CONTRIBUTIONS OF SOIL ORGANIC MATTER TO PRODUCTION POTENTIAL OF SOILS AND SOME PROPOSALS FOR PRACTICAL APPLICATION

Wolfgang FLAIG

Annex II

to the report of W. FLAIG

9 Lectures about: Contributions of soil organic matter to production potential of soils and some proposals for practical application.

delivered at Nuclear Research Laboratory, Indian Agricultural Research Institute, New Delhi, from 12. July to 18. September 1973.

Country	:	India
Project	:	Ind-68-589 - Nuclear Research in Agriculture
Name of Expert	:	Prof. Dr. W. Flaig
Field Report No.	:	Final Report
Period	:	5 July - 30 September 1973
Post Title	:	Soil Chemistry (Soil Organic matter)
Date	:	28th September, 1973

CONTRIBUTIONS OF SOIL ORGANIC MATTER TO PRODUCTION POTENTIAL OF SOILS AND SOME PROPOSALS FOR PRACTICAL APPLICATION

Wolfgang FLAIG

1973

Preface

The increase of yield/ha is important for the food production of Indian Population. For this purpose firstly high yielding varieties of rice, wheat and other crops were bred. These demand a higher quantity of mineral fertilizers. Fertilization alone does not allow the realization of the full genetical potential of cereals. The inorganic ions of the fertilizers enhance also microbial activity. The microorganisms use the carbon from soil organic matter as source for energy and reproduction. As a consequence of decrease of soil organic matter unfavourable processes in soil, the substrate for production occur, which cause a reduction in plant production. Therefore an increase of yield by fertilization alone is limited.

Another way to overwhelm the biological border for the use of the genetical potential of cereals is to utilize the effect of bioregulators on plant metabolism, such as CCC, "Cycocel" to increase the resistance against lodging of wheat. There are some other substances in soil organic matter, which have bioregulating effects under unfavourable growth conditions. This influence of soil organic matteron yield is well known by the farmers as "humate-effect".

Therefore, it is evident, that special procedures for maintaining a critical status of soil organic matter should be followed. More research about humus is necessary. An intensive cereal production is then economical only, when yields are always maintained at a relatively high level. One should try to minimize the yield depressions by appropriate procedures.

The lecutes are an introduction into the problems. The transfer of results of basic research into practice are mentioned and the experiences about the utilization of new findings are summarized.

I have to thank Mr. M.S. Sachdev (M.Sc.) for his indefatigable help, for the revision of the lectures and for compiling the references.

Wolfgang FLAIG

New Delhi, 29. September 1973

Content

Lecture - 8

CHARACTERIZATION OF HUMIC SYSTEMS IN DIFFERENT SOILS

1. Determination of similarity degrees of humic acids by light absorption.
2. Scheme for analysis of humic systems.
3. Example for characterization of humic systems in a morphosequence of soil.
4. Final remarks and Conclusions.

1. Determination of similarity degrees of humic acids by light absorption.

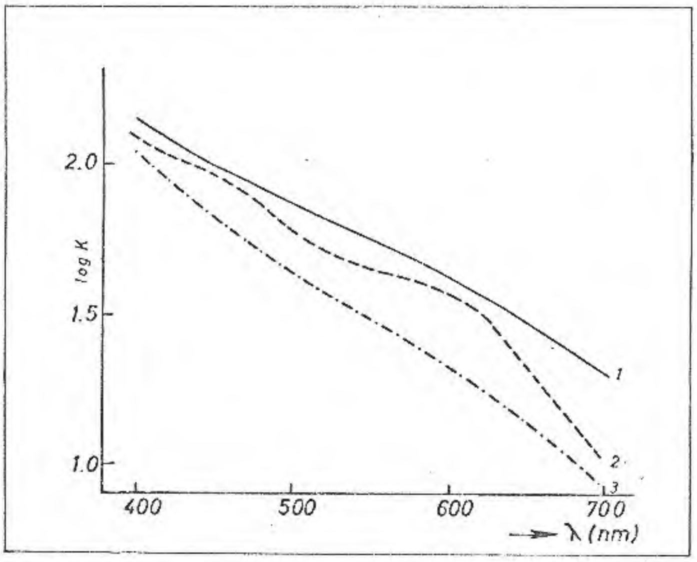

Fig. 1: Spectra of different humic acids. (1) Chernozem, (2) podzol B and (3) black peat in 0.1 N NaOH.

At first it must be established, that the spectra of humic acids are not linear, as the classical soil chemistry describes them. The spectra of humic acids are curved lines, which are different upon the origin of the humic acids. It shall be remembered, that the ratio of the quantities of phenols found after oxidative or reductive cleavage depends on the origin of the humic substances, and that the content and ratio of amino acids differs also after acid hydrolysis.

Therefore the spectra cannot be characterized completely according to classical theory by means of only one quotient of two extinctions at about 400 and 600 nm = 4/6 ratio or by the differences of the logarithms of two extinctions e.g. log 405 - 665.

To expand the possibilities for characterization of humic systems by means of spectrophotometric measurement, the extinction coefficients of three or more ranges of nm in the spectra have been used (SALFELD, 1972).

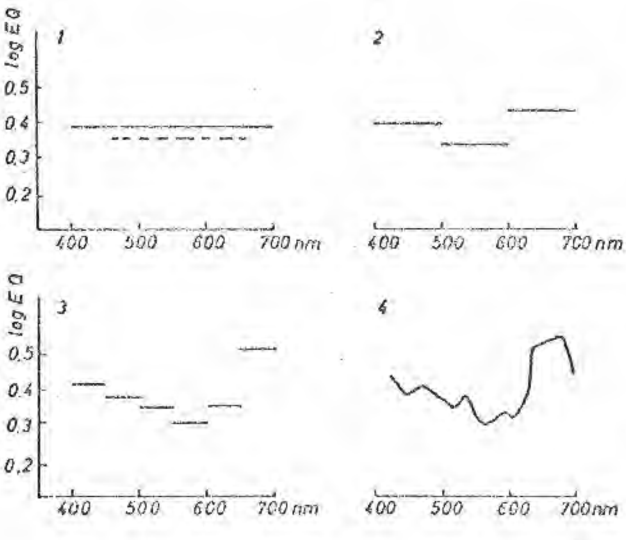

Fig. 2 Characterization of the spectra of the fraction of humic acids from a podzol by means of several extinction coefficients.

In the figure the number 1 represents the logarithm of extinction quotient E 400/600.

The number 2 represents the logarithm of the extinction quotients E 400/500, E 500/600 and E600/700.

Number 3 are the logarithms of extinction quotients in a range of 50 nm and Number 4 in range of 10 nm.

The calculation of the differences of the extinction in smaller ranges of wavelengths $\Delta \log K/\Delta\lambda$ - for instance in the range of 20 nm - results values, which give a better characterization of humic acids. Salfeld describes different humic acids by these "differential spectrograms", or the "differentiation of the spectra".

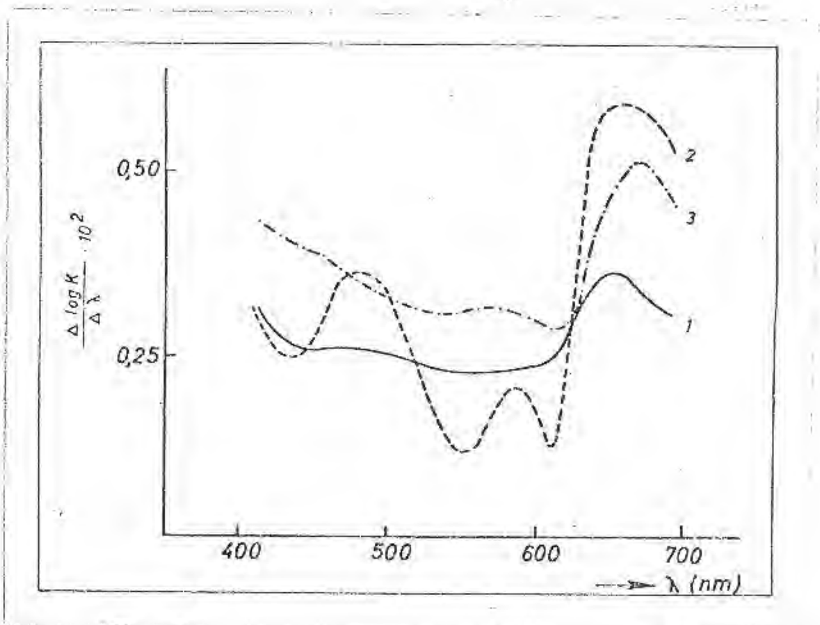

Fig.3: Differential spectrograms of humic acids in a range of 20 nm in 0.1 N NaOH (SALFELD 1965).
(1) Chernozem, (2) podzol B and (3) black peat.

Fig. 3 demonstrates, that the spectra of humic acids are not straight lines with constant gradient, because the gradients change with the range of wavelengths and have minima and maxima between 500 and 600 nm for all 3 spectra. This means, that the spectra have a point of inflexion in this range. The changes of the gradient show remarkable quantitative differences. In the case of chernozem humic acids (1), the gradient decreases from lower to higher wavelengths at first only a little and then increases larger. The podzol humic acids (2) show at first a large decrease, a small maximum and then very large increase. In the case of humic acids from black peat (3) a larger decrease is followed by a larger increase.

The differential spectra vary in the different range of wavelength. Therefore it is not possible, that according to the theory at first fulvic acids, then hymatomelanic, then humic acids are formed. If the different acids would be formed in this sequence, the course of the curves should be the same in all 3 cases:

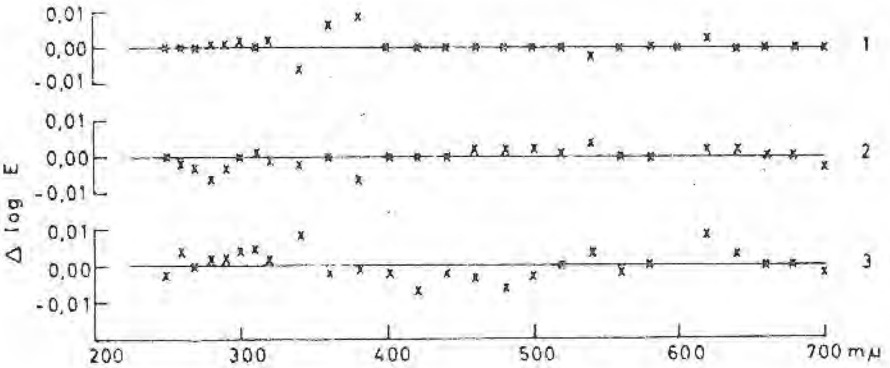

Fig. 4: Reproduceability of differences of logarithms of extinctions of different measurements with the same solution (1 and 2) and with different solutions (3) of the same preparation of chernozem.

To be able to use such measurements for a statistic of the characterization of isolated humic substances and their fractions or of systems of humic substances in soils, in cultures of microorganisms, in humification experiments or in the case of synthesis in vitro with various oxidation of phenols, the limits of reproduceability of the values must be known.

The graph shows the reproduceability of the measurements in the case of spectrum of humic acids from chernozem in 0.1 N NaOH. At first the same solution (1) and (2) has been measured every 3 minutes two times and then a second new prepared solution of the same preparation of humic acids (3) has been measured. The differences of the logarithms of the measured extinctions is plotted against the wavelengths. The differences of the values are here smaller than in the measurements of the differential spectra.

To be able to place in order the humic substances themselves or their alteration products during different processes in a common system, the measured values for characterization of differences must be significant. The limits of reproduceability are not in all cases due to the method of isolation, but also due to the properties of the investigated materials. Because a voluminous material is necessary for such investigations, the methods for this purpose have to be automized in regard to the apparatus as much as possible.

Investigations have been made, in which manner a larger number of samples of humic substances or systems could be compared by means of data of light absorption and could be sorted according to groups of similarity. Thus it was tried to compare and to classify groups of preparations of humic substances by means of the data, from spectra according to a method developed by SNEATH (1957).

As a measure for the similarity the ratio of the number of same properties to the number of the total regarded properties is defined. Each object is compared with each other. In this way diagrams of similarity are obtained; one example is demonstrated in the next graph with a group of 12 humic acids.

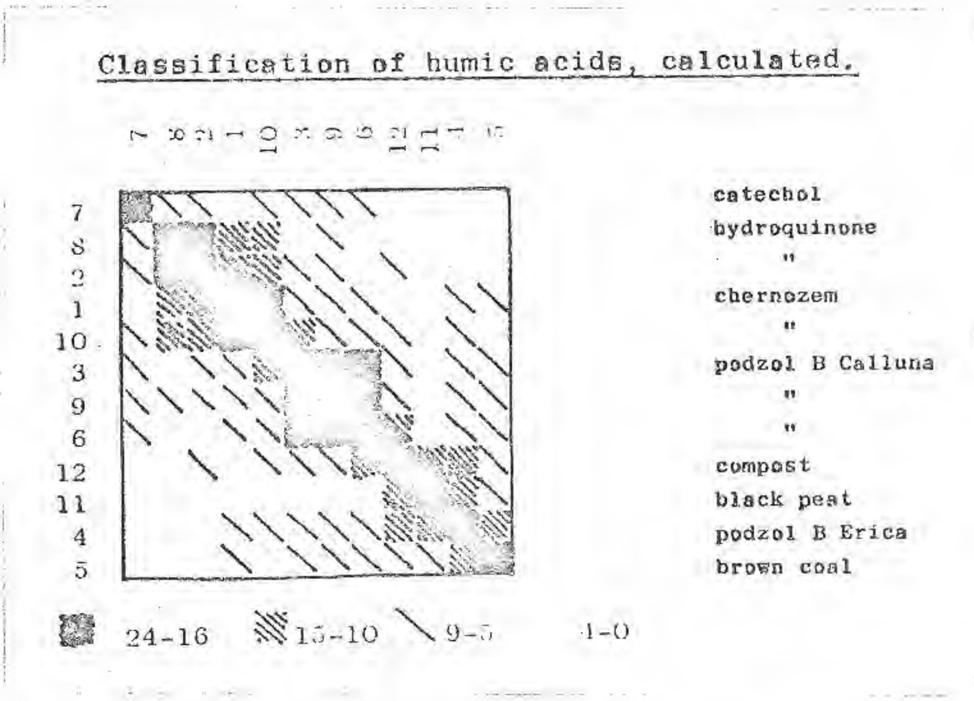

Fig. 5: Classification of humic acids, calculated.

In this example the spectra of 12 humic acids in 8 ranges of wavelengths are subdivided and the gradients as difference of logarithms of extinction are used as measured data. These data are transformed in an index number to simplify the representation. To compare the spectra the same index numbers of two spectra are evaluated with 3 points, a difference between the index numbers of 1 with 2 points and a difference of 2 with 1 point. A number of 24 points for the similarity is obtained, when 2 spectra are identical, because 8 measured values with the same index numbers with an evaluation of 3 points is used. A complete dissimilarity is zero points.

For further simplification the decrease of similarity are subdivided in 4 groups /24 - 16/, /15 - 10/, /9 - 5/ and /4 - 0/. The more black the quadrats are, the more similar are the spectra of the humic acids. The preparations of humic acids at first marked with any number can be arranged (classified) mechanically or by calculation, so that the hydroquinone-, the chernozem- and the podzol humic acids (Calluna) are in each case in one group.

From the diagram also the similarities between humic acids it can be seen, which are not from the same origin. So No. 10, a humic acid from chernozem is relatively similar (degree of similarity 15 - 10) with hydroquinone humic acids No. 8 and No. 2 or with the podzol B Calluna humic acid No. 3, but very dissimilar (degree of similarity 4 - 0) with the humic acid from black peat No. 11.

This method is used especially in a suitable manner, when the objects are characterized by a larger number of qualitative symptoms. If objects - in our case preparations of humic substances or their systems - are determined exclusively by measured data of properties, the similarity can be defined better as the distance of points in a n-dimensional space. For a group of objects, which are characterized by 3 measurable properties, a three-dimensional model can be easily realized. So it is possible to represent the humic acids by means of their spectra as points in a three-dimensional system~~s~~ of coordinates with the three extinction quotients E 400/500, E 500/600 and E 600/E700 as coordinates.

In this model 52 spectra of humic acids are presented as points with the coordinates of the extinction quotients of 3 different ranges of wavelengths. The position of the points in the space is a measure for the similarity. Three accumulations of points can be determined.

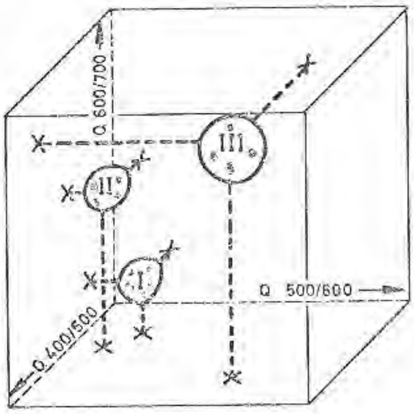

Fig. 6: Strongly schematized model of similarity of 52 humic acids by means of three extinction quotients (Q400/500; Q 500/600 and Q 600/700) (SALFELD 1968). The three groups of humic acids are marked with the numbers I, II, and III.

The closest accumulation contains the humic acids from chernozem (I), which is clearly separated from the humic acids from the podzol (II). A third accumulation is a group of preparations of humic acids (III) from different origin.

These remarks shall point out, that such possibilities of characterization exist and should be worked out to classify systematically the manifold experimental material for humic substances in order to draw more general conclusions. We characterize the fractions of humic substances in dependence of soil genetical and ecological symptoms, but also to find the correlations between the natural factors and those influenced by men during the formation and the decomposition of soil organic matter (SALFELD 1968, 1971, SALFELD and SOCHTIG 1969, SOCHTIG and SALFELD 1971).

Finally it might be also possible to correlate the productivity potential of soil with properties of soil organic matter. But this needs a strong cooperation with the agronomists and others and finally with the economists, because the best recommendations of chemists, biochemists, agronomists and soil scientists are useless, when the recommendations are not economical. Otherwise, the economists must learn, that one cannot calculate only with data based on the past year. A better understanding of progress in biological science should enable them to give advices, if "drought resistance" or "inhibition of nitrification" is more important for the success of the farmers or the welfare of population.

To fulfil this task is only a question of ingenuity and directed cooperation.

Additional attempts have been made for characterization of humic systems by the use of other data of properties such as carbon and nitrogen content and different others.

The data in the literature cannot be used in the most cases to complete such investigations, because they do not correspond to the pretentions of the necessary reproduceability.

2. Scheme for analysis of humic systems

In the following, humic systems will be defined as the total complex of soil organic matter or chemically similar systems of organic substances, fractions of humic systems such as fulvic and humic acid fractions are in this sense also "humic systems".

In the following, a scheme of analysis of humic systems will be shown with which primary values are determined first. Then secondary values are derived from these.

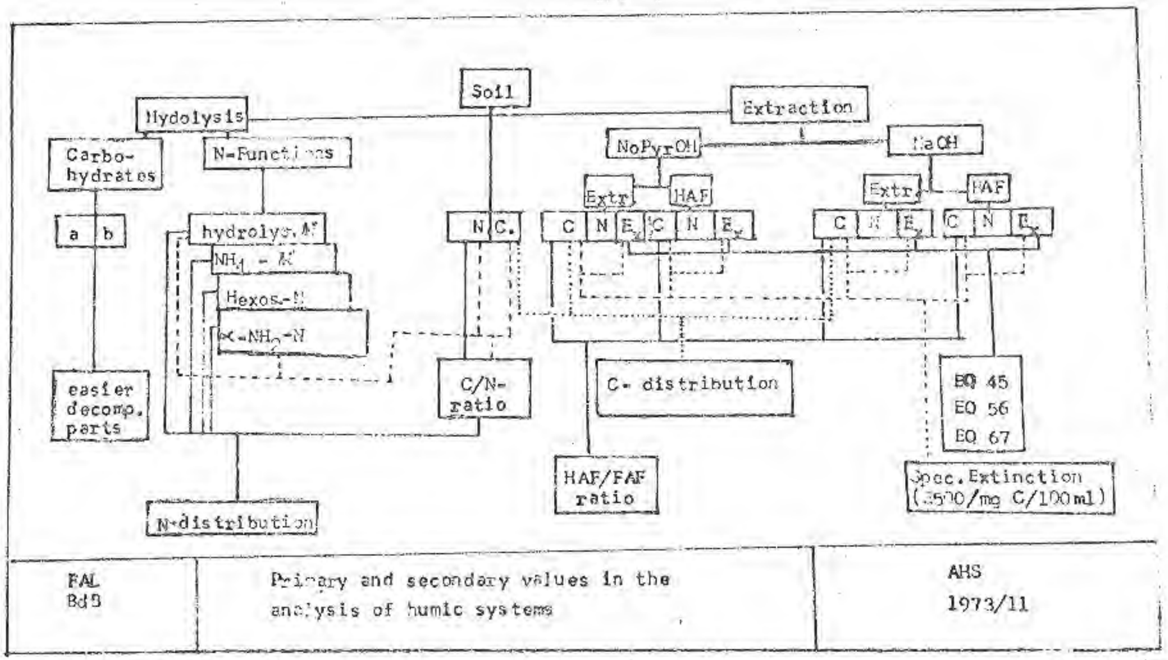

Fig. 7: Primary and secondary values in the analysis of humic systems.

Carbon and nitrogen content is determined in the soil. By hydrolysis with different concentrated acid easier degradable organic parts are determined for instance "carbohydrate fractions". The functions of nitrogen are determined according to Bremner (1965). The following determinations are made:

1) The part of nitrogen which is split off by hydrolysis totally;

2) the part of nitrogen N, which is split off NH_3 as during hydrolysis;

3) hexose amine-N and

4) α -amino-N.

The soil is extracted with two types of extractants:

1) a mixture of sodium pyrophosphate + sodium hydroxide, and
2) sodium hydroxide alone.

In the extract as well in the humic acid fractions precipitated with sulphuric acid at pH 1.0 and redissolved in sodium hydroxide, the following determinations were made:

1) carbon content
2) nitrogen content
3) extinction at 400, 500, 600, 700 nm.

From these primary values, secondary values are calculated.

1) The distribution of carbon in the different soil extracts and humic fractions. This relation leads to an estimation of the binding of humic substances on inorganic constituents.

2) The ratio of the fractions of humic acids and fulvic acids in the extract.

3) Specific extract of the humic system, this means the extinction is calculated based on carbon content in the same volume of extractant.

4) The ratio of the measured extinctions for characterising the spectra. This is also a key value of the slope.

Three ranges of the spectra are specifically divided up in ranges of 100 nm in each case.

5) The ratio of carbon to the differently bounded nitrogen.

6) The distribution of the different forms in which nitrogen is bound.

In the next five figures the scheme is divided up in tables to explain some singularities.

Tab. 1: List of methods for determination of values for analysis of humic systems.

No of method	No of apparatus	Methods
1	2	Pyrophosphat-NaOH-extract Extinction
2	2	" " Humic acids "
3	2	" " " "
4	2	" " " "
5	1	C-determination, Bichromate of method 1
6	1	" " 2
7	1	" " 3
8	1	" " 4
9	1	" " soil sample
10	1	N-determination, Kjeldahl "
11		
12		
13		
14	6	NH_4-N in fresh soil samples
15	6	NO_3-N " " " "
16	6	N-determination, total N, Kjeldahl, total hydrolysate 5
17	6	" " , NH_4-N hydrolysate 5
18	6	" " , " + Hexosamine-N hydrolysate 5
19	6	" " , " + " + $-NH_2$-N " 5
20	6	" " , Kjeldahl, solution method 1
21	6	" " , " " " 2
22	6	" " , " " " 3
23	6	" " , " " " 4
24	6	Activity of dehydrogenase
25		
26	4	C-determination, soil sample combustion (Leco)
27	3	N-determination, " " (Heraeus)
28	1	Glucose-determination in hydrolysate (2 % HCl)
29	1	" " " " (72 % H_2SO_4)

Apparatus 1 = Braun Systematic, Analysensystem,
2 = Unicam SP 3000, 3 = Microrapid-N-, Heraeus,
4 = C-Determinator Leco, 5 = (in development),
6 = Digital pH-Meter Metrohm

In the first one the list of measured values for the determination of different values in the case of analysis of the humic systems is given.

Tab. 2: List of key values.
Normalized measured values of one method: In this list the normalized values (KM) of one method are given, which are calculated per units from the measured values.

KM	1	E 400	of	method	1	Extinction of 10 ml solution/g soil
"	2	E 500	"	"		" " " "
"	3	E 600	"	"		" " " "
"	4	E 700	"	"		" " " "
KM	5	E 400	of	method	2	" " " "
"	6	E 500	"	"		" " " "
"	7	E 600	"	"		" " " "
"	8	E 700	"	"		" " " "
KM	9	E 400	"	method	3	" " " "
"	10	E 500	"	"		" " " "
"	11	E 600	"	"		" " " "
"	12	E 700	"	"		" " " "
KM	13	E 400	"	method	4	" " " "
"	14	E 500	"	"		" " " "
"	15	E 600	"	"		" " " "
"	16	E 700	"	"		" " " "
KM	17		"	method	5	mg/g soil
"	18		"	"	6	"
"	19		"	"	7	"
"	20		"	"	8	"
"	21		"	"	9	"
"	22		"	"	10	"
KM	23		"	"	11	"
"	24		"	"	12	"
"	25		"	"	13	"
KM	26		"	"	14	"
"	27		"	"	15	"
"	28		"	"	16	"
"	29		"	"	17	"
"	30		"	"	18	"
"	31		"	"	19	"
"	32		"	"	20	"
"	33		"	"	21	"
"	34		"	"	22	"
"	35		"	"	23	"
KM	36		"	"	24	mg TPF$^{+)}$/10 g soil
"	37		"	"	25	mg/g soil
"	38		"	"	26	"
"	39		"	"	27	"
"	40		"	"	28	"
"	41		"	"	29	"
"	42		"	"	30	"

+) TPF = Triphenylformazan

Tab. 3: List of key values

Secondary values (KD). Difference from two different normalized measured values.

KD	1	Hexosamine-N	mg/g soil	KM	30	-	KM	29
KD	2	Amino-N	"	KM	31	-	KM	30
KD	3	Residual-N	"	KM	28	-	KM	31
KD	4	FAF-N in Pyrophosphate	"	KM	32	-	KM	33
KD	5	FAF-N in NaOH-extr.	"	KM	34	-	KM	35
KD	6	FAF-C in Pyr.-extr.	"	KM	17	-	KM	18
KD	7	FAF-C in Pyr.-extr.	"	KM	19	-	KM	20
KD	7	FAF-C in NaOH-extr.	"	KM	19	-	KM	20

FAF = Fulvic Acids Fraction

One part of the secondary values is calculated as a difference from two different normalized values.

Tab. 4: List of key values

Secondary values (KQ). Quotient of two key values.

KQ	1	E 400/E 500	KM	1/KM 2	Pyr. extr.
"	"	E 500/E 600	"	2/KM 3	"
"	"	E 600/E 700	"	3/KM 4	"
"	4	E 400/E 500	"	5/ " 6	HAF from extr.
"	5	E 500/E 600	"	6/ " 7	"
"	6	E 600/E 700	"	7/ " 8	"
"	7	E 400/E 500	"	9/ " 10	Na OH-extr.
"	8	E 500/E 600	"	10/ " 11	"
"	9	E 600/E 700	"	11/ " 12	"
"	10	E 400/E 500	"	13/ " 14	HAF from NaOH-extr.
"	11	E 500/E 600	"	14/ " 15	"
"	12	E 600/E 700	"	15/ " 16	"
KQ	13	C/N	"	21/ " 22	total soil, Bichr./Kjel.
"	14	C/N	"	17/ " 31	Pyroph. extr.
"	15	C/N	"	18/ " 33	HAF in Pyr.
"	16	C/N	"	19/ " 34	NaOH-extr.
"	17	C/N	"	20/ " 35	HAF in NaOH
KQ	18	Specif. E. 400 nm, Pyr.			KM 1/KM 17
"	19	" " 500 nm, "			" 2/ " 17
"	20	" " 600 nm, "			" 3/ " 17
"	21	" " 700 nm, "			" 4/ " 17
KQ	22	" " 400 nm HAF-Pyr.			" 5/ " 18
"	23	" " 500 nm "			" 6/ " 18
"	24	" " 600 nm "			" 7/ " 18
"	25	" " 700 nm "			" 8/ " 18
KQ	26	" " 400 nm NaOH			" 9/ " 19
"	27	" " 500 nm "			" 10/ " 19
"	28	" " 600 nm "			" 11/ " 19
"	29	" " 700 nm "			" 12/ " 19
KQ	30	" " 400 nm HAF-NaOH			" 13/ " 20
"	31	" " 500 nm "			" 14/ " 20
"	32	" " 600 nm "			" 15/ " 20
"	33	" " 700 nm "			" 16/ " 20

HAF = Humic Acids Fraction

Other values are calculated as a quotient of the key values.

Tab. 5: List of key values

Secondary values (KP). One key value in per cent of another key value.

KP	1	C-Pyrophosphate	in %	C-total	(KM 17, KM 21)
"	2	C-HAF Pyr.	"	"	" 18, " "
"	3	C-NaOH	"	"	" 19, " "
"	4	C-HAF NaOH	"	"	" 20, " "
"	5	C-HAF Pyr.	"	C-Pyr.	" 18, " 17
"	6	C-HAF NaOH	"	C-NaOH	" 20, " 19
"	7	N-Hydrolysate	"	N-total	" 28, " 22

HAF = Humic Acids Fraction

List of values in which secondary values are given as one key value in per cent of other key value.

These dxplanations demonstrate clearly, that such work can only be done with automatised instruments and electronic registration and evaluation of the values.

3. Example for characterisation of humic systems in a morphosequence of soil.

As an example to characterize humic systems some few results of an investigation of a black earth-griserde-morphosequence, will be mentioned. During the transition of a black earth to a griserde (gray brown, podzolic soil derived from black earth with clay migration) decalcification, clay formation and clay migration occurs. Simultaenously, the black earth-mull - 'A' horizon becomes more and more pale.

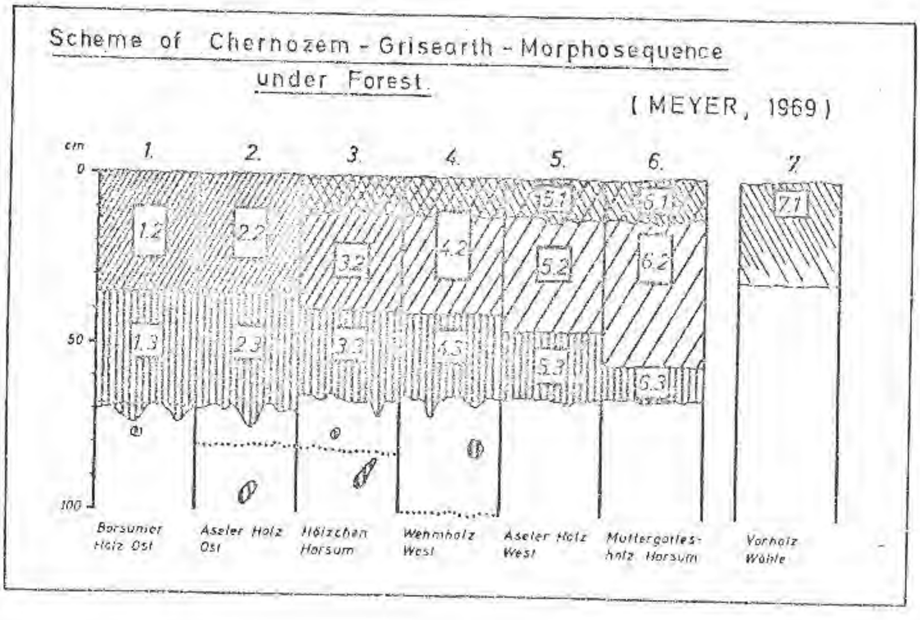

Fig. 8: Scheme of black earth-griserde-morphosequence under wood (profile number 1-6 and for comparison 'A'-horizon of gray brown podzolic soil on loss).

Six profiles had been choosen in which the bleaching in the sub-horizon A_2 was increased. For comparison, 'A' horizon of a gray brown podzolic soil on Loess was also investigated which is not derived from black earth. The visual differences of the six 'A' subhorizons have been also numbered.

1. Describes the subhorizons with recent humus formation:
2. Subhorizons with increasing leaching of the original 'A' horizon.
3. The old mull 'A' horizon.

All data mentioned in the scheme before have been determined. Only the results of the different solubility in sodium hydroxide and sodium hydroxide-pyrophosphate solution will be mentioned.

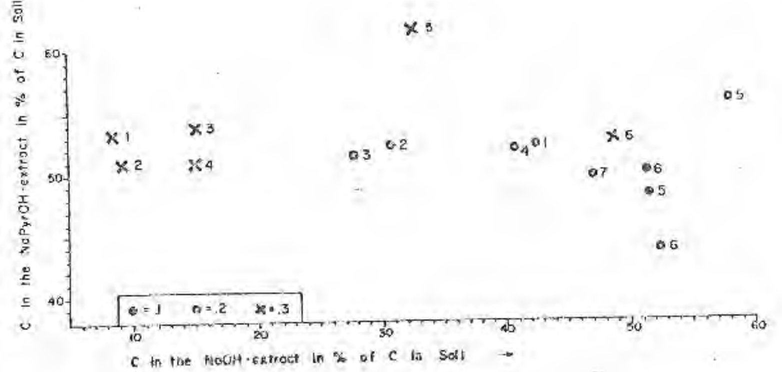

Fig. 9 : Carbon content in the extracts of sodium hydroxide and sodium hydroxide - pyrophosphate in dependence of total carbon content in soil.

The figure 9 shows the different solubility of humic substances in sodium hydroxide-pyrophosphate and in sodium hydroxide solution. In this figure the values for the humic systems from the subhorizons A_1 are marked as points from subhorizon A_2 as circles and from subhorizon A_3 as crosses. Furthermore they are labelled by the numbers of the profile.

An average of 50% of the total C content were extractable with sodium hydroxide-pyrophosphate. This percentage is also the highest in the case of extraction with sodium hydroxide. Therefore, the conclusions about the humic systems represent only half of the total organic substances in the soil. This is not a particular case because nearly every investigation dealing with soil humic substances have been the similar drawback (KONONOVA, 1966). This fact one has to bear in mind in the case of characterisation of humic system in soil, but such data are not found in publications.

The solubility of humic substances in sodium hydroxide-pyrophosphate is nearly constant, while in sodium hydroxide this ranges from 10-60% of the total C in the different profiles.

Increasing solubility with sodium hydroxide indicates a decreased in the calcium linked portion of humic substances and an increase of the free humic substances or those linked with mobile forms of sesquioxides. The humic substances of the subhorizons A_3 of the profiles 1 - 4 are nearly totally connected to calcium, while those of subhorizons are nearly not connected with calcium. Those of subhorizon A_2 of the profiles 1 - 4 are in between.

The humic substances of the intensive "bleached" profiles 5. and 6. are less connected with calcium than those of the not or moderately "bleached" profiles.

4. Final remarks and Conclusions:

Not going in details, it will be only remarked that the combination of all these values is a useful tool for determination of properties of humic systems after statistical calculations with computers.

In the last part of the lecture, it will be reminded that only by the statistical methods determination of similarity or dissimilarity in the case of humic systems is possible. The arguments are the followings:

1) During humification processes "the initial material, the hon-humic substances, are transformed in humic substances". This sentence reproduces only an imagination about humification, because a differentiation between non-humic and humic substances cannot be verified by experiments. It is not possible to separate humic substances

from non-humic substances completely by any method. The only possibility, which will exist, is to take out some fractions from soil organic matter which are either more similar to the fraction which are comparable in its properties with initial plant material or to this fraction which we call humic acids.

2) To make chemical statements as in similar systems of natural substances, one has to isolate chemically uniform substances from soil organic matter and to elucidate their constitution. Since the beginning of this century Schreiner and Shorey (1910) have done such work which was continued. One determined sugars, amino acids and also polycyclic hydrocarbons (Summarized FLAIG 1971)

The determination of numerous chemical compounds is of high value for special questions, for instance the phenol carboxylic acids with their influence on plant metabolism. But the low percentage of the determined organic compounds in soil in comparison to the total amount of carbon is not sufficient to elucidate chemical composition of the total complex of soil organic matter.

The results of many experiments contradict that important fractions with distinguished differences in their chemical compositions may be ever isolated. All results establish more or less that the fractions consist of numerous chemically similar individuals.

Therefore, only statistical statements can be made about the chemical structure of the components and above the chemical nature of the mixture.

3) To characterize the very complex system of humic substances as correctly as possible, many parameters are necessary. For special questions the number of parameters may be decreased. Furthermore the number of parameters increase, if these investigations concern not only chemical composition or chemical processes in the humic systems but also inter-actions with problems of soil science and plant production.

4) For exchange of information without loss, all the measured values as well as their evaluation must be documented on punch cards or other data registering procedures for the use of computers. This is important for over-regional cooperation. The mentioned system is compatible with other systems which are logically build up. Especially it can be fitted up in other corresponding systems.

The technical preposition are in principle known and fulfilled by automatization of the analytics and by electronic registration of the measured values and computerized evaluation of data. Only by this way evaluation of soil organic matter in relation to soil productivity and stabilization of the yield can be per-formed at all places in the world. I believe this must be done in future, because in some decades the food production of the world population is no more a matter of the single countries as it is uptil now.

References:

ACERBO, R., H. KASTORI, H, SOCHTIG, H. HARMS and K. HAIDER: Effect of boron in synthesis and transformation of lignin precursors in Zea Mays. Zeitschr. f. Pflanzenphysiologie, 69, 306-317 (19).

ALEXANDER, M. Biochemical ecology of soil microorganisms. Ann. Rev. Microbial. 18. 217-252 (1964).

BAILEY, N.T., G.G. BRIGGS, G.J. LAWSON, J.M. SCHUTON and S.G. WARD: Observation on the structure of humic acid. 6. Intern. Kohlenwiss. Tagung, Münster, W., 1.-3.6.1965. Beitrag Nr. 3, 1. (1965).

BARTLETT, J.B.: The effect of decomposition of the lignin of plant materials. Iowa State Coll. J. Sci. 14, 11-13 (1939).

BARTLETT, J.B., F.P. SMITH and P.E. BROWN: Lignin decomposition in soils. Proc. Iowa Acad. Sci. 44, 97-101 (1937).

BARTLETT, J.B., and A.G. NORMAN: Changes in the lignin of some plant material as a result of decomposition. Soil Sci. Soc. Amer., Proc. 3, 210-216 (1938).

BELAV, L: Chemische Untersuchungen heimischer Torfbildner ein zur Kenntnis der umwandlung von pflanzenstoffen unter natürlichen und künstlichen Bedingungen. Dissertation Rostock (1967).

BERLING, J., K. BARZ, H. HARMS and K. HAIDER: Degradation of phenolic compounds in plant cell cultures. FEBS LETTERS, 16(2), 141-146 (1971).

BIELAWSKI, J., T.E. THOMPSON and A.L. LEHNINGER: The effect of 2,4-dinitrophenol on the electrical resistance of phospholipid bilayer membranes. Biochem. and Biophys. Res. Comm. 24, 948-954(1966).

BJORKMAN, A.: Isolation of lignin from finely divided wood with neutral solvents. Nature 174, 1057 (1954).

BJORKMAN, A.: Lignin and Lignin-Carbohydrate Complexes. Extraction from wood meal with neutral solvents. Ind. Eng. Chem. 49, 9 1395-1398 (1957).

BLOIS, M.S.: Random polymers as a matrix for chemical evolution. In: The origins of prebiological systems, edit. by Sidney W. Fox, Academic Press New York-London 1965, 19-38.

BONDIETTI, E., J.P. MARTIN and K. HAIDER.: Influence of nitrogen source and clay on growth and phenolic polymer production by Stachy-Botrys species, Hendersonula toruloidea and Aspergillus sydowi. Proc. Soil Sci. Soc. Am. 35(6), 917-922(1971).

BONDIETTI, E., J.P. MARTIN and K. HAIDER: Stabilization of amino sugar units in humic type polymers. Proc. Soil Sci. Soc. Am.36, 597-602 (1972).

BRAUNS, F.E.: Native Lignin. I. Its isolation and methylation. J.Amer. Chem. Soc. 61, 2120-2127 (1939).

BRAUNS, F.E. and D.A. BRAUNS: The chemistry of lignin; supplement volume: Covering the literature for the years 1949-1958. New York and London, Academic Press 516-518, (1960).

BREMNER, J.M.: "Organic forms of nitrogen". Ch. 85 Methods of Soil Analysis. (Agron. Monographs 9) ASA Madison 1965.

BREMNER, J.M., W. FLAIG and E. KÜSTER: Zur Kenntnis der Huminsäuren. IX. Mitteilung. Der Gehalt an Aminosäuren in Streptomyceten-Huminsäuren. Z. Pflanzenernahr., Dung., Bodenkunde 71, 58-63 (1955).

BREMNER, J.M. and T. HARADA: Release of ammonium and organic matter from soil by hydrofluoric acid and effect of hydrofluoric acid treatment on extraction of soil organic matter by neutral and alkaline reagents. J. Agric. Sci. 52, 2 (1959).

BREYHAN, Th.: Eine Mikromethode zur Stickstoffbestimmung. Z. analyt. Chem. 152, 412-417 (1956).

BROADBENT, F.E: Modification in chemical properties of straw during decomposition. Soil Sci. Soc. Amer., Proc. 18, 165-169(1954).

BROCKMANN, H. and E. MEYER: Aquivalent- und Molekulargewichtsbestimmungen durch potentiometrische Mikrotitration in nicht-wässrigen Losungsmitteln. Chem. Ber. 86, 1514-1523 (1953).

BRUCKERT, S.F., F. JACQUIN and M. METEHE: Contribution a l'etude des acides phenols presents dans les sols. Bull. de l'Ecole Nationale Superieure Agronomique de Nancy, IX, 73-92(1967).

BURGES, A. and P. LATTER: Decomposition of humic acid by fungi. Nature 186, 4722, 404-405 (1960).

BURGES, N.A., H.M. HURST and B. WALKDEN: The phenolic constituents of humic acid and their relation to the lignin of the plant cover. Geochim. Cosmochim. Acta 28, 1547-1554 (1964).

CHAMINADE, R.: Action de l'acide humique sur le development et la nutrition minerale des vegetaux. VI. Int. Soil Sci. Congr. Vol.D. Paris, 443 (1956).

CHAMINADE, R.: Effet physiologique des constituants de la matière organique des sols, sur le metabolisme des plantes, la croissance et le rendement. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press Ltd. Oxford 1966, 35-47.

CHOUDRI, M.B. and F.J. STEVENSON: Chemical and physiocochemical properties of soil humic colloids. III. Extraction of organic matter from soils. Soil Sci. Soc. Amer., Proc. 21, 508-513 (1957).

CHRISTEWA, L.A.: Die stimulierende Wirkung der Huminsäuren auf die Lebenstätigkeit höherer Pflanzen und die Effektivität der Humindünger in südlichen Gebieten der Ukraine, SSR. Int. Soil Sci. Congr. Vol. II, Comm. II u. IV. Hamburg 46-55(1958).

CHRISTEWA, L.A.: Theorie und Praxis der Humindüngeranwendung in der Ukraine. Der Internationale Torfkongress, UdSSR Leningrad (1963) (russ.).

COFFIN, D.E. and W.A. DELONG: Extraction and characterization of organic matter of a podzol B-horizon. 7th. Int. Congr. of Soil Sci. Madison, Wisc. USA Vol. II, 91-97 (1960).

CONN, H.J. and J.F. CONN: The stimulative effect of colloides upon the growth of certain bacteria. J. Bact. 39, 99-100 (1940).

CROMARTIE, R.I.T. and H. MASON: The structure of tyrosine melanin. Chem. Ind., 972-973 (1953).

DAMBROTH, M: Einfluß von N-lignin auf Ertrag und wertbestimmende Merkmale von Sommergerste, Z. Pflanzenern., Dung. Bodenk.(1972).

DEUEL, H. and P. DUBACH: Decarboxylierung der organischen Substanz des Bodens. II. Nachweis von Uronsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 82, 97-106 (1958)a.

DEUEL, H. and P. DUBACH: Decarboxylierung der organischen Substanz des Bodens. III. Extraktion und Fraktionierung decarboxylierbarer Humusstoffe. Helv. Chim. Acta 41, 1310-1321 (1958 b).

DEUEL, H., P. DUBACH and R. BACH: Decarboxylierung der organischen Substanz des Bodens. I. Decarboxylierung der gesamten Humusstoffe. Z. Pflanzenernähr., Düng., Bodenkunde 81, 189(1958).

DUBACH, P. and N.C. MEHTA: The chemistry of soil humic substances. Soils Fertilizers XXVI, 293-300 (1963).

DUBACH, P., N.C. MEHTA and H. DEUEL: Extraktion von Huminstoffen aus dem B-Horizont eines Podsols mit ADTE. Z. Pflanzenernähr., Düng., Bodenkunde 95, 119-123 (1961).

DUBACH, P., N.C. MEHTA and H. DEUEL: Schonende Extraktion von Huminstoffen und Isolierung der Fulvosäure-Fraktion aus verschiedenen Bodentypen. Z. Pflanzenernähr., Düng., Bodenkunde 102, 1-7 (1963).

FARMER, V.C. and R.I. MORRISON: Chemical and infrared studies on phragmites peat and its humic acid. Sci. Proc. Roy, Dublin Soc. Series A 1, 85-104 (1960).

FARMER, V.C. and R.I. MORRISON: Lignin in Sphagnum and phragmites and in peats derived from these plants. Geochim. Cosmochim. Acta 28, 1537-1546 (1964).

FILIPS, Z.: The influence of small supplements of bentonite on the development of certain groups of microorganisms in a soil culture. Rostlinna Vyroba (Prague) 14, 209-216 (1968 a).

FILIPS, Z.: Development of microorganisms and humus substance formation in media with different content of bentonite. Pochvovedeniye (Moscow) 9, 55-61 (1968 b).

FILIPS, Z.: Characteristic of humic substances in a soil incubated with additions of bentonite. Rastlinna Vyroba (Prague) 15, 377-390 (1969).

FILIPS, Z., K. HAIDER, W. FLAIG, H. BEUTELSPACHER, E. KUSTER u. J.P. MARTIN: EinfluB der Tonminerale auf die Huminstoffbildung einiger Bodenpilze. Landbauforschung Völkenrode, 21, 97-102 (1971).

FILIPS, Z., K. HAIDER and J.P. MARTIN: Influence of clay minerals on growth and metabolic activity of Epicoccum Nigrum and Stachybotrys Chartarum. Soil Bio. Biochem. 4, 135-145 (1972a).

FILIPs, Z., K. HAIDER and J.P. MARTIN: Influence of clay minerals on the formation of humic substances by Epicoccum Nigrum and Stachybotrys chartarum. Soil Biol. Biochem. 4, 147-154 (1972 b).

FLAIG, W.: Zur Bildungsmöglichkeit von Huminsäuren aus Lignin. Holzforschung 9, 1-4 (1955).

FLAIG, W.: Zur Chemie der Huminsäuren und deren Modellsubstanzen. Vle. Congres Internat. de la Science du Sol. Paris, 2, 471-478 (1956).

FLAIG, W.: Die Chemie organischer Stoffe im Boden und deren physiologische Wirkung. Verhandl. d. II. und IV. Komm. d. Internat. Bodenkundl. Ges., Hamburg, Vol. II (1958).

FLAIG, W: Einige Reaktionen der Benzochinone und ihre Absorptionsspektren. Angew. Chem. 69, 723 (1957).

FLAIG, W.: Chemie der Humusstoffe. Suomen Kemistilehti A 33, 229-251 (1960 a).

FLAIG, W.: Comparative chemical investigations on natural humic compounds and their model substances. Sci. Proc. Roy. Dublin Soc. Ser. A 1, 4. 149 (1960 b).

FLAIG, W.: Zur Umwandlung von Lignin in Humusstoffe. Freiberger Forschungshefte A 254, 39-56 (1962).

FLAIG, W.: Uber den Einfluß von Humusstoffen auf den Stoffwechsel der Pflanzen. Der internationale Torfkongress UdSSR Leningrad 1963.

FLAIG, W.: Chemische Untersauhungen an Humusstoffen. Z. Chem. 4, 253-265 (1964 a).

FLAIG, W.: c) Humusstoffe.
Handbuch der Pflanzenernährung und Düngung. Bd. II: Boden und Düngemittel 1966, S. 282-458, Springer-Verlag Wien.

FLAIG, W.: Uptake of organic substances from soil organic matter by plant and their influence on metabolism. Pontificiae Academiae Scientiarum Scripta Varia 32, 723-770 (1968).

FLAIG, W.: Contribution a la connaissance de la constitution et de la synthese des acides humiques. Extrait de "Sciences du Sol", Supplement au Bulletin de l'Association Francaise pour l'Etude du Sol, No. 2, 39-72 (1970).

FLAIG, W.: Organic compounds in soil. Soil Sci. 111, 19-33 (1971).

FLAIG, W. and H. BEUTELSPACHER: Investigations of humic acids with the analytical ultracentrifuge. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, 23-30.

FLAIG, W. and Th. BREYHAN: Uber das Vorkommen von Indolverbindungen in Schwarzerde-Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 75, 132-135 (1956).

FLAIG, W. and K. HAIDER: Reaktionen mit oxydierenden Enzymen aus Mikroorganismen. Planta Medica, Z.f. Arzneipflanzenforsch. 9, 123-139 (1961 a).

FLAIG, W. and K. HAIDER: Die Verwertung phenolischer Verbindungen durch Weißfäulepilze. Arch. Mikrobiol. 40, 212-223 (1961 b).

FLAIG, W. and K. HAIDER: Über die Beteiligung von Phenolen am Aufbau von Huminsäuren. - 9th International Congress of Soil Science Transactions III, 175-182 (1968).

FLAIG, W. and W. de JONG: Untersuchungen über die Wirkung von p-Benzochinonderivaten auf den aeroben und anaeroben Stoffwechsel der Hefe (Saccharomyces aerevisiae). Arch. f. Mikrobiol. 37, 355-368 (1960 a).

FLAIG, W. and W. de JONG: Vergleich der Wirkung von Thymochinon und Thymohydrochinon mit der von 2,4-Dinitrophenol auf den Stoffwechsel der Hefe (Saccharomyces aerevisiae). Arch. f. Mikrobiol. 37, 369-378 (1960 b).

FLAIG, W. and H. RIEMER: Polarographische Untersuchungen zum Verhalten von Trihydroxytoluolen bei der Reaktion mit Glycin unter Oxydierenden Bedingungen. Justus Liebigs ANNALEN DER CHEMIE 246, 81-85 (1971).

FLAIG, W. and E. SAALBACH: Zur Kenntnis der Huminsäure. XIII. Unterschungen uber die Beeinflussung der Anfangs-emtwicklung von getreide in Neubauerschalen durch- Thymohydrochinon als Modellsubstanz von Vorstufen bzw. Abbauprodukten von Huminsäuren. Z. Pflanzenernähr. Düng Bodek. 72, 7-15(1956)- Beziehungen zwischen Kalium, Wasser und Boden, Kalium-Symposium (1958).

FLAIG, W. and Chr. SALFELD: UV-Spektren und Konstitution von p-Benzochinonen. Liebigs Ann. Chem. 618, 117-139 (1958).

FLAIG, W., K. SCHARRER and G. SCHOLL: Humic acids XVI. The effedt of Thymohydroquinone as model substance of humic matter on the activity of various enzymes in rye. Z. Pflernähr. Düng. 76, 201-209 (1957 a).

FLAIG, W., K. SCHARRER and G. SCHOLL: Humic acids XVII. The effect of Thymohydroquinone as model substance of humic matter on the phosphorus uptake by rye seedlings. Z. Pflernähr. Düng. 76, 210-212 (1957 b).

FLAIG, W. and G. SCHMID: Uber den Wirkungsmechanismus stoffwechselaktiver Substanzen. In: Eigenschaften und Wirkungen der Gibberelline, Symposium der Oberhessischen Gesellschaft fur Natur- und Heilkunde, Naturwissenschaft. Abt. zu Giessen vom 1.-3. Dez. 1960, S. 25-27 (Herausg. R. Knapp). Springer-Verlag Berlin-Gottingen-Heidelberg 1962.

FLAIG, W., U. SCHOBINGER and H. DEUEL: Umwandlung von Lignin in Huminsäuren bei der Verrottung von Weizenstroh. Chem. Ber. 92, 1973-1982 (1959).

FLAIG, W. and G. SCHOLL: Hacia el conocimiento de los acidos huminicos. XVIII. Communicacion "Influencias de la timohidroquinona sobre la economia del agua en plantas de interes agricola. Anales de Edafologia y Agrobiologia XIX, 251-259(1960).

FLAIG, W. and H. SÖCHTIG: Einfluß organischer Stoffe auf die Aufnahme anorganischer Ionen.- Agrochimica 6, 251-264 (1962).

FLAIG, W., F. SCHEFFER and B. KLAMROTH: Zur Kenntnis der Huminsäuren. VIII. Zur Charakterisierung der Huminsäuren des Bodens. Z. Pflanzenernähr., Düng., Bodenkunde 71, 33-37 (1955).

FREUDENBERG, K.: Forshung am Lignin, Fortschr. Chem. org. Naturstoffe 20, 41 (1962).

FREUDENBERG, K.: Entwurf eines Konstitutionsschemas fur das Lignin der Fichte, Holzforsch. 18, 3-9 (1964 a).

FREUDENBERG, K.: Ergänzung des Konstitutionsschemas für das Lignin der Fichte, Holzforschung 18, 166 (1964 b).

FREUDENBERG, K. and J.M. HARKIN: Ergänzung des Konstitutionsschemas fur das Lignin der Fichte. -Holzforsch. 18, 166-168 (1964).

FREUDENBERG, K. and A.C. NEISH: Constitution and biosynthesis of lignin. Springer-Verlag Berlin-Heidelberg, New York 1968.

FRÖMEL, W.: Uber Absorptionsspektren von Huminsäuren in Losungen. Bodenkunde und Pflanzenernähr. 6, 93-119 (1938 a).

FRÖMEL, W.: Uber UV-Absorptionsspektren von Huminsäuren in Losungen. Bodenkunde und Pflanzenernähr. 11, 129-144 (1938 b).

FRÖMEL, W.: Uber Fulvosäuren. Bodenkunde und Pflanzenernähr. 25, 345-358 (1941).

FÜHR, F.: Untersuchungen zur Aufnahme von Kohlendioxid und Strohabbauprodukten durch die Pflanzenwurzel. Dissertation Bonn 1962.

FÜHR, F. and D. SAUERBECK: Uber die Aufnahme und Translokation ^{14}C-markierter organischer Rotteprodukte bei Raphanus sativus. Z. Pflanzenernähr., Düng., Bodenkunde 105, 136 (1964).

FÜHR, F. and D. SAUERBECK: Die raumliche und chemische Verteilung durch die Wurzel aufgenommener organischer Rotteprodukte bei Daucus carota. - Z. Landw. Forsch. 19., Sonderheft 153-163 (1965).

FÜHR, F. and D. SAUERBECK: The uptake of straw decomposition products by plant roots. In: "The use of isotopes in soil organic matter studies". Report of the FAO/IAEA Technical Meeting. Oxford Pergamon Press Ltd., 73-83 (1966).

FÜHR, F. and D. SAUREBECK: The uptake of colloidal organic substances by plant roots as shown by experiments with ^{14}C-labelled humus compounds. Isotopes in plant nutrition and physiology. International Atomic Energy Agency, Vienna 1967, 317-328.

GALE, E.F.: The bacterial amino acid decarboxylases. Advan. Enzymol 6, 1-32 (1946).

GRABBE, K. und K. HAIDER: Die Huminstoffbildung und die Stickstoffverteilung bei der Strohrotte in Beziehung zur mikrobiellen Phenolbildung. Z. Pflanzenern., Bodenkunde 129, 202-216 (1971).

GRABBE, K. and K. HAIDER: Z. Pflanzenernahr., Bodenkunde (1971) in press.

GREAVES, M.P. and M.J. WILSON: The adsorption of nucleic acids by montmorillonite. Soil Bio. Biochem. 1, 317-323 (1969).

GREENLAND, D.J.: The adsorption of sugar by montmorillonite II. Chemical studies. J. Soil-Sci. 7, 329-334 (1956).

GROSS, S.R., R.D. GAFFORD and E.L. TATUM: The metabolism of protocatechuic acid by Neurospora. J. Bio. Chem. 210, 781-796 (1956).

GUMINSKA, Z. and J. SULEJ: The effect of sodium humate and sodium versenate upon sprouting of seed. Bioletyn Institutu Howowli i Aklimatyzaji. Roslin Nr. 3 29 (1964).

HAIDER, K.: Untersuchungen uber den mikrobiellen Abbau von lignin. Zbl. Bakterial. Parasitenkunde Infektionskrankh. und Hygiene, 198, 308-316 (1965).

HAIDER, K. and J.P. MARTIN: Synthesis and transformation of phenolic compounds by Epicoccum nigrum in relation to humic acid formation. Proc. Soil Sci. Soc. Am. 31(6), 766-772 (1967).

HAIDER, K., J.P. MARTIN: The role microorganisms in the formation of humic acids. - In: Isotopes and radiation in soil organic matter studies. Proceedings of the Symposium on the use of isotopes and radiation in soil organic matter studies. Intern. Atomic Energy Agency, Vienna 1968, 188-195.

HAIDER, K., Z. FILIPS, and J.P. MARTIN: Einfluss von Montmorillonit aufdie Bildung von Biomasse und Stoffwechselzwischeuprodukte durch einige Mikroorganismen. Arch. Mikrob. 73, 201-215 (1970).

HAIDER, K. and J.P. MARTIN: Humic acid-type phenolic polymers from Aspergillus sydowi culture medium. Stachybotrys spp. cells and autoxydized phenol mixtures. - Soil Biol. Biochem. 2, 145-156 (1970).

HAIDER, K., L.R. FREDERICK and W. FLAIG: Reactions between amino acid compounds and phenols during oxydation. - Plant and Soil XXII, 49-64 (1965).

HAIDER, K., S. LIM and W. FLAIG: Untersucheingen uber die Einwirkung von Mikroorganismem auf ^{14}C-markierte phenolische verbindungen, Landw. Forschung 15, 3/4, 1-9 (1962).

HAIDER, K., S. LIM and W. FLAIG: Experimente und Theorien über den Ligninabbau bei der Weißfäule des Holzes und bei der verrottung pflanzlicher substanz im Boden. Holzforsch. 18, 81-88 (1964).

HAMILTON, G.L. : Mechanismen of two- and four-electron oxidations catalysed by some metalloenzymes in "Adv. in Enzymology", 32, 55-96 (1969) Interscience Publishers, New York, London, Sydney, Toronto (1969).

HANF, M.: Pflanzenschutzentwicklung i. J. 1946-1971. BASF-Mitteilg. f. d. Landbau, Pflanzenschutz März 1972.

HANSEN, E.H. and M. SCHNITZER: The alkaline permanganate oxidation of Danish illuvial organic matter. Proc. Soil Sci. Soc. Am. 30, 745-748 (1966).

HANSEN, E.H. and M. SCHNITZER: Zn-dust destillation and fusion of a soil humic and fulvic acod. Soil Sci. Soc. Amer. Proc. 33, 29-36 (1969).

HARMS, H. : Untersuchungen zur Aufnahme von phenolischen Ligninspaltstucken durch die Wurzeln von Weizenkeimpflanzen. Dissert. Justus-Liebig-Universität Giessen (1967).

HARMS, H. und I. PRIESS: Positionsspezifische O-Demethylierung von Benzoesäuren in Weizenkeimpflanzen. Planta 109, 307-315 (1973)

HARMS, H., H. SÖCHTIG and K. HAIDER: Untersuchungen zur Aufnahme und Umwandlung C^{14}-markierter Phenole durch die Pflanze. I. Aufnahme von C^{14}-carboxylmarkierter p-Hydroxy-benzoe-, Vanillin- und Syringasäure durch die Wurzeln von Weizenkeimpflanzen und Verteilung der Aktivität uber die Pflanze. Plant and Soil XXXI, No. 1 129-142 (1969 a).

HARMS, H., H. SÖCHTIG and K. HAIDER: Untersuchungen zur Aufnahme und Umwandlung C 14-markierter Phenole durch die Pflanze. II. Die Umwandlung von p-Hydroxy-benzoesaure, Vanillinsäure, sowie Syringasäure nach der Aufnahme durch die Wurzeln von Weizenkeimpflanzen.- Plant and Soil XXXI, No. 2, 257-272 (1969 b).

HARMS, H., H. SÖCHTIG and K. HAIDER: Aufnahme und Umwandlung von unterschiedlichen Stellungen C^{14}-markierter Phenolcarbonsäuren in Weizenkeimpflanzen.-Z. Pflanzenphysiologie 64, Heft 5, S. 437-445 (1971).

HARMS, H., K. HAIDER, J. BERLIN, P. KISS and W. BARZ: Uber O-demethylierung und Decarboxylierung von Benzoesauren in pflanzlichen Zellsuspensions-kulturen. Planta 105, 342-351 (1972).

HOLLECK, L. and D. BECHER: Untersuchungen uber den EinfluB der Leitsalzionen auf die polarographische Reduktion aromatischer Nitroverbindungen in Acetonnitril und Dimethylformamid. J. electroanal. Chem. 4, 321-331 (1962).

HOLMBERG, B: Thioglykolsaure als Ligninreagenz. Ing. Ventenskaps Akad. Handl. No. 131, 5-15 (1934).

HOLMBERG, B. : Hypobromite lignin. - Ber. 75, 1760-1764 (1942).

ISHIWATARI, R. : An estimation of aromaticity of lake sediment humic acid by air oxidation and evaluation of it. Soil Sci. 107, 53-57 (1969).

JACQUIN, F. : Chromatographic study of various types of humic acids. C. R. hebd. Seances Acad. Sci. 250, 1892-1893 (1960).

JACQUIN, F. : Contribution a l'étude des processus de formation et d' evolution des divers composés humiques. Thèse Docteur des Sciences. Bull. ENSAN V, 1-156 (1963).

JANSSON, S.L. and J. PERSON: Co-Ordination of humus chemistry and soil organic matter biology by isotope techniques. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, 111-123.

JENKINSON, D.S.: The turnover of organic matter in soil. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966 a, 187-197.

JENKINSON, D.S.: The priming action. In: the use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press, Ltd., Oxford 1966 b, 199-208.

JENKINSON, D.S.: Experimental techniques for using carbon-14 in studies of soil organic matter. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966 c, 365-369.

JENKINSON, D.S.: Studies on the decomposition of plant materials in soil I-III. J. Soil Sci. 16, 104-115 (1965; 17, 280-302 (1966 b); 19, 25-39 (1968).

KAILA, A. : Humification of straw at various temperatures. Acta agral. fenn. Helsinki 78, 3-32 (1952).

KANG, K.S. and G.T. FELBACK: A comparison of the alkaline extracts of tissues of Aspergillus niger with humic acids from soils. Soil Sci. 99, 175-181 (1965).

KASATOCHKIN, V.I. and O.I. ZILBERBRAND: X-ray and infrared spectroscopy applied to the study of the structure of humic substances. Pochvovedenie No. 5, 80-85 (1956).

KASATOCHKIN, V.I., M.M. KONONOVA and G.I. ZILBERBRAND: Infrarotspektren von Huminsauren des Bodens. Dokl. Akad. Nauk 119, 785-788 (1958). (russ.)

KASTORI, R., H. HARMS, H. SÖCHTIG and K. HAIDER: Untersuchungen zur Aufnahme und Umwandlung C^{14}-markierter Phenole durch die Pflanze. III. Die Aufnahme, der Transport und die Umwandlung von C^{14}-markiertem Thymohydrochinon durch Weizenkeimpflanzen. Plant and Soil 33, 597-611 (1970).

KHAN, S.U. : Distribution and characteristics of organic matter extracted from the black solonetzic and black chernozemic soils of Alberta; the humic acid fraction. Soil Sci. 112, 401-409 (1971).

KHAN, S.U. and F.J. SOWDEN: Distribution of nitrogen in the black solonetzic and black chernozemic soils of Albertacan. J. Soil Sci. 51, 185-193 (1971).

KHAN, S.U. and F.J. SOWDEN: Distribution of nitrogen in fulvic acid fraction extracted from the black salonetzic and black chernozemic soils of Alberta. Can. J. Soil Sci. 52, 116-118 (1972).

KLEIST, H. and D. MUCKE: Stabile freie Radikale in Huminsäuren. Experientia 22, 136-137 (1966).

KLEIST, H. : 4.Torf-Kolloquium DDR-VR Polen 1/4 Rostock (1967).

KOLENBRANDER, G.J.: Die Verluste an organischer Substanz im Stalldünger. Z. Pflanzenernähr., Dung., Bodenkunde 69, 125-134 (1955).

KONONOVA, M.M.: Humus der Hauptbodentypen der UdSSR, seine Natur und Bildungsweisen. Rapports VI. Congr. Internat. de la Science du Sol, Chemie du Sol, S. 5, Moskau (1956) (russ.)

KONONOVA, M.M.: Soil organic matter. Its nature, its role in soil formation and in soil fertility. Pergamon Press Oxford, London, New York, Paris (1961).

KONONOVA, M.M.: Gedanken zur Nomenklatur der im Boden vorhandenen organischen Stoffe. 8th Internat. Congr. of Soil Sci. Transaction, Vol.III, Bucharest-Romania, 401-404 (1964). Discussions regarding the terminology in the field of humus, 405-413.

KONONOVA, M.M.: Soil organic matter, its nature, its role in soil formation and in soil fertility. Pergamon Press, Oxford, London, Edinburgh, New York, Toronto, Sydney, Paris, Braunschweig, (1966).

KRATZL, K. and P. CLAUS: Zur quantitativen Bestimmung der monomeren Äthanolysenprodukte aus dem Lignin monocotyler und dicotyler Angiospermen, Monatsh. Chem. 93, 219-229 (1962).

KRATZL, K., and E. RISNYOVSZKY: Zum Mechanismus der alkalischen Hydrolyse der Ligninsulfossure. Chimie et Biochimie de la Lignine de la Cellulose et des Hemicelluloses. Actes du Symposium International de Crednoble, Juillet (1964).

KRATZL, K., G. BILLEK, E. KLEIN, K. BUTSCHER: Über das Vehalten von markiertem Coniferin in der verholzenden Pflanze. Monatsh. f. Chemie 88, 721-734 (1957).

KRATZL, K., E. RISNYOVSZKY, P. CLAUS and E. WITTMANN: Uber den Mechanismus der alkalischen Hydrolyse von Guajacylglyzerin-B-guajacylather-a-sulfosäure. I. Witteilung, Modellversuche zur Fragmentierung der Ligninsulfosäure in alkalischem Medium. Holzforschung 20, 21-27 (1966).

KRATZL, K., W. SCHAFER, P. CLAUS J. GRATZL and P. SCHILLING, Zur Oxydation von ^{14}C-markierten Phenolen (Ligninmodellen) Mh. Chemie 98, 891-904 (1967).

KUBISTA, K.: The influence of bentonite and of aeration on the dynamics of the development of microorganisms during the decomposition of lucerne in a sand culture. Rostlinna Vyroba (Prague) 15, 221-228 (1969).

KUMADA, K.: Studies on the colour of humic acids. Part. I. On the concepts of humic substances and humification. Soil Sci. and Plant Nutr. 11, 11-16, (1965).

KUMADA, K. and A. AIZAWA: The infrared spectra of humic acids. Soil and Plant Food 3, 1 2-159 (1958).

KUMADA, K. and K. AIZAWA: The infra-red absorption spectra of soil components. Soil and Plant Food 4, 101-188 (1959).

KÜSTER, E.: Umwandlung von Mikroorganismen-Farbstoffen in Huminstoffe. Z. Pflanzenernahr., Dung., Bodenkunde 57, 51-57 (1952).

KÜSTER, E.: Humusbildung und Phenoloxydasen bei Streptomyceten. Z. Pflanzenernähr., Düng., Bodenk. 69, 137-142 (1955).

KÜSTER, E.: Beitrage zur Physiologie der Streptomyceten. VI. Congres International de la Sci. du Sol. Paris 3, 67-72 (1956).

KYUMA, K.: A fractional precipitation technique applied to soil humic substances. Soil Sci. Plant Nutr. 10, 33-35 (1964).

LANTZ, R. and H. MICHEL. Action de l'ammoniaque en des amines primaires sur le benzene substitué en 1,3 et par des groupes amino ou hydroxyles, non substitués ou substitués. Bull. Soc. Chim. France 12, 2402-2408 (1961).

LAATSCH, W1, L. HOOPS and O. BIENECK: Uber Huminsäuren des Pilzes Spicaria elegans. Z. Pflanzenernähr., Düng., Bodenkunde 58, 258-268 (1952).

LEVESQUE, M. and M. SCHNITZER: Organo-metallic interactions in soils: 6. Preparation and properties of fulvic acid-metal phosphates. Soil Sci. 103, 183-190 (1967 b).

LIM, S.: Beiträge zur Aufklärung der Zusammenhange zwischen dem mikrobiellen Abbau des Lignins und der Bildung von Humusstoffen. Dissertation der Rheinischen Friedrich Wilhelms-Universitat Bonn (1965).

LYINCH, D.L., L.M. WRIGHT and L.J. COTNOIR: The adsorption of carbohydrates and related compounds on clay minerals. Proc. Soil Sci. Soc. Amer. 20, 6-9 (1956).

LYNCH, D.L., L.M. WRIGHT and L.J. COTNOIR: Some factors affecting the adsorption of cellulose compounds, pectins and hemicellulose compounds, on clay minerals. Soil Sci. 84, 113-126 (1957).

MAEDER, H. : Chemische und pflanzenphysiologische Untersuchungen mit Rottestroh. Diss. Justus Liebig Universität Giessen (1960).

MARSHALL, K.C.: Methods of study and ecological significance of Rhizobium-clay interactions. In methods of study in Soil Ecology. (J. Phillipson, Ed) Proceedings of UNESCO and IBP, Paris 1970. pp. 107-110. UNESCO, Paris (1967).

MARTIN, A.E. and R. REEVE: The extraction of organic matter from podzollic B-horizons with organic reagents. Chem. and Ind. 1955, 356.

MARTIN, A.E. and R. REEVE: Chemical studies on podzolic illuvial horizons. I. The extraction of organic matter by organic chelating agents. J. Soil Sci. 8, 268-270 (1957 a).

MARTIN, A.E. and R. REEVE: Chemical studies on podzolic illuvial horizons. II. The use of acetylacetone as extractant of translocated organic matter. J. Soil Sci. 8, 279-286 (1957 b).

MARTIN, A.E., P. DUBACH, N.C. MEHTA and H. DEUEL: Bestimmung der funktionellen Gruppen von Huminstoffen.-Z. Pflanzenernähr., Düng., Bodenkunde 103, 29-39 (1963).

MARTIN, J.P. and K. HAIDER: Phenolic polymers of Stachybotrys atra, Stachybotrys chartarum und Epicoccum nigrum in relation to humic acid-formation. Soil Sci. 107, 260-270 (1969).

MARTIN, J.P. and K. HAIDER: Microbial activity in relation to soil humus formation. Soil Science 111, No. 1, 54-63 (1971).

MARTIN, J.P., S.J. RICHARDS and K. HAIDER: Properties and decomposition and binding action in soil of humic acid synthesized by Epicoccum nigrum. Soil Sci. Soc. Amer. Proc. 31, 657-662 (1967).

MASON, H.S: Chemistry of melanin. III. Mechanism of oxidation of 3,4-dihydroxyphenylalanine by tyrosinase. J. Bio. Chem. 172, 83-99 (1948).

MAYAUDON, J. and P. SIMONART: Etude de la decomposition de la matière organique dans le sol au moyen de carbone radioactif. II. Decomposition du glucose radioactif dans le sol. A. Repartition de la radioactivité dans fractions humiques du sol. Plant and Soil IX, 376-380 (1958).

MAYAUDON, J. and P. SIMONART: Stude de la decomposition de la matiere organique dans le sol au moyen de carbon radiocatif. III. Decomposition des substances solubles dialysables des proteines et des hemicelluloses. Plant and Soil XI, 170(1959 a).

MAYAUDON, J. and P. SIMONART: Etude de la décomposition de la matière organique dans le sol au moyen de carbone radioactif. V. Decomposition de cellulose et de lignine, Plant and Soil XI. 181-192 (1959 b).

MAYAUDON, J. and P. SIMONART: Stabilité de l'humus du sol etudiée a l'aide d'humus marqué au ^{14}C-Arch. Internat. de Phys. et de Biochim. 68, 512 (1960).

MAYAUDON, J. and P. SIMONART: Decomposition of cellulose C^{14} and lignin C^{14} in the soil. Ecology of Soil Fungi (1961).

MAZUMDAR, B.K., S.K. CHAKRABARTTY and A. LAHIRI: Aromaticity and oxidation of coal. Sci. Ind. Res. (India) 16, B. 275 (1957).

McCALLA, T.M.: The adsorbed ions of colloidal clay as a factor in nitrogen fixation by Azotobaiter. Soil Sci. 48, 281-286(1939).

McCALLA, T.M.: Physico-chemical behavior of soil bacteria in relation to the soil colloid. J. Bact. 40, 33-43 (1940).

McLAREN, A.D. and G.H. PETERSON: Introduction to the biochemistry of terretial soils. In Soil Biochemistry (A.D. McLaren and G.H. Peterson, Eds.) pp. 1-15, MarcelDekker, New York(1967).

MEYER, B.: Exkursionsführer zur Jahrestagung 1969 in Hannover. Mitt. Deutsche Bodenkundl. Ges. 9, 104 u. 105 (1969).

MIGITA, N. and M. KAWAMURA: Studies on lignin. I. A comparison between the insoluble and soluble portions of lignin sulfate isolated from various trees.- J. Agr. Chem. Soc. Japan 20, 348-352 (1944 a).

MITCHELL, L.P.: Chemiosmotic coupling in oxidative and photosynthetic phosphorylation. Bio. Rev. Cambridge philos. Soc. 41, 445-502 (1966).

MITSCHERLICH, E.A: An der Grenze der Ertragssteigerung. Z. Pflanzenernähr., Düng., Bodenkunde 40, 193-200 (1948).

MOHTADI, S: Beitrag zur Isolierung von pflanzenphysiologisch wirksamen Stoffen wahrend der Rotte von Stroh. Dissertation Giessen (1962).

MORRISON, R.I.: Products of the alkaline nitrobenzene oxidation of soil organic matter. J. Soil Sci. 14, 201-216 (1963).

MOSCHO PEDIS, S.E.: Fuel, 31, 425 (1962).

MUSSO, H.: Uber Phenol-Oxydationen. - Angew. Chem. 75, 965-977(1963).

MUSSO, H., U.V. GIZYCKI, H. KRAMER and H. DOPP: Uber Orceinfarbstoffe. XXIV. Uber den Autoxydationsmechanismus bei Resorcinderivaten. Chem. Ber. 98, 3952-3963 (1965).

NAUMOVA, A.N. and E.P. GROMYKO: The influence of gumbrin on the microorganism of gray-soil. Mikrobiologiya. 22, 1 (1953).

NEHRING, K. and R. SCHIEMANN: Untersuchungen zum Humusproblem. I. Mitt. Beitrage zur Kenntnis der Vorgänge bei der Rotte von Stallmist und Komposten sowie zur Kenntnis der Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 57, 97-113 (1952 a).

NEHRING, K. and R. SCHIEMANN: Untersuchungen zum Humusproblem. I. Mitt. Beitrage zur Kenntnis der Vorgange bei der Rotte von Stallmist und Komposten sowie zur Kenntnis der Huminsauren. 2. Teil Beitrage zur Kenntnis der Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 57, 193-215 (1952 b).

NICOLAUS, R.A.: Biogenese der Melanine. Conf. VII Corso chim. Acad. naz. Lincei, Milano (1962).

NOVAK, B.: Contribution to the Theory of microbial formation of humus. For. Social Agri. Sci. (Prague) 12, 401-418 (1963).

NOVAKOVA J.: The effect of different amounts of bentonite and kaolinite on the decomposition of glucose. In Studies about Humus. Trans. Intern. Symp. "Humus et planta IV", Prague:185-188 (1967).

NOVAKOVA J.: The influence of different quantities of bentonite and kaolinite on glucose mineralization. Rostlinna Vyroba(Prague) 15, 215-220 (1969).

OBERLANDER, H.E. and K. ROTH: Transformation of ^{14}C-labelled plant material in soils under field conditions. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Wien 1968, 251-264.

ORLOV, D.S. and N.M. GRINDEL: Spectrophotometric determination of the humus content in soil. Pochvovedenie Nr. 1, 112-122(1967) (russ.)

ORLOV, D.S., O.H. ROZANOVA and S.G. MATYUKHINA: Infrared absorption spectra of humic acids. Pochvovedenie Nr. 1, 17-25 (1962) (russ.)

OTTEY, L., E.L. TATUM: Protocatechuic acid oxidase of Neurospora. J. Biol. Chem. 223, 307-311 (1956).

PEOVER, M.E. and J.D. DAVIES: Einfluß der Ionenassoziation auf die Polarographie der Chinone in Dimethylformamid.-J. electroanalyt. Chem. 6, 46-53 (1963).

PHILLIPS, M: The chemistry of lignin. Chem. Rev. 14, 103-170 (1934).

PLOETZ, Th.: Beiträge zur Ligninbestimmung mit starker Schwefelsäure. Cellulosechemie 18, 49-57 (1940).

PLOETZ, Th.: Polymere Chinone als Huminsäuremodelle.-Z. Pflanzenernähr., Düng., Bodenkunde 69, 50-58 (1955).

PLOTHO, O.v.: Die Humusbildung der Mikroorganismen. Z. Pflanzenernähr., Düng., Bodenkunde 51, 212 (1950).

PLOTHO, O.v.: Weitere Untersuchungen zur Humusbildung der Mikroorganismen. Z. Pflanzenernähr., Düng., Bodenkunde 55, 151-169(1951).

POSNER, A.M.: The humic acid extracted by various reagents from a soil. Part. I. Yield, inorganic components, and titration curves. J. Soil Sci. 17, 65-78 (1966).

POSNER, A.M., B.K.G. THENG and J.R.H. WAKE: The extraction of soil organic matter in relation to humification. 9th Internat. Congr. Soil Sci., Adelaide, Australia, Transaction III, 153-162 (1968).

RAPER, H.S.: Die Einwirkung von Tyrosinase auf Tyrosin. Fermentforschung 9, 206 (1927).

RAPER, H.S.: The aerobic oxidases. - Physiol. Rev. 8, S.245-248(1928).

REINHARDT, G.: Untersuchungen uber die Einwirkung von Lignin und dessen Abbauprodukten auf das Wachstum und den Stoffwechsel von Pflanzen. Dissertation Universitat Giessen 1961.

RIEMER, H.: Polarographische Untersuchungen über Beziehungen zwischen Struktur und Reaktivitat bei Benzochinonen. Dissertation TU Braunschweig 1970.

RIFFALDI, R. and M. SCHNITZER: Electron spin resonance spectrometry of humic substances. Proc. Soil Sci. Soc. Am. 36, 301-305 (1972).

RITTER, G.J., R.M. SEBORG and R.L. MITCHELL: Factors affecting quantitative determination of lignin by 72 percent sulfurnic acid method. Ind. Eng. Chem. Analyt. Edit. 4, 202 (1932).

RUHEMANN, H.: Untersuchungen zur Auftrennung physiologisch aktiver Stoffe aus Lignin unter Anwendung von Radiokohlenstoff. Dissertation Th Braunschweig 1964.

RUIZAMIL, M. and W. FLAIG: The effect of Thymohydroquinone on the organic-acid metabolism and the respiration of plants. An. Edafol. Agrobiol. 19, 1-9 (1964).

RUIZAMIL, M. and W. FLAIG: Influence de la timohidroquinona sobre el metabolismo de carbohidratos en algunas dicotiledoneas. Annles de Edafologia y Agrobiologia XIX, 1, 11-22 (1960 b).

SAALBACH, E.: Zur Kenntnis der Huminsäuren, XIV. Mitt. Einfluß von Modell-substanzen von Humusstoffen auf den Stoffwechsel von Getreide, Landw. Forsch. 9. Sonderheft 95-100 (1957).

SAGAVE, B.: Grundzüge der Abschätzungslehre. P. Parey, Berlin 125-131 (1934).

SALFELD, J. Chr.: Zum Reaktionsmechanismus der Purpurogallinbildung. Angew. Chem 69, 723-724 (1957).

SALFELD, J. Chr.: Fraktionierung eines Huminstoffpräparates mit wasserhaltigen Lösungsmitteln. Landbauforsch. Völkenrode 14, 131-136 (1964).

SALFELD, J. Chr.: Die Charakterisierung von Huminstoffen durch Differenzen-Spektrogramme. Mitt. Dtsch. Bodenkundl. Ges. 4, 289-290 (1965).

SALFELD, J. Chr.: Untersuchungen zur Klassifizierung der organischen Bodensubstanz. Mitt. Dtsch. Bodenkundl. Ges. 8, 133-135(1968)

SALFELD, J. Chr.: Optical measurements on humic systems. Symposium Humus at Planta V, Prag (1971), 257-266.

SALFELD, J. Chr. and E. BAUME: Über die Oxydation von Pyrogallol und Pyrogallolderivaten. IV. Die Konstitution der Purpurogallincarbonsäure -(9). Chem. Ber. 97, 307-311 (1964)

SALFELD, J. Chr. and H. SÖCHTIG: Ergänzung zum Exkursionsführer der Jahrestagung der Dtsch. Bodenkundl. Ges. in Hannover (1969).

SAUERBECK, D.: Stability of recently formed humus compounds in soil. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968 b, 57-66.

SAUERBECK, D.: Die Umsetzung markierter organischer Substanzen im Boden in Abhängigkeit von Art, Menge und Rottegrad. Landwirtsch. Forsch. 21, 91-102 (1968 a).

SAUERBECK, D.: Comparison of plant material and animal manure in relation to their decomposition in soil. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968 c, 219-225.

SAUERBECK, D. and F. FÜHR: Alkali extraction and fractionation of labelled plant material before and after decomposition - a contribution to the technical problems in humification studies. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, 3-11.

SAUERBECK, D. and F. FÜHR: Die Umsetzung von markiertem Pflanzenmateria im Boden unter Feldbedingungen. Mitt. Deutsche Bodenkundl. Gesellsch. 10, 174-177 (1970).

SCHARPENSEEL, H.W.: Herstellung und Reinigung von tritiummarkierten Grau und Braunhuminsäurepräparaten sowie von Tritium-Purpurogallin. -Z. Pflanzenenrnähr., Düng. und Bodenkunde 91, 131-146 (1960 a).

SCHARPENSEEL, H.W.: Untersuchungen mit radioaktiv markierten Huminsäuren und Vorstufen. 2. Teil.-Z. Pflanzenernähr., Düng. und Bodenkunde 91, 193-202 (1960 b).

SCHARPENSEEL, H.W.: Labelling of soil organic matter. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting, Pergamon Press. Ltd. Oxford 1966a, 351-364.

SCHARPENSEEL, H.W.: Aufbau und Bindungsform der Ton-Huminsäurekomplexe. Teil IV. Z. Pflanzenernahr. Dung. V. Bodenk. 55, 151-169 (1970).

SCHARPENSEEL, H.W. and W. ALBERSMEYER: Infrarotspektroskopische Untersuchungen an Huminsäuren, Huminsäureaufschlüssen und phenolisch-chinoiden Vergleichssubstanzen. Z. Pflanzenernähr. Düng., Bodenkunde 88, 3, 203-211 (1960).

SCHARPENSEEL, H.W. and H. BECKMANN: Untersuchung zur Kohlendioxid-Entbindung des Bodens. II. Teil. Spezielle Studien unter Verwendung radioactiver Tracer.-Z. Pflanzenernähr., Düng, Bodenkunde 104, 110-119 (1964).

SCHARPENSEEL, H.W. and R. KRAUSSE: Aminosäureuntersuchungen an verschiedenen organischen Sedimenten, besonders Grau- und Braunhuminsäurefraktionen verschiedener Bodentypen (einschließlich C14-markierter Huminsäuren). Z. Pflanzenernähr., Düng, Bodenkunde 96, 11-34 (1962).

SCHARPENSEEL, H.W., E. KÖNIG and E. MENTHE: Infrarot- und Differentialthermo-Analyse an Huminsäureproben aus verschiedenen Bodentypen, aus Wurmkot und Streptomyceten, Z. Pflanzenernähr., Düng., Bodenkunde 106, 134-150 (1964).

SCHEFFER, F. and B. ULRICH: Lehrbuch der Agrikulturchemie und Bodenkunde. III. Teil. Humus und Humusdungung 1, Enke Stuttgart, pp. 266 (1960).

SCHEFFER, F., O.v. PLOTHO and E. WELTE: Untersuchungen über die bildung von Humusstoffen durch Actinomyceten. - Landwirtsch. Forsch. 1, 81-92 (1950).

SCHMID, G. and W. FLAIG: Pflanzenstoffwechsel und Wirkstoffe. Landbauforsch. 12, 51-56 (1962).

SCHNITZER, M.: The application of infrared spectroscopy to investigations on soil humic compounds. Canad. Spectroscopy 10, No. 5, 121-127 (1965).

SCHNITZER, M. and J.G. DESJARDINS: Molecular and equivalent weights of the organic matter of a podzol. Soil Sci. Soc. Amer., Proc. 26, 362-365 (1962).

SCHNITZER, M. and J.G. DESJARDINS: Carboxyl and phenolic hydroxyl groups in some organic soils and their relation to the degree of humification. Can. J. Soil Sci. 45, 257-264 (1965).

SCHNITZER, M. and I. HOFFMAN: Thermogravimetry of soil humic compounds. Geochim. Cosmochim. Acta 29, 359-370 (1965).

SCHNITZER, M. and SU. KHAN: "Humic substances in the Environment". Marcel Dekker Inc. New York. (1972).

SCHNITZER, M. and S.I.M. SKINNER: Organo-metallic interactions in soils: 3. Properties of iron- and aluminium-organic matter complexes, prepared in the laboratory and extracted from a soil. Soil Sci. 98, 197-203 (1964).

SCHNITZER, M. and S.I.M. SKINNER: Organo-metallic interactions in soils: 4. Carboxyl and hydroxyl groups in organic matter and metal retention. Soil Sci. 99, 278-284 (1965 a).

SCHNITZER, M. and S.I.M. SKINNER: The carboxyl group in a soil organic matter preparation. Soil Sci. Soc. Amer., Proc. 29,400-405 (1965 b).

SCHNITZER, M., D.A. SHEARER and J.R. WRIGHT: A study in the infrared of high molecular weight organic matter extracted by various reagents from a podzolic horizon. Soil Sci. 87, 252-257 (1959).

SCHNITZER, M. and U.C. GUPTA: Some chemical characteristics of the organic matter extracted from the C and B2 horizons of a gray wooded soil. Proc. Soil Sci.Soc. Am. 28, 374-377 (1964).

SCHNITZER, M. J.R. WRIGHT and J.G. DESJARDINS: A comparison of the effectiveness of various extractants for organic matter from two horizons of a podzol profile. Can. J. Soil Sci. 38, 49-53 (1958).

SCHOBINGER, U. : Chemische Untersuchungen uber die Umwandlung von Weizenstrohlignin im Laufe der Verrottung.- Dissertation, ETH Zurich (1958).

SCHREINER, O. and E. SHOREY: Chemical nature of soil organic matter. U.S. Dept. Agric. Bureau of Soils Bull. 74, 5-48 (1910).

SIMONART, P. and J. MAYAUDON: Etude de la décomposition de la matière organique dans le sol au moyen de carbone radioactif. I. Cinetique de l'oxydation en CO_2 de divers substrats radioactifs. Plant and Soil 9, 367-375 (1958 a).

SIMONART, P. and J. MAYAUDON: Etude de la décomposition de la matière organique dans le sol au moyen de carbone radioactif. II. Decomposition du glucose radioactif dans le sol. B. Repartition de la radioactivité dans l' a-humus. - Plant and Soil 9, 381-384 (1958 b).

SIMONART, P. and J. MAYAUDON: Etude des transformations de la matière organique du sol au moyen du carbone-14. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966,245-258.

SIMONART, P., J. MAYAUDON and L. BATISTIC: Etude de la décomposition de la matière organique dans le sol au moyen de carbone radioactif. IV. Décomposition des pigments foliaires. Plant and Soil 11, 176-180 (1959).

SKUJINS, J.J.: Enzymes in soil. In soil Biochemistry (A.D. Mclaren and G.H. Peterson, Eds.) pp. 371-414, Marcel Dekker, New York. (1967).

SLYKE, D.D. van, D.A. MacFAYDEN and P. HAMILTON: Determination of free amino acids by titration of the carbon dioxide formed in the reaction with ninhydrin. J. Biol. Chem. 141, 671-680 (1941).

SMITH, J.H.: Some inter-relationships between decomposition of various plant residues and loss of soil organic matter as measured with carbon-14 labelling. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 223-233.

SMITH, F.B., W.H. STEVENSON and P.E. BROWN: The production of artificial manures. Agr. Exp. Sta. Res. Bul. 126, (1930).

SNEATH, P.H.A.: The application of computers to taxonomy. J. Gen. Microbiol. 17. 201-226 (1957).

SÖCHTIG, H.: Beeinflussung des Stoffwechsels der Pflanzen durch Humus und seine Bestandteile und die Auswirkung auf Wachstum und Ertrag. - Landbauforschung Völkenrode 14, 9-16 (1964)

SÖCHTIG, H.: Ein Pflanzentest zur Feststellung der Wirkung stoffwechselaktiver Substanzen, Methodik und Erfahrungen. Deutsch-Polnisches Torf-Kolloquium DDR-Polen in Rostock 1967.

SÖCHTIG, H.: Uber den einfluB von N-Lignin auf die Nitrifizierung im Boden sowie den Ertrag und den Nitratgehalt der Pflanzen - Qual. Plant. Mater. Veg. XX, 1-2, 137-150 (1970).

SÖCHTIG, H.: (1972) In press.

SÖCHTIG, H. and H. HARMS: Uber den EinfluB von Torf auf Keimung und Anfangs-wachstum von Pflanzen.- Landw. Forsch. 26/II (1971)

SÖCHTIG, H. and F. MACIAK: Bindung des Stickstoffs und Vorkommen phenol-ischer Verbindungen im Torf. Telma, Band 1, 49-61 (1971).

SÖCHTIG, H. and J. Chr. SALFELD: Characterization of humic systems in a black earth-Griserde-morphosequence in the area of Hildesheim. Symposium Humus et Planta V, Prag 1971, 247-256.

SØRENSEN, H.: Studies on the decomposition of ^{14}C-labelled barley straw in soil. Soil Sci. 95, 45-51 (1963).

SØRENSEN, H.: Formation of soil organic matter during decomposition o plant components. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 271-274.

SOWDEN, F.J. and H. DEUEL: Fractionation of fulvic acids from the B-horizon of podzol. Soil Sci. 91, 44-47 (1961).

SPRINGER, U.: Stoffabbau und Humusaufbau untersucht an einem Strohmis und Strohlignin ist (Laboratoriumsversuch). Prakt. Blätter f. Pflanzenbau u. Pflanzenschutz 21/22, 1-57(1944/45).

SPRINGER, U.: Über Komposthuminsäuren aus verschiedenen pflanzlichen Ausgangsstoffen.-Z. Pflanzenernähr., Düng., Bodenkunde 69, 66-71 (1955).

SPRINGER, U., and A. LEHNER: Stoffabbau und Humusaufbau bei der aerobe und anaeroben Zersetzung landwirtschaftlich und forstwirtschaftlich wichtiger organischer Stoffe. I.Z. Pflanzenernähr., Düng., Bodenkunde 58, 193-231 (1952 a).

SPRINGER, U. and A. LEHNER: Stoffabbau und Humusaufbau bei der aeroben und anaeroben Zersetzung landwirtschaftlich und forstwirtschaftlich wichtiger organischer Stoffe. II. Z.Pflanzenernähr., Düng., Bodenkunde 59, 1-27 (1952 b).

SPRINGER, U. and F. SELSCHAB: Zur Kenntnis der bei der Kompostbereitun auftretenden stofflichen Veranderungen. Mit Ergebnissen eines dreijahrigen GefaBversuches. Bayr. Landw. Jahrbuch 38, 250-300 (1961).

STAHLER, R.Y. and J.L. INGRAHAM: Protocatechuic oxidase.- J. Biol. Chem. 210, 799-808 (1954).

STEELINK, C.: Free radical studies of lignin, lignin degradation products and soil humic acids. Geochim. Cosmochim. Acta 28, 1615-1622 (1964).

STEELINK, C. and G. TOLLIN: Stable free radicals in soil humic acid. Biochim. Biophys. Acta 59, 25-34 (1962).

STEELINK, C., J.W. BERRY, A.HO and H.E. NORDBY: Alkaline degradation products of soil humic acid. Sci. Proc. Roy. Dublin Soc. Ser. A 1, 59-67 (1960).

STEINMETZ, A.: Modellversuche zur Beteiligung von Polyphenoloxydasen bei der Bildung naturlicher Huminsauren. Dissertation TH Braunschweig (1956).

STOCKLI, A.: Uber den Abbau von Lignin, Cellulose und Hemicellulose durch Pilze. Versuche mit Streumaterialien, Holz und Ligninsulfonsäure. Promotion ETH Zurich (1952).

STOTZKY, G.: Influence of clay minerals on microorganisms. II. Effect of various clay species, homoionic clays, and other particles on bacteria. Can. J. Microbiol. 12, 831-848 (1966).

STOTZKY, G.: Clay minerals and microbial ecology. Traus. N.Y. Acad. Sci. Ser II, 30, 11-21 (1967).

STOTZKY, G. and L.T. REM: Influence of clay minerals on microorganisms. I. Montmorillonite and Kaolinite on bacteria. Can. J. Microbiel. 13, 1535-1550 (1967).

SUNDMAN, W., K. HARO: On the mechanism by which cyclolignanolyctic agro-bacteria might cause humification. Finiska Kemists Med. 75, 11-118 (1966).

SWABY, R.: Soil organic matter. -8th, 9th, 10th C.S.I.R.O. Annual Reports. Government Printers, Sydney. (1956-1958).

THENG, B.K.G. and A.M. POSNER: Nature of the carbonyl groups in soil humic acids. Soil Sci. 101, 199-201 (1967).

TINSLEY, J. and A. SALAM: Extraction of soil organic matter with aqueous solvents. Soils and Fertilizers 24, 81-84 (1961).

TOKUDOME, S. and I. KANNO: Nature of the humus of some Japanese soils. 9th Internat. Congr. Soil Sci., Adelaide, Australia, Transactions III, 163-173 (1968).

TRAYNARD, Ph. and A. EYMERY: Delignification par les solutions hydrotropiques. II. Etude des lignines hydrotropiques. Holzforschung 10, 6-11 (1956).

TRIPPETT, S., S. DAGLEY and D.A. STOPHER: Bacterial oxidation of protocatchuic acid. Biochem. J. 76, 9p (1960).

TSCHAPEK, W. and A.J. GARBOSKY. The principles of adsorption of the Azotobacter, Transactions of the Fourth International Congress of soil science, Proceedings, Amsterdam 3, 102-104 (1950).

WAKSMAN, S.A. and J.W. SMITH: Transformation of methoxyl group in lignin in the process of decomposition or organic residues by microorganisms. J. Amer. Chem. Soc. 56, 1225 (1934).

WAKSMAN, S.A. and F.G. TENNEY: The composition of natural organic materials and their decomposition in the soil. I. Methods of quantitative analysis of plant materials. Soil Sci. 24, 275-283 (1927 a).

WAKSMAN, S.A. and F.G. TENNEY: The composition of natural organic materials and their decomposition in the soil. II. Influence of age of plant upon the rapidity and nature of its decomposition - rye plants. Soil Sci. 24, 317-333 (1927 b).

WAKSMAN, S.A., F.C. TENNEY and R.A. DIEHM: The chemical and microbiological principles underlaying the transformation of organic matter in the preparation of artificial manures. J.A.S.A. 21, 533-545 (1929).

WHITEHEAD, D.C. and J. TINSLEY: Extraction of soil organic matter with dimethylformamide. Soil Sci. 97, 34-42 (1964).

WIESEMÜLLER, W.: Untersuchung uber die Fraktionierung der organischen Bodensubstanz. Albrecht Thaer Archiv 9, 419-436 (1965).

WINTER, A.G.: Untersuchungen uber die Aufnahme von Penicillin und Streptomycin durch die Wurzeln von Lepidum sativum und ihre Beständigkeit in näturlichen Boden. Z. Bot. 40, 153 (1952)

WINTER, A.G., H. PREUSS and F. SCHÖNBECK: Untersuchungen über die Aufnahme organischer Substanzen durch die Wurzeln höherer Pflanzen. I. Phenolische Verbindungen. Naturwissensch. 46, 536-537 (1959).

WRIGHT, J.R. and M. SCHNITZER: Oxygen containing functional groups in the organic matter of the Ao and Bh-horizon of a podzol. 7th Internat. Congr. Soil Sci. Madison, Wisc. USA 2, 120-12 (1960).

WRIGHT, J.R. and M. SCHNITZER: An estimate of the aromaticity of the organic matter of a podzol soil. Nature 190, 4777, 703-704 (1961).

ZENK, M.H.: Einbau von p-Hydroxybenzoesäure in die Hydrochinonkomponente des Arbutins in Bergenia crassifolia. - Z. Naturforsc 19 b, 856-857 (1964).

ZIECHMANN, W.: Spectroscopic investigations of lignin, humic substanc and peat. Geochim. Cosmochim. Acta 88, 1555-1566 (1964).

ZIECHMANN, W.: Infrared spectra of humic acids. Brennstoff-Chem. 39, 353 (1958).

ZIECHMANN, W.: Die Darstellung von Huminsäuren im heterogenen System mit neutraler Reaktion. Z. Pflanzenernähr., Düng., Bodenkunde 84, 155-159 (1959).

ZIECHMANN, W. and H. SCHOLZ: Spektroskopische Untersuchungen an Huminsäuren. Naturwissenschaften 47, 193-196 (1960).

ZVJAGINCEV, D.G.: Some regularities of adsorption of microorganisms on ion exhhange resins. Mikrobiologiya. 31, 399 (1962).

ZYJAGINCEV, D.G. and L.L. VELIKANOV: Effect of adsorbents on the activity of bacteria growing on media containing amino acids. Mikrobiologiya 37, 1017-1023 (1968) (russ.).