluctuations in fish after the first day of exposure. Figure 2 shows the evolution of the percentage of consumed available activity with the time period. At most, after the thirteen day trial 0.0006% of the total available activity was in or on the fish. Because of these extremely low levels of cobalt, it seems that water is not an important vehicle for fish to uptake this metal. This result is comparable to other similar study cases. For mollusks uptake from water is the main route for Co accumulation, however simultaneous intake from labelled food did not increase the contamination level (Harrison, 1973). However Co bound to sediment increased the amount of radionuclide concentrated in benthic deposit feeders (Evans, 1984).

Uptake of Cobalt-57 by Goldfish from a Labelled Food Source

Tests conducted prior to this experiment had confirmed that leaching of Co-57 from the pellets to the water was negligible over a twenty-four hour period. Data, in actual, represented uptake from food alone. As for other potential trouble areas, note that although each fish on average should have consumed 80mg of food, the fish were not kept individually and thus major variations in consumption between fish were quite possible.

The results show a linear increase in the amount of Co-57 absorbed by the goldfish with time (Fig. 3).

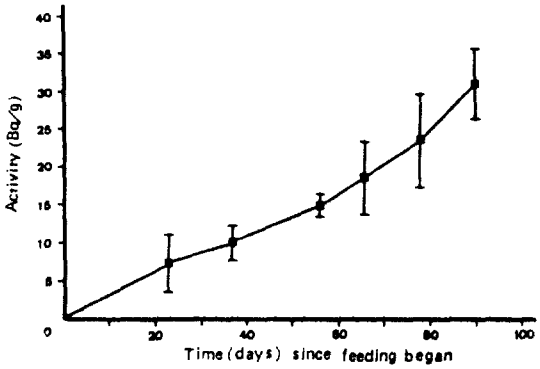

Figure 3. Uptake of Co-57 by goldfish from labelled feed pellets. Bar indicates one standard deviation.

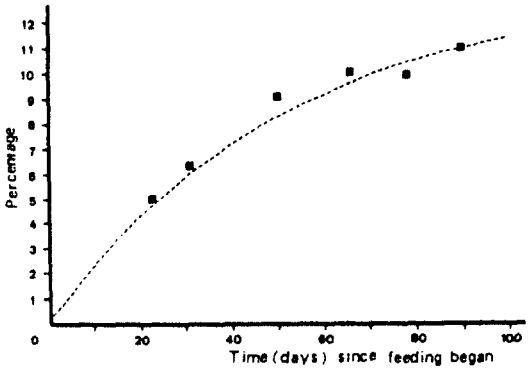

Figure 4. Percentage of Co-57 activity consumed by goldfish from labelled feed.

Each point represents the mean measure activity on each day taken over the seven goldfish gutted. Variables in consumption such as different rates of feeding of different fish probably account for most of the variation in the figures.

Unfortunately there are complications to this simple picture of food uptake not yet having reached an equilibrium. Overall activity levels in the fish food increased on the fifty-fourth day of the experiment by approximately 30% and continued to increase slightly thereafter. This change was not noticed soon enough to correct the problem. Due to this increase, we do see a steady increase in activity levels in figure 3. However, the percentage of available activity consumed data is approaching an equilibrium point at roughly 12% of the total activity fed to the goldfish. This compares to the percentage values obtained from experiments on Co-57 uptake from water by goldfish (Fig.2), which were 0.0006% at best on the 13th day of exposure.

From the results of these two experiments, the Co-57 uptake through the feed source seems more effective than that through the water. According to these results, it seems that high levels of cobalt found in fish in natural conditions are possibly due to the uptake of cobalt through the food chain.

요 약

어류에 의한 물과 먹이로부터의 물질 흡수를 연구하기 위하여 방사성 동위원소를 추적자로 이용하였다. 금붕어가 들어있는 네개의 수조에 Co-57을 처리한 후 각기 다른 온도 조건하에서 실험을 실시하였고, 또 다른 네개 수조의 어류는 동위원소를 처리한 먹이를 주었다. 실험결과로부터 수온은 물로부터의 코발트 흡수에 거의 영향을 미치지 않는 것으로 나타났다. 물에 동위원소를 처리한 후 13일째 어류가 흡수한 코발트의 양은 총가용량의 0.0006%에 불과해 물을 통한 흡수과정은 매우 서서히 진행됨을 알 수 있었다. 먹이를 통해 어류체내에 흡수된 방사능은 90일간의 실험기간에 걸쳐 시간경과에 따라 선형 증가 양상을 보였으며, 실험 개시 후 90일째에 마리당 투여한 총 방사능의 12% 수준에서 거의 평형상태에 도달하였다.

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