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Influence of Various Factors on the Content of Iodine in the Soils of Western Siberia

ABSTRACT

Important biological role of iodine is due to the fact that being a part of the hormones thyroxine and triiodothyronine, it regulates the rate of metabolism in living organisms. In this paper we present the results of the study of the content and patterns of distribution of iodine in soils of Western Siberia, which are the link in the chain: the atmosphere-soil-water-plants-animals and people. Soil, due to its accumulative properties, refers to natural objects, concentrating iodine. If we talk about the barriers, where there is concentration of halogen, it is a priority for iodine -biochemical -the accumulation of soil organic matter. Geochemical barrier for iodine exists only in the evaporation conditions. The study of the content and distribution of iodine in different types of soil showed that the accumulation of these halogen most influence their degree of humus content. On the processes of accumulation and migration of iodine in the soil profile is influenced by other physical and chemical properties of soils: size distribution, the reaction of the soil medium, the content of iron and aluminum oxides, as well as the type of water regime and chemical properties of the trace element. We have studied the content of I in the soils of Western Siberia in the direction from north to south. Soils of tundra and forest tundra (typical cryozems and coarse humus cryozems, cryometamorphic cryoturbic cleyzems, entic podsols). These soils are largely characterised by the low concentration of humus that varies from 0.07% to 3.12%, sometimes the absence of distinct humus horizon (podzols) and the excess of fulvic acids. Soils that have low pH are characterised by low level of iodine retention. Contrary results were obtained from soils samples taken in the southern parts of Western Siberian Region. At the sod-podzolic soils, gray forest soils of the iodine content was respectively 1.36 -2.36 and 1.44-2.82mg/kg. These soils are well-drained, low on humus content and have low pH. Chernozems (categories zonal soils) are the most iodine-rich soils (min 1.2, max 6.4mg/kg) due to their

higher than average level of organic matter. Albic luvisols и haplic kastanozems soils can be attributed to the middle range based on their iodine concentration. Within the intrazonal group of soils, alkali soils are found to have the highest level of iodine content (min-5.6, max-33.2 mg/kg). The solonchak is located in low lying grounds that are often to be found in an iodine-rich environment. The more alkaline (higher pH) a soil is the greater is its iodine concentration. Several smaller halogen found in solonetzes (min-1.8, max-18.7 mg/kg) with a maximum in the illuvial horizon enriched by fine mineral particles, oxides and hydroxides aluminium and iron, volumetric rainfall which ness actively absorb iodine. In stratozemah easily exposed to wind and water erosion, humus content does not exceed 0.5%, which resulted in low levels of iodine 0.12-1.43mg/kg.

Important biological role of iodine is due to the fact that, being a part of the hormones of thyroxine and triiodothyronine, it regulates the rate of metabolism in living organisms. Deficiency of the microelement leads to the development of endemic goiter, and its excess - to iododerm - the allergic reaction to contact with excess of iodine.

The quantitative content of microelement in the human body is in direct proportion to their concentrations in different components of the environment such as rocks, soils, natural waters and atmospheric air (aerosol chemical elements).

Therefore, in this report we present the results of studying the content and distribution of iodine and its forms in soils of Western Siberia. The soils are an important link in the chain: atmosphere-soil-water-plants-animals and people.

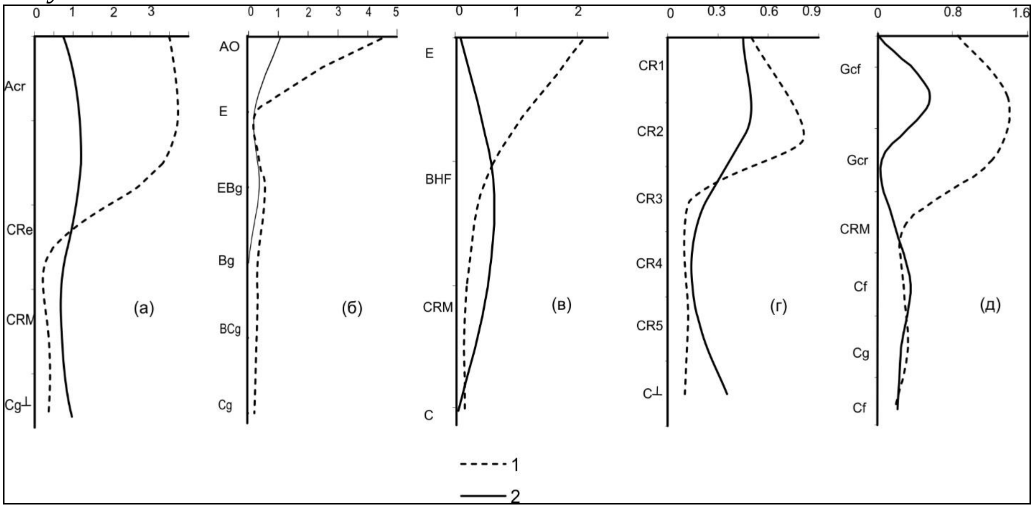
The study of the content and distribution of iodine in different soil types showed that the highest its accumulation in soils was influenced by humus content (Vinogradov, 1957; Whitehead, 1978; Yamada, Hidekazu et al., 1999). The other physicochemical properties of soils, such as soil reaction, particle size distribution, concentration of oxides iron, aluminum and carbonates, readily soluble salts, type of water regime and chemical properties of itself element are influenced a lesser extent the halogen accumulation.

We studied the soils on the territory of Western Siberia in the direction from the north to the south. The soils of the zones of tundra and forest tundra have been studied such as cryometamorphic cryoturbic gleysols, haplic cryosols, coarse humus cryosols and podzolic podburs ashed. The content of iodine in these soils will be negligible because here no preconditions for its significant accumulations.

The content of humus in the soils under study ranges from 0.1 to 1.4%. Maximum content of clay fraction does not reach even 20%, so that its ability to fix or adsorb halogen is limited. The reaction medium in these soils is acidic and strongly acidic, so that its contribution to the accumulation of halogen is negative. The reactions (taking place in an acid medium) lead to the formation of free iodine, which subsequently evaporates.

It is known that the sorption of iodine is enhanced in the presence of various salts, but in this case there is no question of an enrichment of northern soils by different salts, therefore, the contribution of this factor is also negative. The results are shown in Figure 1.

Figure 1. *Distribution of Humus, % (1) and Iodine, mg/kg (2) in Soil Profile of the North of the Western Siberia: a – Coarse Humus Cryosol, b – Gley-Podzolic Soil, c – Podzolic Podbur, d – Haplic Cryosol, e – Cryometamorphic Gleysol*



The content of water-soluble iodine varies within the range of 0.002-0.026 mg / kg.

This is followed by soil of the northern and middle taiga (gleyic albeluvisols, haplic podsols). They have much in common with the previous soils, for example, low humus content, acidic and weakly acidic medium, periodically washing type of water regime in upper horizons. The iodine content varies in these soils from trace amounts to 1 mg/kg.

For comparison, the data are given on zonal soils spread southward such as sod-podzolic, cutanic luvisols, haplic chernozems, luvic chernozems and haplic kastanozems (Figure 2, Table 1), where iodine content is already more significant, especially in chernozems. This fact is due to the high content of humus and clay fraction. Humus acids are markedly predominant among organic compounds. It was established experimentally that the iodine is mainly fixed with humic acids (88%). Only 12% of iodine is accounted for fulvic acids [2] (Table 1).

Figure 2. *Distribution Humus, % (1) and Iodine, mg/kg (2) in the Soil Profile Western Siberia: a- Haplic Chernozems, b- Luvic Chernozems, c- Cutanic Luvisols, d- Gleyic Albeluvisols, e- Haplic Podsols*

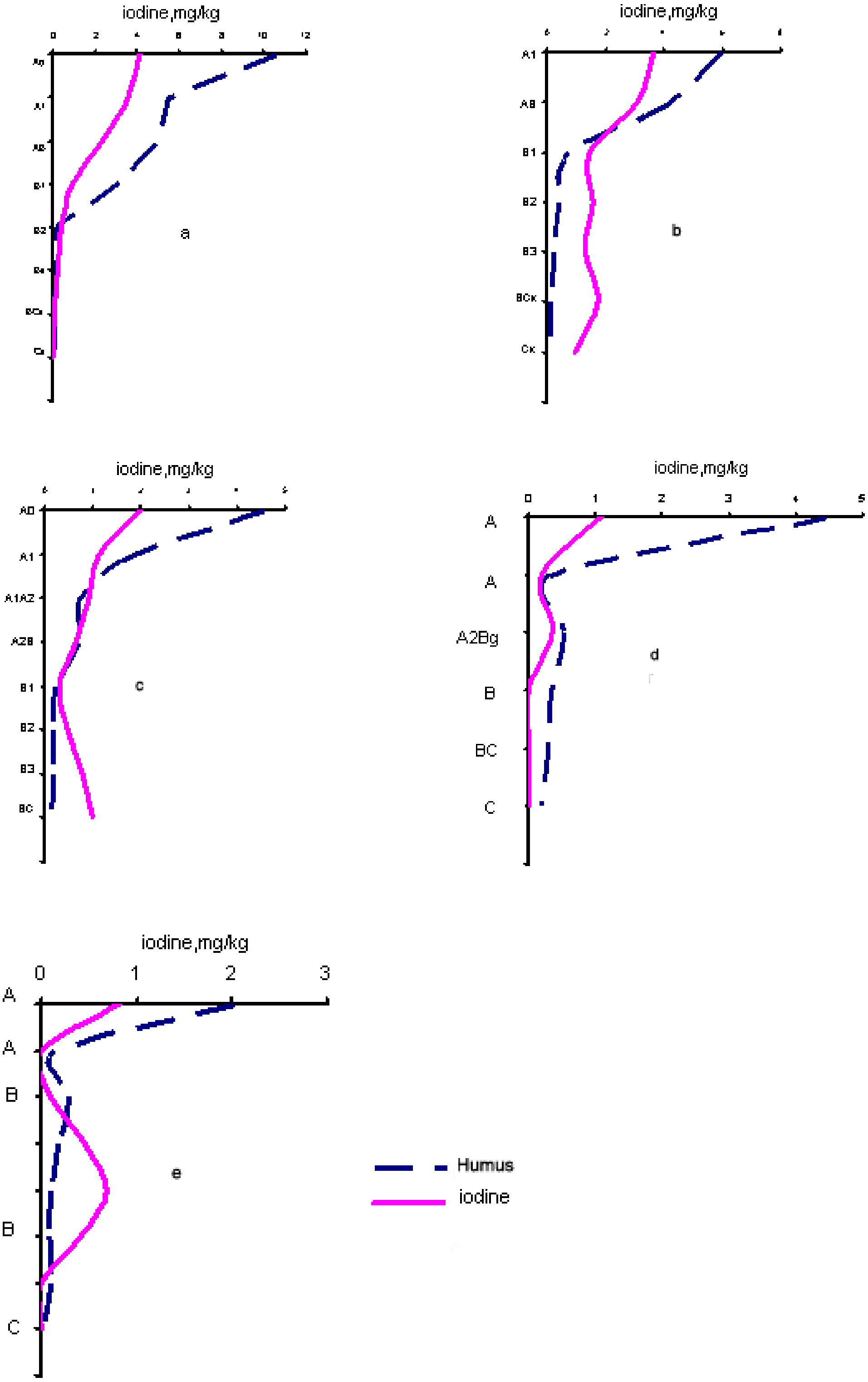


Table 1. *Physicochemical Properties of Zonal Soils and their Iodine Content*

Soil type	pH	Physical clay	Humus	Iodine, mg/kg	
		%		Total	$H_2O_{soluble.}$
Zonal soils					
Haplic albeluvisols	4.9-6.5	39.4-54.9	0.1-1.98	0.6-2.20	traces-0,006
Cutanic luvisols	5.3-7.2	42.0-65.56	0.18- 2.54	0.64- 3.2	0,015-0,038
Chernozems	6.6-8.3	45.5 – 65.3	0,41 – 6.0	1.2- 6.72	0,01-0,09
Haplic Kastanozems	6.4-8.2	15.48-33.20	0.14-2.42	traces-2.60	traces-0,024
Intrazonal soils					
Solonetz	7.3- 9.7	27.8-57.0	0.12-2.40	2.1-14.3	0.05-0.6
Solonchaks	8.3-10.5	36.0-59.0	0.53- 6.93	5.6-33.2	0.08-1.1

Haplic Albeluvisols are least rich in iodine, as they are poor in humus, have an acid reaction of the soil medium and a washing water regime, which intensifies migration and halogen losses. Gray forest (Cutanic Luvisols) and Haplic Kastanozems soils occupy an intermediate position by the degree of saturation with iodine.

Higher content of iodine is characteristic for intrazonal soils, such as solonetzes and solonchaks, it is favored by some factors, for example strongly alkaline medium, pH value ranges at a level of 8.5 -10. Under these conditions the formation of the most stable anions of iodine takes places, i.e. I^- and IO_3^-. The formation of these soils occurs in the lowest places of intermountain depressions which are the final point of local transgression of salts, including iodine salts as well. Halogen content in solonetz is slightly lower than in solonchaks, but at the same time it is significantly higher than in zonal soils. The maximum content of iodine in makes up 19.7 and 35.4 mg/kg in solonetzes and solonchaks respectively.

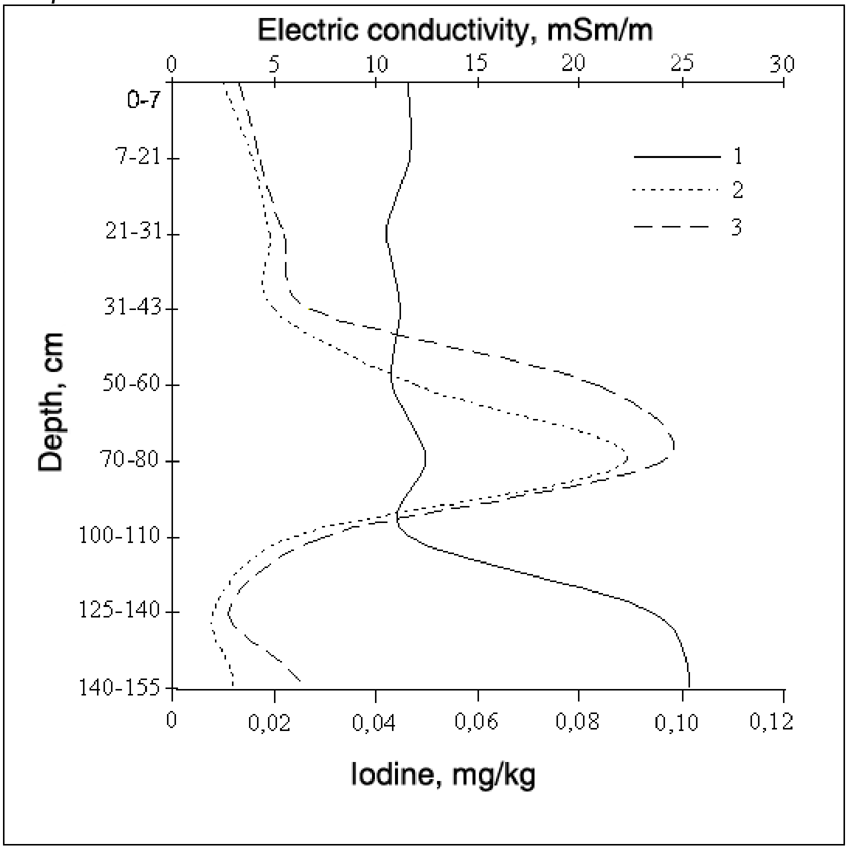
We studied in detail the planosols and fluvisols of Kulunda plain. The main type of water regime of planosols is periodically wash. Low content of organic matter in the humus horizon (2.61 -3.28%) and humus-eluvial (0.28-1.31%) and increased its fulvate acids suggest low iodine content in the planosols. It is known that a light-graded soil iodine poorer than heavy-graded soil, due to the fact that less light soils iodine chemically bound to the components of the soil, and more - and the mechanisms associated occlusion. Gross iodine content in the planosols varies from 0.02 to 1.68 mg / kg, the salt-soluble form varies from 0.01 to 0.09 mg / kg.

The studing stratozems (Fluvisols) distributed also in the territory of the Kulunda plain. These soils are an unstable link in the landscape of agricultural meadowlands (grasslands and pastures). They are easily exposed to wind and water erosion, and their area transformation can lead to the change of the properties of surrounding areas. Obvious decrease in depth of humus content, as it is characteristic of the zonal soils, was not observed here, whereas there is a very slight layer change in its content throughout the profile. These soils are sandy by texture, physical clay content is less than 10%, clay fraction makes up 4-6%; pH value ranges within the limits of 7.74- 9.03. The upper horizons are not saline; the lower ones have slight soda-chloride salinization (Table 2).

Table 2. *The Content of Total Iodine and its Mobile Forms in Fluvisols*

Horizon	Depth of sampling, cm см	Iodine, mg/kg		
		total	salt-soluble	Water-soluble
AJ_{aq}	0-7	0.58	0.013	0.010
D_1	7-21	1.19	0.017	0.016
D_2	21-31	0.74	0.022	0.019
RJ_{aq1}	31-43	0,70	0.027	0.020
D_3	50-60	1.43	0.084	0.048
RJ_{aq2}	70-80	1.96	0.096	0.089
D_4	100-110	0.62	0.029	0.023
RJ_{aq3}	125-140	0.12	0.011	0.008
D_5	140-155	0,21	0.025	0.012

Figure 3. *The Distribution of the Electric Conductivity of Aqueous Extract (1), A Water-Soluble Iodine (2) and Salt-Soluble (3) in Fluvisols (Stratozem) Profile*



Thus studies have shown that the soil of Western Siberia in the direction from north to south are gradually enriched with iodine, the maximum content of which is observed in Solonchaks. The soils with a low content of halogen are found both in the north and in the south of Western Siberia.

The gross amount of iodine, according to the criteria proposed by Kowalski in 1972, is estimated as follows: 5 mg / kg - insufficient, 5-40 - normal and more than 40 mg / kg -excess. The amount of water-soluble iodine, according to the criteria proposed by Pokatilov in 1993, is estimated as follows: low 0.011-0.03, decreased 0.03-0.05, optimal 0.05-0.1 mg / kg.

So, one can state general considerations about the ecological status of iodine in Western Siberia. Almost all types of zonal soils are depleted of gross iodine, except for chernozems. Solonchaks, solonetses are provided with iodine. There is a clear deficit of water-soluble iodine in many types of soils. Sometimes the content of iodine in plants exceeds the concentration of water-soluble form of halogen. This means that other mobile forms, in particular the soluble form, also participate in plant nutrition. This makes it necessary to further study it, especially since its concentration is higher than the water-soluble form.