

DETERMINATION OF IODINE IN SOIL BY THE INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS*J. BENEŠ^a, J. FRÁNA^b and A. MAŠTALKA^b^a *Laboratory of Radiological Dosimetry,
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The instrumental activation analysis, based on the employment of the radiation of short-lived nuclides, has been used for the determination of iodine in soil samples. The limits of this determination and the factors affecting it have been determined. Moreover, the possibility to determine also other elements in soils has been studied. The method has been used for their fast chemical analysis.

The mobility of various elements or water molecules in the soil can be effectively studied using the radioactive or non-radioactive indicators. However, in field experiments the use of non-radioactive indicators is usually preferred due to the problems with radiation safety. When using an isotopic indicator that can be activated, the activity needed for the measurement can be achieved later, after the experiment was accomplished. The choice of the indicator is affected by several factors¹. Iodine is a commonly used indicator for soil experiments due to its permeability through the soil. Not only its radioactive isotopes²⁻⁵ but also the stable isotope¹²⁷I has been recommended several times for these measurements (*cf.*^{1,6}). The use of ¹²⁷I for the trace studies in soils depends on the methods of its determination. The isotope ¹²⁷I in soil samples can be determined by the neutron activation analysis because the isotope ¹²⁸I, formed by the reaction ¹²⁷I(*n*, γ) ¹²⁸I, emits γ -radiation with the half-life of 25 min, the energies of which are 0.46 (17%), 0.54 (1.8%), 0.9 (0.3%), and 0.75 MeV (0.3%) (*cf.*⁷).

In this work the non-destructive method has been used to study the possibility of the activation analysis determination of ¹²⁷I in soil samples. The concentration limits of its determination in soils of various chemical composition have been determined. The high-resolution Ge(Li) spectrometry was used for the measurements. The same method was employed also for the determination of the content of some other elements in the soil samples. The list of elements that can be determined in rocks and minerals by the method of short-lived neutron activation is given in *ref.*⁸, together with the data of the respective nuclear reactions and with the nuclear properties of the radionuclides formed.

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EXPERIMENTAL

Samples of the most important pedological types of soils that can be found in Czechoslovakia were used for the analysis. The properties of several of them have already been described⁹. Samples of about 10 mg, together with standards (of the same composition as that used in ref.⁸, except that 0.1 mg of iodine was added), were irradiated in the nuclear reactor VVR-S, Nuclear Research Institute, Řež, by the neutron flux of $2 \cdot 10^{17}$ neutron $m^{-2} s^{-1}$. The pneumatic tube transportation permitted the determination of short-lived isotopes. The γ -spectra of irradiation samples were measured on the spectrometer equipped with the Ge(Li) detector and with the 4096-channel analyzer. The detector resolution with 30 ml of the active volume for the 661.6 keV γ -transition of ^{137m}Ba was 2.3 keV. The experimental data and all the necessary corrections were processed on a computer.

RESULTS AND DISCUSSION

Five different soil samples were analyzed by the method of short-lived neutron activation and the results are presented in Table I. These samples were used for the determination of the sensitivity of the method, exploiting the determination of the content of the isotope ^{127}I in soils, and for the determination of factors that have

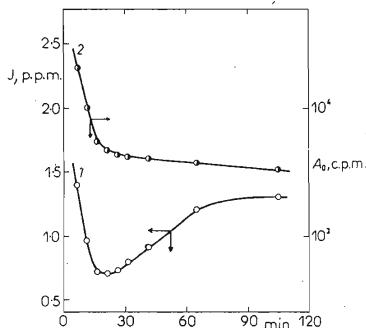


FIG. 1

The Dependence of the Determination Limit of Iodine and the Background of the Characteristic Line on the Delay t_v

$J = \log c_j^{min}$; A_0 the measured pulse rate for the 0.46 MeV line used for the determination of iodine.

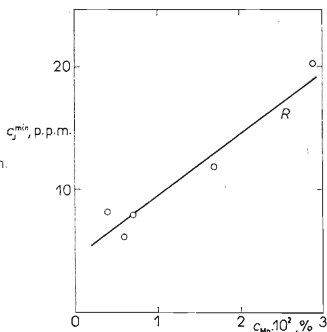


FIG. 2

Correlation between the Content of Manganese and the Determination Limit of Iodine in Soils

an effect on this sensitivity. Analysis of the γ -spectra and their comparison with the spectra of standard iodine preparates enabled to determine the limit of the iodine determination, c_j^{min} , in soil samples. The obtained values of c_j^{min} vary with the time lag between the irradiation of the sample and the measurement of its γ -spectrum, *i.e.*, with the delay time t_v . The dependence of c_j^{min} on t_v has a characteristic shape with a minimum and it can serve for the determination of the range of t_v values for the optimum measurement of irradiated samples (*cf.* curve 1 for the sample of the brown soil in Fig.1). The dependence of the background (curve 2 in Fig. 1) together with the decay curve of ^{128}I explains also the minimum on the dependence of c_j^{min} on t_v . Analysis of these curves, obtained for the soils given in Table I, showed that the best interval for the measurement of samples activated by neutrons is after 15–30 min after the irradiation.

The determination limits of iodine by the method of instrumental activation analysis vary within rather broad limits and depend on the chemical composition of the analyzed sample. The analysis of the results obtained for a series of 15 samples gave $c_j^{\text{min}} > 5$ p.p.m. For the soils given in Table I the values of c_j^{min} range from 6 to 21 p.p.m. The value of c_j^{min} is most affected by the content of manganese in soils and in a lesser extent also by the content of aluminum. The dependence of c_j^{min} on the content of manganese in the soil for the samples given in the table is shown in Fig. 2, where the experimental points are plotted together with a calculated regressive straight line.

In trace experiments with iodine the natural content of iodine in the soil and its variations with the soil type must be taken into consideration. Higher concentrations

TABLE I
Content of Several Elements in Soils

Element	Chernozem	Brown soil	Brown acid soil	Podzolic soil	Illimerized soil
Na, %	0.64	0.61	0.43	1.49	0.76
Mg, %	1.3	0.5	1.2	1.1	1.1
Al, %	4.6	3.6	5.3	6.7	4.4
K, %	2.3	1.8	2.4	3.9	1.9
Ti, %	0.42	0.40	0.24	0.15	0.47
Mn, %	0.07	0.06	0.17	0.04	0.29
V, p.p.m.	76	56	67	36	79
Ba, p.p.m.	380	460	420	290	450
Eu, p.p.m.	1.3	1.1	<1.5	<1.5	<1.5
Dy, p.p.m.	7.7	6.2	2.6	5.0	5.5
U, p.p.m.	2.7	2.9	<2	<3	<3

have been found in heavy clay soils, in alkaline soils and also in clay soils with a high content of loess and colloids. On the other hand low concentrations of iodine are typical for podzolic soils, sandy and clay soils with a low content of loess. The data for the natural content of iodine in soils range⁶ from 0.1 to 6 p.p.m., sometimes the upper limit is as high as 18 p.p.m. (cf.¹⁰). The sensitivity of the instrumental neutron activation analysis is therefore insufficient for the determination of the natural content of iodine in the soils so that this determination must be done only after the destruction of the sample, when all the interfering components were removed. According to ref.¹¹ the decomposition of the sample must be done in all soil samples in which the content of organic components is <80%. On the other hand the sensitivity of the instrumental method is adequate for a large number of trace experiments in soils.

REFERENCES

1. Knälmann M.: *Thesis*. Technische Hochschule, Hannover 1967.
2. Benecke P.: *Isotope and Radiation Techniques in Soil Physics and Irrigation Studies*, p. 227. IAEA, Vienna 1967.
3. Bondarenko E. H., Globus A. M.: *Isotope and Radiation Techniques in Soil Physics and Irrigation Studies*, p. 291. IAEA, Vienna 1967.
4. Essington E. H.: *Evaluation and Selection of Tracers for Field Measurement of Coefficient of Dispersion*. Report NVO-1229-176, Las Vegas 1971.
5. Lallemand A., Grison G.: *Isotope Hydrology*, p. 823. IAEA, Vienna 1970.
6. Kühn W. K. G.: *Isotope and Radiation Techniques in Soil Physics and Irrigation Studies*, p. 271, IAEA, Vienna 1967.
7. *The Radiochemical Manual* (B. J. Wilson, Ed.), 2nd Edition, p. 194. The Radiochemical Centre, Amersham 1966.
8. Frána J., Vobecký M., Řanda Z., Benada J., Kuncič J.: *Radiochem. Radioanal. Letters* 8, 97 (1971).
9. Beneš J., Dlouhý Z.: *Jaderná energie* 18, 229 (1972).
10. *Gmelin's Handbuch der Anorganischen Chemie, Jod*. Verlag Chemie, Weinheim/Berlin 1955.
11. Lag J., Steinnes E.: *Isotopes and Radiation in Soil-Plant Relationships Including Forestry*, p. 383. IAEA, Vienna 1972.

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