UDC 537.547.1:537.451:504.4.054:546.11.02.3

STUDY OF TRITIUM TRANSFER INTO FREE WATER MEAT AND EGGS FROM LAYING HENS AT PROLONGED INTAKE WITH AIR, WATER AND GRASS MAELL

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In 2010, at the regular meeting of the IAEA [1]there were presented data on exploration maturity of the tritium transfer (OBT - organically bound tritium, TW - tritiated water) in agricultural products, where it became known that in the world there are no data on the tritium transfer (here in after - T) into poultry products. There are only a few works of Russian scientists associated with the study of T transfer into chicken eggs [2].

It should be noted that T is one of the main dose-forming radionuclides present at the Semipalatinsk test site (hereinafter - STS). The registered facts of residence and agricultural activities near the Degelen Mountain located at STS, where there is a likelihood of a T intake into the human body through agricultural products, necessitates the performance of work in this direction.

This paper considers the T transfer into free water of muscle tissue and eggs (whites and yolk) of laying hens with air, water and TW of grass meal from Degelen Mountains Massif.

MATERIALS AND METHODS OF RESEARCH

To study the formation of tritium contamination of poultry products in vivo, we selected radioactively-contaminated ecosystem of the watercourse at tunnel №177 of "Degelen" testing site located at the former Semipalatinsk test site. Location of the experiment is shown in the figure (Figure 1). Tunnel № 177 was created to improve nuclear weapons, where on March 30, 1983 was carried out nuclear test with charge capacity of 0,001-20 kt [3]. Waterway formed by groundwater, which flow through the cavity of the explosion, bringing the radionuclides to the surface [4], thus forming the main contamination of ecosystems with tritium and other radionuclides over a large territory.

Figure 1. Location of the experiment ("Degelen" experimental site on former STS)

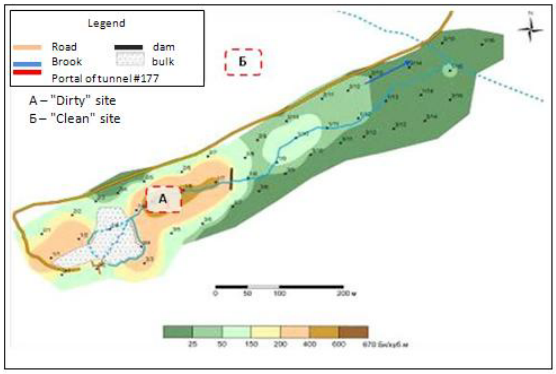

Figure 2. Scheme of watercourse ecosystem at tunnel #177

The width of the watercourse at tunnel177, in general, does not exceed 1 m. The average water flow rate is $4.4*10^8$ liters (more than 500 l/min) [5]. Works performed in 2007-2009 let us know that the concentration of T during this period in the tunnel water was from 250-300 kBq/l, in the air - up to 1400 Bq/m^3, and the concentration of T in the vegetation reaches $2,4 *10^5$ Bq/kg [6]. Scheme of watercourse ecosystem territory is represented in the figure (Figure 2).

Location of the experiment is conditionally divided into two sections. "Clean" - section with the background concentrations of T in the air and plants (0,6 ± 0,06 Bq/m^3, 60±7 Bq/kg, respectively), "contaminated" - section where the results of previous studies recorded the largest concentration of T in the air, plants and water (streambed of the tunnel №177). At these sections we set up facilities for poultry breeding. Territory of the research sections was demarcated in order to study the T transfer into poultry products during air and peroral intake of T with different terms of their content.

As the object of study we chose laying hens from poultry factory in Semey (East-Kazakhstan, Kazakhstan) aged at 1.5 years and live weight of 1,600-1,800 grams. The birds were divided into three groups, each group had 18 hens.

1st group of birds was on the section with a high content of T in the air, in the vicinity of tunnel №177 (Figure 1, "A" - "contaminated" section). Feeding and watering of chickens was carried out with "clean" mixed fodder and water.

2-group of birds was fed with tritium contaminated water, this water was taken from the watercourse of tunnel №177. The birds were fed with "clean" of full-feed mixed fodder without any additional feed. Birds of this group were kept in "clean" area in the vicinity of № 177 (Figure 1, "B" - a “clean” area).

3-group of birds received grass meal in the form of supplements in the daily diet, made from vegetation growing along the T polluted waterway of tunnel № 177. They were watered with "pure" water, imported from the town of Kurchatov. Birds of the third group were kept in "clean" area of the tunnel № 177.

Birds of all three groups were kept 1, 3, 7, 14, 21, 28, 36, 50, 55 days in special cages. At each time two birds were killed and sampled muscle tissue and eggs as their laying. Birds were fed in accordance with established norms of feeding laying hens [7], for which we used full-feed "Ardager".

Sample preparation and method for measuring T. Analytical sample for determination of T was obtained by distillation or refining. The first received condensate in amounts of 10 ml was removed, and for the tests were taken following 5-6 ml. Separated from the shell white and yolk were measured together. Activity of tritium water, air and water fraction of grass meal, eggs and muscle tissue was measured on a beta-spectrometer TRI CARB 2900 TR, by liquid-scintillation research method according to ISO 9698 [8]. Analytical measurement error is no more than 30%.

Calculation of T transfer coefficient (hereinafter - C_tT) into products. As the parameter of T intake level from environment into poultry products we used radionuclide transfer coefficient (hereinafter - C_t), calculated as the ratio of specific activity of poultry products (Bq/l) to the total amount of radionuclides intaken during the day in the animal with air or diet (Bq/day):

$$C_t = \frac{A}{A_{days}}$$

where, A – specific activity of T in products (eggs, muscle tissue), (Bq/l); A_{days} – total activity of T intaken into bird during 24 hours, Bq/days.

RESEARCH RESULTS AND DISCUSSION

Study of changes in dynamics in concentration of T in the muscle tissue and eggs of laying hens at prolonged intake with atmospheric air.

Birds of the first group received T with atmospheric air by constant keeping the birds in the "contaminated" section, i.e. on a section with a high content of T in the air. For this purpose were designed cages for birds and placed on the most contaminated parts of the tunnel №177. To determine the intake of T into hens with air we studied the dynamics of changes in the concentration of T in the air where birds were kept. Determination of T concentration in the air was done by the method of cryogenic freezing. Sampling was carried out during the day with an interval of 2 hours four times during the experiment. The results are shown in the figure (Figure 3).

Assessment of T intake into the body of birds. Based on the average values obtained from the results of four measurements, there were made dynamics of changes in the concentration of T in the air during the period of birds breeding in the experiment. As can be seen (Figure 4), the concentration of T in the atmosphere during the day varies. Therefore, when calculating daily intake, mean values were divided into two segments, as the volume of inhaled air is changed during rest and wakefulness. Thus, the average concentrations of T in the air in the daytime from 06.00 to 18.00 and night from 18.00 to 06.00 amounted to ~ 190 Bq/m^3 and ~ 140 Bq/m^3 respectively.

The volume of daily intake of air into the body of chickens is calculated based on minute volume of the lungs, ie, the amount of air that comes through the lungs per minute [9]. According to Selyanskiy V.M., the average frequency of breaths per minute is 30, and vital lung capacity and air sacs of 169 cm^3. It is known that the purity of breathing during sleep slows down to 30% [10], so the volume of air inhaled during waking hours for 12 hours, was ~ 3.65 m^3, night- ~ 2.55 m^3. The average intake of T for 24 hours with the atmospheric air into the body of birds was ~ 1.0 kBq/day.

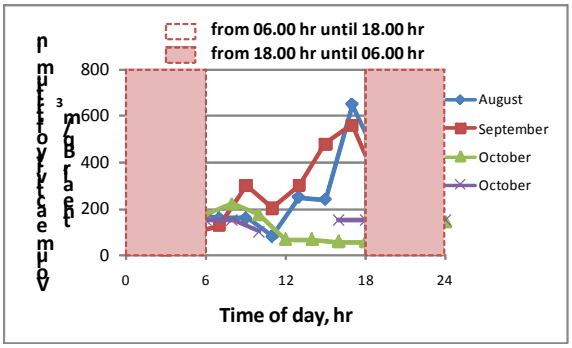

Figure 3. Tritium concentration in the air on-site where birds were kept (different periods of the experiment)

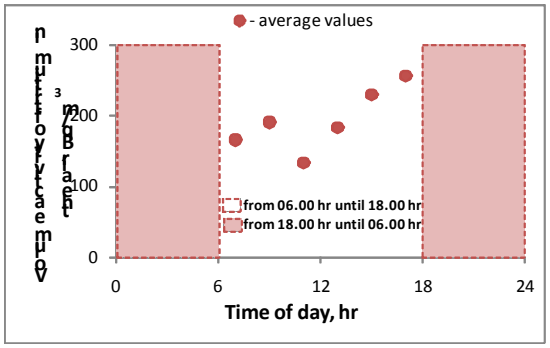

Figure 4. Average concentrations of tritium in the air where birds were kept (during the day)

Assessment of T concentration in eggs and muscle tissue. Results of the study for the first phase are shown in figures (Figure 5, Figure 6), which show that in case of T intake with atmospheric air into the body of chickens during the first week there is a rapid increase in the concentration of T both in muscle tissue and in the eggs. Next comes the dynamic equilibrium of intaken and extracted T from the body. Thus, during the entire experiment the

specific activity of T in the muscle tissue does not exceed 4 kBq/l and in eggs - 10 kBq/l. The average values of Ct for the muscle tissue at equilibrium is 2.4 and for eggs - 8.

The results show that areal intake of T into the body of birds can make a significant contribution to the formation of contamination of poultry products.

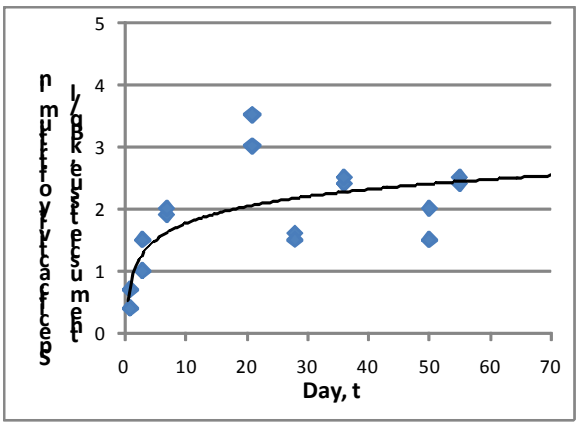

Figure 5. Concentration of T in the muscle tissue of laying hens at prolonged intake with atmospheric air

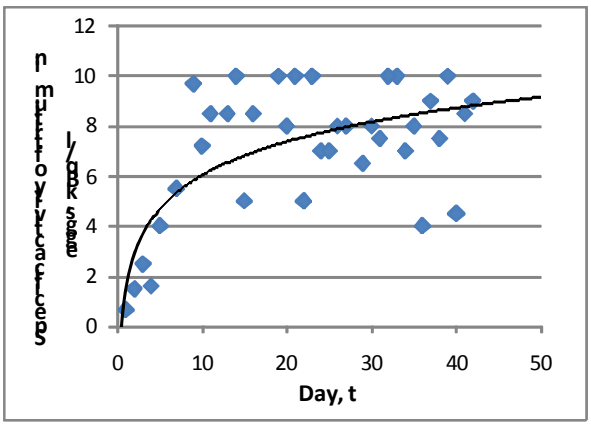

Figure 6. Concentration of T in the eggs of laying hens at prolonged intake with atmospheric air

Study of the dynamics of changes in the concentration of T in the muscle tissue and eggs of hens laying at prolonged intake with tunnel water.

Hens of this group received tritium with tunnel water every morning and evening. In the process of watering there was carried out daily records of the amount of water drunk by birds, which defined that each hen drank an average of ~ 155 ml (max - 175 ml / day, min - 133 ml / day) of water per day.

Assessment of T in the body of birds. To assess the income of T with water for 55 days there was daily record of drunk "contaminated" water. To determine the content of T in the tunnel water we weekly conducted water sampling. The results of determining T in tunnel water are presented in the table (Table 1). Based on data on the concentration of T in tunnel water, which is on average was 240 kBq/l, and the average amounts of drunk water per day 155 ml there was calculated average daily intake of T into birds, which amounted to ~ 37 kBq/day.

Table 1. Specific activity of T tunnel water intended for watering hens

№	Specific activity of T, kBq/day
1	180
2	290
3	230
4	240
5	160
6	240
7	270
8	300
Average value	**~240**

Assessment of T concentration in eggs and muscle tissue. The dynamics of changes in the concentration of T in the muscle tissue and eggs of hens at prolonged intake with water is shown in the figures (Figure 7, Figure 8). As a consequence of T intake with water, the maximal concentration of T in the muscle tissue was - 90-100 kBq/l and was fixed after two weeks of watering the birds with contaminated water. The figure (Figure 7) shows that after two weeks of watering with "contaminated" water there was no T increase in muscle of hens until the end of the experiment, respectively, at this time interval C_tT into the muscle tissue is 2.1. Transfer of T into eggs of the same hens has a slightly different character. The dynamics of the T transfer into eggs of hens (Figure 8) can be divided into three segments, the first is an increase in the concentration of T in the time interval from the beginning to 20 days of the experiment, the time interval from 20 to 25 days there is a reduction in the concentration of T, then comes the equilibrium of tritium of in eggs. C_tT into hens eggs is calculated at steady state (25 days), which is equal to 1.9.

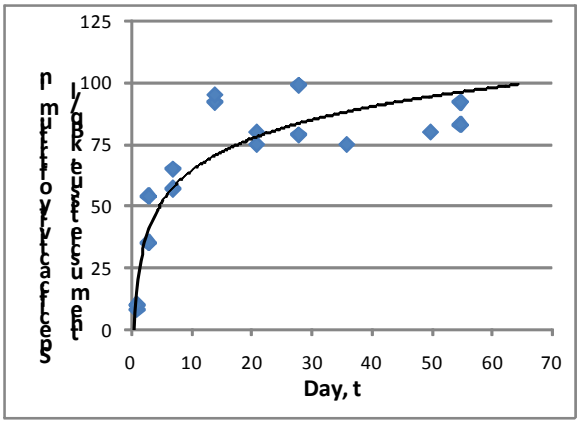

Figure 7. Concentration of T in the muscle tissue of laying hens at prolonged intake with water

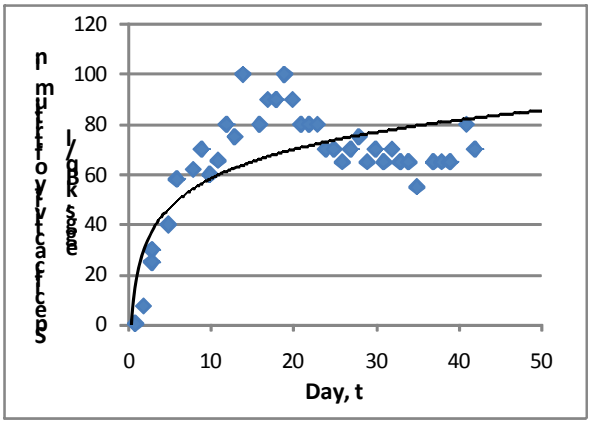

Figure 8. Concentration of T in the eggs of laying hens at prolonged intake with water

Study of the dynamics of changes in the concentration of T in the muscle tissue and eggs of laying hens at prolonged intake with grassy meal.

The hens obtained, as a supplement to the daily, ration of ~ 50 g grass meal, prepared from vegetation contaminated with T. Grass meal preparation consisted of the following operations: mowing green mass, grinding, drying to air dry state, crushing of dry matter to the state of grass meal.

Assessment of T intake into the body of birds. To control the T intake into birds there was carried out daily records of feed eaten. Determination of T in the free water of grass meal was carried out based on the analysis of plant samples, samples taken every week. The results of the specific activity of T in the free water of grass meal used for feeding hens are presented in the table (Table 2). To assess the T intake into the animal there was calculated the T intake with the free and organically bound water of grass meal.

Assessment of T in free water of grass meal was carried out by experimental method. Determination of the amount of free water of the plants was carried out by the standard method of determining the initial and hygroscopic moisture [11]. It was determined that the amount of free water of grass meal averages about 20% (min - 15%, max - 24%).

Determination of organically bound water was conducted by the computational method. We proceeded from the fact that organically bound water in the dry matter of grass meal is approximately 60%. Activity of T in the organically bound water of plant was taken as the activity of T in the free water of grass meal.

Thus, the total amount of water in grass meal is approximately 67%, amount of daily T intake with grassy meal into the body of birds was ~ 0.37 kBq/day.

Table 2. Specific activity of T in the free water of grass meal intended for feeding hens

№	Specific activity of T, kBq/day
1	10
2	12
3	10
4	10
5	10
6	15
7	10
Average value	**~11**

Assessment of T concentration in eggs and muscle tissue. The dynamics of changes in the concentration of T in the muscle tissue and eggs of hens at prolonged intake with grassy meal are shown in the figures (Figure 9, Figure 10). T concentration in the muscle tissue of laying hens increases up to two week feeding, then comes the dynamic equilibrium, the activity of T varies from 1 up to 1, 5 kBq/l. Concentration of T in eggs much more quickly reaches an equilibrium state already on the sixth day of feeding, activity of T in the whites and yolk is 7 kBq/l. C_tT at intake of grass meal into hens is equal for muscle 2.8 and for eggs - 16.

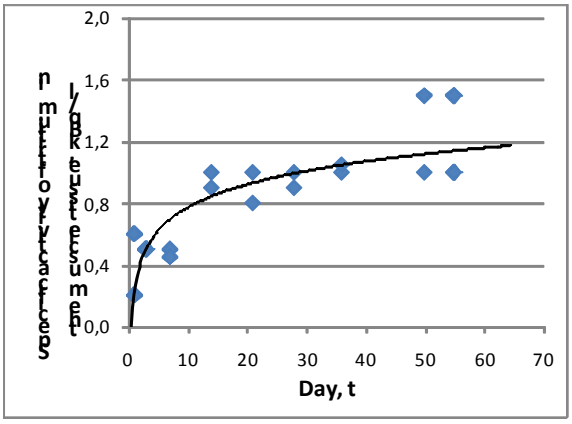

Figure 9. Concentration of T in the muscle tissue of laying hens at prolonged intake with grass meal

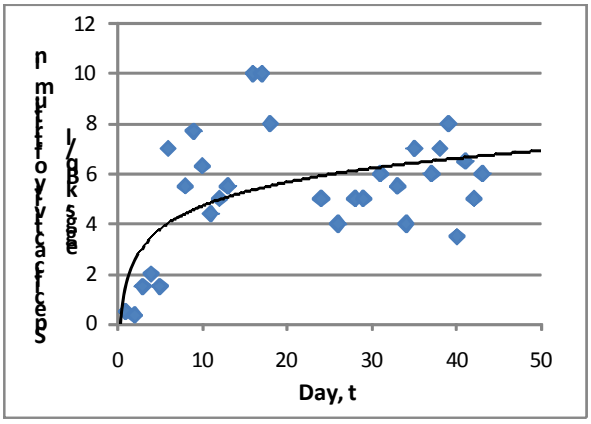

Figure 10. Concentration of T in the eggs of laying hens at prolonged intake with grass meal

CONCLUSION

C_t obtained from these studies are presented in the table (Table 3).

Table 3. C_tT in the free water muscle tissue and eggs from hens laying hens on admission of air, water and grassy meal

Poultry products	C_tT at intake into body with…		
	air	water	grassy meal
Meat	2,4	2,1	2,8
Eggs	8	1,9	16

The table shows that the T transfer in poultry products at long-term income differs depending on the nature of intake. Also ratio of C_t in meat is different from C_t in eggs under different conditions of intake. At intake of T in the organism of hens with air the ratio of C_tT in meat and eggs is 3.3, when entering with water - 0.9 and intake with grass meal - 5.7. Attention is to be drawn to high values of the C_tT with grass meal in poultry products. Of course, it is necessary to determine, by the experimental method, the OBT in grass meal, which in this paper was obtained by computational method and to study the distribution of OBT in poultry products.

Overall, these results show that at T intake into the organism of laying hens with different components (air, water and grass meal) the first two weeks there is an increase in the concentration of T, both in muscle tissue and eggs. Next comes the dynamic equilibrium of T concentration in these products.

REFERENCES

1. 3rd Meeting of the EMRAS II Working Group 7, “Tritium”, IAEA Headquarters. - Vienna, Austria: IAEA, 2010 (25–29 January).

2. Сельскохозяйственная радиоэкология // под ред. Р.М. Алексахина, Н.А. Корнеева. – М.: Экология, 1991. – 397с.

3. Ландшафтно-экологические, радиоэкологические карты с таблицами надфоновых значений радиометрических параметров:отчет НИР /исполн.: Хасанов Э.Г. – Курчатов: ИРБЭ НЯЦ РК,1999. - Инв. № 0-284.

4. Ахметов М.А. Радиационный мониторинг водотоков и проблемы реабилитации на горном массиве Дегелен Семипалатинского испытательного полигона / М.А. Ахметов, О.И. Артемьев, Л.Д. Птицкая // Вестник НЯЦ РК. Радиоэкология. Охрана окружающей среды. – 2000. - Вып. 3(9). - С.23-28.

5. Отчет о научно-технической деятельности Института радиационной безопасности и экологии НЯЦ РК, выполненного по НТП 0346 "Развитие атомной энергетики в Республике Казахстан" за 2005 год: отчет о НИР (информационный) /рук. Птицкая Л.Д. – Курчатов: ИРБЭ, 2005. – 39 с.

6. Комплексное изучение миграции радионуклидов в почве, воде, растениях, животных и влияние малых хронических доз радиации на биологические объекты в местах водопроявлений штолен горного массива «Дегелен»» за 2008 год / отчет о НИР(информационный) /рук. Лукашенко С.Н. – Курчатов: ИРБЭ НЯЦ РК, 2008. – 34 с.

7. Кормление сельскохозяйственных животных, птиц и технология кормов в современных условиях: справочное пособие / под ред. Н.А. Жазылбекова. – Алматы: ТОО «Бастау», 2008. – 436 с.

8. Качество воды – определение активности трития, соответствующей данной концентрации – жидкостной метод сцинтилляционного счета. Международный стандарт ISO 9698:1989 (E). – Введ.1989-12-01.– Москва: ВЦП НТЛИД, 1990. – 17с. – Инв. № Т-1008.

9 Физиология сельскохозяйственных животных / Георгиевский В.И. - М: Агроаромиздат, 1990. – 511с.

10. Анатомия и физиология сельскохозяйственных птицы / Селянский В.В. - 4-е изд., перераб. и доп. - М: Агроаромиздат, 1986. – 272 с.
11 Методическое указание для лабораторных занятий по зоотехническому анализу Абанова М.Н. - Семипалатинск, 1984. – 25с.