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INFLUENCE OF RADIATION FROM AN UNSHIELDED REACTOR ON A NATURAL MICROFLORA

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ABSTRACT

The soil microflora and its respiratory activity were measured in soil cores collected at different distances from an unshielded reactor. No direct correlation was found between dose received and microbial counts or respiration. Indication of a correlation between dose and microbial respiration was obtained after eliminating the overriding influence of moisture. Radiation probably affected the soil microflora through damage to the phanerogam vegetation rather than directly. This preliminary study indicates the need to have undisturbed sampling areas close to the new ORNL fast burst reactor. Extensive dosimetry, both in and above the soil, in these areas, and a program of long-term ecological description, should be started before the reactor becomes operational.

Introduction

Increasing occurrence of ionizing radiation as a tool in medicine, genetics, and food preservation, as well as from increasing use of nuclear energy plants, nuclear propulsion, and radioisotopes necessitates increasing attention to radiation effects. Improved shielding techniques, however, will reduce the level of resultant radiation. Consequently, there will be more low level radiation. The influence of low level radiation, less than 10 r, has recently been demonstrated in long-term genetic experiments on short-lived organisms (1) and on delicate equilibria such as that exists between bacteria and higher plants in root nódules. Both conditions are an integral part of natural biological systems. Therefore, studies of effects of radiation on these systems are of primary interest. A program concerning the influence of radiation on natural biological systems needs to be started after the ORNL fast burst reactor is put in operation. In anticipation of this program, an exploratory study on the effects of radiation on natural populations of soil microorganisms was made at the unshielded reactor facility at Dawsonville, Georgia. Knowledge of the effect of radiation on the soil microflora is important because of the key position of this flora in the cycling of matter in nature.

Materials and Methods

The tree vegetation surrounding the Dawsonville reactor had been killed, or caused to drop its leaves early due to intensive radiation, mainly in June 1959.

Samples were collected on July 1, 1960, from six sites at different distances from the reactor ranging from 70 to 425 m, S.W. Microflora, soil respiration, and per cent moisture were determined from five soil cores, 10 ml each, from the top 2 cm of each site. The microflora was enumerated by the dilution plate method, using nutrient agar for bacteria and peptone-dextrose agar with 30 ppm streptomycin and 30 ppm rose bengal for fungi. Consumption of O_2 by the whole cores was measured by the Warburg technique.

The radiation air dose at the different sites was calculated from data obtained from Dr. Robert B. Platt, head of the radiation ecology program of Emory University, Atlanta, Georgia. The accumulated air dose ranged between 3-330 x 10^4 rad for the entire operation period February 1958--July 1960 and between 3-320 x 10^3 rad for the period May 1--July 1, 1960, for the 425 and 70 m stations, respectively. The dose received in the top 2 cm of the litter and soil was assumed to approximate the corresponding air dose, as loss of dose through attenuation in the soil will be compensated for by the increase of radiation due to scatter within the soil (oral communication, J. A. Auxier, Health Physics Division, ORNL). The three stations furthest from the reactor were not in line of sight; their dose received at ground level was from 1/3 to 1/5 of the calculated dose.

Results

A graph of the biological data and distance from the reactor suggested that there was a positive correlation between soil respiration, counts of bacteria, and actinomycetes, and soil moisture (Fig. 1). The fungal counts fluctuated erratically. No direct correlation between dose and any of these factors was found. Elimination of the overriding influence of moisture by plotting respiration/moisture against dose indicated a negative

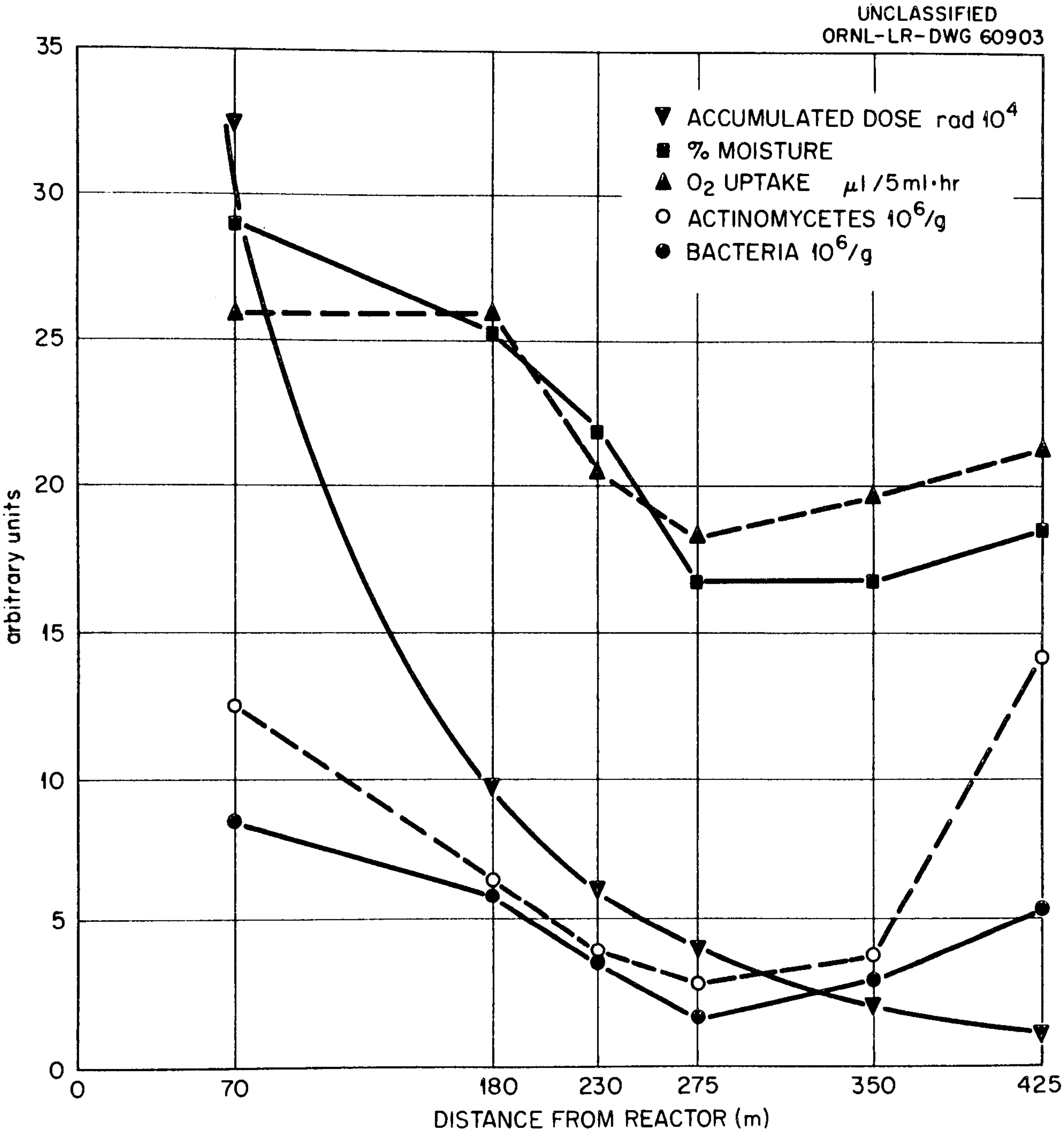

Fig. 1. Accumulated Dose (1 May–1 July), % Moisture, Microflora and Respiration of the Soil at Various Distances from the Unshielded Reactor at Dawsonville, Georgia.

correlation (Fig. 2), the significance of which could not be tested due to the limited numbers of observations. No such correlation was found between counts of organisms/moisture and dose.

Discussion

The influence of fast neutrons on the number of microorganisms in soil was studied by McLaren et al (2). This study indicated that an acute dose of 2.2 and 1.1 x 10^6 rad was required to eliminate all viable propagules of bacteria and fungi, respectively. At 0.24 x 10^6 rad, counts of these organisms were reduced to less than 1%. In our work the dose rate during the year preceding sampling was at no time adequate to sterilize the soil. Stozky and Mortensen (3), using Co^{60}, found that doses up to 250 x 10^3 r did not significantly affect bacterial counts and CO_2 evolution. However, doses from 8-250 x 10^3 r increasingly inhibited fungal counts in peat soil. The only period in which radiation effects on soil respiration and bacterial numbers could have occurred was in May 1960, at the station 70 m from the reactor, when the monthly dose slightly exceeded 250 x 10^3 rad.

Little evidence of radiation effects that might have occurred in May would have remained in July on account of the short life span of soil microorganisms, only partial elimination of the microflora at times of highest radiation, and the continuous influx of microorganisms from outside areas. Reestablishment of microbial population equilibrium in soil within two months was found by Davis et al (4), who studied the effect of gamma radiation on natural soil floras, and by Warcup (5) and Mollison (6) who studied partial soil sterilization with heat and chemicals. This is in accordance with the absence of any apparent radiation effect on

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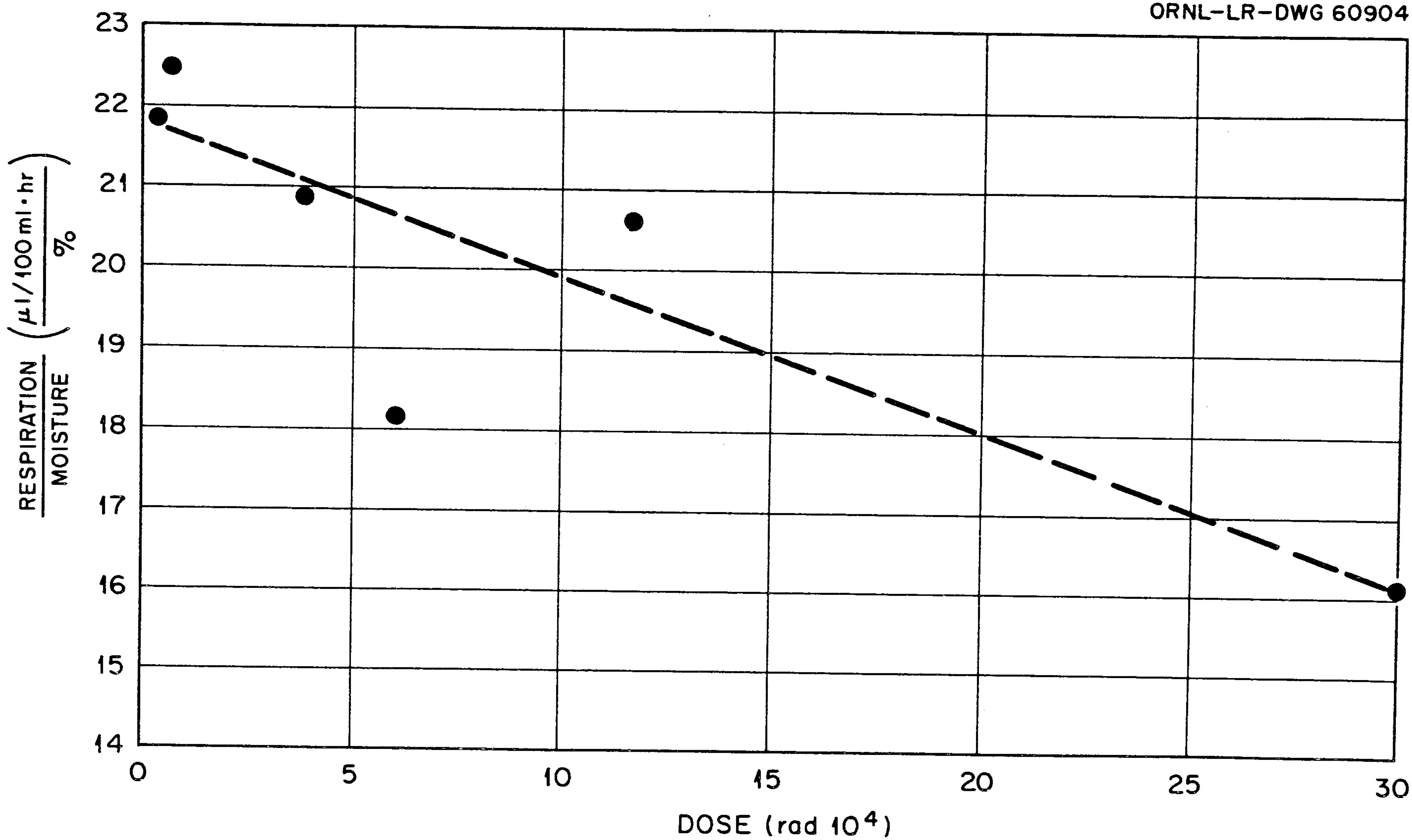

Fig. 2. Accumulated Dose (1 May–1 July) and O_2 Uptake/Moisture Content of Soil Around the Unshielded Reactor at Dawsonville, Georgia.

bacterial numbers on July 1. Any effect on the CO_2 production was even less likely since, after one sector of a microflora is suppressed, other sectors take over and utilization of the available substrate continues at about the same rate (7, 8). Therefore, the observed correlation between the radiation and respiration is assumed to be indirect. High radiation dose in June 1959 caused the vegetation to drop its leaves early, contributing to the forest floor a smaller amount of younger, more easily decomposable leaves at an earlier than usual date. In the most heavily irradiated areas only a small amount of litter consisting of the most resistant fractions remained at the time of sampling. Consequently, the rate of respiration there was low.

These results indicate that: (1) to obtain any immediate radiation effect on the soil microflora a large dose received within a limited time is required, (2) during construction of the fast burst reactor at ORNL, conservation of some undisturbed areas in the immediate vicinity of the reactor is desired for sampling purposes, (3) underground dosimetry at various depths and in various substrates is necessary for the interpretations of possible changes in the microflora of the soil, and (4) factors other than dose and organisms should be measured, as demonstrated above by the role of soil moisture.

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