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**PACIFIC NORTHWEST LABORATORY
MONTHLY ACTIVITIES REPORT
FOR SEPTEMBER 1967**

**DIVISION
OF
BIOLOGY AND MEDICINE
PROGRAMS**

OCTOBER, 1967

**AEC RESEARCH &
DEVELOPMENT REPORT**

NAME	WEEK	LOCATION	FILE NUMBER
<i>P. J. Dionne</i>	<i>30721</i>	<i>MATH</i>	<i>NOV 28 1967</i>

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PACIFIC NORTHWEST LABORATORY
MONTHLY ACTIVITIES REPORT
SEPTEMBER 1967

Division
of
Biology and Medicine
Programs

by the
Staff of Battelle-Northwest
S. L. Fawcett, Director

October 1967

PACIFIC NORTHWEST LABORATORY
RICHLAND, WASHINGTON

PACIFIC NORTHWEST LABORATORY

MONTHLY ACTIVITIES REPORT

SEPTEMBER 1967

AEC DIVISION OF BIOLOGY AND MEDICINE PROGRAMS - R. S. PAUL

TOXICITY OF RADIOELEMENTS

Metabolism and Effects of Radionuclides in the Developing
Fetus and the Young - M. F. Sullivan

Rats injected with various doses of ^{239}Pu at birth, weaning or young adulthood are being subjected to neurologic testing devices, namely a water maze and an audio shocking device, to determine if plutonium deposition is damaging to the nervous system. The same animals will be killed later to supplement earlier data that indicated an age-dependent response of the liver and the skeleton to plutonium.

An experiment was initiated by mating guinea pigs to provide baseline prenatal thyroid development data prior to commencement of a planned ^{131}I carcinogenicity study.

Radiation Effects in Aquatic Systems - R. E. Nakatani

To assist in the evaluation of studies on the uptake of ^{51}Cr by Columbia River fishes, studies were carried out with stable chromium. Adult rainbow trout were exposed to a 2.5 ppm in concentration of Cr(VI) for periods as long as 3 weeks. Chromium levels in the 25 tissues examined rapidly reached equilibrium concentrations within a 4-day exposure period. Highest Cr levels (on a dry weight of tissue basis) were found in the brain, gill and posterior kidney. Preliminary enzyme studies suggest that liver mitochondrial electron transport activity and certain microsomal activities are elevated in trout exposed to Cr(VI). Additional studies with fish enzyme systems will be conducted to help establish the toxic sites for Cr in fish.

Continued observations among several populations of freshwater mussels have indicated tumor incidence figures considerably

higher than those reported by others. The lowest incidence observed (Devil's Lake - Anodonta) was 4.2% and the highest (Columbia River - Anodonta) was 15.7%. Almost all of the tumors were observed on the foot of these animals. However, among the Anodonta population from the Columbia River, two mussels were observed with lesions on the mantle and two animals were observed with tumors on the gills. Tumors arising from the gills have not previously been recorded for mollusks.

Effects of Radioiodine in Sheep and Swine - J. L. Palotay

Two swine injected with 10 μCi amounts of ^{131}I will be used to determine the most effective methodology in the counting of the balance of animals given iodine dosage last year. All animals have been bled and samples submitted for protein-bound iodine determination.

Effects of Radiostrontium in Miniature Swine - W. J. Clarke

Several additional cases of porcine leukemia were observed on histologic examination of the tissues from ^{90}Sr fed animals. One case was in a 1.0 $\mu\text{Ci/day}$ pig.

Further evaluation of the serum protein studies on ^{90}Sr fed pigs that were reported last month shows that the alterations noted are detectable before hematologic evidence of a leukemic state is observed. This may be partly attributable to the extensive proliferation of myelogenous or lymphogenous tissue in the liver of these animals.

Uncompleted observations of cultures of peripheral leukocytes from pigs on 625 μCi $^{90}\text{Sr/day}$ indicate that, 3-4 months post-initiation of feeding, the circulating lymphocytes lose their ability to respond in vitro to stimulation by phytohaemagglutinin.

Inhalation Studies - W. J. Bair

Thoracic radiographs showed a pulmonary tumor in another dog, exposed 5½ years ago to $^{239}\text{PuO}_2$. Fifteen dogs of the 40 initially exposed have now shown pulmonary tumors. Thirteen dogs still alive do not show pulmonary tumors. Two of these were exposed 8 years ago, the others 5½ years ago.

Only about 0.02-0.2% of ^{239}Pu in the skeleton is leached when autoclaving is used to deflesh dog skeletons. This confirms earlier tests showing the feasibility of this technique.

Experiments were completed showing that lung mitochondria are capable of synthesizing lecithin, a constituent of lung surfactant.

By combined autoradiography and electronmicroscopy it was shown that $^{239}\text{PuO}_2$ particles occur in vacuoles of peritoneal mononuclear cells after intraperitoneal injection of $^{239}\text{PuO}_2$. In some preparations several particles were seen in a single vacuole. These phagocytic cells appear to be relatively insensitive to the alpha irradiation from the ^{239}Pu . These cells also phagocytize $^{238}\text{PuO}_2$ particles. The relative sensitivity of phagocytes to ingested ^{239}Pu and ^{238}Pu particles is being examined.

Work on a lung model for inhaled PuO_2 in beagle dogs was continued with the development of a digital simulation program that matches the analog program. Whole body retention curves were derived by digital computer analysis of excretion data from two dogs up to 1000 days after exposure. The power function expressions obtained were similar to those derived for several dogs over much shorter periods of time.

Two designs for an in vivo blood irradiator are being reviewed for a possible study of the effects of radiation on circulating lymphocytes. The purpose of this experiment will be to obtain information that may contribute to a better understanding of the lymphopenia seen in dogs after plutonium inhalation.

Comparative Disposition of Plutonium and Americium
After Inhalation - W. J. Bair

Three dogs exposed 4 months ago to enriched $^{239}\text{PuO}_2$ were sacrificed to determine relative levels of ^{239}Pu and ^{241}Am in tissues. Three others will not be sacrificed until next summer. Samples of tissues from six dogs exposed about 3 months ago to $^{239}\text{PuF}_4$ were collected for ^{239}Pu and ^{241}Am analysis. Longitudinal whole-body scans of these dogs suggest that a separation of Pu and Am occurred.

Space Nuclear Systems Studies - R. C. Thompson

TTHA-chelated ^{60}Co was fed to three miniature swine to determine the passage time of a non-particulate tracer which might be indicative of the normal passage time of ingested foodstuffs. The results indicated that 82% was excreted on Day 3, 15% on Day 4, and the remaining 3% excreted during the following 2 days, which agrees well with data from larger swine obtained by others after ingestion of soluble markers. These results indicate that the much longer passage times previously measured for $^{238}\text{PuO}_2$ microspheres are characteristic of the microspheres and not typical of passage times for any ingested material.

Because of the difficulty of maintaining large particles suspended in air for a sufficient time to permit inhalation by animals, a new technique for maintaining suspended particles was devised. Basically, this technique involves an updraft of air so that the terminal velocity of the large particles is matched by an updraft of air. Due to turbulence within the air, a screen or grid was placed within the chamber to provide a series of small jets across the cross section of the chamber. A sample chamber of this sort was tested with sand particles which were then observed to oscillate in an approximate 1 cm range above the grid and most of the 1 to 2 mm particles remained suspended for more than 10 minutes. Tests were also conducted with lead particles but these were observed to oscillate more widely. Optimizing the air jet size and spacing should improve performance.

Internal Deposition of Radionuclides in Man

- W. J. Bair/C. E. Newton, Jr.

The plutonium-237 was subjected to several measurements. The photon spectrum was found to contain the following: 14, 18, 21 keV X rays, 59 keV gamma rays and 97.1, 101.1, 114 and 117.5 keV X rays. In terms of gamma emitters the product is highly pure ^{237}Pu . The final product solution was, however, found to contain 1.5×10^6 d/m/e of the following α emitters:

^{236}Pu 42.6%	^{224}Ra	2.4%
^{238}Pu 24.9%	^{220}Rn	2.4%
^{239}Pu &/or ^{240}Pu 15.1%	^{216}Po	2.4%
^{233}U &/or ^{234}U 3.0%	^{212}Bi	0.8%
^{228}Th 4.8%	^{212}Po	1.6%

Study on the effects of these quantities on the acceptability of this material continues although rough calculations suggest that the material will result in an excessive dose and, consequently, is unsuitable for use in humans. The ratio of ^{236}Pu to ^{238}Pu suggests that the material was irradiated with higher energy particles than desired and hope for eventual use of ^{237}Pu in humans may rest with more careful control of target foil irradiation energy.

Arrangements to collect total urine from six volunteer human test subjects in the $^{143}\text{Pm}/^{147}\text{Pm}$ metabolism and excretion experiment were completed. This collection is to establish a 14-day pre-injection daily creatinine excretion for participants in the experiment. Creatinine in urine is being studied as an index of metabolic time periods.

Adequate animal experiments were designed which would permit an evaluation of the extent of correlation of the Pm excretion factors between man and animals. The full program costs exceed the level of support; therefore, restricted and simplified animal studies are being explored.

Six dogs were sacrificed 4 months after inhalation of $^{239}\text{PuF}_4$. Three of the dogs were treated with DTPA. Tissues and excreta are being analyzed for ^{239}Pu . Whole-body scans of all six dogs showed a distribution of radioactivity markedly different from that seen in animals which have inhaled PuO_2 .

Inhalation Hazards to Uranium Miners - W. J. Bair

Four dogs were exposed daily, 5 days/week for 3 months to pitchblende dust. Whole-body monitoring suggests that the radionuclide body burden has nearly reached an equilibrium level. Tissues and excreta of the dogs will be analyzed to determine the extent of possible disequilibrium of uranium and daughter products.

Uranium Ore Inhalation - R. W. Perkins

Uranium ore contains an extremely complex mixture of radionuclides including all of the radionuclides from the ^{238}U and ^{235}U series. Studies of uranium mine atmospheres containing aerosols of these radionuclides and of the behavior of these aerosols following inhalation by uranium miners or experimental animals require precise measurements of many of the individual

radionuclides. A careful study is being conducted to determine the feasibility of measuring the radionuclides in uranium ore by direct counting on a high resolution large volume germanium diode. The germanium diode spectrum of a uranium ore sample is extremely complex containing about 100 photopeaks. Initial studies have shown that the radionuclides ^{235}U , ^{234}Th , $^{234\text{m}}\text{Th}$, ^{226}Ra , ^{214}Pb , ^{214}Bi and ^{210}Pb can be determined directly from the spectrum. Other radionuclides can probably also be measured but will first require that the spectrum of the pure radionuclides be determined so that their photopeaks can be identified in the uranium ore spectrum.

MOLECULAR AND CELLULAR LEVEL STUDIES

Cellular Regulator Mechanisms - W. H. Matchett

Last month we reported the isolation of a proteinaceous material from Neurospora crassa by the method of osmotic shock. Using the method of gel filtration on sephadex, we have shown that the proteinaceous material isolated from Neurospora crassa by osmotic shock has the ability to bind tryptophan. The binding activity is labile, being lost after 1 week at 4°C . Binding was not enhanced by ATP or by pyridoxal phosphate. Potassium chloride stimulates the activity slightly. Comparative work with similar preparations obtained from Escherichia coli are presently under way.

Studies on the Regulation of Tryptophan Metabolism in Neurospora Crassa - W. H. Matchett

We have shown previously that when Neurospora is grown in the presence of indole acrylic acid, the cells accumulate large amounts of indoleglycerolphosphate and, further, that this compound appears to interfere with the ability of tryptophan to act as a small molecule effector. A critical test of this interpretation was achieved in experiments with a mutant strain blocked between anthranilic acid and indoleglycerolphosphate. When this strain is grown in the presence of indole acrylic acid, no indoleglycerolphosphate is accumulated, presumably because of the genetic block. In this strain neither the formation of tryptophan synthetase nor the tryptophan mediated induction of kneurase is altered by the presence of indole acrylic acid. This experiment tells us that there is no direct effect of indole acrylic acid on the control mechanisms of these two enzymes.

Control of these enzymes in this strain is, however, altered by the presence of imideazoleglycerolphosphate, a compound which is accumulated by this strain in the presence of 3-amino-triazole. These observations argue strongly in favor of our contention that indole derivatives alter the ability of tryptophan to act as a small molecule effector.

We are now examining the synthesis of chloramphenicol RNA in Pseudomonas indigofera, obtained from Dr. Bruce McFadden, Department of Chemistry, Washington State University. The RNA polymerase from this organism was purified there to crystalline form. If RNA synthesis in this organism behaves similarly to the Escherichia coli system we have been studying, we shall prepare ribonucleoprotein particles from this organism to be used in in vitro studies with the crystalline enzyme preparation. These studies, it is hoped, will test in a critical way our idea that ribonucleoprotein particles are active in the regulation of synthesis of ribosomal RNA. Thus far we have found that Pseudomonas indigofera is sensitive to chloramphenicol, synthesizes chloramphenicol RNA and that this RNA occurs in the form of ribonucleoprotein particles with sedimentation velocities similar to those observed in Escherichia coli. If we find that the presence of these particles in vivo is inhibitory to RNA synthesis, then we shall examine a reconstituted in vitro system in an effort to get at the kinetics of the inhibition.

Electron Microscope Studies of Human Spermatogenic Tissue

- W. H. Matchett

We are accumulating electron micrographs of control tissues in an attempt to learn the different stages of cell associations at the level of the light microscope. Preliminary observations have turned up two interesting bits of information: (1) we have observed a cell type previously not described which for several reasons appears to be a spermatogonial precursor, (2) we have observed intranuclear inclusions in material taken from a drug-treated subject. These inclusions have been observed before but only in material taken from subjects in excess of 70 years of age. Further study is necessary before one could invoke a similarity between the mechanism of aging and the action of this particular drug.

Characterization of Radiation-Induced Free Radical Reactions
in Aqueous Systems - D. R. Kalkwarf

The multi-lined ESR spectra of radicals formed from flavin mononucleotide following radiolysis in aqueous solution contain important information concerning the precise chemical structure of these long-lived radicals. Due to poor spectral resolution, however, much of this information is obscure so that further experiments were conducted to interpret the spectra. One of the phenomena which cause ESR-line broadening in this system is electron-exchange between the radical and its parent, flavin mononucleotide. Several attempts were made to separate the radical from its parent chromatographically; however, the disproportionation rate was always too rapid to allow a separation to occur. A more promising approach was discovered in preparing the radical by chemical reduction in non-aqueous solvents. It was first shown that the radical formed by reduction of flavin mononucleotide in acid aqueous solution with zinc or sodium metal gave the same ESR spectrum as did the radiation-induced radical in acid. Reduction with metal in anhydrous n-butanol or acetone increased the spectral resolution and also decreased the number of lines in the spectrum. The most reasonable interpretation at present is that the hyperfine splittings due to hydrogen and nitrogen nuclei in the radical have shifted to cause more coincidence of spectral lines. Since the hyperfine splittings due to nitrogen generally show a strong solvent effect, it is hoped that a detailed analysis of the spectra of the radical in both aqueous and organic-solvent samples can distinguish between the lines due to nitrogen nuclei.

PROJECT ALE

Administrative and Technical Summary - D. W. Pearce

Progress was made on the scientific plans for ALE project lands along with the master research plans for PNL in the environmental sciences. Key technical representatives have been identified and methods of approach were being developed at the month-end. The plans are scheduled for completion in early December.

Composition of the Scientific Advisory Committee and preparation of guidelines for conduct of the committee business

were further detailed.

The fencing contract under the administration of RL was well past the 50% completion mark and was proceeding on schedule.

Various aspects of the beetle study and preliminary measurements of leaf water potential were carried out on parts of the Arid Lands Ecology site.

ENVIRONMENTAL RADIATION STUDIES

Eskimo Food Chain Studies - R. E. Nakatani

Body burdens of ^{137}Cs were measured in residents of Anaktuvuk Pass, Ambler and Arctic Village during mid-August. Results for adults were as follows:

<u>Location</u>	<u>No. of Adults</u>	<u>^{137}Cs Body Burden (nanocuries)</u>	
		<u>Mean</u>	<u>Range</u>
Anaktuvuk Pass	34	660	380-1420
Ambler	15	500	290-1080
Arctic Village	10	350	160-660

The total number of persons of all ages examined in the villages were: Anaktuvuk Pass, 75; Ambler, 52; Arctic Village, 24.

The presented values represent the annual maximum of Anaktuvuk Pass and the annual minima at Ambler and Arctic Village. This variability is related to the different patterns of caribou utilization by the people. The Anaktuvuk Pass value is 40% less than 1 year ago because of the decreasing trend of ^{137}Cs in the food chain and a shortage of caribou meat stored during the spring killing period. Snowmelt occurred earlier than usual this spring and much of the landscape at Anaktuvuk Pass was bare when the caribou migration passed the village. Many of the natives felt that packing the animals from the main killing ground to the cellars (about 12 km) was too arduous and most of the families estimated their caribou meat consumption this summer was about two-thirds normal.

Samples of lichens were collected from the caribou wintering range at Anaktuvuk Pass, the control plot to which ^{137}Cs , ^{134}Cs , and ^{90}Sr were added during 1964 and 1965, and from 13 other locations covering the northern section of Alaska from Canada to the Bering Strait. The latter group will provide comparison of radionuclide content of several lichen species from diverse habitats. Vegetation samples were obtained from the Cape Thompson region to continue the series of measurements begun in 1959. These are now being processed for gamma spectrometric analyses.

Radioelements in Alaskan Eskimos - R. W. Perkins

Salmon, which provide a major source of ^{55}Fe to some of the Alaskan natives, have been shown to also contain relatively large amounts of several other fallout and natural radionuclides. A comparison of the radionuclide concentrations in salmon liver with that in their muscle tissue shows much higher concentrations of most radionuclides in liver tissue. It thus appears that if a relationship between radionuclide concentrations in liver and muscle tissue were established that a subsequent liver tissue measurement might serve as an index of muscle tissue radionuclide concentrations. Salmon muscle and liver tissue from the west coast of Alaska has shown measurable amounts of 13 radionuclides including: ^{40}K , ^7Be , ^{22}Na , ^{54}Mn , ^{60}Co , ^{65}Zn , $^{110\text{m}}\text{Ag}$, ^{137}Cs , ^{106}Ru , ^{125}Sb , ^{55}Fe , ^{210}Pb and ^{208}Tl (^{232}Th). In addition, one sample from Kenai, Alaska, showed a considerable amount of ^{51}Cr (27.8 days). The only logical source of this radionuclide is from the Columbia River and it is suspected that this salmon had spent some time in the river prior to its migration to Alaska.

Terrestrial Ecology - R. E. Nakatani

A comparison of beetle populations in adjacent burned and unburned Artemisia Purshia (sagebrush-bitterbrush) vegetation was conducted by pitfall traps visited at weekly intervals for a period of 1 year. Four species comprised the bulk of the trap catch. These were: Eleodes hispilabris, Calosoma luxatum, Pelecophorus densicolis and Coniosatus sp. In all, 1361 beetles were caught in the unburned area as compared to 1302 in the burned area. Although fire killed the dominant shrubs, the herbaceous plants, especially cheatgrass and sandberg bluegrass, were not visibly influenced by burning. It is concluded that wildfire is not an effective factor in reducing the population of ground dwelling beetles in desert steppe vegetation.

Columbia River Ecology - R. E. Nakatani

The extensive program of sampling Columbia River biota for radionuclide assay to fill in the gap experienced last year because of the reactor shutdown period was concluded with September collections.

Radionuclide concentrations for the invertebrates continue to fit well with the curves established before and after reactor shutdown last year. Fish data are quite variable as expected.

Environmental Plant Physiology - F. P. Hungate

New techniques and equipment are being utilized to study water relationships in plants and soils in the vicinity of Rattlesnake Springs. A pressure vessel, similar to that described by Waring and Cleary, was employed to identify the total force by which plant, stems and leaves retain water. The woody branch with leaves attached is inserted inside the pressure vessel with the tip of the stem showing through a hole in a rubber stopper. The pressure inside the vessel is then raised until a barely perceptible evidence of moisture is observed on the end of the cut stem. The pressure inside the vessel then gives a measure of the total force by which the stem and leaves retain moisture. As yet, no completely consistent results have been obtained using this equipment, primarily because of minor leakages between the rubber stopper and the inserted stem.

A second method of measuring leaf water potential utilizes a thermocouple psychrometer contained in a very small series of chambers into which leaves can be placed. After allowing the leaf to come to equilibrium with its environment, the thermocouple is wetted by cooling below the dew point by Peltier cooling. The measured thermocouple EMF, as compared with a dry reference junction, gives a measure of relative humidity in the test environment. The following values were obtained on September 21 which was a typically sunny day. Two series of values are given, one from leaves sampled at 8:30 in the morning and the other from leaves sampled at 1:15 in the afternoon.

	<u>8:30 a.m.</u>	<u>1:15 p.m.</u>
Greasewood	33 bars	38 bars
Greasewood	31 bars	35 bars
Rabbit Brush	26 bars	32 bars
Sagebrush	44 bars	55 bars
Willow	20 bars	28 bars
25 Bar KCl solution as control	24.5 bars	24.5 bars

A longer period is required for sagebrush and rabbit brush to come to equilibrium than for the other leaves.

During this summer a trailer was prepared for housing instruments for field use. The trailer is currently ready to take to the field and equipment will be installed for measurements of temperature, carbon dioxide and relative humidity. Appropriate recording equipment will also be installed so that continuous recording of these environmental parameters can be obtained.

Biological Effects of Thermal Discharges in a Large River
- R. E. Nakatani

The cooperative study, with the Bureau of Commercial Fisheries, USFWS, of sonic-tagged salmon and steelhead trout continued during September. The "A" or August peak of adult steelhead trout migration completed its run through the Hanford Reservation early in the last week of August. During the first week of September, some steelhead were actively moving downstream. These fish followed deep water in contrast to the upstream-migrating fish which followed the shoreline closely and stayed in shallow water. While a small number of steelhead return to the ocean after winter spawning, this cannot explain the downstream movement at this time. None of these downstream-moving fish approached the heated plumes, so no thermal-response information was gained from them.

The "B" or September peak of steelhead has been late to arrive at Hanford. While several river surveys have been made, no fish from this peak (tagged with a code different from the "A" peak) have been found farther upstream than Ringold. During the lull between steelhead peaks, temperature measurements were made in the plumes.

Testing of juvenile Chinook salmon for lethal thermal dose time at 27°C is presently in progress. The fish are acclimated to a base temperature of 15°C, exposed for a limited time to the test temperature, and then returned to the base temperature. Immediate and delayed effects are recorded. Studies will also be made at 26, 28, and 29°C.

About 600 three-inch, Coho salmon juveniles from the Leavenworth Federal Hatchery were recently transported to this lab and are being acclimated to our conditions and 15° temperatures. They are from parent stock that have passed through Hanford waters in their life cycle. High temperature resistance times for this species will be determined, and compared with those for Chinook.

Analysis of Natural Systems - R. E. Nakatani

A simple deterministic model of the food chain passage of ^{137}Cs in Alaska was programmed for computer simulation with the advice of Dr. Gerald Paulik, College of Fisheries, University of Washington. Preliminary runs of the model have been used to examine various facets of our study of the lichen-caribou-Eskimo food chain. Results of the analysis emphasize two problems: (1) anomalously high body burdens of ^{137}Cs in both caribou and Eskimos (supported by results across the Canadian Arctic, but not in Scandinavia); and (2) the need for further understanding of what may be called "conversion factors" or "transfer rates" from one level to the next--better estimates of loss rates are also needed, but uncertainty about transfer rates precludes much appraisal of these factors from the present simulation.

Earth Sciences - W. A. Haney

Planning and development of software for the hydrologic analysis, computer-display equipment is directed toward a monitor-type control program. The general framework of the monitor is contained in the CONAFIR program which was built around a master controller concept that can be expanded to provide the control function for all the large computer programs for hydrologic analysis. The goal of the monitor when completed is that any of the present programs, e.g., STEADY, GENORO, CONAFIR, FUNEVAL, or STREAM, may be called and controlled essentially automatically through the display equipment.

The increased capability of the expanded grid for the solution of steady-state flow problems with finite differences required the ability to search such a matrix for isocontour lines. A program was developed which uses a straight-line interpolation between points in the matrix and takes into account the variable grid spacing when plotting results.

Geological evidence indicates that uplift of the Horse Heaven Hills at Wallula Gap has been slower as well as later in starting than in other ridges. Calculations suggest an uplift rate there of about 1 foot/14,000 years, thus corroborating the conclusions based on indirect geological evidence. Although the figures are averages, precise leveling in the White Bluffs in 1960 disclosed steady decreases in dip upward that do not suggest either hiatuses or sudden increases in the deformation rate there. Deformation rates in the Pasco Basin appear to average significantly less than creep recently recorded on active faults in California along which earthquakes have occurred. For instance, the Hayward fault currently is moving at a rate of about 1 foot/100 years.

The suggested low rate of deformation in the Pasco Basin, together with the demonstrated absence of significant surface faults on which offset has occurred, further suggests low seismic activity.

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Radioisotopes as Particles and Volatiles - L. C. Schwendiman

Turbulent Deposition in Vertical Tubes - G. A. Sehmel

Computer solutions have been obtained for a theoretical model describing turbulent deposition in tubes. The model is based upon a steady state concept of eddy diffusion of the particles from the tube center to within a stopping distance of the tube wall. This diffusional concept would be applicable to cases in which particle concentration decreased as the tube wall was approached. At the start of the stopping distance, each particle is assumed to possess a radial velocity equal to the local root-mean-square (rms) turbulent velocity of the air. The distances are a function of tube Reynolds number and of particle size and density.

Comparisons of predicted with experimental deposition velocities show only moderate agreement over a limited range of variables. Modeling is being continued and will include modifications of the free-flight distance as well as inclusion of Brownian diffusion.

Particle Sampling Studies - G. A. Shemel

Isokinetic sampling studies were continued for a 0.135 in. ID probe for smaller particle sizes from 1 to 4μ diameter and for a larger sampling probe diameter of 0.402 in. ID for particles from 1 to 18μ diameter. The samples are withdrawn through the probes from the center of a 2.81 in. ID tube through which air flows at an average velocity of 10 mph. A sampling velocity of 1.25 times the average flow rate in the 2.81 in. tube is used to sample isokinetically from the center of this turbulent air flow.

The concentration calculated from the sample entering the probe divided by the average concentration at the sampling level in the 2.81 in. tube is the ratio, C/C_0 . For isokinetic sampling through the 0.135 in. probe, the ratio of C/C_0 decreases from 1.23 for 1μ diameter particles to 1.15 for 3μ diameter particles. These results show a smooth relationship when compared to the results previously reported for 8- 17μ diameter particles.

Of concern is the fact that C/C_0 is greater than unity for the 1- 3μ diameter particles. Previous results were obtained in which radial concentration profiles in the 2.81 in. tube were obtained from filters placed entirely across the tube. The maximum to average particle collection on the filter was about 1.2 which is similar to the ratio of maximum to average velocity for turbulent flows. Thus, the previous conclusion was that these small particles were uniformly distributed with the turbulent air. In comparison, the present sampling results can be interpreted to indicate either that these small particles are preferentially concentrated at the tube center or that a probe edge effect might cause preferential collection within the probe.

For a probe size of 0.402 in. ID, the ratio for C/C_0 decreases from 1.07 for 1μ diameter particles to 0.85 for 18μ diameter particles. These C/C_0 results show that the concentration ratio for a larger diameter probe is less than for the

smaller diameter probe of 0.135 in. inside diameter. In addition, the C/C_0 ratio appears to become less dependent upon probe size as the probe diameter is increased from 0.245- to 0.402 in. Isokinetic sampling results for this 10 mph air velocity are summarized as follows:

CONCENTRATION RATIO FOR ISOKINETIC SAMPLING AT 10 MPH

Particle Diameter (micron)	C/C ₀ for Probe Inside Diameter			
	0.135 in.	0.21 in.	0.245 in.	0.402 in.
0.5 - 1	1.21-1.24	--	1.06-1.07	1.09-1.15
2	1.20	--	1.05	--
3 - 4	1.15	--	0.98-1.01	--
8	1.04-1.07	0.97-0.98	0.93-0.96	0.86-0.91
12	0.93-0.97	--	0.88	--
17 - 19	0.91-0.93	--	0.82-0.87	0.82-0.88

The reproducibility is good and results show consistent trends. For any probe size, the concentration ratio decreases as the particle size is increased. For any particle size, the concentration ratio decreases as the probe size is increased.

The tentative conclusion is that small particles (1-3 μ) may be preferentially concentrated at the tube center. For larger particles (about 18 μ), the particles have been previously shown to be concentrated near the tube walls. These radial concentration profiles in the tube will have to be considered in both sampling studies and in turbulent deposition studies.

Radioactive Fallout Rates and Mechanisms - R. W. Perkins

The vertical profile of concentrations of the cosmic-ray-produced radionuclides and fission products have been compared for the past high altitude sampling flights. It is interesting that the cosmic-ray-produced radionuclide ^7Be has a concentration profile which nearly parallels that of the fission products ^{137}Cs and ^{106}Ru . Also the concentration profile of ^{24}Na (15 hr) is similar to ^7Be and the fission products above 20,000 feet. The observed concentrations of ^7Be , Na and Na have been compared with calculated production rates by D. Lal. He estimates that these production rate calculations are good to

20% for ^7Be and ^{22}Na and to within a factor of 2 to 3 for ^{24}Na . A plot of the ratio of the observed to calculated ^7Be concentrations ranges from about 0.75 in the middle stratosphere to about 0.1 in the upper troposphere then increases to about 6 near ground level. A similar curve for ^{22}Na ranges from 0.3 in the middle stratosphere to near unity at ground level. The ^{24}Na ratio ranges from about 4 in the middle stratosphere to about 1.5 at ground level and is always above unity. This indicates that the calculated cosmic ray production rate of ^{24}Na in the middle stratosphere is at least four times too low. This information is providing basic data for determining the rates and mechanisms of the atmospheric transport of radionuclides and aerosols.

The concentrations of the radionuclides, $^{95}\text{Zr-Nb}$, ^{141}Ce and ^{103}Ru have continued to increase during the past month at the air sampling station at Wenatchee, Washington; however, the concentrations are still about 0.0001 to 0.00001 of those being observed in the stratosphere.

Neutron activation analyses of the air filters collected during the high altitude flight of June 5, 1967, were completed and provided a measurement of the Sb, Co, Sc, Cs, Zn and Ag concentrations in the 35,000 foot level. With the exception of the Zn, all of these trace elements were at least 10 times higher on the exposed air filter than on a blank filter. Measurements from subsequent high altitude flights indicate that the trace concentrations on exposed filters are well above the blank filters. It thus appears that with proper pre-cleaning and handling of filter assemblies, the tropospheric and stratospheric aerosols can be collected in a manner so that their trace element composition can be defined.

Radioanalytical Methods and Evaluation - R. W. Perkins

Group separation procedures are being developed for the determination of radionuclides in fresh fission product mixtures. A major problem in the analysis of fresh fission products is the interference from the large amounts of radioiodine isotopes present. Removal of these iodine isotopes provides only temporary benefit since many are produced by decay of tellurium parents and thus grow back into the mixture. A rapid procedure has been developed in which tellurium isotopes are quantitatively precipitated as the element using SO_2 while the iodine isotopes are precipitated with PdCl_2 . On applying this procedure to a four-day-old fission product mixture, the tellurium and iodine radioisotopes were removed and from the

resulting simplified spectrum as measured with a Ge(Li) detector, 24 fission products could be quantitatively determined.

A group separation procedure was developed for the determination of many rare earths in reactor effluent and river water. The procedure has been tested on reactor effluent water and the feasibility of its application to Columbia River water has been demonstrated. The procedure involves passing a large volume of river water through an aluminum oxide sorption bed on which the rare earths are quantitatively retained. In the laboratory the rare earths are eluted from the sorption bed with 2N nitric acid, contaminants are removed by a manganese dioxide scavenging precipitation, and the rare earths are separated as a group by fluoride and oxalate precipitations. By this technique it is possible to measure the concentrations of 14 rare earths and yttrium radioisotopes with half-lives ranging from 3.5 hours to 12.7 years, and an additional 6 rare earth radionuclides can possibly be determined. All of these measurements are performed by a direct count on a large-volume high-resolution Ge(Li) diode.

The procedure eliminates the need for individual rare earth separations and could be applied to the quantitative determination of the rare earths in many systems.

Further studies of group separation procedures for neutron activation analysis of trace elements in tissues indicate that combining the more successful steps of the two previously developed procedures will give a more satisfactory overall procedure. This procedure would involve dissolution of the tissue sample and distillation of the volatile elements Se, As, Sb, Br and Hg from a $\text{H}_2\text{SO}_4\text{-H}_2\text{O}_2\text{-HBr}$ mixture. The excess sulfuric acid is then removed by evaporation, the residue converted to the perchlorate, dissolved in water and passed through a carbonate-hydroxide-sulfide-anion exchange column. Tracer studies on this procedure indicate that it will give ample decontamination from ^{24}Na and ^{40}K to extend the activation analysis coverage to several additional trace elements with short-lived radioactive daughters.

^{55}Fe Studies - R. W. Perkins

In our study to determine the transfer of ^{55}Fe from mother to fetus, all of the blood samples from some 50 mothers participating in the study and many of the cord blood samples from the

infant placentas have been received. Several variations in specific activity of the ^{55}Fe have been observed and will be analyzed along with patient histories to determine the cause. Iron-55 determinations are being made on ocean water samples collected through a depth of one mile in the Pacific Ocean. These measurements indicate a relatively slow decrease in radioactivity with depth compared with the other artificial radionuclides which have been studied.

Precipitation Scavenging

Theoretical Studies - T. W. Horst

In order to calculate the amount of airborne contamination scavenged below cloud by rainfall, it is necessary to know the fraction of contaminant particles within the cylinder defined by a falling raindrop which collides with the drop. This fraction, i.e., the collision efficiency of the drop relative to the particle, can be calculated by numerically integrating the equation of motion of the drop and particles, taking into account the forces acting on them. Langmuir has performed the only calculation to date applicable to this problem and he has merely done an empirical interpolation between two limiting cases of air flow around the drop which he assumes bracket the possible values of the collision efficiency. Since these calculations do not take into account the wake behind raindrops larger in diameter than about 280μ and this wake might have a large effect on the collision efficiency, an attempt is being made to improve on Langmuir's work.

In order to begin investigation of the effect of the wake, Proudman and Pearson's second-order Stoke's approximation to the flow past a sphere is used. This solution is not theoretically expected to be valid for Reynolds number greater than 4, but in fact correctly describes the wake up to $\text{Re} = 120$. Thus it may be useful for raindrops as large as 660μ in diameter.

A computer program was written by the Mathematics Department incorporating this flow field that numerically calculated the trajectories of the particles relative to the drop as a function of the size and charge of the raindrop, the size, density, and charge of the particle, and the initial position of the particle. The output is either the trajectory of the particle in the form of a graph and tabulated position or the critical starting position which defines the collision efficiency for a given drop-particle pair.

Transport and Diffusion

Field Releases of Krypton-85 Tracer - P. W. Nickola and
J. D. Ludwick

Three field releases of krypton-85 were made during the mid-August to mid-September interval. These field experiments were the first testing of a recent addition to the Hanford field diffusion course instrumentation. This krypton sampling network consists of 20 samplers spaced at 2° increments along an arc 200 meters from the release point, with 4 additional samplers in the vertical on each of 3 towers on this arc. Thirty-two samplers are spaced similarly on an arc 800 meters from the source. A 64 x 64 multiparameter analyzer permits receipt and storage of krypton-85 concentrations from the 64 field sampling positions for 64 time intervals each. The dwell time for each complete field assay is variable from 1.2 seconds to 38.4 seconds.

Two of the field releases were instantaneous bursts while the third was a 15-minute continuous release of krypton. Although the data have not been reduced to concentration values yet, preliminary plotting and isoplething of the counts from each field location vs. time show a pattern with very good continuity.

These raw data permit easy observation of the stretching out of a plume by the shearing action of wind and vegetation. During the 15-minute release, with a wind speed of less than one meter per second at the release height, the first detectable tracer arrived at the 200-meter distance 125 seconds after onset of tracer generation. It took about 5 more seconds for a concentration 10% of the peak value to arrive, and 180 additional seconds for the 50% of peak value to arrive. After tracer shutdown, about 100 seconds were required before the tracer concentrations fell to the 50% peak value, 450 more seconds to reach the 10% peak value, and 420 more seconds to reach the detection limit of the system.

MARINE SCIENCESPhysical Chemistry of Ocean Solutions - R. W. Perkins

Most of the marine organisms collected during the joint BNW-OSU oceanographic study during July 1967 have been analyzed for their radionuclide content. In 11 organisms ranging from surface to benthos the concentrations of ^{54}Mn , ^{65}Zn , ^{60}Co , ^{137}Cs and ^{226}Ra have been measured. For these radionuclides there is relatively little difference in concentration of the surface, mid-water and benthos organisms. On comparing the specific activities of Cs, Co and Zn in sea water with those in the ocean organisms, it was observed that while the ratio of the specific activity of ^{137}Cs in the water to that in organisms is near unity, the specific activities of ^{60}Co and ^{65}Zn range from 10 to 1000 times higher in the organisms than that in the sea water. This is an extremely important observation since it means that these artificial radionuclides are 10 to 1000 times more available for uptake by the marine organisms than the stable elements in the ocean and thus their potential hazard is much greater than would be estimated from specific activity observations on ocean water alone.

Measurements of the ^{210}Po and ^{55}Fe on a deep sea profile, between the surface and the depth of one mile were completed. Polonium concentrations of about 0.020 dpm per liter were observed over this depth except near the surface where the concentrations range 0.04 to 0.12 dpm per liter. The ^{55}Fe showed concentrations between 0.01 and 0.04 to depths of 5000 feet with surface concentrations between 0.2 and 0.02 dpm per liter. The change in concentration of ^{55}Fe between 1000 and 5000 feet was less than a factor of four and is far less than that of ^{137}Cs and other artificial radionuclides which have been studied.

Micro manganese nodules from a low sedimentation area in the Pacific Ocean were analyzed by neutron activation analysis for Fe, Cu, Zn, Co, La, Sc and Sb. These nodules were found to contain concentrations of most of the elements which were comparable to those reported for the large manganese nodules but they contain substantially larger amounts of Zn and La than the maximums which have been reported for large nodules.

RADIOLOGICAL AND HEALTH PHYSICS

Whole Body Counting - H. E. Palmer

The ^{143}Pm is presently being prepared for use in humans by Abbott Laboratories, with delivery of the material expected within ten days. The anticipated starting date of October 2 will be delayed until October 7 or 14. A shadow-shield counter has been set up for this study and is ready to be used for both total body counting and differential scanning. The volunteers have been selected.

Studies are continuing on methods to provide a more uniform irradiation and a counting geometry more independent of body size for the University of Washington study under Dr. Nelp on the determination of total body calcium in man by in vivo neutron activation analyses and total body counting. Methods under consideration include a water bath around the person for both irradiation and counting. This will make all people appear to have the same thickness and width. Measurements of thermal neutron fluxes in the extremities of the cadaver indicated the necessity for adding a moderating lid and a moderating floor to the enclosure, and the use of an additional trimming moderator to smooth the activation profile for the legs and head. The modifications to the enclosure have been effected and experiments are under way to determine the most suitable means of controlling the flux to the extremities. Gallon containers of a saturated $\text{Ca}(\text{NO}_3)_2$ solution were activated and counted in the whole body counter to establish the gross counts obtainable. Four such containers exposed with a subject would provide sufficient calcium activation to serve as standards for comparison with activation in the subject. A steel post used to support the cadaver in the enclosure was found to influence the activation profile through the abdomen and has been replaced with a suspension involving less metal. A new exposure technique is being used in which the subject presents either front or back aspect to the target for 90% of the exposure, spending only 10% of the time in rotating from one aspect to the other.

As part of the work supported by the committee for the American Public Health Association on in vivo gamma ray spectrometry, a standard field method for determining ^{137}Cs in humans was developed. The method uses a 3 in. NaI crystal and can be calibrated using a simple water phantom and other items

that are easily obtained. The method supplies a conversion factor between the phantom and humans. This method is for use with people having ^{137}Cs body burden of 50 nCi or more.

If a person exposed to a criticality accident were brought to a whole body counter within an hour after the criticality, considerably more information about the dose to the body could be obtained. A measure of the distribution of the radioactive calcium could give much information about what dose each part of the body received. ^{24}Na does not give this information. The distribution of radioactive calcium can be determined for uniform exposure from our cooperative studies with the University of Washington. Discussions are being held with personnel of the Critical Mass Laboratory of the Reactor Physics Department of Battelle-Northwest to explore the possibilities of exposing phantoms or cadavers to the critical mass assembly. It is contemplated that such exposures would be immediately followed by whole body counting studies.

Radiation Dosimetry - W. E. Wilson

A thermal baffle was installed in the tissue equivalent plastic calorimeter and tests conducted in a temperature-stabilized room show that the calorimeter is capable of reproducing to 0.05%. Several measurements with the calorimeter using 1.7 MeV protons on tissue-equivalent plastic and aluminum indicate that $4 \pm 0.5\%$ of the energy from the proton beam does not appear as heat in the tissue-equivalent plastic. Some beam instabilities and room temperature fluctuations are the major sources of the rather large error at present. Although the error is relatively large, so far as we know this is the first direct measurement ever made of this effect. Best estimates were that it would be around 2-3%. To date the sample has received a total dose of about 10^8 rads and the effect shows no signs of reaching saturation.

Radiation Physics - W. E. Wilson

Construction of a mock-up gas target for low energy proton scattering experiments was completed. It will be used to confirm calculations of pumping rates and pressure distributions. Testing will begin when vacuum equipment is available.

Radiological Chemistry - R. W. Perkins

The lifting mechanism was completed for the new multi-dimensional gamma ray spectrometry detector system and an initial test on the response of one of the detectors has been carried out. Each of the two detector units consists of a 9 in. diameter by 8 in. thick NaI(Tl) crystal with a 3 in. thick light pipe and is surrounded by an annular 15 in. diameter by 11 in. thick NaI(Tl) anticoincidence shield. The overall response of the lower crystal unit is excellent. The resolution of the principal 9 in. diameter by 8 in. thick crystal is 8.5% while that of the annulus is about 15%. The undesirable Compton response with a ^{137}Cs source is less than half that obtained on the 11 in. by 6 in. multidimensional detector system at the Compton edge and less than a third at other Compton energies. A background comparison has not yet been completed but indications are that the counting efficiency to background ratio will be substantially higher than that of any other multidetector systems.

RADIATION INSTRUMENTSRadiation Detection and Measurement Instruments - W. G. Spear

Isolation circuitry added to the breath counter of the experimental tidal volume air monitor corrected the transient noise problems encountered during initial tests. All remaining circuits work well; however, preliminary checks indicate that the device cannot properly record short breaths, gasps or coughs. Thus, a divide-by-100 electronic circuit, designed to correct the condition, will be fabricated. The installation at the Biology Laboratory will include two remote stations, one connected into the inhalation exposure laboratory and the other wired directly into the dog "smoking room" for useful application.

Completion of a study of a pulse-shape discriminator unit provided information for improvement in the photopeak-to-Compton shoulder ratio of the gamma spectrometer system used in the measurement of mixed-field neutron-gamma dose rates. Through use of such an approach, it is estimated that the ratio can be improved by a factor of three. Components necessary for fabricating a prototype have been ordered.

Progress on the improved animal physiological data telemetry system continues with initiation of physical layout procedures and instrument packaging. No major size increase over the earlier version of the completed unit is anticipated. Design of the demodulator circuits required for the radio-nuclide uptake channel of the receiver unit commenced; the center sub-carrier frequency will be 14.5 kHz. Completion of this portion of the system will allow complete testing to be initiated. Scheduled tests include count-rate transmission capabilities and interference considerations.

New applications for the germanium solid-state detector continue to demonstrate the versatility and usefulness of this system. In an experiment to determine if the relative amounts of radium and radon daughter in a sample could be assessed, observations made of the ratio of the 187 keV radium gamma ray and the radium daughter gamma rays at 242, 295 and 352 keV demonstrate the increase with the buildup of the daughter products, as expected.

Expansion of the solid state detector system to include low noise counting and fast coincidence capabilities progressed with the preparation of specifications for the required capital equipment.

Evaluation of thermistors and strain gauge blood pressure transducers proceeded satisfactorily. Hard copy data on the performance of these units will be obtained when it is possible, after the swine are placed in the metabolism cages. Surgery scheduling continues to delay implantation of the resistance thermometer for its direct evaluation.

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