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THE RADIOACTIVE FALLOUT;
ITS PERSISTENCE AND PROTECTIVE MEASURES

The radioactivity which falls out of the atmosphere after the explosion of a nuclear weapon is called the radioactive fallout. Nuclear weapons produce these radioactivities as end products. The conditions of fallout are largely determined by the amount and type of material vaporized into the fireball of the bomb itself. A bomb fired in the air contributes such a small amount of matter to the cloud that the particles are, of necessity, very tiny and very slow in settling. The result is that most of the radioactivities are expended in the air, and the area over which the fallout occurs is rendered very large indeed, extending to the ends of the earth in minute although detectable amounts.

A bomb fired on the surface of the earth, however, may have an appreciable portion of its radioactivity reprecipitated within relatively short distances, while bombs fired beneath the surface of the earth may place essentially no fallout radioactivity in the atmosphere. So, the question of the area of contamination to be expected from nuclear weapons cannot be answered categorically without specifying the degree of contact of the fireball with the

surface of the earth, and probably also specifying the characteristics of this surface. Firing on water should create very different precipitation conditions from firing on soil for example. It also seems likely that firing over various kinds of soil should affect, to a great degree, the rate and extent of contamination by fallout.

I would like to discuss with you today a difficult and largely unexplored aspect of the fallout problem--the persistence of fallout in a contaminated area, i.e., the question of how long an area will be denied to normal occupation after it has been ~~sullied by~~ the deposition of almost ~~invisible snow of~~ fallout particles. We should remember that ~~nearly~~ the ~~only~~ main way in which fallout will be observed is by instruments; the precipitate being so fine as to be nearly unobservable. A contaminated area may look little different from an uncontaminated area and there will be no certain way except by the use of instruments in which to determine the degree of contamination. It is clear, therefore, that the Federal Civil Defense Administration, the states, the counties, and the cities all have a two-fold task in dealing with radioactive fallout--to furnish the instruments and to educate the people in their use and in the understanding of the principles of radioactivity, a knowledge which would prove to be vital. The Atomic Energy Commission is anxious to assist in any way it can in these tasks. We hope that the public discussion of radioactive fallout which has occurred already has served the educational purpose to a considerable degree. The instrument problem appears to be moving along toward practical solution.

The nature of radioactivity and its physical manifestations are gradually becoming general knowledge. The widespread interest in uranium prospecting has caused large numbers of people to learn first-hand about them. The obvious importance they have in the peaceful applications of atomic energy is requiring that another considerable segment of the population learn these fundamentals. So we see that progress is being made in the educational problem. It is obvious, however, that until this knowledge is much more widespread, much will remain to be done. We probably should greatly increase our effort at encouraging the inclusion of elementary instruction on radioactivity in high schools, particularly in the science courses so that we will feel assured of an eventual solution.

The radioactivity from fission is a composite of about ninety different radioactive species varying in radioactive lifetimes from a fraction of a second to many years. The radioactivity of the mixed fission products decreases about ten-fold for every seven-fold increase in the age of the fission products. If, for example, a bomb is fired 7 hours before the fallout occurs, then at 49 hours, or about 2 days, the average intensity of radiation would be 10 percent of that observed immediately after the fallout, and at two weeks it would be reduced to about 1 percent simply by radioactive decay.

It is plain from this that one of the effective methods of protection against fallout in its early stages is to sit out its decay in a shelter. A house with possibly some decontamination of the roof may be sufficient in certain circumstances but it is quite certain that an underground shelter and it is possible that most shelters would afford adequate protection. One must note that this is most effective in the first day or so and that the rate of decrease due to radioactive decay is much less thereafter--twelve days additional aging being required to produce a further ten-fold reduction over that which occurs in the first two days.

It is clear, however, that since the radioactivities are deposited as a very, very fine grained dust, more important than the rate of disappearance by radioactive decay may be the rate at which the dust is blown about or buried, or dissolved in water and carried into the soil, or otherwise physically transported. We hope this morning to discuss various possible methods by which we might clean up or restore an area that had been contaminated by radioactive fallout and a technique for discovering and testing such methods.

We know by the study of radioactive strontium--an isotope of 27-year half-life produced in high yield--that the rainwater carrying Strontium-90 (Sr^{90}) is purified in the top few inches of almost any soil, and that the run-off water is essentially purged of this potentially dangerous radioactivity by the cleansing action of the soil itself. If similar effects are obtained for the other fission products (and these studies remain to be done), we should

expect that river water might be essentially purified by the action of the soil. For snow, of course, it is clear that the soil will have little chance to cleanse it and it is possible that run-off water from snow might be contaminated.

We should hope that fallout occurring in the absence of rain or snow will be removable by the use of water from fire hoses, or other devices creating water streams of some velocity, and that a program of decontamination of buildings based on this principle of hosing down the roofs might well be quite effective. The radioactivity would be carried into the sewer system and thus covered by the necessary several feet of earth which is all that is required for effective shielding of even the largest amounts of fission products. The dust falling on the city streets would probably be similarly removed by hosing, although judicious sweeping with care to prevent dusting and inhalation might be effective in this instance.

In the open countryside the problem is different. Rain will move the contamination down into the soil and will thus reduce the hazard due to external radiation appreciably--possibly by three-fold. The movement of the fallout by the winds is more difficult to predict. It seems likely that in the absence of real dust storm effects, the effects should not be large. The effects of farming operations would be to incorporate the fallout more deeply into the soil and thus to further reduce the external hazard. Deep plowing would of course be best.

It is necessary to caution, however, that though the external radiation hazard due to fallout is undoubtedly the most important, an

internal hazard does exist in one of the fallout radioactivities--radioactive strontium which can be taken up from the soil into farm products. At a fallout intensity such that the dose rate 3 hours after the firing of the bomb were 20 roentgens per hour, the radioactive strontium introduced into the soil would be about the maximum allowable amount--which is approximately 5 curies per square mile for average soil. (The present radiostrontium content of United States soil is about one-thousandth of this.) This effect probably would last for extended periods--possibly years--unless special measures were taken. What might these be? How can we learn of their effectiveness?

The fraction of the radioactive strontium finding its way into the crops and grass is determined mainly by the amount of diluting non-radioactive strontium or calcium. Ordinary soil has about 400 tons of available calcium per square mile in the top 4 inches. The corresponding strontium content is much lower so calcium is the controlling element. It is so similar to strontium chemically that the assimilation follows calcium fairly closely. For these reasons, we can expect that for soils particularly deficient in calcium, fertilization of the soil of a contaminated area with calcium would protect to a considerable extent the agricultural products against becoming excessively radioactive. At present prices this should not be particularly expensive. For areas in which the soil is rich in calcium, little will be accomplished by calcium addition, but the

dangerous threshold fallout in these areas is much higher. In certain areas in Wales the Sr^{90} content of calves is ten-fold higher than in other parts of the world because of this. Of course, it is clear that certain crops are denied to human consumption by this internal contamination more definitely than others. Beef is one extreme in being very insensitive. This is so because the radioactive strontium is deposited in the bones and is not present in significant amounts in the meat. Milk and cheese, however, would more readily become inedible since they would possess a relatively high radiostrontrium content because of their high normal calcium contents. Vegetables would, in general, be questionable, their normal calcium contents being intermediate between meat and cheese.

We can expect that nothing but direct experiment will tell us the exact truth about these matters. The remarks I have made this morning are based on general physical principles and not on direct experimentation, except the remarks about Sr^{90}, and, even there, we do not know for all types of soil the exact details. It is clear that this type of consideration could prove to be extremely important if vast areas of valuable land could be reclaimed for farming operations only by methods such as those mentioned. We cannot imagine that the predictions of the very real effects of water washing, sweeping, calcium fertilization, etc., will be very wrong, but it would be far better to know this with some certainty.

Direct experiment is possible using the minute fallout which occurs outside the testing areas over essentially the whole hemisphere

whenever bombs are tested. Apparatus is available which will measure this tiny amount of material, thousands of miles from the test sites, and I believe you will agree that the assumption is likely to be sound that the susceptibility of test fallout to decontamination measures will closely resemble that of actual heavy fallout. It is probable that the dust particles will be only slightly finer in the case of the test fallout. On the whole, it seems that a great deal could be learned by taking typical buildings, streets, and countryside, monitoring them for general fallout, and then subjecting them to various decontamination measures and re-monitoring. I am sure many of you must have had the experience during some of the test series in Nevada of noticing geiger counters responding to fallout. Certainly prospectors in the Western part of the United States, in the general vicinity of the test area, are well aware of this fact. Although there is no appreciable health hazard connected with tests, it is still possible to make measurements and we should consider utilizing this opportunity to study how an area could be decontaminated and made habitable again after the fallout which might well come from the modern nuclear weapons. There are problems in connection with water supply, food supply, etc., which come to mind which also could be tested in this way.

It seems there are few problems in connection with the persistence of fallout question which cannot be answered, at least qualitatively, by vigorous effort on the part of local organizations using the

minute fallout from test bombs and modern sensitive instruments to detect the radiations. The program would be an ambitious one, but it seems difficult to imagine any other way in which we will learn whether our civil defense against the radioactive fallout is sound. If we try it, we may learn ways in which period of denial of cities and farm areas may be reduced.

The approach suggested might utilize a mobile radiochemical laboratory such as the one the United States exhibited at the recent Geneva Conference to make the radioactivity measurements, while local civil defense task forces could undertake the decontamination measures. Special instrumentation capable of detecting radioactivity at particularly low levels would be necessary. All could be placed in the mobile laboratory and it dispatched to the area selected for the study of the persistence or decontamination question.

A policy of experimental attack on the persistence of fallout questions and the testing of various reasonable decontamination and protective measures will give everyone a better understanding of the problem, better judgment about the various unavoidable policy decisions, and help to interest people in helping protect themselves against these possible dangers.

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