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THE PROPERTIES OF SOILS OF ERODED MORAIN AREAS  
WITH PARTICULAR ALLOWANCE FOR QUALITATIVE  
COMPOSITION OF ORGANIC MATTER

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Biological, physical, and chemical properties of soils on which the yield of plants depends, reflect a complicated and causally connected soil forming processes. The role of humus in the formation of the mentioned above properties is very important and commonly known. Nevertheless this problem is much more complicated in hilly areas where “soil forming processes” and “soil processes” are affected by erosion. The numerous data are quoted in the world and native literature which prove that there is a great differentiation in the thickness of humus layers and content of humus in the soils of different parts of slope. In general there are no publications on the changes of properties and composition of humus, caused by erosion. In Polish soil science literature only two positions indicate that these differences occur [1, 4]. In connection with this it was decided to take this problem under investigations which are carried out on Masurian Lakeland by the workers of the Soil Science Department of the College of Agriculture in Olsztyn.

METHODS

Four soil cross-sections of many performed in Masurian Middle Lakeland were chosen to detail investigations. They were: Zawidy, Wilkowo, Jeziorany, Orłowo (districts Kętrzyn and Reszel). On each slope the samples were taken from all genetic horizons and, in the case of deluvial soils, from every layer. The ditches for sampling were made in each characteristic part of slope.

The samples were analyzed on: mechanical composition, chemical properties, exchange capacity. The qualitative analysis of organic matter was carried out by Tiurin method [2, 3]. Besides in the humic acids of

I group (extractable by 1n NaOH) the flocculation according to Kononova's method [2] and the optical density with spectrophotometer were determined.

## RESULTS

The soils of investigated slopes belong to different types, developed on morain loams. On tophills and eroded parts of slopes the brown and brown leached soils occur. On lower parts of slopes and in basins the deluvial soils of different types are found.

The morphological differentiation of soil layers caused by erosion occurs on each particular part of slope. The soils differ with mechanical and chemical composition, cation exchange capacity as with quantity of exchangeable bases.

The washed deposits (deluvial sediments on lower parts of slopes) contain 7—35 per cent more sand and 1—31 per cent less clay (particles smaller than 0,02 mm.) to compare with soils of higher parts of slopes. Instead the deluvial deposits in valley with restricted outflow and in basins contain 6—30 per cent less sand and 12—50 per cent more clay respectively.

In respect to the contents of  $\text{Fe}_2\text{O}_3$ ,  $\text{CaO}$ ,  $\text{MgO}$ ,  $\text{P}_2\text{O}_5$  the deposits of lower parts of slopes are the poorest, slightly richer are soils on slope and the richest sediments in valleys and basins. The latter contain from 1.5 up to 3 times more of these components, to compare with soils on the slope. The changes of chemical properties may be also deduced from the ratio of  $\text{SiO}_2$  to  $\text{R}_2\text{O}_3$ . This ratio in sediments of basins is 2.27—3.25, in soils on slopes and tophills is larger 5.86—9.25 the largest is in the washed sediments on slope 11.37—13.19.

It was confirmed that exchange capacity as well as quantity and quality of exchangeable cations are in strict correlation with mechanical composition, content of humus and are changed by soil erosion processes. Sediments in basins and in valleys with restricted outflow have 2.5 times higher exchange capacity (in upper horizon 0—25 cm.  $Eh = 14.69—37.11$  m e/100 g. of soil), in deeper layers  $Eh = 16.02—70.82$  m e/100 g. of soil, than in eroded soils on slope (in horizon  $A_1$   $Eh = 6.18—18.62$ , deeper 7.14—26.82).

To compare with washed deposits the exchange capacity of sediments in the valley was 4 times higher. The sediments in basins and in valleys with restricted outflow always show out a very high degree of saturation with basic cations with regardless of the acidity of the soils of the higher parts of slopes.

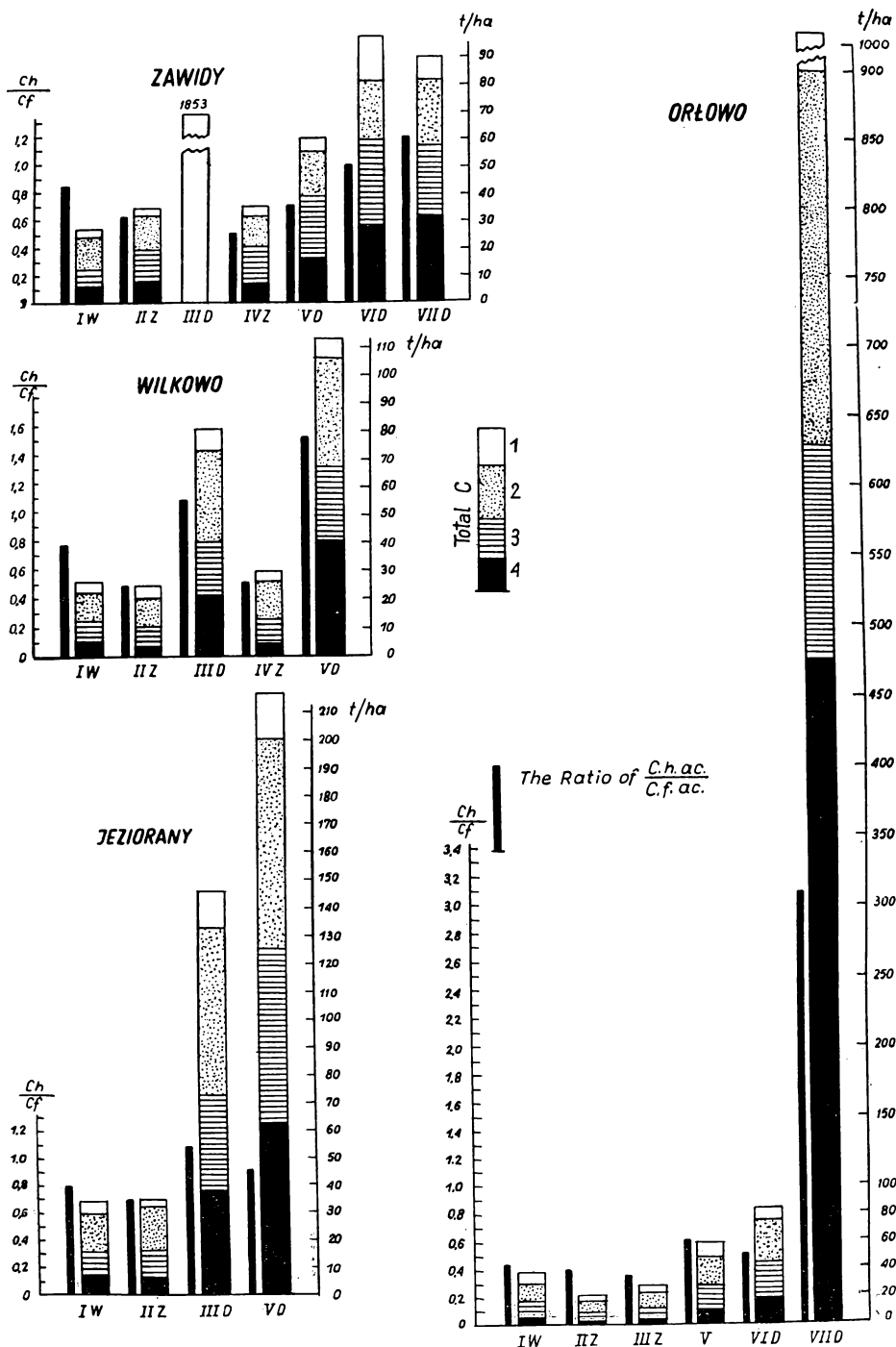


Fig. 1. Resources of organic carbon in rolling territory in tons/ha  
 Total C: 1 — C humic acids, 2 — C fulvic acids, 3 — C of humins and ulmins, 4 — other fractions.  
 Soils: W — soils on hilltop, Z — soils denuded by erosion, D — deluvial soils slope, I, II, III ... —  
 Nr. of profiles

The carried-out investigations indicate, that the content of humus and its composition vary under influence of erosion. It may be seen in Fig. 1 in which the total content of C (in tons/ha) into the whole humus horizon is presented as a diagram, as well as the participation of C of individual fraction of humus in total carbon content.

In both types of soils situated on slopes, because of erosion and leaching of more mobile components of humus, the relative content of bitumins (which are more stable forms) increases.

The content of humic acids of I group expressed as per cent of total C of organic matter was: from 10.25 per cent up to 17.87 per cent in the soils of tophills and eroded slopes and, in the deluvial deposits from 12.5 per cent up to 45.8 per cent.

The proof of different course of humus forming processes on hilly areas is the ratio of C humic acids (Ch) to C of fulvic acids (Cf). This ratio (Ch:Cf) in soils on tophills is from 0.62 up to 0.91, in soils on eroded slopes from 0.41 up to 0.63 but in deluvial soils it extends very often over 1. It shows that in eroded soils the humus is "younger" than on tophills and in deluvial sediments.

Determinations of optical density (Fig. 2) and flocculation of the humic acids of I group confirmed correctness of our supposition of the possibilities of quantitative differentiation of humus in rolling areas. Humic acids extracted from eroded soils in general showed out the lowest optical density what indicate they have less complicated structure. Those from deluvial soils appeared to be the "ripest" forms — the most polimerized. In deluvial soils the "ripeness" (degree of polimerization) of humic acids increases with depth.

The susceptibility of humic acids to flocculation also confirmed that above holds true. The humic acids of I group from soils on tophills coagulated at 30—40 m e of  $\text{CaCl}_2$  per liter of humic acids solution during 2 hours since coagulator was added. (The concentration of humic acids was 100 mg. C/l. of solution). At this quantities of  $\text{CaCl}_2$  the coagulation in most cases was not complete. The humic acids from eroded soils were the most stable against coagulation. They did not coagulate even at 40 m e of  $\text{CaCl}_2$  (except one case). On the other hand the humic acids from deluvial soils coagulated easily an very easily at 2—15 m e of  $\text{CaCl}_2$ . Very often the coagulation was observed just after adding of coagulator. Only humic acids extrated from too moist deluvial soils were more stable on coagulation than those from deluvial soils of higher parts of slopes, but in every case they coagulated more easily than humic acids from eroded soils.

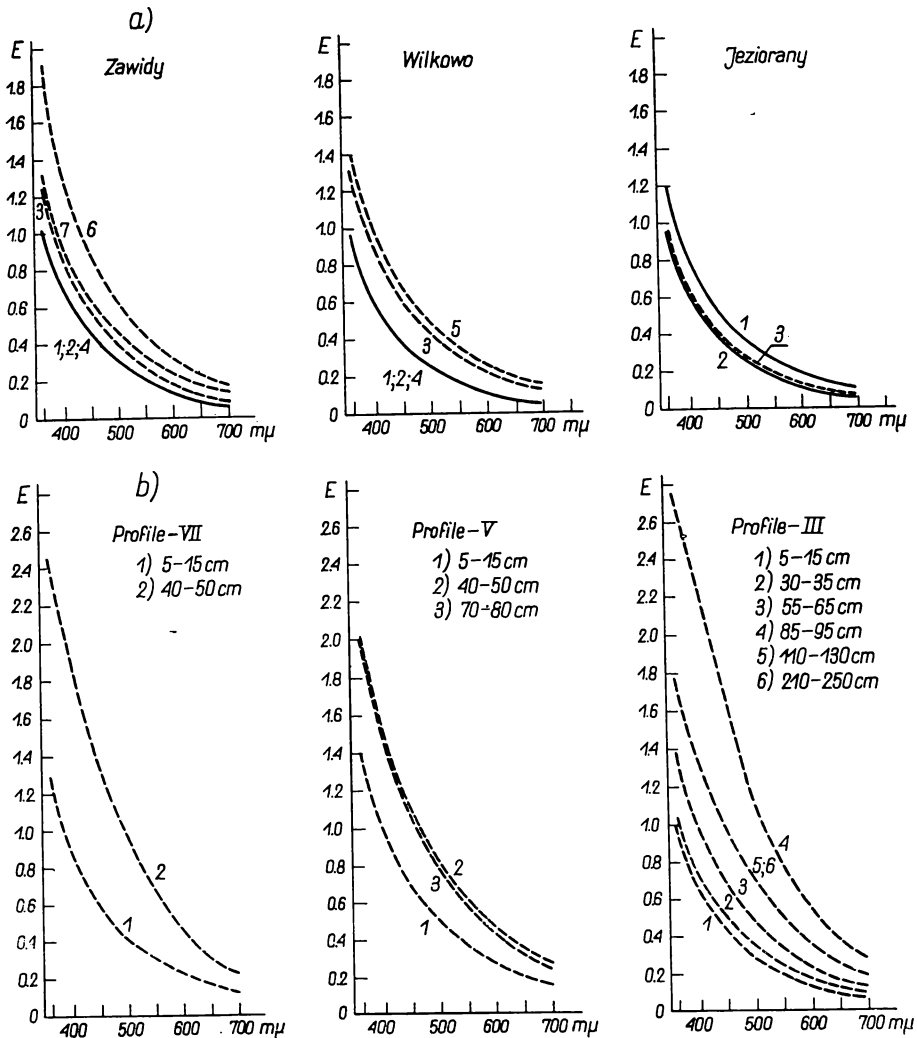


Fig. 2. Optical density of humic acids of I group

a — from soils of different parts of slope (horizon  $A_1$ ), b — from deluvial soils; 1–7 — Nr. of profile, — — humic acids from deluvial soils, — — humic acids from other soils on the slope

The results of our investigations allow to make the following conclusions.

1. As a result of soil erosion processes in Masurian Middle Lakeland the differentiation of soils with regard to mechanical and chemical composition, exchange capacity, content and character of humus take place.

2. The poorest soils in humus are those eroded on slopes, slightly richer — on topfills and the richest deluvial soils in basins and valleys with restricted outflow.

3. With an increase of the content of humus an increase of the absolute content of humic acids was always observed.

4. The humic acids from eroded soils on slopes show the lowest degree of polymerization. It may be deduced from: the ratio of Ch:Cf, the optical density of humic acids of the I group as also from the resistance to coagulation with  $\text{CaCl}_2$ . Humic acids from deluvial soils showed out the highest degree of polymerization amongst those under investigations.

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#### DIE EIGENSCHAFTEN DER BÖDEN IN ERODIERTEN MORÄNENGEBIETEN, MIT BESONDERER BERÜCKSICHTIGUNG DER ZUSAMMENSETZUNG DES BODENHUMUS

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#### Zusammenfassung

Die quantitativen und qualitativen Verhältnisse, die im Bodenhumus — unter dem Einfluss der Wassererosion gestaltet werden — sind bis jetzt noch kaum erforscht worden. Dieses Problem zu klären, wenn auch nur teilweise, war das Ziel einer Arbeit, die im hügeligen, mittleren Teil des Masurischen Seengebietes durchgeführt wurde. Der Verfasser prüfte die chemische Zusammensetzung des Humus und auch dessen Sorptionsvermögen sowohl der Böden auf den Hügelkuppen- und Hängen, als auch derjenigen, die sich am Fusse der Hänge als Deluvial (Coluvial)-Böden abgelagert haben. Er stellte fest, dass zwischen den Eigenschaften dieser Böden bemerkenswerte Unterschiede auftreten insbesondere im Sorptionsvermögen und der Zusammensetzung des Humus. Die Deluvial-Böden, die in Tälern mit schwachem Wasserabfluss (oder sogar ohne Abfluss) abgelagert wurden, haben sich als die nährstoffreichsten erwiesen. Es zeichnet sie, unabhängig vom Chemismus der Böden an den Hängen und auf den Kuppen, ein hoher Sättigungsgrad aus. Dagegen die, an den unteren Hängen abgesetzten Böden sind die ärmsten. Auf Grund des allgemeinen Gehaltes an Huminsäuren, des Verhältnisses Ch:Cf, des Durchsichtigkeitsgrades dieser Säuren und deren Koagulationsschwelle konnte festgestellt werden, dass die Huminsäuren der Deluvialböden den höchsten, die erodierten Böden der Hänge, den niedrigsten Polymerisationsgrad aufweisen. Die Polymerisation der Huminsäuren wächst in den Deluvialböden im allgemeinen mit der Tiefe an

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## LES PROPRIÉTÉS DES SOLS DANS LES TERRAINS MONTEUX DE MORAINES, AVEC MISE EN ÉVIDENCE PARTICULIÈRE DE LA COMPOSITION D'HUMUS

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## R e s u m é

Les changements quantitatifs et qualitatifs de l'humus, qui ont lieu sous l'influence de l'érosion pluviale ne sont jusqu'à maintenant qu'insuffisamment étudiées. Résoudre ce problème, au moins partiellement, était le but d'un travail réalisé dans la partie centrale de la Masourie en Pologne. L'auteur a déterminé la composition chimique de l'humus et son pouvoir absorbant dans les sols des sommets, des pentes et des pieds des collines. Les sols colluviaux, dans de petits vallons, avec l'écoulement faible d'eau, sont les plus riches en éléments minéraux. Ils se caractérisent par un taux de saturation élevé indépendamment des propriétés chimiques des sols des pentes et des sommets. Les sols sédimentés aux pieds des pentes sont au contraire les plus pauvres en éléments nutritifs. La détermination de la teneur totale en acides humiques, de leur densité optique et de leur seuil de floculation ainsi que du rapport  $Ch : Cf$  a permis de conclure que le degré de polymérisation des acides humiques dans les sols colluviaux est le plus élevé, tandis que celui des sols sur les pentes est le plus bas. La polymérisation des acides humiques dans les sols colluviaux augmente avec la profondeur.

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WŁAŚCIWOŚCI GLEB TERENÓW MORENOWYCH ERODOWANYCH  
ZE SZCZEGÓLNYM UWZGLĘDNIENIEM SKŁADU  
JAKOŚCIOWEGO PRÓCHNICZY

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## S t r e s z c z e n i e

Z uwagi na brak opracowań odnośnie wpływu erozji na ilościowe i jakościowe zmiany próchnicy glebowej w terenach urzeźbionych w Katedrze Gleboznawstwa WSR w Olsztynie postanowiono zbadać to zagadnienie na obszarach morenowych Pojezierza Środkowo Mazurskiego. Badano skład chemiczny gleb, własności sorpcyjne oraz skład próchnicy glebowej. Na podstawie uzyskanych danych stwierdzono, że gleby poszczególnych elementów stoku różnią się pod względem wyżej wymienionych właściwości. Szczególnie duże różnice występują w pojemności kompleksu sorpcyjnego, stopniu nasycenia zasadami i składzie próchnicy. Najzasobniejsze w składniki okazały się gleby deluwialne kotlin i dolin o utrudnionym odpływie. Wykazują one zawsze bardzo wysoki stopień nasycenia kationami zasadowymi bez względu na chemizm gleb wyższych partii stoku. Najuboższe były gleby deluwialne położone w dolnych partiach stoku. Na podstawie zawartości kwasów huminowych, stosunku  $Ch : Cf$ , gęstości optycznej i progu koagulacji stwierdzono, że najwyższy stopień polimeryzacji posiadają kwasy huminowe z gleb deluwialnych, najniższe — z gleb podlegających erozji na zboczu. W glebach deluwialnych stopień polimeryzacji kwasów huminowych na ogół wzrasta wraz z głębokością.

## З. МИРОВСКИ

СВОЙСТВА ПОЧВ МОРЕННЫХ ЭРОДИРОВАННЫХ РАЙОНОВ  
С ОСОБЕННЫМ УЧЁТОМ КАЧЕСТВЕННОГО СОСТАВА ПЕРЕГНОЯ

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## Резюме

В виду недостатка работ по влиянию эрозии на качественные и количественные изменения почвенного перегноя в районах с изрезанным рельефом, проводили исследования по этому вопросу на моренной территории Средне-Мазурского Приозерья. Определяли химический состав почв, сорбционные свойства и состав почвенного перегноя. На основании полученных данных установлено, что почвы отдельных элементов склона различаются по выше перечисленным свойствам. Особенно больше различия наблюдаются в ёмкости сорбционного комплекса, степени насыщенности основаниями и в составе перегноя. Наиболее богаты компонентами оказались делювиальные почвы котловин и долин с затрудненным оттоком. Эти почвы обладали всегда высокой степенью насыщенности основаниями независимо от химизма почв более высокой части склона. Наиболее бедными были делювиальные почвы, лежащие в нижней части склона. На основании содержания гуминовых кислот, отношения  $S_{гум.} : S_{фульв}$  оптической плотности и предела коагуляции установлено, что наиболее высокой степенью полимеризации обладают гуминовые кислоты делювиальных почв, наиболее низкой — подверженные эрозии почвы на склоне. В делювиальных почвах степень полимеризации гуминовых кислот увеличивается совместно с глубиной.