Reports

Beneficiation of Soils Contaminated with Strontium-90: Beneficial Effects of Potassium

There appears to be a possibility that strontium, like calcium, exists in soils in forms that make it unavailable to plants and thus to the biosphere. Evidence from the fallout data of the Sunshine project (*1*) disclosed disparities between total fallout as judged from actual pot collection of rain and from plant contents and soil analyses; these disparities could be due to some type of chemical aging or of chemical inaccessibility to plants of the radiostrontium carried in the rain. R. Scott Russell (*2*) has noted that the availability of radiostrontium to plants is lowered on its addition to certain soils, and Lyle T. Alexander (*3*) and R. F. Reitemeier (*4*) both report evidence that the accessibility to plants of radiostrontium in certain soils can be reduced by something like 30 percent.

These results indicate the possibility that treatment of heavily contaminated soils with ordinary fertilizers in reasonable amounts may have beneficial effects. These effects might reduce the consequences of reactor accidents or of local fallout during wartime very considerably. It seemed to be reasonable that the formation of certain insoluble inorganic compounds, such as strontium sulfate, might produce such effects. Strontium sulfate occurs in some soils (*3*) as the mineral celestite, and it might be expected to be sufficiently insoluble to accomplish at least a partial segregation of soluble strontium that is introduced into the soil. It is so insoluble [the solubility product is 7.6×10^{-7} at 25°C (*5*, p. 322)] that it seemed likely that, in contrast to gypsum ($CaSO_4 \cdot 2H_2O$) [with solubility product (*5*, p. 320) of 2.4×10^{-5} at 25°C], which apparently can feed calcium into plants, the strontium in strontium-sulfate might be truly unavailable to plant life. On the other hand, similar proposals with respect to barium had been tested by Bradfield (*6*) and by Robinson, Whetstone, and Edgington (*7*), and the results had shown that barium sulfate, which is even less soluble than strontium sulfate, could be utilized by plants in certain soils. However, the possibility seemed to exist that the addition of sulfate to contaminated soils might be helpful, so an investigation was undertaken.

During the course of the investigation it was suggested (*8*) that potassium might have a considerable beneficial effect with respect to radiostrontium absorption, as earlier work (*9, 10*) had indicated. As a result of these suggestions, a search for a specific potassium effect was also undertaken.

This report describes the experiments made to test these two proposals.

Soil from Washington, D.C. (from a garden at the Geophysical Laboratory of the Carnegie Institution of Washington, 2801 Upton Street, N.W.) was used by mixing two parts of soil with one part of the commercial soil thinner Vermiculite and with one part of horse-manure fertilizer. The soil used to make the mixture had 32 milliequivalents of exchangeable calcium per 100 g. To about 2 lb of this mixture was added, in very dilute aqueous solution, approximately 10 μc of Sr^{90}. Four earthen pots (A, B, C, and D) were used for trial with radish seeds for testing the efficacy of the addition of SO_4^{--} and of K^+ in the reduction of plant pickup of the radiostrontium.

Pot A, containing 370 g of the contaminated soil mixture, was prepared as follows, within a few minutes after the addition of the radiostrontium to the soil. To it, in dilute aqueous solution, was added 32 mg of ordinary nonradioactive strontium, as nitrate. The soil was stirred and made into a thick mud by further addition of water. After this mixture had stood for about 15 minutes, 35 mg of K_2SO_4 was added, in dilute aqueous solution, and stirred in. After one crop had been produced, 81 mg of strontium, as nitrate, and 200 mg of K_2SO_4 were added, in the same manner.

Pot B was prepared in exactly the same way, except that no sulfate was added. After the first crop, 265 mg of potassium nitrate was added to test the potassium effect. No additions whatsoever were made to pot C, except for the tracer radiostrontium; this pot served as a control. Pot D was filled with the pure soil, unfertilized and untreated with Vermiculite. To it was added radioactive strontium in the form of solid, insoluble strontium sulfate, 690 mg of the radioactive strontium sulfate being used to 726 g of soil, the two being intimately mixed before the radish seeds were planted.

The pots were planted with radish seeds and cultivated by being set in the ground out in the open during the summer or by being exposed to a bank of fluorescent lights indoors in the winter. At maturity the plants were ashed (after careful washing), the ash was dissolved in dilute hydrochloric acid, and sodium carbonate solution was used to precipitate the insoluble hydroxides and carbonates. The insoluble hydroxides and carbonates were measured for Sr^{90} content. The results are shown in Table 1.

The results of these experiments in-

Table 1. Effect of sulfate and potassium treatment of radiostrontium-contaminated soils on the availability of radiostrontium to radish crops. In column 2, each entry represents findings from one crop.

Conditions	Sr^{90} content of radish ash carbonates (arbitrary units)
Pot A (370 g mixture of soil and Vermiculite)	
8.9 mg of Sr/100 g, as nitrate, + 9.5 mg of K_2SO_4/100 g	0.63
Above + 22 mg of Sr/100 g, as nitrate, + 50 mg of K_2SO_4/100 g	0.64, 0.58
Pot B (356 g mixture)	
9 mg of Sr/100 g, as nitrate	0.81
Above + 72 mg of KNO_3/100 g	0.62, 0.63
Pot C (380 g mixture)	
No additions, except tracer Sr*	1.00, 1.01, 0.98
Pot D (726 g soil only)	
43 mg of Sr*/100 g, as Sr^*SO_4	0.90

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

dicate clearly that the addition of sulfate is not very effective as a means of reducing radiostrontium pickup by crops grown on contaminated soils. Although the addition of soluble strontium does seem to have some effect, the principal reduction observed was that effected by the addition of potassium; for potassium, in amounts as low as about 60 lb per 2 million lb of soil (or about 30 lb per acre for normal 2-in. depth of penetration of water-soluble fallout), something like a 40-percent reduction of radiostrontium uptake was observed.

Although these experiments show that radish plants in certain kinds of soil certainly can utilize the strontium in strontium sulfate, and that the formation of radiostrontium sulfate does not necessarily reduce the uptake of radiostrontium, the positive effect of potassium is established. It is possible that other fertilizers or other additives may have a more marked effect than either the fertilizer or the Vermiculite used in this investigation.

The effects observed by Russell, Alexander, and Reitemeier may involve effects other than those tested here. Certainly one knows that, as strontium lies in the soil, it is very likely eventually to be incorporated into large crystals, in which form it will become physically unavailable to the plants. And so the possibility of chemical aging, taking place slowly over several years, exists. It does not seem likely, however, that this process will be of sufficient magnitude to restore heavily contaminated soil to a useful condition, and further work needs to be done on methods of quick beneficiation.

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References and Notes

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Purine Catabolism in Drosophila melanogaster

Recently, it has been demonstrated that an eye color mutant, *rosy*^{2} (*ry*^{2}), does not contain isoxanthopterin which occurs widely in *Drosophila* (*1*). It has been reported that 2-amino-4-hydroxypteridine (AHP) is oxidized to isoxanthopterin by an enzyme prepared from *Drosophila* (*2, 3*) and named pterine dehydrogenase (*3*); xanthine is also converted into uric acid by the same enzyme (*2*), and xanthine oxidase is also capable of oxidizing AHP to isoxanthopterin (*4*).

I have found that the mutant *ry* does not contain a trace of uric acid at any developmental stage. Therefore, purine compounds and the activity of xanthine oxidase both in a wild type (Oregon-R) and in the mutant *ry* of *D. melanogaster* were investigated. Purine compounds were detected by paper chromatography. The results are shown in Table 1.

It was discovered that *ry* does not contain isoxanthopterin at any developmental stage, but rather contains a larger amount of AHP than does the wild strain at the pupal stage. It is well known that, as a rule, uric acid is a final product of purine catabolism in insects. On the other hand, mutant *ry* accumulates a larger amount of hypoxanthine, instead of uric acid. The occurrence of hypoxanthine was identified by the absorption spectrum of material isolated from *ry*, and xanthine in pupae and adults of *ry* was also demonstrated by paper chromatography.

The uric acid content of *D. melanogaster* was determined by the reduction of optical density at 295 mμ (*4*). The wild strain has the enzyme, but the *ry* strain does not. Furthermore, it seems that the enzyme is a true dehydrogenase, because it requires methylene blue or diphosphopyridine nucleotide (DPN) as an electron acceptor.

In some double mutants homozygous for *ry*, such as *v : ry*, *cn : ry*, *bw : ry*, and *se : ry*, neither isoxanthopterin nor uric acid is found to any extent in any developmental stage. Among them, *v : ry* and *cn : ry* have a light pinkish-red eye pigment, but *bw : ry* is similar in phenotype to *bw*, and *se : ry* is similar to *se* phenotypically. However, these strains have the same amount of hypoxanthine in each pupal stage as does the *ry* strain.

From these results, it seems that in *Drosophila* uric acid is produced from xanthine and hypoxanthine along the general pathway (*5*) shown in the following scheme.

Hypoxanthine → xanthine → uric acid

The deficiency of both isoxanthopterin and uric acid in *ry* strains may be due to the lack of xanthine oxidase. There is still a problem whether or not xanthine oxidase and pterine dehydrogenase are the same enzyme, and further researches are being carried out along this line (*6*).

Table 1. Pteridines and purines occurring in strains Oregon-R and *ry* of *D. melanogaster*.

Substance	Larvae	Pupae	Adults
Strain Oregon-R			
AHP	±	+	±
Isoxanthopterin	±	++	+
Hypoxanthine and xanthine	±	±	±
Uric acid	±	+	+
Strain ry			
AHP	±	++	+
Isoxanthopterin	−	−	−
Hypoxanthine and xanthine	±	++	+
Uric acid	−	−	−

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6. I am indebted to Dr. H. Kikkawa (Osaka University) and to Dr. C. Oshima (National Institute of Genetics) for their invaluable advice and encouragement. The greater part of this work was performed at the National Institute of Genetics in Misima, Japan.

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Cobalt Activation of Fatty-Acid Synthesis in Yeast Homogenates

Abstract. The incorporation of acetate into lipids in homogenates of *Saccharomyces cerevisiae* was inhibited at low concentrations of ethylenediaminetetraacetate, under both aerobic and anaerobic conditions. Of various cations tested, none could effectively reverse this inhibition. However, Co^{++} completely restored the synthesis of fatty acids, but not of nonsaponifiable lipids.

Previous reports from this laboratory have dealt with the synthesis of lipids in yeast cells (*1*) and in extracts prepared from yeasts (*2*). It has been shown that cell-free preparations incorporate acetate into various cellular lipids and that a particulate fraction consisting of uniform particles, of the order of 30 mμ in diameter, plus the soluble supernatant is required for this activity (*2*).

During the course of the studies de-