AEC RESEARCH AND DEVELOPMENT REPORT

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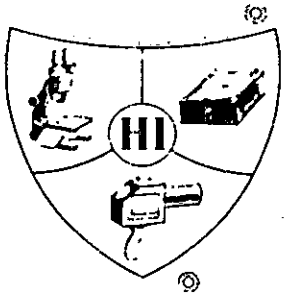
ACTIVITY DENSITIES IN WATERFOWL OF THE HANFORD RESERVATION AND ENVIRONS

AUGUST 21, 1951



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AEC RESEARCH AND DEVELOPMENT REPORT

ACTIVITY DENSITIES IN WATERFOWL OF THE HANFORD RESERVATION AND ENVIRONS

by

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August 21, 1951

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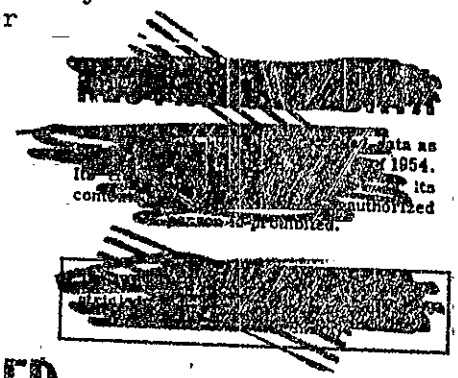

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ABSTRACT

Various sources of contamination available to waterfowl on the Hanford Works Reservation were monitored by radioassay of tissues of pekin ducks from established colonies. The fowl were sacrificed at monthly intervals to indicate seasonal differences. Tissues of wild waterfowl taken both on and off the project were also assayed. Iodine ^{131} deposition upon vegetation of the project and environs was monitored at the same time by thyroid assay. Bone and thyroid usually had the highest activity densities resulting from accumulation of radiophosphorus and radioiodine respectively in those organs. Prior to a special metal dissolving test at the separation plant no thyroid samples exceeded the chronic MPC for man of 0.003 μc/g for I^{131} (1). After the test activity densities detected in the thyroids increased abruptly to about eight times the chronic MPC.

ACTIVITY DENSITIES IN WATERFOWL OF THE HANFORD RESERVATION AND ENVIRONS

INTRODUCTION

There are three principal sources of radioactive contamination in the water available to waterfowl at Hanford Works. Nuclear reactor cooling water containing induced radioactive isotopes enters the Columbia River at each of the reactor areas. The waste water ditches and ponds at the separation areas contain very low concentrations of the fission mixture, and the principle contaminant of the ponds at the pilot plant and uranium process area is uranium, much of it from routine washing of the floors and equipment of the uranium processing units. Volatile fission wastes (especially I^{131}) from separation area stack gases are potentially of importance in range contamination.

Aquatic plants and invertebrate organisms have been found to concentrate radioactivity. Algae are probably responsible for the original concentration while progressively more complex organisms in the food chain of waterfowl may contribute quite significant concentrations (2, 3). Waterfowl which feed upon the contaminated organisms and are later killed for food are a potential hazard to man. To define that hazard, colonies of pekin ducks maintained at three locations and wild waterfowl of the region were collected for radioassay of tissues.

METHOD

Seven adult pekin ducks and fifteen young were maintained at a location immediately down river from all reactor areas, one adult and four young were placed on a pond fed by the waste waters from the uranium processing area, and one adult and seven young were located at a waste ditch of a metal storage building of the separation area. All fowl were confined in pens constructed at these sites for two weeks of orientation before being liberated to feed upon available natural food

organisms. Yellow corn was fed only in sufficient quantities to maintain healthy stock and encourage foraging.

In June, 1949, and for each successive month of that year two or more ducklings and one mature duck were sacrificed from the Columbia River flock. At the other stations a single duckling was assayed each month beginning in July. Samples of the various tissues or organs were assayed for beta-gamma-emitting isotopes. Liver, lung, muscle, and bone samples were also analyzed for uranium by the fluorophotometric method from all pekin ducks taken from the pond of the uranium processing area.

Radioassays were also made of wild waterfowl on the project and surrounding areas especially during the waterfowl hunting season. Sportsmen cooperated by offering tissue specimens from birds obtained off the reservation. During that period the thyroid gland was the most useful organ assayed, due to its power of concentrating I^{131}, made especially abundant by a special metal dissolving test (4) which immediately preceded the 1949 hunting season.

Species of wild waterfowl assayed were Canada goose, Branta canadensis; mallard, Anas platyrhynchos platyrhynchos; American widgeon or baldpate, Mareca americana; gadwall, Anas streperus; green-winged teal, Anas carolinensis; American golden-eye, Bucephala clangula americana; coot, Fulica americana; double-crested cormorant, Phalacrocorax auritus; great blue heron, Ardea herodias; and common loon, Gavia immer.

RESULTS

Analysis of radioassay data of the various tissues and organs of pekin ducks from below the reactors on the Columbia River (Table 1) indicates that the age of the bird assayed had no significant effect on activity densities accumulated except in bone. Radioisotope deposition in the skeleton of ducklings was consistently higher than in mature ducks. The rate of radioactive decay indicated that P^{32} was the principle isotope present. This suggests a direct correlation between activity

TABLE 1

ACTIVITY DENSITIES IN TISSUES OF PEKIN DUCKS FROM BELOW REACTORS ON THE COLUMBIA RIVER

Recorded as median* and maximum $\mu c/g \times 10^5$ for each month

Tissues or Organs	June		July		August		September		October		November		December	
	Med.	Max.	Med.	Max.	Med.	Max.	Med.	Max.	Med.	Max	Med.	Max.	Med.	Max.
Bone (Ducklings)	40	80	50	90	330**	800**	150**	370**	85	140**	90	160**	40	40
Bone (Mature Ducks)	1	1	9	9	6	6	60	60	8	8	25	25	4	4
Pancreas	5	7	10	10	30	90	30	40	20	20	15	20	7	7
Liver	3	6	6	7	24	60	20	40	10	10	10	15	6	6
Spleen	5	50	5	10	24	70	30	40	20	20	8	15	9	10
Gonads	3	8	8	8	14	70	20	30	10	20	10	10	4	6
Kidneys	5	6	4	6	18	40	10	20	10	10	7	10	5	6
Muscle	2	4	3	6	14	40	10	20	8	10	6	10	4	4
Lung	3	3	3	4	14	40	10	10	8	10	5	8	3	3
Blood	2	2	2	3	8	30	8	20	6	8	8	10	3	3
Brain	2	8	2	3	7	30	8	20	5	8	6	10	2	2
Feces	2	3	5	10	20	50	50	50	7	8	7	50	8	10
Thyroid	7	17	10	90	30	60	40	40	20	50	40	60	275	300**

* The middle value in an odd number of recordings, half-way between the middle two in an even number.

** Activity density in excess of chronic MPC for man (P^{32} in bone, I^{131} in thyroid).

densities and the metabolic demand for phosphorus. The levels detected in various body parts except the thyroid show a strikingly similar pattern with respect to time and a distinct difference between organs. Tissues, organs, and excretions are listed in Table 1 in order of descending activity density except for thyroid and feces. Relatively low feces activities suggest rather efficient absorption from the gut. The pattern of variation with time in thyroids reflects the entirely independent source of radioactivity, i.e., atmospheric and subsequent vegetation contamination with I^{131} emitted from the separations waste stacks. In several fowl the skeletal deposition exceeded the chronic MPC of P^{32} for man, while in only one case thyroid deposition equalled the chronic MPC of I^{131} for man. Activity densities were generally significantly higher than those observed earlier by Herde and Cline (5).

Table 2 shows fission product accumulation in the various parts of pekin ducks exposed at a small separations area waste ditch. The tissues and organs are listed from left to right in approximate order of activity densities. It is interesting to note that there was little difference in the relative magnitude of deposition within tissues when levels detected in this colony were compared with those from the Columbia River colony. The outstanding exception is suggested by the similarity of activity densities of bone of the 7-month duck and the 24-month duck each sampled January 10th. The bone-seeking isotopes of the fission mixture seemed to have no preferential deposition rate for younger fowl. As noted in the river colony, thyroid activities varied quite independently of other tissues, confirming the supposition that radioiodine in the atmosphere was more critical than traces which may have been present in the water of the pond toward influencing thyroid activity densities. The radioactivity of feces from ducks of the separations area waste ditch was usually higher than that of tissues while in the Columbia River ducks the reverse relationship was observed. These findings suggest lower gut absorption of the non-volatile fission isotopes than of those contained in reactor effluent.

TABLE 2

ACTIVITY DENSITIES IN TISSUES OF PEKIN DUCKS FROM A SEPARATIONS AREA WASTE DITCH

Quantities recorded are in $\mu c/g \times 10^5$

Date Sampled	Age (months)	Thyroid	Bone	Pancreas	Liver	Spleen	Gonads	Kidney	Muscle	Lung	Blood	Brain	Feces
7-11-49	1	10	130*	30	20	20	-	10	10	8	8	8	120**
8-10-49	2	100	340*	40	30	35	30	20	20	10	7	10	40
9-9-49	3	20	210*	20	20	20	10	20	10	10	6	7	30
10-6-49	4	60	50	10	10	8	20	8	8	8	7	4	20
11-7-49	5	50	110	40	30	30	20	30	10	10	10	4	170**
12-5-49	6	900*	120*	30	20	20	30	20	6	8	6	7	30
1-10-50	7	360*	90	30	20	20	30	20	10	10	7	6	100
1-10-50	24	230	100	40	20	20	10	20	15	10	10	6	140**
Median values	-	285	95	35	20	20	18	20	12	10	8	6	120

* Activity density in excess of chronic MPC for man.

** Radiation to wall of gut exceeded 300 m rep/week.

The four pekin ducklings and one mature duck taken during the period from July to December from the retention pond in the uranium processing area had significant activity densities only in the thyroid and feces. All other tissues commonly assayed had less than 4×10^{-5} $\mu c/g$. Thyroid deposition usually amounted to about 10^{-5} $\mu c/g$ prior to the special dissolving. After that test there was an increase to 1.4×10^{-4} $\mu c/g$ in thyroid. Fluorophotometric analysis for uranium in the ducks assayed showed highest accumulation in the skeleton (6 to 28 $\mu g/g$). Liver, muscle and lung tissues were shown to have less than 1 $\mu g/g$.

The results of tissue analyses of wild waterfowl taken on the Hanford reservation are tabulated in Table 3. Since all species sampled are migratory in habit, great fluctuation and little geographical correlation of activity densities were to be expected. The double-crested cormorant and the two great blue herons were fledglings of about the same age taken from nests in the same tree. Although both species are mainly piscivorous, the cormorant was significantly higher in activity densities in all tissues assayed. The dissimilarity in activity densities was confirmed by sampling similar birds at a later date. The phenomenon may be associated with differences in the food-seeking range of parent birds or with species of fish preyed upon. Thyroid activity densities, which were the only ones occasionaly exceeding the chronic MPC for man, are evidently associated with dissolving waste gases while other tissues reflect the probable levels accumulated from occasional river feeding. As indicated in domestic ducks, bone and pancreas seem to concentrate higher levels of reactor effluent radioisotopes. The two ducks taken from the effluent waste pond in the separations area show a wide divergence of activity density that is undoubtedly associated with time spent on the pond.

Table 4 illustrates the geographical range of detection in native waterfowl possible after the single dissolving of relatively "green" metal. Three thyroids significantly exceeded the chronic MPC for man.

TABLE 3

ACTIVITY DENSITIES IN TISSUES OF WILDFOWL TAKEN FROM THE HANFORD RESERVATION

Quantities recorded are in $\mu c/g \times 10^5$

Location on Columbia River	Species	Date	Thyroid	Bone	Pancreas	Liver	Spleen	Gonad	Kidney	Muscle	Lung	Blood	Brain	Feces
Near Reactors	Canada Goose	1-27-49	30	1	1	1	2	1	1	1	1	2	-	2
"	Canada Goose	1-27-49	8	1	1	1	1	1	1	1	1	1	-	1
"	Canada Goose	2-9-49	3	1	1	1	-	2	1	1	1	-	-	2
"	Baldpate	2-9-49	2	4	5	1	1	1	3	3	2	2	-	3
"	D. C. Cormorant	7-8-49	10	60	-	5	1	-	5	1	4	1	-	6
"	G. B. Heron	7-8-49	<3	1	1	2	1	-	1	1	1	1	-	1
"	G. B. Heron	12-1-49	<3	5	1	1	2	-	-	1	<1	-	-	-
"	Gadwall	12-22-49	15	-	12	15	-	-	10	8	3	-	-	-
"	Baldpate	12-22-49	900*	20	4	2	-	-	8	5	3	-	-	-
"	Baldpate	12-22-49	430*	10	10	-	5	-	5	3	1	-	-	-
"	Baldpate	2-2-50	500*	8	7	5	2	3	1	5	4	-	-	-
"	Canada Goose	1-28-49	50	1	1	2	3	-	6	1	2	4	-	1
5 mi. downstream	Am. Golden-eye	1-28-49	1	9	7	3	5	-	10	5	1	2	-	1
"	Unident. Diver	1-17-50	10	25	15	5	1	1	1	8	1	1	-	-
"	Coot	2-1-50	7	1	1	1	1	-	2	1	1	4	-	3
"	Common Loon	7-13-49	1	4	1	1	1	3	7	4	1	1	1	5
15 mi. downstream	Mallard	7-13-49	1	20	7	3	10	1	1	1	1	1	1	2
"	Canada Goose	7-13-49	60	1	1	1	10	<1	2	5	4	1	1	1
"	Canada Goose	1-24-49	110	2	1	1	10	3	1	-	1	1	1	1
20 mi. downstream	Mallard	3-21-49	1	10	7	7	-	4	6	5	1	1	1	1
"	Coot	3-21-49	4	1	1	1	1	<1	1	-	1	1	-	1
"	Teal	9-28-49	4	<1	1	1	1	2	<10	1	1	-	-	-
200-E Pond**	Mallard	10-4-49	200	1	1	1	1	2	-	1	1	-	-	-
"	G.W. Teal		7	50	50	30	40	-	30	10	-	-	-	-

* Activity density in excess of chronic MPC of I^{131} for man

** Small effluent waste pond in separation area

Other tissues were assayed in four specimens and with the exception of the spleen of one duck were essentially the same as tissue background levels.

SUMMARY

Domestic ducks

Results of radioassay of thirty-five pekin ducks placed at three locations on the Hanford Works showed that waterfowl and their food organisms concentrated the induced radioisotopes of river water after exposure to the contamination from one to eighteen months to levels occasionally exceeding the chronic MPC for man. The skeletons of young ducklings exhibited greater activity densities than those of older birds, probably because of higher metabolic requirements for phosphorus. Activity densities in soft tissues were often about equal to those in bone in mature animals under normal plant operations. The highest single value found before the special dissolving test of December 2, 1949, was 0.008 μc/g in the skeleton of a duckling. After the dissolving higher activity densities were found in thyroids. Radioactivity in both organs exceeded the chronic MPC for man of either P^{32} or I^{131}.

Wild waterfowl

A survey of wild waterfowl on and off the project was conducted during the same period and showed the same general pattern of thyroid activities with other tissues usually below detectable levels. Following the special dissolving, the radioactivity of thyroid glands increased, with a maximum of 0.026 μc/g being found in a duck taken fifteen miles from the separations stacks. This value is well in excess of the chronic MPC in man of 0.003 μc/g for I^{131} in the thyroid gland. Five other waterfowl assayed exhibited thyroid activity greater than the MPC stated above.

TABLE 4

ACTIVITY DENSITIES IN TISSUES OF WILDFOWL TAKEN NEAR THE HANFORD RESERVATION

Quantities recorded are in $\mu c/g \times 10^5$

Location	Distance from Waste Stack	Species	Date	Thyroid	Pancreas	Liver	Bone	Spleen	Kidney	Muscle	Lung
Benton City	15 miles	Mallard	12-18-49	2600*							
Benton City	15 miles	Mallard	12-15-49	440*							
Benton City	15 miles	Mallard	12-18-49	180							
Benton City	15 miles	Mallard	12-18-49	90							
Benton City	15 miles	Mallard	12-18-49	20							
Prosser	20 miles	Mallard	12-15-49	1900*							
Prosser	20 miles	Mallard	12-15-49	2							
Richland	20 miles	Mallard	12-8-49	4	2	2	2	6	1	1	1
Kennewick	30 miles	Mallard	12-23-49	50	2	-	1	-	1	1	1
Kennewick	30 miles	Can. Goose	11-21-49	7	1	1	1	-	-	1	-
Kennewick	30 miles	Can. Goose	11-21-49	4	1	-	1	1	-	-	-
Lacrosse	70 miles	Mallard	12-12-49	30							
Lacrosse	70 miles	Mallard	12-12-49	20							
Lacrosse	70 miles	Mallard	12-12-49	10							
Lacrosse	70 miles	Mallard	12-12-49	10							
Lacrosse	70 miles	Mallard	12-12-49	5							
Lacrosse	70 miles	Mallard	12-12-49	4							
Lacrosse	70 miles	Mallard	12-12-49	2							

* Activity density in excess of the chronic MPC of I131 for man

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