THE NATURAL BACKGROUND APPROACH TO SETTING RADIATION STANDARDS

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ABSTRACT

The suggestion has often been made that an additional radiation exposure imposed on humanity as a result of some important activity such as electricity generation would be acceptable if the exposure was "small" compared to the natural background.

In order to make this concept quantitative and objective, we propose that "small compared with the natural background" be interpreted as the standard deviation (weighted with the exposed population) of the natural background. We believe that this use of the variation in natural background radiation is less arbitrary and requires fewer unfounded assumptions than some current approaches to standard-setting. The standard deviation is an easily calculated statistic that is small compared with the mean value for natural exposures of populations. It is an objectively determined quantity and its significance is generally understood. Its determination does not omit any of the pertinent data. When this method is applied to the population of the United States, it suggests that a dose of 20 mrem/year would be an acceptable standard. This is closely comparable to the 25 mrem/year suggested by the Environmental Protection Agency as the maximum allowable exposure to an individual in the general population as a result of the operation of the complete uranium fuel cycle. Other agents

for which a natural background exists can be treated in the same way as radiation. In addition, a second method for determining permissible exposure levels for agents other than radiation is presented. This method makes use of the natural background radiation data as a primary standard. Some observations on benzo(a) pyrene, using this latter method are presented.

Introduction

At the Institute for Energy Analysis of the Oak Ridge Associated Universities, a small group of biologists has been trying to develop alternative approaches to the radiation standard setting problem. At the same time, the group has been concerned with standard setting for chemical agents, emphasizing those that are by-products of power production. We are relatively new in this field. It is therefore likely that we will rediscover approaches that have been explored before. We hope, however, that we can add some element of novelty and, for this reason, we present our results here.

The "Natural Background" Approach to Radiation Standard Setting

It has frequently been suggested that the natural background of ionizing radiation could provide important information pertinent to exposure standard setting for the general human population. For example, in 1959 the Ad Hoc Committee of the U.S. National Committee on Radiation Protection and Measurements stated: "The Committee recommends, pending more precise information, that maximum permissible doses for the general population should be related to the average natural background level of radiation".[1] In the intervening years, some of the "more precise information" requested by this committee and others has been laboriously and expensively produced but, in our opinion, no data has appeared that negates the basic correctness of the original position. As a matter of fact, it may be that laboratory data which will further improve our understanding of the effects of low doses of radiation on large human populations will never be available. There are many reasons for this and they have been frequently discussed. We call attention here to one factor, introduced in recent years, that may not be as obvious. The new world-wide concern for the setting of standards for a large host of chemical agents necessarily draws the attention of many scientists previously conducting radiation studies. It appears likely that, even if it were theoretically possible to collect the "more precise information", the appropriate scientists will have been diverted to other tasks and will not be available.

The human population has evolved more or less satisfactorily in an environment which has always contained ionizing radiation and the levels of this radiation have varied over time and from place to place. This certainly should provide us with large amounts of data directly applicable to the setting of standards. How do we best make use of this grand experiment? This paper contains some suggestions that we hope will stimulate discussion of the question. In addition, we will attempt to develop some ideas that stem from the "natural background" approach to radiation standard setting and show how they may be applied to other chemical and physical agents.

This approach begins from the premise that the most pertinent information we have is the fact that, throughout all of human history, the environment has been providing a continuous, low dose rate exposure. This dose rate varies in different locations and at different altitudes and has been measured with considerable accuracy. Attempts to correlate cancer of other forms of ill health with the variations in this "natural" background radiation have failed. Apparently, even those regions of the world providing the highest natural doses do not produce human populations with detectable radiation-associated defects. Because of these findings, it has often been suggested that the effects of an additional dose imposed on humanity as a result of human activities would also be undetectable and acceptable as long as that dose is "small" compared with the natural background. This concept is particularly appealing if the man-made radiation hazard is imposed as a by-product of some legitimate beneficial activity — such as the generation of electricity.

In order to make this concept quantitative and objective, we have proposed that "small compared with the natural background" be interpreted as the standard deviation (weighted with the exposed population) of the natural background.[2] We believe that this use of the variation in natural background radiation is less arbitrary and requires fewer unfounded assumptions than some current approaches to standard-setting. The standard deviation is an easily calculated statistic that is small compared with the mean value for natural exposures of populations. It is an objectively determined quantity and its significance is generally understood. Its determination does not omit any of the pertinent data. If, as a result of new measurements, additional information on the variance in natural background becomes available, the appropriate adjustment of the standard deviation is readily made and does not require new decisions and debate. It may be noted that if the standard deviation is used as the exposure standard, then, on the average, the actual exposure to the population at large would almost surely be much less than the standard deviation.

In order to demonstrate the proposed method, we have used data provided by the United States Environmental Protection Agency on the radiation exposures due to the natural background experienced by the populations living in each of the United States. Members of the Health Physics Division of the Oak Ridge National Laboratory have used this data to produce a histogram for which it is possible to derive a standard deviation. The value of the standard deviation is 20 mrem/year, a figure closely comparable to the 25 mrem/year suggested by the Environmental Protection Agency as the maximum allowable exposure to an individual in the general population as a result of the operation of the complete uranium fuel cycle. This agreement suggests that the "natural background-standard deviation approach" may be worth further exploration. Refinements of the techniques are certainly possible. Perhaps a statistic other than the standard deviation is more appropriate. A more detailed understanding of the quality and intensity of radiation exposure of the human population would be desirable.

The Application of the Natural Background Approach to Agents Other Than Radiation

In theory, any agent that has been present in the environment for much of human history may be treated as we propose for radiation. The basic condition that must be met is that the natural background exposures of humans to the agent is different in different locations and that, over this range of exposures, no overt ill health directly attributable to the agent exists.

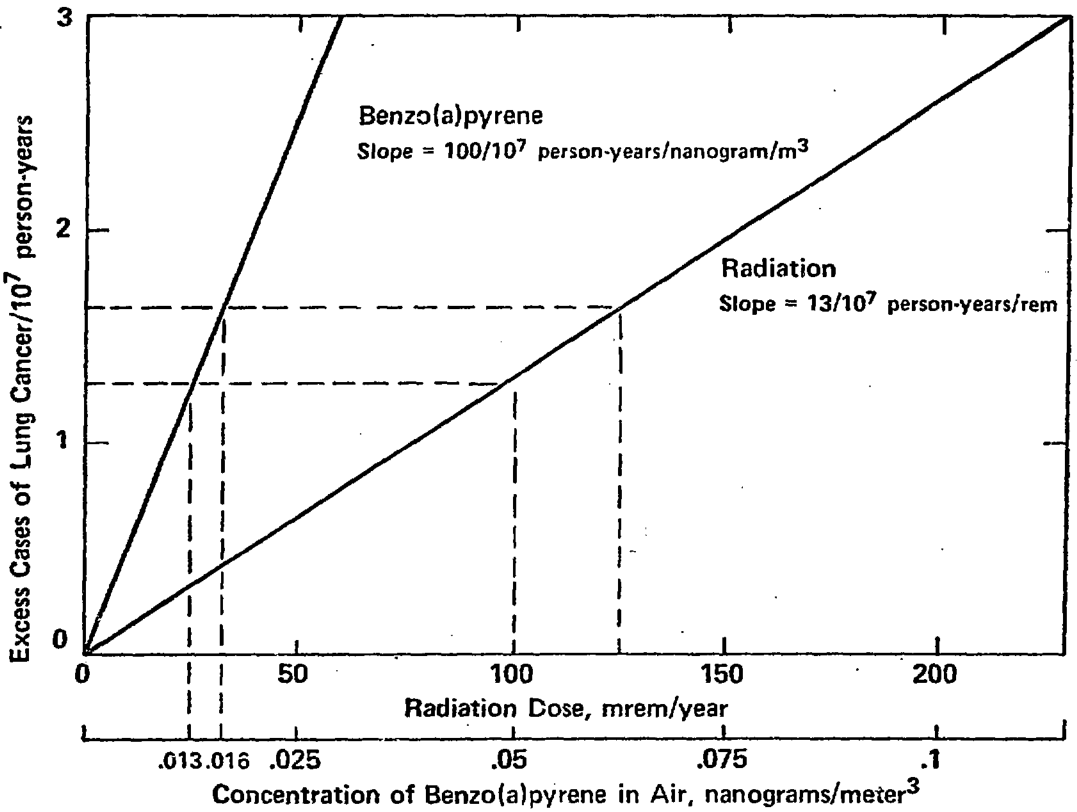
Some chemical constituents of soil and water may meet these conditions. If the appropriate exposure data can be developed for these agents, and the standard deviation is used as we have done for radiation, then a beginning may have been made towards a uniform approach to standard setting for many naturally occurring agents. We are currently attempting to find the appropriate data for fluorine and its compounds. This element is an example of an agent that is naturally widespread and has been present for all of human history. As for radiation, population exposures vary widely at different locations without any serious effects on health. In recent years, in parallel to the case for radiation, human populations have been exposed to additional amounts of fluorine in the expectation of deriving some benefit. How much additional fluorine should be permitted? We are currently attempting to use the "natural background" approach to answer this question, but our data are incomplete at this time.

<u>Agents for Which the "Natural Background" Approach is Impractical</u>

Many potentially harmful agents cannot be treated as described in the preceding paragraphs. Either no natural background exists or it is unlikely that, if one exists, we will be able to accumulate the appropriate data. For such agents we are considering a different approach. This proposed method is based on the premise that radiation data can be used as a primary standard to which other agents can be compared. This concept is not new and, in one version, is illustrated by the report of Committee 17 of the Environmental Mutagen Society.[3] We have taken a slightly different approach. We assume that the slope of the radiation dose vs. effect curve obtained from high dose information is an accurate reflection of the slope at very low doses. The same assumption is made for the new agent under study. The two agents are then compared as illustrated in Figure 1. For such a comparison, it is desirable to use data from the same species for both agents and the same measure of biological damage. In the figure we use human radiation data from the BEIR 1 report and human benzo (a)pyrene data from M. C. Pike et al.[4,5] The induction of lung cancer is the common criterion of biological damage. The slope assumed for the radiation curve is the average of the Hiroshima-Nagasaki data, the uranium miner data and the Newfoundland Fluorospor miner data. The slope assumed for benzo(a)pyrene is an average of data for smokers and nonsmokers weighted slightly towards cigarette smokers for ease of calculation.

If we were to accept an excess lung cancer rate due to benzo (a)pyrene in the atmosphere equivalent to the rate that might be due to natural background radiation, then an appropriate standard for the concentration of benzo(a)pyrene in air would be 0.013 nanograms/meter^3. If we allow an additional increment equivalent to that we have suggested as reasonable for radiation (25 mr) then the value becomes 0.016 nanograms/meter^3. Both these values are distinctly lower than the values of benzo(a)pyrene found in the atmosphere of U.S. cities considered to be in low concentration areas. As a matter of fact, these values are approximately two orders of magnitude lower than the U.S. national avenage.

These results suggest several possibilities. It may be that



Benzo(a)pyrene
Slope = 100/10⁷ person-years/nanogram/m³
Radiation
Slope = 13/10⁷ person-years/rem
Excess Cases of Lung Cancer/10⁷ person-years
3
2
1
0
0
50
100
150
200
Radiation Dose, mrem/year
.013
.016
.025
.05
.075
.1
Concentration of Benzo(a)pyrene in Air, nanograms/meter³

we have used inappropriate data. Perhaps the results merely reflect the peculiar attitude that has generally been taken towards the hazards of ionizing radiation. In general, it is clear that radiation standards are much more restrictive than standards for other agents. Clearly we must extend our observations to other agents in order to establish its usefulness. We are currently examining aflatoxin and asbestos by this same technique but do not yet have results to report.

Conclusion

We have discussed two approaches to standard setting for the general population. The primary one makes use of information derived from natural backgrounds. It is applicable to ionizing radiation and certain other naturally occurring agents. The second method allows us to relate agents for which the natural background approach seems unsuitable to a radiation standard based on the natural background. Both methods are open to criticism but we hope that we have contributed some elements of novelty that will lead to the development of useful approaches to standard setting.

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