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PRELIMINARY REPORT ON HUMAN EXCRETION OF TRITIUM

Work Done By:

Ernest C. Anderson
Ernest Pinson

Written By:

Ernest C. Anderson

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PRELIMINARY REPORT ON HUMAN EXCRETION OF TRITIUM

Ernest C. Anderson and Ernest Pinson

An investigation of the human body water turn-over and of the distribution and exchange equilibria of body water has been begun at this laboratory using tritium tracer. In this paper are reported some preliminary data which have been obtained on the rate of turn-over of body water.

Six subjects received a few millicuries of tritium by inhalation of isotopically labeled hydrogen gas. The concentration of H^3 in the urine of these individuals has been followed for a period of some 15 days. Analyses were performed by allowing vapor from the urine to pass over hot Zn (zinc dust suspended on glass wool) in an evacuated system. The H_2 produced by the reaction - $H_2O + Zn \longrightarrow H_2 + ZnO$ - was passed through a dry ice-cooled trap to remove any unreacted water and other chemical species of low volatility. The non-condensable gases were transferred to an ion chamber by means of a Toeppler pump. Urine samples of 0.1 cc. volume were reduced giving a pressure of 412 mm. Hg in a 250 cc. chamber. The pressure was increased to 970 mm. with carbon dioxide and the ion current measured with a vibrating-reed electrometer. Relative values only are given in this report. Ion currents of the order of 10 to 100 times background were obtained from the samples. Only negligible amounts of material were found condensed in the dry-ice trap and quantitative measurements with pure water indicate that the reduction procedure is stoichiometric to better than 95%.

The rate of excretion of the tritium was found to be constant for a given subject but to vary considerably among individuals. Data on five individuals arbitrarily normalized to coincide at zero time are plotted in Figure 1, showing a range in biological half-life from about 9 days to nearly 13 days. These values are to be compared with the value calculated for the Chalk River "Standard Man" of 13.5 days, assuming the tritium to be confined to the body water.

Figure 2 shows the results of a more detailed experiment on a sixth subject. The daily total volume of urine excreted by this individual was measured for a period of 6 days on a "normal" but uncontrolled water intake. From the sixth to the tenth day inclusive, the subject consumed as large a quantity of water as was reasonable during the course of his normal activities. Urine volume was measured daily during this period also. On the eleventh day, the subject returned to his "normal" water intake. During the first period, an average urine output of 1.1 liters per day was observed. This value rose to 5.0 liters per day during the middle period. Half-times of 12.5 days, 4.8 days and roughly 14.3 days were observed during these periods. The abrupt increases in excretion rate observed twice during the third period make it difficult to interpret this portion of the data. It is believed that these periods of increased elimination can be correlated with periods of unusual activity and increased water consumption. Assuming that the total body water and the total water elimination in forms other than the urine remained constant, it is possible to estimate the effective size of the reservoir from which H^3 is being eliminated. Using only the first and second periods and letting V_1 = volume of water eliminated in the urine per day; V_2 = volume of water eliminated in other forms per day during the first period, the primed symbols being the corresponding values for the second period; and V_3 = total volume of the H^3 reservoir expressed as water equivalents, we have:

For the first period: $$\frac{V_1 + V_2}{V_3} = .055 \text{ day}^{-1}$$

and for the second period: $$\frac{V_1' + V_2'}{V_3'} = 0.144 \text{ day}^{-1}$$

Setting: V_1 = 1.08 liters per day

V_1' = 5.0 liters per day

$V_2 = V_2'$ and: $V_3 = V_3'$

we find that: V_2 = 1.38 liters per day

V_3 = 44 kg.

Since Subject #5 has a body weight of 65 kg. the "reservoir" corresponds to 68 per cent of total body weight in agreement with the assumption that the reservoir is principally body water with no large degree of exchange with other hydrogen, although it must be admitted that this calculation is not a sensitive test of the assumption. It is hoped that further data on this point will be obtained in future experiments.

It is planned to measure the H^3 content of blood plasma, exhaled water vapor and perspiration and to look for any gradual lengthening of the biological half-time with time after exposure which might indicate a slow, reversible exchange with other chemical forms of hydrogen in the body. Animal experiments permitting detailed examination of specific body organs and chemicals for tritium uptake are also planned.

If it is assumed that tritium inhaled as hydrogen gas or water vapor exchanges only with the water of the body, an assumption on which it is hoped to obtain some relevant information in the course of these experiments, it is possible to calculate a value for the amount of tritium which can safely be tolerated in the body. Assuming irradiation of the body by tritium in body fluids to be equivalent to an external irradiation by penetrating X- or gamma rays and using the accepted tolerance of 0.3 rep/week for this type of irradiation, ten millicuries is found to be the maximum permissible body tolerance for tritium. This value differs from the one millicurie value recommended at Chalk River by the arbitrary additional safety factor of ten which the committee elected to introduce.

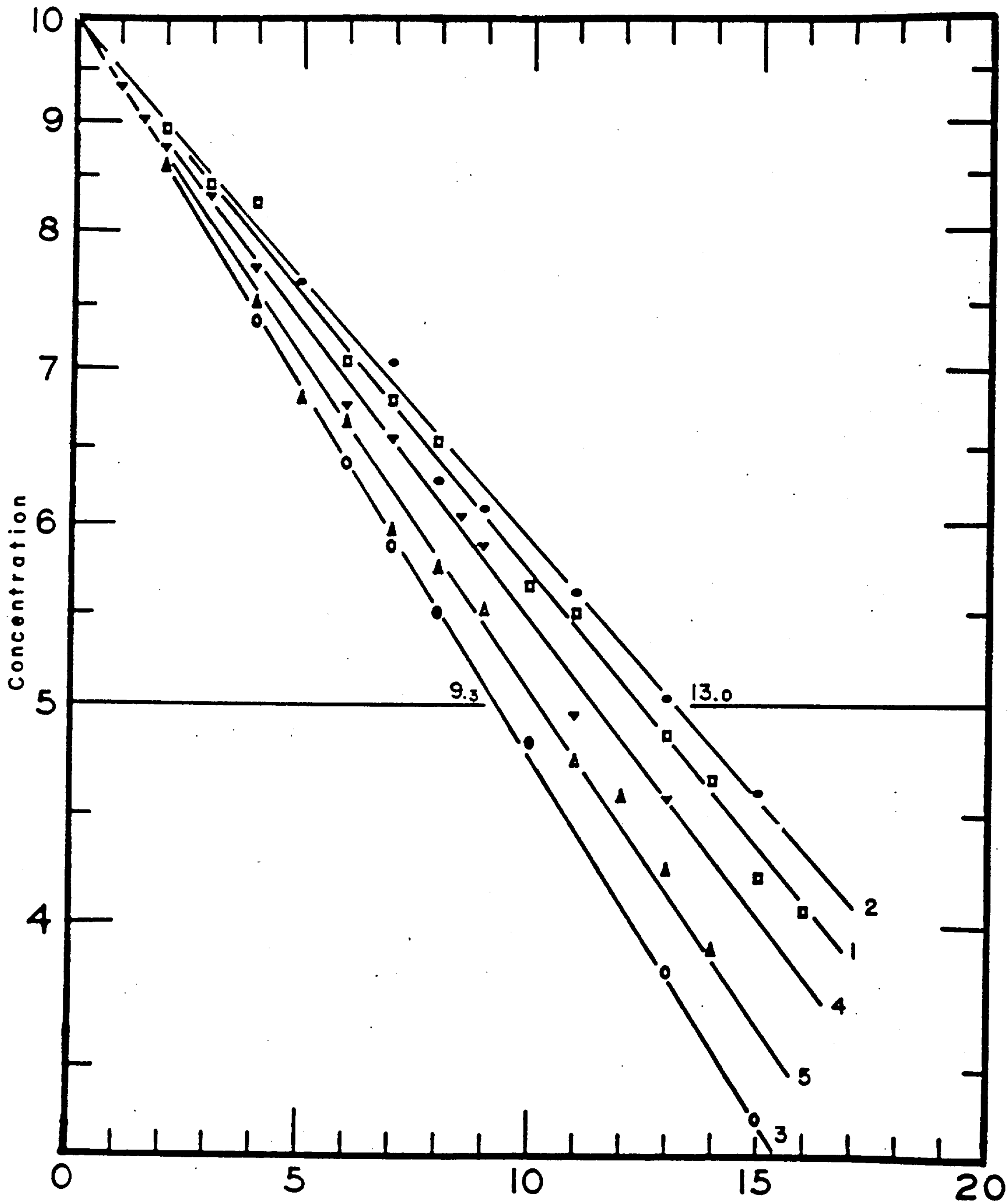

Figure 1

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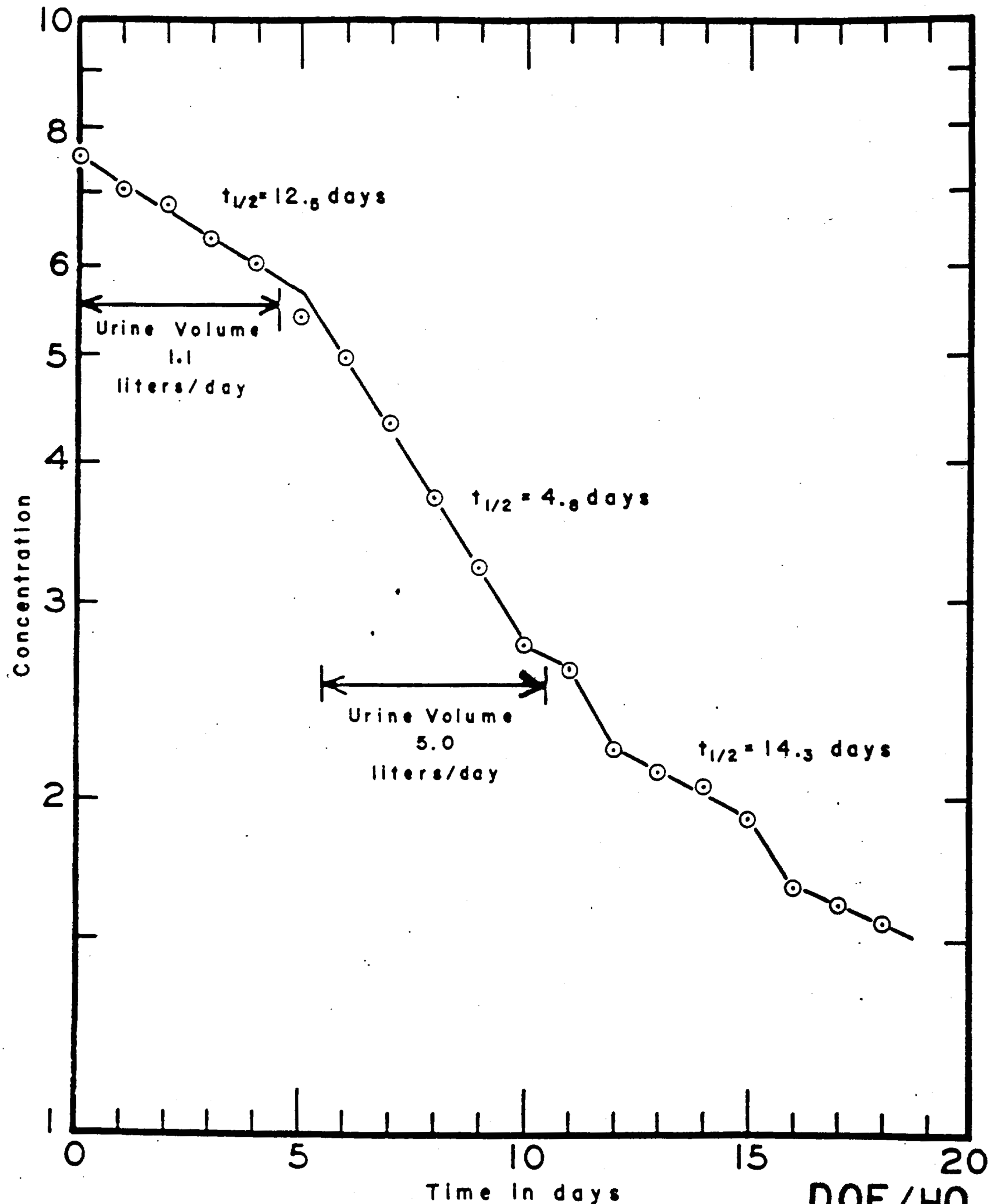
10
8
6
5
4
3
2
1
Concentration
$t_{1/2}$ = 12.5 days
Urine Volume
1.1
liters/day
$t_{1/2}$ = 4.8 days
Urine Volume
5.0
liters/day
$t_{1/2}$ = 14.3 days
0
5
10
15
20
Time in days

Figure 2