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THE NEED FOR CONTINUATION OF STUDIES OF RADIATION CONTAMINATION OF BIOTIC FORMS AT THE BIKINI AND ENIWETOK TESTING GROUNDS

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THE NEED FOR CONTINUATION OF STUDIES OF RADIATION CONTAMINATION OF BIOTIC FORMS AT THE BIKINI AND ENIWETOK TESTING GROUNDS

In the years 1945-1951 inclusive, this country detonated a total of twenty-four (24) atomic bombs. These detonations were essentially tests of bomb efficiency, for even the two detonations over the Japanese cities of Hiroshima and Nagasaki were experimental models and contributed much to our understanding of the forces involved. In twenty-two of the tests the physical forces involved were evaluated and some attention paid to the immediate biological problems in as much as they constituted potential health hazards of varying degrees.

Some of the tests, notably the Bikini experiments and the Eniwetok testing program in the spring of 1951, included biological testing of the effects of external exposure to neutrons and gamma rays, while only the Bikini underwater test included an exploratory phase of the effects of radiation contamination from residual fission products and induced radiation.

The subsequent studies made after the testing program at Alamogordo, New Mexico, by the Atomic Energy Project, University of California at Los Angeles, and those at Bikini and Eniwetok for the resurveys conducted by the Commission through

their contractors, have partially filled in the gaps in our knowledge. However, these "spot checks" leave much to be desired in completing the story of radiation contamination in biotic materials following an atomic bomb burst.

The order of magnitude of a complete study of biotic contamination in a field-testing area is very great, but the data to be obtained are of such extreme importance that it is worth any amount of effort which may be expended to attain this information.

The amount of fission products in the mud at the bottom of the target area of Bikini Lagoon has been calculated at 2×10^6 curies[1], a week after the explosion. By 1947 the radiation had apparently disappeared from the water, but hydroids growing on floats anchored in the lagoon picked up radioactive materials so that when they were counted on January 14, 1948, recorded 1,700 counts per minute per gram of dry weight material[2].

In the bottom of Bikini Lagoon near the target area coralline algae (Halimeda) dredged from the bottom in August of 1949 and counted November 6, 1951, produced counts varying from 1,868 to 10,325 with an average of 8,342 counts per minute per gram of ashed material.

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[1] The Effects of Atomic Weapons, U. S. Government Printing Office, Washington 25, D. C., June 1950, p. 283.

[2] Collected by the Applied Fisheries Laboratory resurvey group, August 1947; counted January 14, 1948,--245 counts per minute per gram; counts made with an end window counter of approximately 15 percent geometry.

The alpha contamination of the Bikini target area has been re-evaluated. Ether extractions from a 9- normal nitric acid solution of Halimeda collected at Bikini during August of 1949 and counted during August of 1951 ranged from 58.2 to 820 d/m/g with the average count of 378 d/m/g for the sixteen samples counted.

At Eniwetok both terrestrial and aquatic environments were contaminated by the detonation of seven (7) atomic bombs. The problems are complex but still very usable in studying the over-all effects of residual radiation upon living forms. The surveys of the fauna and flora of Eniwetok during the summers of 1948 and 1949 provided data on the amount of biotic contamination and on some of the more obvious effects such as the mortalities observed in birds, fishes, and invertebrate animals in the fallout area, mutations in plants on the shot islands, apparent calcium deficiencies occurring in plants growing on mountains of calcium, plant tumors, etc. These observations are only the more conspicuous ones, for the complete story can be written only after continuous observation by a number of specialists over a period of years.

Eniwetok at the present time has sufficient radioactive material to warrant continued study. Samples of the soil from

the target islands were brought to the Applied Fisheries Laboratory during the summer of 1951. At this writing this material has a specific activity of as much as 7.5×10^6 d/m/g or approximately 3 μc per gram. Unfortunately we do not have data concerning the location from which the sample was taken, nor do we know whether the sample was scraped only from the surface or taken from some depth. Consequently it is impossible to calculate either the average activity or the total activity present on a given island. In any case, this is obviously sufficient radioactivity to permit valid radioassays of organisms taken from the area.

Except for the problems of transportation, Bikini and Eniwetok Atolls are almost ideal locations for studying the overall problems of radioactive contamination. The combination of terrestrial and aquatic environment is ideal. The land forms of the atolls have a unique advantage in the simplicity of their ecology as compared with continental areas. Since the number and species of animals and plants, the types of soils, and the areas are more narrowly circumscribed, it is reasonable to suppose that here is an excellent opportunity to determine the pattern of effects of radioactive contamination in a natural environment. Revegetation and reconstruction of soil in completely devastated

areas should be studied both by following the naturally occurring processes and by planting suitable island crops. This would furnish both basic information concerning the stabilization of islands on an atoll and data applicable in the consideration of potential concentration of radioactive fission products by crop plants and their possible toxic effects.

In the aquatic environment a very complex fauna exists. The populations, however, are almost completely confined to the particular atoll. Except for some of the tuna fish, that migrate freely throughout the open seas, the fish populations are largely local to the atoll, many of them remaining about a particular coral head for their entire life span. All the various feeding types exist in the atolls so that food chain studies are definite possibilities.

Laboratory experiments in themselves cannot substitute for direct observations in the field. The total ecological situation is of such a complex nature that only comparatively minute segments can be duplicated under controlled laboratory conditions. Which segments deserve priority can and should be determined from results obtained in field studies. Experiments in progress at the Applied Fisheries Laboratory concerning the uptake of specific isotopes by aquatic organisms have, in fact, been based on information obtained in previous surveys of Bikini and Eniwetok Atolls.

It is essential to the understanding of the atomic energy testing program that studies evaluating biotic contamination keep pace with the changes in weapon design, materials used, and efficiencies obtained.

Questions on Future Resurveys

At a meeting with the staff of the Applied Fisheries Laboratory on August 20, 1951, Dr. Paul B. Pearson, Chief, Biology Branch, Division of Biology and Medicine, Atomic Energy Commission, asked seven (7) specific questions concerning Bikini-Eniwetok resurveys. We have attempted to answer these questions in a general way, presenting our viewpoints as based on past experience rather than projecting future studies into the discussion.

1. What data of importance are to be gained by the Laboratory and by the Division of Biology and Medicine from new resurveys?

    a. The most important contribution of repeated resurveys is a better understanding of living processes that can be obtained by evaluating the fauna and flora of Bikini and Eniwetok Atolls "tagged" with identifiable materials.

b. Quite unlike physical measurements, which have a definitive end point that can be measured at a single observation, biological processes are constantly changing and it is only through continuous or repeated observations that the problems can be evaluated.

c. The time factor in biological studies of this sort is often little appreciated and it is only after the lapse of sufficient time that many effects become obvious.

d. The data collected over a period of years will determine if the selection and retention of radioactive material in a natural environment as at Bikini and Eniwetok are transitory phenomena or if there will tend to be a balance at some level with these materials in equilibrium.

e. Studies of the so-called insoluble, non-available isotopes at Bikini and Eniwetok should be made. For example, Zr^{95} was found in the soft parts of fish,[3] although the principal fission product ZrO_2 is insoluble except in sulphuric or hydrofluoric acid. It

[3] U. S. Atomic Energy Commission report, OC-155 (Classified)

has been found that plutonium is now being taken up by the plants and animals in the New Mexico area after a delay of five (5) years.[4] The selection of Pu^{239} by food organisms is important in as much as the permissible amount for humans in food or water is 3.3 d/m/g or cubic centimeter on a continued basis. Other fission product isotopes supposedly not available by virtue of insolubility that should be studied are Ce^{144}, Pm^{147}, and Ru^{106}.[5]

f. Soluble fission products such as Sr^{90} and Cs^{135}, with long half lives, are still present at Bikini and Eniwetok. The very low maximum permissible amount of Sr^{90} for humans increases the importance of a thorough survey of the amounts and locations of this isotope within the food chains in the contaminated environment. (The maximum permissible amount of Sr^{90} in the food or water on a continued basis is 1.8 d/m/g or cubic centimeter. The total amount of Sr^{90} to be permitted in the body is 6 millimicrograms.[6]

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[4] U. S. Atomic Energy Commission report, UCLA-108

[5] "Maximum permissible concentrations of radioisotopes in the air, water and in the human body." Subcommittee on Internal Dose of the National Committee on Radiation Protection. 1951.

[6] U. S. Atomic Energy Commission report, AD-325 (C).

Contrary to expectations Ca^{45} occurs in the radioactive materials from Eniwetok.[7] Samples obtained from the shot islands after the last tests have up to 65 percent of the activity from calcium. Further study of this element in the field is important because of its abundance, long half life and relation to living organisms.

h. Small amounts of any radioactive material in a water environment are of greater importance from a contamination standpoint than like amounts on land. The ease with which they are transported in this medium, with a greater chance of being taken up by living organisms, results in a monitoring problem which cannot be effectively measured with field-type monitoring instruments.

2. What advantages have field studies over laboratory studies?

a. Laboratory experiments in themselves cannot substitute for direct observation in the field. The field studies, where the entire balance of interrelations of faunal and floral systems is involved, presents the

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[7]U. S. Atomic Energy Commission report, UWFL-23 (AECD-3446).

entire picture, while only comparatively minute segments can be duplicated under controlled laboratory conditions.

b. Only on the basis of the field studies can the relative merit of various sections of the problem be evaluated. Experiments now in progress at the Laboratory concerning the uptake of specific isotopes by aquatic organisms are based on survey data from previous Bikini and Eniwetok studies.

c. Food chain transfers of material in the atolls are constantly in progress. These transfers follow the natural paths, while in laboratories the limitations of both space and variety of forms available restrict the scope of the studies.

d. With the laboratory type of experiment, it is not possible to obtain the necessary data for determining if and at what time and at what level an equilibrium for the different long-lived fission products and unfissioned bomb material will occur within the various forms. The inability to predict the time of and level at which equilibrium will be reached within the

various organisms utilized by man for food is a major consideration when one realizes the low level of activity now considered to be the maximum permissible amount for humans for some of the isotopes in question.

3. Why use mixed fission products in preference to known isotopes?

   a. Work with known isotopes in the fission product series has been done and other studies should continue, but very little work has been carried out with mixed fission products.

   b. Studies leading to evaluation of possible contamination of continental sites in the advent of war or in case of accident should involve mixed fission products, not single isotopes.

   c. Basic work on the biological half life and site of deposition has been done for some forms, but studies on the biological half life and selection and retention of fission products by aquatic forms have not been done. It is known that the presence of even trace amounts of some elements may increase or hinder

the uptake and metabolism of other elements by plants or animals and that an over-abundance of one element may, after a time, reduce or increase the uptake of itself and related elements according to the organism.[8]

d. It is desirable to determine the intermediate steps involved in the retention of radioactive contamination within a food chain by using single isotopes. However, the end results for a given type of detonation near or under water can be obtained in a much shorter time by using mixed isotopes as laboratory checks against data collected in the field.

4. What are the advantages of working at Eniwetok rather than in continental sites?

a. Bikini and Eniwetok represent the only under or near water detonations. All the continental sites used to date have been in desert areas far removed from water.

b. Very complete biological surveys have been made at Eniwetok and at other locations in the Marshall Islands

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[8]U. S. Atomic Energy Commission report, MDDC-496.

so that adequate base lines are available for measuring changes.

c. The isolation of Eniwetok means that little in the way of interference of the usual sort would be expected at the test site. The present controls should be adequate to prevent interference with experiments planned and to give sufficiently high priority so that others in the test group would not interfere.

d. The climate, warm water, freedom from severe storms, protected waters of the lagoon, etc., all contribute to the desirability of Eniwetok as a base of operations.

e. The distance from the mainland and the dependence upon military transportation are the major handicaps of the Eniwetok site.

5. Is the radiation level sufficiently high to be of interest to the Commission?

a. Information is not available to us on the level of radiation contamination in which the Atomic Energy

Commission is interested.

b. The level of radiation at Eniwetok as measured by the sample sent to the Laboratory has an activity level of 7.5×10^6 d/m/g, which is sufficiently high for biological work.

c. The level of alpha activity of 329 d/m/g from the Eniwetok sample is sufficiently high to do alpha contamination studies for years to come.

6. In recurrent tests how could revegetation be studied?

a. It is difficult to do other than generalize on this question without knowing the physical changes that have been made or those which are planned for the islands prior to and after the tests.

b. It would seem that this problem might be approached by following the revegetation and reconstruction of the soil in completely devastated areas. A pie-shaped portion of the shot island could be reserved for these studies.

c. The re-establishment of the floral cover of the test islands could be followed by using the naturally

occurring native flora and by planting suitable crops with known growth and variation patterns.

7. Could some of the conclusions you are seeking be drawn from a trip possibly this next summer?

   a. Another point could be placed on the scale of studies of biotic contamination in the field laboratory at Eniwetok. The amount and kinds of contamination in the biotic forms could be measured and their distribution mapped.

   b. The mutations, tumor growth, etc., of the plants on the shot islands could be determined. Sufficient time has now elapsed since previous visits that additional changes will be evident.

   c. The repopulation of the devastated areas in the water adjacent to the shot islands should be evaluated.

   d. The basic problems of contamination of aquatic and terrestrial areas from an atomic bomb detonated at a low elevation need constant study, and Eniwetok is the logical place for such a study.