Biochemistry of Soil Organic Matter in Relation to Crop Production

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Content

Lecture 6.

Physical Properties of Humic Substances. Some Problems Related to Molecular Structure of High Molecular Weight humic Fractions.

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1. Particle form, size and weight of humic acids.

1.1 Random polymerisation and effect of nitrogen.

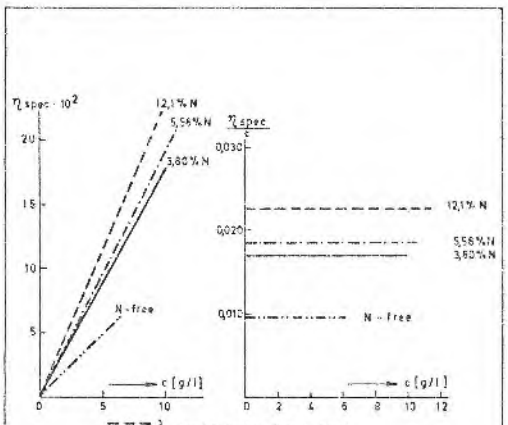
In lecture 3. it was established, that the polymerisation of phenolic units in the presence of nitrogenous compounds leads to the formation of the dark coloured higher molecular weight, humic acid-like substances. The proposed enzymatic random polymerisation of tyrosine to melanin under oxidising conditions was used for the explanation of the processes which occur during formation of humic acids. Melanin too is a higher molecular substance, and the polymerisation leading to its formation occurs through quinonoid intermediates as it is the case in the formation of humic acids.

The mentioned scheme showed, that not only the indol-5,6-quinone formed on oxidation, but also that all intermediates participate in the formation of the threedimensional, high molecular weight melanin (BLOIS 1965).

The processes of polymerisation are more complex in the case of humic substances, since several phenols and several nitrogenous components participate in the formation of the polymers.

By random polymerisation mostly spherical shaped colloids are formed.

We made measurements of the viscosity of model humic acids from hydroquinone, which had been oxidised in alkaline solution in the presence of variable amounts of ammonia. The synthetic humic acids contained therefore different amounts of nitrogen. It was concluded from the requirement of volume - that is the measured viscosity number to the theoretical viscosity number of 0,0025 according to Einstein-, that the humic acids are not compact spherical shaped colloids. They have pores and internal spaces and possess a structure which is comparable with that of a sponge. (FLAIG and BEUTELSPACHER 1954).



Effect of nitrogen content on the viscosity number and the volume ratio $\left(Z_\eta / Z_{\eta_0} ; Z_{\eta_0} = 0{,}0025\right)$ of natural and synthetic humic acids.

	Z_η	volume ratio
pH = 3		
hydroquinone humic acid, N-free	0,0097	3,9
" " " , 5,56 % N	0,0185	7,4
" " " , 12,1 % N	0,0228	9,0
natural humic acid , 3,81 % N	0,0172	6,9
pH = 12		
hydroquinone humic acid , N-free	0,0027	1,1
" " " , 5,7 % N	0,0027	1,1

Fig. 1: Viscosity number in dependency of nitrogen content of hydroquinone humic acids.

In the case of hydroquinone humic acids, the viscosity number increases with an increase in nitrogen content at pH = 3. The higher nitrogen content effects a stronger linkage inside the structure of the particles. For both nitrogen containing and nitrogen free humic acids the requirement of volume is nearly 1 at pH = 12. It is supposed, that the hydration is larger in acid than in alkaline solution.

If one transfers these results to natural humic acids it is not necessary that the relation between viscosity number and total nitrogen content exists since analytically determined α-amino nitrogen contributes less to the crosslinking than the nitrogen which is non-hydrolizable and partly bound in heterocyclic form. This is the reason for the exact relationship between nitrogen content and viscosity number in the case of hydroquinone humic acids; deviations will occur in the case of natural humic acids.

1.2 Investigations with the electron microscope.

It is oftentimes possible to detemine the particle form and size of colloids with the electron microscope.

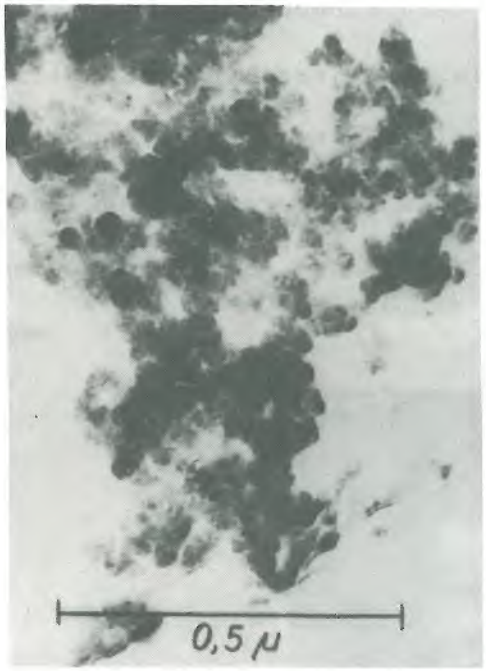


Fig. 2: Humic acids isolated from chernozem at pH 3.5. Humic acids isolated from chernozem at pH 8.

The aggregation to the ramified structure and the simultaneous formation of coacervates occurs at pH-values of 3.5, whilst the humic acids are dispersed in alkaline suspension to nearly single particles.

The particle diameters of humic acids from chernozem reprecipitated 23 times are in order of 50 to 100 Å.(BEUTELSPACHER 1952, FLAIG and BEUTELSPACHER 1951). The numerous precipitations reduced the ash content to below 1% and allowed only high molecular weight materials to remain in the suspension.

According to the mentioned requirement of volume and the deduced spongy structure of the humic acids, it can be concluded from the results of W. OSTWALD (1928), that the units of humic acids are also hydrated inside of the colloids. The strength of hydration varies with environmental conditions. From our measurements with the ultracentrifuge an increase in density of the particles in 0.2 M sodium chloride solution at a pH-value of 5.0 was found compared with a suspension in water only. It is assumed, that this is due to a decrease of hydration, which leads to a change in the partial specific volume.

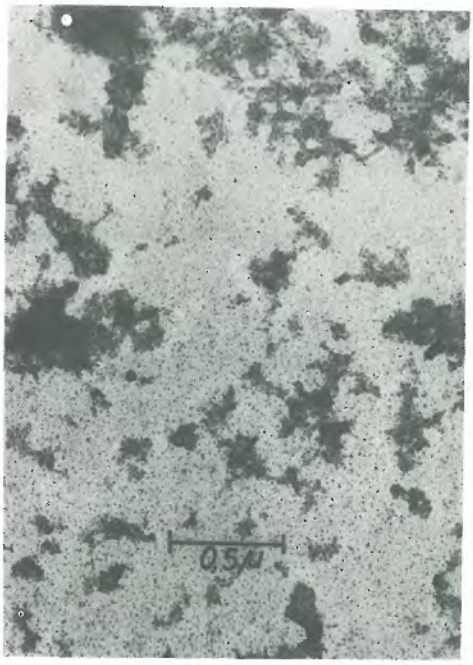


Fig. 3: Humic acids (pH = 3.5)treated with ultrasonic.

Hydration shells are diminished also mechanically by ultrasonic vibration. By ultrasonic treatment of suspensions of humic acids the electron optical density increased and the concervates were partly degraded.

1.3 Investigations with the ultracentrifuge.

In published accounts of work in which the ultracentrifuge has been used, only values for the sedimentation constant have been reported (PIRET, WHITE, WALTHER and MADDEN jr. 1960, SCHEFFER, ZIECHMANN and SCHLÜTER 1958). The sedimentation constant alone without the diffusion constant does not allow a statement about the particle weight of high molecular weight substances to be made. The authors mentioned above stated that an exact determination of the diffusion constant is impossible, since the preparation of monomolecular humic acids does not or did only seldom succeed. For our investigations a new ultracentrifuge, which has been constructed and improved by BEUTELSPACHER in cooperation with the firm M. Christ, Osterode, was used. The special advantages of this centrifuge are a more intensive source of light for investigations of coloured substances, a higher constancy of rotation, a higher constancy of temperature ($\pm$ 0.01°C) and the application of a new optical system for analytical purposes, for sedimentation and diffusion.

Apparative errors, such as the contra diffusion to the center of rotation, which are described in measurements of humic acids (SCHEFFER, ZIECHMANN and SCHLÜTER 1958), and which are evidently based on the inconstancy of the temperature, no longer occur.

1.31 The influence of hydrogen ion concentration on the determination of sedimentation and diffusion constant as well as on particle weight, diameter and friction of humic acids in water suspensions and in the presence of 0.2 M NaCl.

The humic acids were isolated from a "marsch" soil with 0.1 M sodium hydroxide solution. The soil was acidified before extraction and

washed with water. After acicifying the extraction solution the humic acids were reprecipitated 4 times and electrodialysed using 0.10 milliampere and 110 volt. The fractions were taken from the center of the dialyser at the mentioned pH-values and immediately investigated with the ultracentrifuge. (FLAIG and BEUTELSPACHER 1968).

The time dependent course of sedimentation of the electrodialysed samples of humic acids in water suspension was determined in the ultracentrifuge by measuring the movement of the refractive index gradient with a schlieren optic.

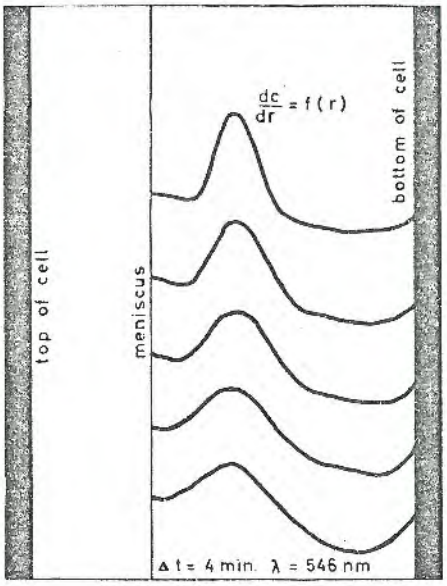


Fig. 4: Density gradient sedimentation patterns of a water suspended, electrodialysed humic acid pH 4.5.

The diagrams of sedimentation, recorded by photography at 4 minute intervals show, that humic acids consist of particles of different size. One part appears as a high molecular weight substance in form of a Gaussian distibution pattern, whilst the other accumulates at the bottom of the moving boundary cell under the influence of gravitation at 50.000 rpm in between some few minutes as a macromolecular

substance and effects there a strong increase of the refractive index. The Gaussian distribution curve shows an asymmetric course by th presence of different sizes of molecules. This is shown especially by th descending part of the curve.

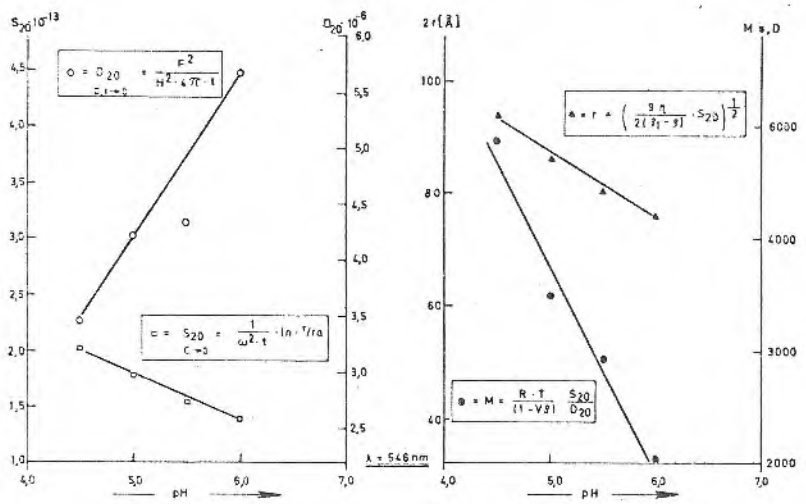


Fig. 5: a) Effect of pH on the sedimentation and diffusion properties of an electrodialysed humic acid.

b) Effect of pH on the determination of particle weight and diameter of an electrodialysed humic acid from ultracentrifugal data.

The graph shows that the sedimentation constant increases and the diffusion constant decreases with increasing hydrogen ion concentration (fig. 5).

The particle weights calculated according to the formula of SVEDBERG (1934) increasesfrom 2.050 at pH = 6.0 to 4.850 at pH = 4.5.

The diameters (radii) of the particles also increase from 76 Å (r=38) to 94 Å (r=47) with increasing hydrogen ion concentration.

Fraction of humic acids							serumalbumine (horse)
pH =	4.5		5.0	5.5	6.0		7.3
	I	Is	II	III	IV	IVa	
	0.2 M NaCl without	with			0.2 M NaCl without	with	with 0.2 M NaCl
$s_{20} \cdot 10^{-13}$	2.01	4.71	1.77	1.53	1.38	4.46	4.46
$D_{20} \cdot 10^{-6}$	3.45	0.65	4.21	4.32	5.66	0.48	0.61
$M_{s,D}$	4850	60.400	3500	2950	2050	77.000	70.000
r (Å)	47	71	43	40	38	69	
f/fo	1.1	1.2[1]	1.1	1.1	1.0	1.5[1]	1.27

$$s_{20} = \frac{1}{\omega^2 . t} \cdot \ln \frac{r}{r_a} \qquad M = \frac{R \cdot T \cdot s_{20}}{(1 - V^* \rho) D_{20}} \qquad f/f_o = \frac{1}{\eta} \left[\frac{R^2 \cdot T^2}{N_L^2 \cdot D_{20}^2} \cdot \frac{(1 - V^* \cdot \rho)}{162 . V^* \cdot s_{20}} \right]^{\frac{1}{3}}$$

$$D_{20} = \frac{F^2}{H^2 . 4\pi . t} \qquad r = \text{(radius)} \left[\frac{9 \cdot \eta}{2 (\rho_1 - \rho)} \cdot s_{20} \right]^{\frac{1}{2}} \qquad f/f_o^{1)} = \left[\frac{1 - V^* \cdot \rho}{D_{20}^2 \cdot s_{20} \cdot V^*} \right]^{\frac{1}{3}} \cdot 10^{-8}$$

ω = angular velocity; F = area, H = height; V^* = partial specific volume; η = viscosity of solution; ρ = density (solution and solvent); N_L = Loschmidt number

1) corrected for the amount of salt added

Fig. 6: Effect of pH on sedimentation (s_{20}), diffusion (D_{20}) particle weight ($M_{s,D}$) particle diameter (2r) and the friction coefficient (f/f_o) of humic acids in water and in 0.2 M NaCl suspension.

In these investigations it is possible to estimate the particle form by means of the friction coefficient from the pH-dependent values of the sedimentation and diffusion constants. It can be seen from the ratio f/f_o (f_o = molar friction coefficient of globular particles according to the formula of STOKES (1949), f = measured coefficient), the values are in the range between 1.0 and 1.1. Therefore it can be concluded that the humic acids are spheric colloids. This result confirms our former investigations with the electron microscope.

The effect of charge must be recognized when the dissociation of high molecular weight substances is studied, since the polyions and counter ions possess different charges and different sedimentation and diffusion coefficients due to large differences in their particle sizes.

Therefore, a charge gradient occurs during sedimentation leading to a decrease in the rate of sedimentation of humic acid polyions. An addition of neutral salts decreases the primary charge effect, and the necessary electron neutrality for an unhindered sedimentation is reached. The minimum amount of neutral salt which must be added depends upon the concentration of the polyelectrolytes. The empirical values for a 1 % solution of protein are in the range of 0.2 Molar sodium chloride. We used this concentration of sodium chloride for our measurements with humic acids.

Humic acids may be compared with globular proteins to a certain extent. Like globular proteins, humic acids contain acidic groups and nitrogen which is assumed to have a basic function. Furthermore, it may be established from the determined values of α-amino-nitrogen and from the amino acids bound in peptide-like fashion, that humic acids have a protein content of about 5 %. Therefore the values of serum albumin are mentioned under comparable conditions (ELIAS 1961).

The results of experiments with 2 electrodialysed samples in the presence of sodium chloride are depicted in fig. 6 (column Ia and IVa). The values have been measured at pH = 4.5 and 6.0 after addition of sodium chloride. It should be noted, that remarkable differences occur in salt containing suspensions in comparison to water suspension. The sedimentation constant increases from 1.38 to 4.46 x 10^{-13} at pH = 6.0 and from 2.11 to 4.71 x 10^{-13} at pH = 4.5.

The values of the diffusion constant are especially influenced by the addition of sodium chloride. A comparison of the diffusion constants determined in water shows, that the values decrease from 5.66 to

0.48×10^{-6} at pH = 6.0 and from 3.45 to 0.65×10^{-6} at pH = 4.5. The sedimentation constant is more than doubled on the addition of sodium chloride , while the diffusion constant decreases about ten fold.

Due to the considerable decrease on the diffusion constants, particle weights of 77.000 versus 2.050 at pH = 6.0 and 60.400 versus 4.850 at pH = 4.5 were determined for the main part of the suspension. The high values are not essentially different from the particle weights estimated in the electron microscope studies. The radii of the particles deviate from those which were determined in pure water suspension. The values obtained were 69 and 71 Å respectively against 38 and 47 Å.

The friction ratio $f:f_o$ moves to 1.2 and 1.5 and is therefore a little higher than that in water suspension. Therefore, it can be concluded that the morphology of humic acids shows little deviation from the ideal sphere.

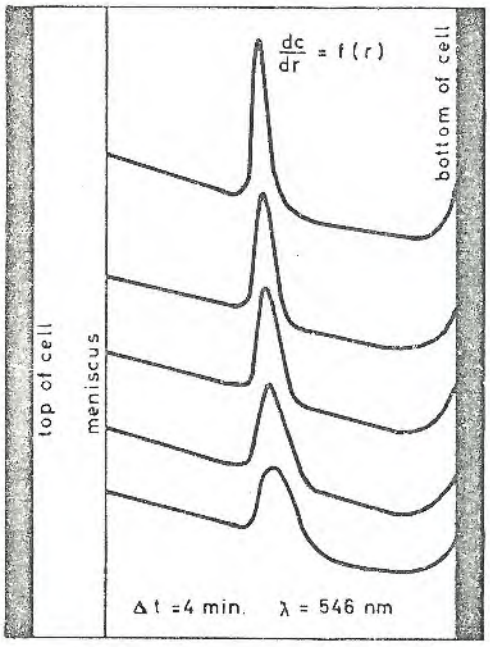


Fig. 7: Density gradient sedimentation pattern of an electrodialysed humic acid at pH 4.5 suspended in o.2 M NaCl.

If one compares the sedimentation diagrams of humic acids with and without addition of salt, which have been obtained under the same conditions, it can be established that the polydispersity in the salt containing suspension is not as marked as in a water suspension. The half-width value of the Gaussian distribution curve is remarkably smaller, and the precipitation at the bottom of the cell is reduced. But the right part of the Gaussian distribution curve always deviates more from the frequency maximum in the course of the progressing sedimentation. This may be evidence in support of our opinion, that particles with a higher weight are present.

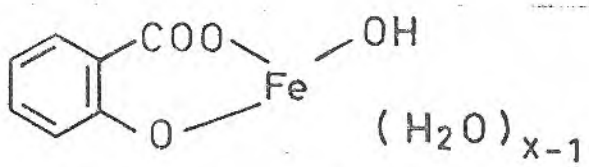
Several authors believe, that humic acids could be characterized simply by determination of the sedimentation constant by ultracentrifugation, and that it is possible to estimate particle weights by consideration of a variable sedimentation coefficient at a constant value of the diffusion constant.

According to our results, the above procedure would lead to misinterpretations, because the diffusion constant shows a strong variation due to environmental conditions. A two fold increase in the sedimentation constant and a ten fold decrease in the diffusion constant, relative to the primary values, cause a 15 to 20 fold increase in particle weight. These deviations are not negligible in particle weight determinations. Therefore, it can be concluded that particle weights can be used for characterization of humic acids only when both constants are measured. Aggregation and dispersion in dependence of salt concentration are important factors for soil structure.

2. Complex formation of humic fractions with heavy metals.

From the data about the structure of humic acids it can be concluded, that these polymers are cation exchangers. They have several constituents of their molecules, by which complex formation with heavy metals are are possible.

The complexes of metals with the high molecular weight parts of humic fractions are very insoluble. The stability of the complexes increases from earth alkaline metal to manganese $Mn^{++} > Co^{++} > Ni^{++} > Fe^{++} > Zn^{++} > Pb^{++} >$ copper$^{++} > Fe^{+++}$ at a pH-value of 5. According to van Dijk (1967) the following structure units participate in formation of the complexes. The nitrogen seems to be not important for the fixation of the heavy metals in the molecule of humic acids.



Monohydroxo - humato - ferrate
(van Dijk, 1967)

The complex formation of humic acids with metal ions is only mentioned, because this plays a role for the interactions with inorganic soil colloids.

3. Principles of interactions of spheric and linear organic colloids of soil with inorganic soil colloids.

The interactions of organic colloids such as humic acid and polyuronides with inorganic ones in soil are important for soil structure. About 30% of soil organic matter consists of polyuronides. These are linear colloids in contrast to humic acids which have more or less a globular form.

Details of this complex problem shall not be reported. But investigations with the electron microscope demonstrate models of the interactions very well. The aggregation and dispersion of humic acids in dependence of the pH-value of the solution was mentioned above.

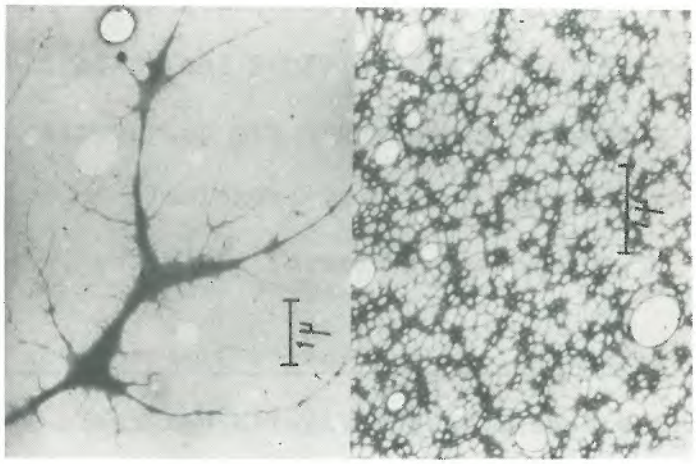


Fig. 8: "Krilium" at low (left) and high (right) concentration.

The aggregation of linear colloids such as polyacrylic acid ("Krilium") or polyuronides causes after dessication a type of network. Its form depends on the concentration. In purified form humic acids, polyuronic acids and clay minerals are all negatively charged. No interaction should occur.

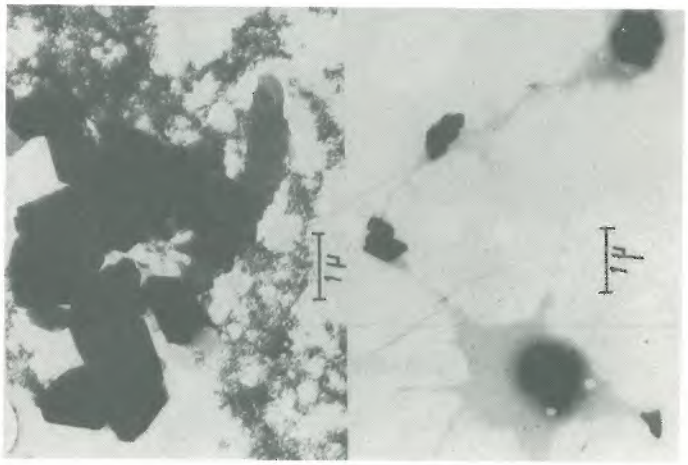


Fig. 9: Interaction between spherical (left) and linear (right) organic colloids and kaolinite (electrodialysed).

In the case of electrodialysed humic acids and kaolinite no interaction is observed. The globular humic acids are statistically distributed whilst polyuronic acid connects the single kaolinite particles with a network. But this is only then the case, when certain concentrations of salts do not exceed. (BEUTELSPACHER 1955, FLAIG and SÖCHTIG 1957, 1959, FLAIG, BEUTELSPACHER and SÖCHTIG 1958). The interactions between kaolinite, humic acids, which are observed in the soil, may be explained by complex formation of aluminium - and iron oxide -ions on the surface of the clay minerals, which are formed by weathering.

4. Importance of soil organic matter for the retention of pesticides.

Many investigations about the alterations of bioactivity of herbicides and insecticides as well as these about the quantitative determination of Freundlich' adsorption isotherme established that a direct correlation exists between the content of organic matter in the soil and absorption of pesticides.

Properties of soils.

No.	pH	C.E.C meq/100g	Clay %	Organic carbon %
1	8.1	6.3	8	0.7
2	8.1	10.4	18	0.9
3	6.8	10.2	6	1.1
4	6.8	10.6	6	1.3
5	7.5	13.0	26	1.4
6	8.0	21.9	36	1.7
7	8.1	10.6	10	1.7
8	7.2	14.0	21	1.8
9	6.5	10.7	7	1.8
10	7.8	19.8	18	2.7
11	6.3	18.2	2	2.8
12	7.5	44.8	11	7.6
13	7.7	48.2	16	8.8
14	7.6	74.0	36	11.0
15	7.2	66.4	25	12.0
16	5.1	83.4	62	15.0
17	6.9	118.8	peat soil	31.0

Relationship between soil organic carbon and adsorption.

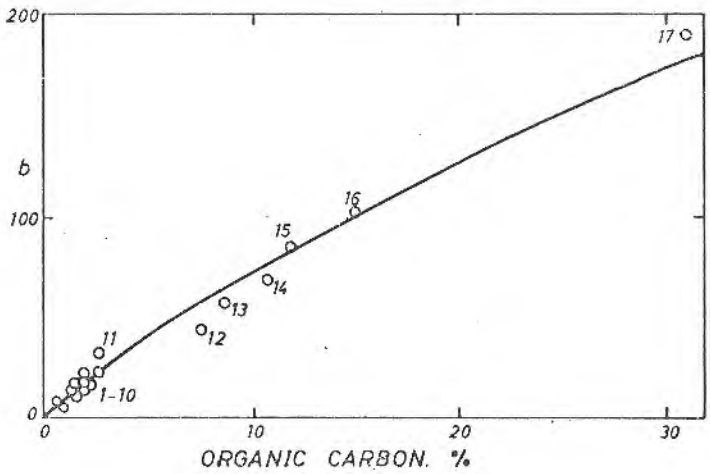


Fig. 10: Properties of soils and relationship between soil organic carbon and absorption of "Disulfoton" (diethyl-S-[2-(ethylthio) ethyl]phosphorothiolothionate), (GRAHAM-BRUCE 1967).

The content of clay fraction in the investigated 17 soils has not such influence on the sorption of pesticides as does the organic carbon content. The correlation between cation exchange capacity and adsorption of pesticides may be caused by the fact, that soil organic matter participates generally in sorption capacity of soils with about 30 % and more.

The adsorption of different types of pesticides may be of physical or chemical nature.

The physical adsorption occurs on the surface by van der Waal's forces. By this process the adsorption of uncharged molecules such as substituted urea- or triazine derivatives can be explained. The chemical adsorption is effected by Coulomb' forces and includes ion exchange and formation of compounds between adsorbent and adsorbed substance. Transformation of compounds is not yet observed and can be largely excluded. The fractions of humic substances are negatively charged. By this reason cationic herbicides such as pyrazones, amino-triazoles and bipyridiles are fixed, whilst the fixation of anionic herbicides such as 2,4-dichlorophenoxyacetic acid and "Dalapon" (2,2-dichloropropionic acid) is not so much influenced.

4.1 Proposed mechanism of retention.

For the elucidation of the mechanism of sorption infrared spectroscopical investigations have been made (SULLIVAN and FELBECK, 1968).

The absorption of the bands in the range of 3,0 μ (phenolic hydroxyl), 3,4 μ (C-H) and 5,8 μ (>C=O) decreases significantly.

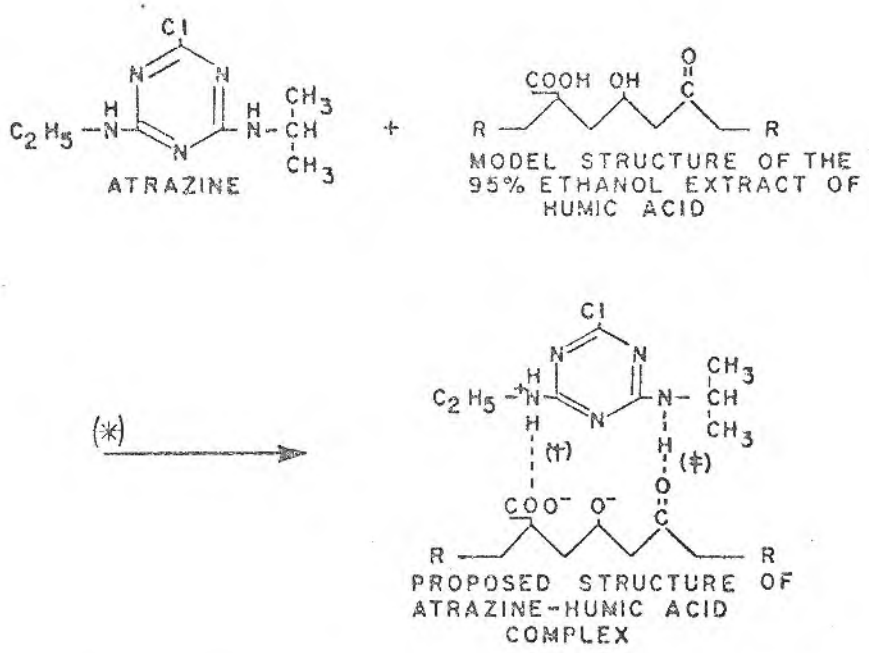


Fig. 11: Proposed mechanism for the adsorption of s-triazines (atrazine) by humic acids (SULLIVAN and FELBECK, 1968).

Changes of the absorption at 6,15 /u (presumably C=N of s-triazines) and 7,2 /u (carboxylate- anion) lead to the conclusion, that the carboxyl groups and the phenolic hydroxyl groups as well as the nitrogen atoms of the alkylamino-substituted s-triazines participate in the formation of hydrogen bridge linkages.

The observation, that soil organic matter is very effective for the retention of pesticides, does not answer the question, which constituent of soil organic matter is the most effective. The few data in literature describe that humic acids have a relatively high sorption capacity for pesticides. But there are also results published according to which not completely humified material should have a higher sorption capacity.

Also in connection with retention of pesticides the characterization of humic systems as the most active constituents of the soil is very

important. The effectivity of humic systems at different locations for retention of pesticides needs to be investigated not only for the production of qualified plant material but also to solve problems of environment hygiene.

References:

ADLER, E.: Über den Stand der Ligninforschung. Z. Papier, 15,604-609 (1961).

AUDUS, L.J.: The transport of growth regulators in plants. Transporto delle molecole organische nelle piante. Atti del VI Simposio Internazionale di Agrochimica Varenna 5-10 Settembre 1966, 273-295.

BADZHOV, K. and E. IKONOMOVA: ^{15}N for studying nitrogen transformations in soil, nitrogen nutrition of plants and in assessing available nitrogen in soil. - Proc. Symp. Vienna 1969. - IAEA, Vienna, 21-32 (1971).

BAILEY, N.T., G.G. BRIGGS, G.J. LAWSON, J.M. SCRUTON 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).

BEILER-KELBRITSCH, H. and B. RADEMACHER: Isolierung von Indolderivaten aus Laubkompost und deren Einfluß auf Stellaria media. Beitr. Biol. Pflanzen 40, 237-264 (1964).

BERTHELOT, M. and G. ANDRÊ: Ann. Chim. Phys. 25, Ser. 6, 362 (1892).

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).

BEUTELSPACHER, H.: Physikalisch-chemische Beiträge zur Humusforschung. Z. Pflanzenernähr., Düng., Bodenkunde 57,57-65 (1952).

BEUTELSPACHER, H.: Natürliche Fadenkolloide und Krümelbildung. Landbauforsch. 5, 90-92 (1955).

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

BJÖRKMAN, A.: Studies on finely divided wood. I. Extraction of lignin with neutral solvents. Svensk papperstidning 59, 477-485(1956).

BJÖRKMAN, 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.

BONDY, A. and H. MEYER: Lignin in young plants. Biochem. J. 43, 248 (1948).

BLUMER, M.: Benzyprenes in soil. Science 134, 474-475 (1961).

BÖRNER, H.: Untersuchungen über phenolische Verbindungen aus Getreidestroh und Getreiderückständen. Naturwissenschaften 42, 583 (1955).

BÖRNER, H.: Der papierchromatographische Nachweis von Ferulasäure in wässrigen Extrakten von Getreidestroh und Getreiderückständen. Naturwissenschaften 43, 129 (1956).

BÖRNER, H.: Die Abgabe organischer Verbindungen aus den Karyopsen, Wurzeln und Ernterückständen von Roggen (Secale cereale L.), Weizen (Triticum aestivum L.) und Gerste (Hordeum vulgare L.) und ihre Bedeutung bei der gegenseitigen Beeinflussung der höheren Pflanzen. Beitr. Biol. Pfl. 33-38 (1957).

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.: The nitrogenous constituents of soil organic matter and their role in soil fertility. Pontificae Academiae Scientiarum Scripta Varia 32, 143-193 (1968).

BREMNER, J.M. and F. FÜHR: Tracer studies of the reaction of soil organic matter with nitrite. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA technical Meeting. - Pergamon Press Ltd. Oxford 1966, 337-348.

BREMNER, J.M., W. FLAIG and E. KÜSTER: Zur Kenntnis der Huminsäuren. IX. Mitteilung. Der Gehalt an Aminosäuren in Streptomyceten-Huminsäuren. Z. Pflanzenernähr., Düng., 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.: Nitrogen release and carbon loss from soil organic matter during decomposition of added plant residues. Soil Sci. Amer. Proc. 12, 241 (1948).

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

BROADBENT, F.E. and A.G. NORMAN: Some factors affecting the availability of organic nitrogen in soil - a preliminary report. Soil Sci. Soc. Amer. Proc. 11, 264 (1947).

BROCKMANN, H. and E. MEYER: Äquivalent- und Molekulargewichtsbestimmungen durch potentiometrische Mikrotitration in nichtwässrigen Lösungsmitteln. Chem. Ber. 86, 1514-1523 (1953).

BRUCKERT, S.F., F. JACQUIN and M. METCHE: Contribution à l'étude des acides phénols présents dans les sols. Bull. de l'École Nationale Supérieure 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, A., H.M. HURST and S. B. WALKDEN: Nature of humic acids. Nature 199, 696 (1963).

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 développment et la nutrition minérale des végétaux. 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.

CHAMINADE, R.: Rôle specifique de la matière organique sur la nutrition et le rendement des végétaux. Pontificial Academiae Scientiarum Scripta Varia 32, 777-804 (1968).

CHAKRABARTRY, S.K., B.K. MAZUMDAR, S.N. ROY and A. LAHIRI: Structural parameters of coal based on oxidation experiments. Brennstoff-Chem. 41, 5, 138 (1960).

CHENG, H.H. and L.T. KURTZ: Chemical distribution of added nitrogen in soils. Soil Sci. Soc. Amer. Proc. 27, 312 (1963).

CHESHIRE, M.V., P.A. CRANWELL, C.P. FALSHAW, A.J. FLOYD and R.D. HAWORTH: Humic Acid-2. Tetrahedron 23, 1669-1682 (1967).

CHOUDRI, M.B. and F.J. STEVENSON: Chemical and physicochemical 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.).

CHRISTEWA, L.A.: Über die Einheitlichkeit des Wirkungsmechanismus physiologische aktiver Stoffe (russ.).
Ministerium für Landwirtschaft der UdSSR, Landwirtschaftliche Hochschule Dnjepropetrowsk, 6-9 (1965).

CHRISTEWA, L.A.: About the nature of physiologically active substances of the soil humus and of organic fertilizers and their agricultural importance. Pontificiae Academiae Scientiarum Scripta Varia 32, 702-721 (1968).

CHRISTEWA, L.A., K.I. SOLOCHA, R.L. DYNKINA, A.I. GOROVAYA and V.E. KOVALENKO: Effect of physiological active substances of soil humus and fertilizers on the transformation of nuclein acids, growth of plants and quality of the seeds. Studies about Humus. Trans. Int. Symp. "Humus et Planta IV" Prague, russ. 212-276 (1967).

CINCEROVA, A.: The effect of humic acid on transamination in winter wheat plants. Biol. Plant 6, 183-188 (1964).

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).

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).

DIJK, van H.: Die Kationenbildung der Huminsäuren. 4. Torf-Kolloquium DDR - VR Polen, 1-3 (1967) (Rostock).

DINCHEV, D. and K. BADZOV: Bestimmung des pflanzenaufnehmbaren Stickstoffs durch agrochemische Methoden mit Hilfe des stabilen Isotops ^{15}N. - Agrochimica (in press).

DRAGUNOV, S.S., ZHELOKHOVTSEVA and E.I. STRELKOVA: A comparative study of soil and peat humic acids. Pochvovedenie (7), 409 (1948).

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 ÄDTE. 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).

ELIAS, H.G.: Ultrazentrifugen-Methoden. Beckman Instruments G.m.b.H., München, 2. Auflage 1961, S. 126.

ERDTMAN, H.G.H. and C.A. WACHTMEISTER: Phenoldehydrogenation as a biosynthetic reaction. Festschrift Prof. Dr. W. Stoll, 8. Jan. 1957, 144-165.

EVANS, L. T.: The use of chelating reagents and alkaline solution in soil organic matter extractions. J. Soil Sci. 10, 110-118 (1959).

EVANS, W.C., B.S.W. SMITH, R.P. LINSTEAD and J.A. ELVIDGE: Chemistry of the oxidative metabolism of certain aromatic compounds by microorganisms. Nature 168, 772-775 (1951).

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).

FARMER, V.C., M.E.K, HENDERSON and J.D. RUSSELL: Reduction of certain aromatic acids to aldehydes and alcohols by Polystictus versicolor. Biochim. Biophys. Acta 35, 202-211 (1959).

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

FLAIG, W.: Zur Chemie der Huminsäuren und deren Modellsubstanzen. Vle. Congrès 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.: 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.: Über den Einfluß von Humusstoffen auf den Stoffwechsel der Pflanzen. Der internationale Torfkongress UdSSR Leningrad 1963.

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

FLAIG, W.: Gedanken zur Nomenklatur der im Boden vorhandenen organischen Stoffe. 8th Internat. Congr. Soil Sci. Transaction, Vol. III, Bucharest-Romania, 389-399 (1964 b). Discussions regarding the terminology in the field of humus, 405-413.

FLAIG, W.: Action des produits de dégradation de la lignine surgle métabolisme végétal mecanisme possible de cette action. C.R. Hebd. des Séances de l'Academie d'Agriculture de France No. 17, 1118-1138 (1965).

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 à la connaissance de la constitution et de la synthèse des acides humiques. Extrait de "Sciences du Sol", Supplément au Bulletin de l'Association Française pour l'Étude du Sol, No 2,39-72 (1970).

FLAIG, W. and H. BEUTELSPACHER: Zur Kenntnis der Huminsäuren. II. Elekronenmikroskopische Untersuchungen an natürlichen und synthetischen Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 52, 1-21 (1951).

FLAIG, W. and H. BEUTELSPACHER: Physikalische Chemie der Huminsäuren. Landbouwkund.Tijdschr. 66, 306-336 (1954 a).

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: Über 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 S. MOHTADI: Chemische Eigenschaften von Extrakten aus Rottestroh und deren Einwirkung auf den Trockensubstanzertrag von Keimpflanzen. Landbauforsch. Völkenrode 15, 63-64 (1965).

FLAIG, W. and H. RIEMER: Polarographische Untersuchungen zum Verhalten von Trihydroxytoluolen bei der Reaktion mit Glycin unter oxydierenden Bedingungen. Justus Liebigs ANNALEN DER CHEMIE 746, 81-85 (1971).

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

FLAIG, W. and J.Chr. SALFELD: Zwischenstufen bei der Bildung von Huminsäuren aus Phenolen. Transactions Vol. II, 7th Internat. Congr. of Soil Science, Madison, Wisc. USA, 648-656 (1960 b).

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

FLAIG, W. and G. SCHMID: Comparison of the effect of chemical compounds and low doses of radiation on plant metabolism. "Effects of low doses of radiation on crop plants". Technical Reports Series No. 64, International Atomic Energy Agency, Vienna 1966, 26-38.

FLAIG, W. and H.L. SCHMIDT: Über die Einwirkung von Huminsäuren auf das Wachstum einiger Penicilliumarten. Arch. Mikrobiol. 27, 1-32 (1957).

FLAIG, W. and G. SCHOLL: Hacia el conocimiento de los acidos huminicos. XVIII. Comunicacion "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: Einige Grundlagen zur Frage der Krümelbildung.- Landbauforsch. 7, 80-83 (1957).

FLAIG, W. and H. SÖCHTIG: Über die Wechselwirkung von Kaolinit und Polyanionen. -Z. Pflanzenernähr., Düng., Bodenkunde 87, 1 44-57 (1959).

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

FLAIG, W. and H. SÖCHTIG: Organische Verbindungen als Stickstoffquelle für die Ernährung der Pflanzen. - Anales de Edafologia y Agrobiologia XXVI, 801-828 (1967).

FLAIG, W., H. BEUTELSPACHER and H. SÖCHTIG: Humus als Kationenaustauscher. Kalium-Symposium 1954, 81-107.

FLAIG, W.,H. BEUTELSPACHER and H. SÖCHTIG: Tagungsberichte Nr. 13, Probleme der Krümelstabilitätsmessung und der Krümelbildung.- Deutsche Akad. d. Landbauwiss. zu Berlin, 225-244 (1958).

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).

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

FORSYTH, W.G.C.: The characterization of the humic complexes of soil organic matter. J.Agric. Sci. 37, 132-138 (1947 b).

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

FREUDENBERG, K.: Entwurf eines Konstitutionsschemas für 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 für 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.

FREUDENBERG, K., J.M. HARKIN, H. NIMZ and H. RENNER: Chem. Commun. 1965, p. 224.

FREYTAG, H.E.: Über die Zersetzung von pflanzlichem Material im Boden und einige Erfahrungen in der Messung von 14 CO_2 mit einer Gas-Zählkammer.- Thaer-Archiv 10, 685-697 (1962).

FREYTAG, H.E. and H. IGEL: Ein Bericht über den Einsatz des ^{14}C bei respirometrischen Messungen in der Humusforschung. Zbl. Bakteriol. Parasitenkunde. Infektionskrankh. Abtl. II, 117, 525-531 (1964).

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

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

FRÖMEL, W.: Über 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: Über 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 räumliche 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. SAUERBECK: 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.

FÜHR, F. and D. SAUERBECK: Decomposition of wheat straw in the field as influenced by cropping and rotation. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, 241-250.

FUKUZUMI, R., K. MINAMI and S. SHIBAMOTO: Metabolic products from aromatic compounds by the wood-rotting fungus "Polystictus sanguineus".II. Acetoacetic acid and a-ketoglutaric acid from the medium containing benzoic acids. J. Japan. Wood. Res. Soc. 5, 76 (1959).

GADET, R. and L. SOUBLES: Le bilan de l'azote dans les sols. - Experimentation de longue durée en cases lysimétriques et utilisation de l'isotope stable de l'azote 15 N.C.R.A. cad. Agric. 1962, 145-153.

GADET, R. and L. SOUBLES: Bilan apparent et bilan réel de l'azote minéral appliqué au sol mesure en cases lysimétriques avec utilisation de l'azote 15. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press Ltd. Oxford 1966, 297-305.

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

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

GRAHAM-BRUCE, I.J.: Ausorption of disulfoton by soil J. Sci. Fd. Agric. 18, 72-77 (1967).

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

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

HAIDER, K.: Untersuchungen über den mikrobiellen Abbau von Lignin. Zbl. Bakeriol., Parasitenk., Infektionskrankh. u. Hygiene 198, 308-316 (1966).

HAIDER, K., J.P. MARTIN: The role of 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. 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).

HAMENCE, H.: The effects of organic manures on the auxin content of soils and the "auxin balanca" in soils. J. Soc. Chem. Ind. (London) 67, 277-281 (1948).

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

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

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 über 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-benzoesäure, 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).

HAUCK, R.D.: N-Isotope distribution in nitrogen gas evolved from soil during denitrification. Possible application to N-transformation studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press Oxford 1966 , 447-456.

HAUCK, R.D. and D.R. BOULDIN: Distribution of isotopic nitrogen in nitrogen gas during denitrification. - Nature 191, 871 (1961).

HAUCK, R.D. and S. W. MELSTED: Some aspects of the problem of evaluating denitrification in soils.- Soil Sci. Amer. Proc. 20, 361 (1956).

HAUCK, R.D., S.W. MELSTED and P.E. YANKWICH: Use of N-isotope distribution in nitrogen gas in the study of denitrification. - Soil Sci. 86, 287 (1958).

HAYAISHI, O., M. KATAGIRI and S. ROTHBERG: Mechanism of the pyrocatecase reaction. J. Amer. Chem. Soc. 77, 5450-5451 (1955).

HENDE, A. van den: L'incorporation d'azote dans la matière organique du sol; Possibilités de l'utilisation de l'usage d'azote lourd N-15. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 319-327.

HENDERSON, M.E.K.: Release of aromatic compounds from birch and spruce sawdusts during decomposition by white-rot fungi. Nature (London) 175, 634-635 (1955).

HILLMANN, W.S. and A.W. GALSTON: Inductive control of indoleacetic acid oxidase activity by red and near infrared light. - Plant Physiol. 32, 129-135 (1957).

HOBSON, R.P. and H.J. PAGE: Studies on the carbon and nitrogen cycles in the soil. VII. The nature of the organic nitrogen compounds of the soil: "Humic" nitrogen. J. Agric. Sci. 22, 497-515 (1932).

HOCK, A.: Beziehungen zwischen Konzentration und Farbwerten von Huminsäurelösungen. Z. Bodenkunde und Pflanzenernähr., 7, 99-117 (1938 a).

HOCK, A.: Grundsätzliches bei Farbmessungen in Huminlösungen. Z. Bodenkunde und Pflanzenernähr., 7, 279-302 (1938 b).

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

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

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

HORNER, L. and W. DÜRCKHEIMER: Zur Kenntnis der o-Chinone. XII. o-Chinone aus Brenzcatechin-Derivaten. - Z. Naturforsch. 14B, 741 (1959).

HÜSER, R.: Probleme zur biologischen Luftstickstoffbindung in Waldböden. Z. Pflanzenernähr., Düng., Bodenkunde 103, 220-226 (1963).

HÜSER, R.: Experiences with the ^{15}N tracer technique to estimate the microbial fixation of elementary nitrogen in the organic matter of forest soils. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 457-469.

ISHIKAWA, H., W.J. SCHUBERT and F.F. NORD: Investigations on lignins and lignification. XXVII. The enzymic degradation of softwood lignin by white-rot fungi. - Arch. Biochem. Biophys. 100, 131-139 (1963 a).

ISHIKAWA, H., W.J. SCHUBERT and F. F. NORD: Investigations on lignins and lignification. XXVIII. The degradation by Polyporus versicolor and fomes fomentarius of aromatic compounds structurally related to softwood lignin.- Arch. Biochem. Biophys. 100, 140-149 (1963 b).

ISHIKAWA, H., W.J. SCHUBERT and F.F. NORD: Investigations on lignins and lignification. XXX. Enzymic degradation of guajacolglycerol and related compounds by white-rot fungi. Biochem. Z. 338, 153-163 (1963 c).

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

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

JANSSON, S.L.: Tracer studies on nitrogen transformations in soil.- Ann. Roy. Agr. Coll. Sweden 24, 101 (1958).

JANSSON, S.L.: Balance sheet and residual effects of fertilizer nitrogen in a 6-year study with N 15.- Soil Sci. 95, 31 (1963).

JANSSON, S.L.: Nitrogen transformation in 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 a, 283-296.

JANSSON, S.L.: Experimental techniques with isotope-N 15. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting.- Pergamon Press. Ltd. Oxford 1966 b, 415-422.

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. and J. TINSLEY: A comparison of the ligno-protein isolated from a mineral soil and from a straw compost. Sci. Proc. Roy Dublin Soc. A 1, 141-147. (1960)

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).

JONES, E.J.jr.: The ultraviolet absorption spectra of complex hydroxyaromatic compounds and derivatives, with particular reference to lignin. Tappi 32, 311-315 (1949).

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

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 Huminsäuren 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).

KAUR-SAWHNEY, R., M. BARA and A. GALSTON: Analysis of labelling patterns in soluble RNA preparations from green pea stem sections supplied with ^{14}C-carboxyl-labelled indoleacetic acid.- Annals of the New York Academy of Sciences 144, Art. I. 63-67 (1967).

KILBY, B.A.: The bacterial oxidation of phenol to ß-ketoadipic acid. Biochem. J. 43, V (1948).

KILBY, B.A.: The formation of ß-ketoadipic acid by bacterial fission of aromatic rings. Biochem. J. 49, 671-674 (1951).

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

KOLENBRANDER, G.J.: Die Verluste an organischer Substanz im Stalldünger. Z. Pflanzenernähr., Düng., 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).

KONONOVA, M.M. and N.P. BELCHIKOVA: Rapid methods of determining the humus composition of mineral soils. Pochvovedenie (10), 75 (1961).

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 Ligninsulfosäure. Chimie et Biochimie de la Lignine de la Cellulose et des Hémicelluloses. Actes du Symposium Internationanl de Grenoble, Juillet (1964),

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

KRATZL, K., E. RISNYOVSZKY, P. CLAUS and E. WITTMANN: Über den Mechanismus der alkalischen Hydrolyse von Guajacylglyzerin-β-guajacyläther-α-sulfosäure. I. Mitteilung, 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).

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 infra-red 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).

KUMADA, K. and A. SUZUKI: Isolation of anthraquinone from humus. Nature (London) 191, 415-416 (1961).

KUO, L.H. and A.V. BARTHOLOMEW: On the genesis of organic nitrogen in decomposed plant residue. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press Ltd. Oxford 1966, 329-335.

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

KÜSTER, E.: Beiträge zur Physiologie der Streptomyceten. VI. Congrès 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 benzène substitué en 1,3 et par des groupes amino ou hydroxyles, non substitués ou substitués. Bull. Soc. Chim. France 12, 2402-2408 (1961).

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

LAROCHE, J. and R. COMBELLES: Préparation et micro-analyse de composés marqués à l'azote 15. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 423-428.

LEMAIRE, F.: Influence of the organic matter on the phosphate nutrition of plants. Vortrag anläßlich des Symposiums Humus et Planta in Prag vom 18.-24. September 1967.

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 Zusammenhänge zwischen dem mikrobiellen Abbau des Lignins und der Bildung von Humusstoffen. Dissertation der Rheinischen Friedrich Wilhelms-Universität Bonn (1965).

LITTLE, E.C.S.: An apparatus for the determination of carbon-14 in organic matter. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 371-374.

MacDONALDS, D.L., R.Y. STANIER, J.L. INGRAHAM: The enzymatic formation of ß-carboxymucconic acid. J. Biol.Chem. 210, 809-820 (1954).

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

MARTIN, A.E. and R. REEVE: The extraction of organic matter from podzolic 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. Biol. Chem. 172, 83-99 (1948).

MASON, H.S.: Mechanisms of oxygen metabolism. Advan. Enzymol. 19, 79-231 (1957).

MASON, H.S., W.L. FOWLKS and E.W. PETERSON: Oxygen transfer and electron transport by the phenolase complex. J. Amer. Chem. Soc. 77, 2914-2915 (1955).

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

MUSSO, H., U. GIZYCKI, U.I. ZAHORSZKY and D. BORMANN: Die Bildung von Hydroxy-Chinonen durch Addition von Phenolen an Chinone. Liebigs Ann. Chem. 676, 10 -20 (1964).

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

NEHRING, K.: Untersuchungen an aus verschiedenen Bodentypen isolierten Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 69, 71-86 (1955).

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

NITSCH, J.P. and C. NITSCH: Phenolic compounds and plant growth. Ann.Physiol. végét. 4, 211-225 (1962).

NORMAN, A.G. and S.H. JENKINS: The determination of lignin. I. Errors introduced by the presence of certain carbohydrates. Biochem. J. 28, 2147-2159 (1934 a).

NORMAN, A.G. and S.H. JENKINS: The determination of lignin. II. Errors introduced by the presence of proteins. Biochem J. 28, 2160-2168 (1934 b).

NORMAN, A.G. and C.H. WERKMAN: The use of nitrogen isotope N 15 in determining nitrogen recovery from plant material decomposing in soil.- J. Amer. Soc. Agr. 35, 1023 (1943).

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

OGNER, G. and M. SCHNITZER: Chemistry of Fulvic Acid, a Soil Humic Fraction, and its Relation to Lignin. Canad. Journ. of Chem. 49, 1053-1063 (1971).

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

OSTWALD, W.: Kolloid Z. 7, 255 (1928).

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

OWENS, L.S.: Nitrogen movement and transformations in soils as evaluated by a lysimeter study utilizing isotopic nitrogen.- Soil Sci. Soc. Amer. Proc. 24, 372-376 (1960).

OXFORD, A.E.: Anti-bacterial substances from molds. V. The bateriostatic powers of the methyl ethers of fumigatin and spinulosin and other hydroxy-, methoxy- and hydroxy-methoxy-derivatives of toluquinone and benzoquinone. - J. Soc. Chem. and Ind. 61, 189-192 (1942 a).

OXFORD, A.E.: The chemical reactions occurring between certain substances which inhibit bacterial growth and constituents of bacteriological media. Biochem. J. 36, 438-444 (1942 b).

OXFORD, A.E. and H. RAISTRICK: Antibacterial substances from molds. IV. Spinulosin and Fumigatin, metabolic products of Penicillium spinulosum Thom and Aspergillus fumigatus Fresenius.- J. Soc. Chem. and Ind. 61, 128-129 (1942).

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).

PIRET, E.L., G. WHITE, H.C. WALTHER jr. and A.J. MADDEN jr.: Some physicochemical properties of peat humic acids. Sci. Proc. Roy. Dubl. Soc. A 1, 4, 69-79 (1960).

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).

POLICARD, A. and M. BESSIS: Sur un mode d'incorporation des macromolécules par la cellule, visible en microscope électronique: la rhophéocytose. C.R. Acad. Sci. 246, 3194-3197 (1958).

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).

PRAT, S. and F. POSPISIL: Humic acids with C^{14}. Biol Plantarum (Praha) 1, 71 (1959).

PRAT, S.: Distribution of the humic substance fractions in plants. Biol. Plantarum (Praha) 2, 308 (1960).

PRAT, S.: On permeability and the effect of humic substances on plant cells. 5th Int. Congr. Biochem. Moskau (1961).

PRAT, S.: Das Problem des Eindringens und der Einwirkung von Humusstoffen auf die Pflanzenzellen.-Intern. Congress of Peat, Leningrad (1963).

PRIDHAM, J.B. and M. SALTMARSH: The biosynthesis of phenolic glucosides in plants. Biochem. J. 87, 218-224 (1963).

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

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

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

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

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

ROCHUS, W.: Die unterschiedliche physiologische Wirkung verschiedener Huminstoffqualitäten.- Vortrag anläßlich der Tagung der Deutschen Bodenkundlichen Gesellschaft in Mainz vom 4.-9.9. 1967.

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

RYPACEK, V.: Der Einfluß isolierter Humusstoffe auf einige physiologische Äußerungen der Pflanzenzelle.- Studies about Humus, Symposium Humus and Plant, Praha and Brno. 28. IX. - 6.X.1961, 235-243 (1962).

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

SAALBACH, E.: Beitrag der Grundlagenforschung zum Problem der Strohdüngung. Landwirtsch. Forsch. 8, 83-84 (1958).

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 et 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).

SAUERBECK, D.: Zur Markierung von Pflanzen mit ^{14}C. Atompraxis 6, 221-225 (1960).

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: Experiences on labelling whole plants with carbon-14. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 391-399.

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 Agenca, Vienna 1968, 3-11.

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

SAUERLANDT, W. and O. GRAFF: Die Strohdecke auf dem Ackerboden. - Landbauforsch. Völkenrode 9, 57-60 (1959).

SCHANEL, L.: Laccase activity and decomposition of lignin by white-rot fungi. CSc. Thesis, Fac. Nat. Sci. UJEP Brno, (1962) (Czech.).

SCHARPENSEEL, H.W.: Herstellung und Reinigung von tritiummarkierten Grau- und Braunhuminsäurepräparaten sowie von Tritium-Purpurogallin. - Z. Pflanzenernähr., 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.: Zur Herstellung von allseitig C-14-markiertem Pflanzen- und Huminsäurematerial.- Landw. Forschung 14, 42-48 (1961).

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 1966 a, 351-364.

SCHARPENSEEL, H.W.: Results and problems of radiocolumn chromatographic work with humic acids. In : The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966 b, 375-390.

SCHARPENSEEL, H.W.: Experimental techniques with tritium including the production of labelling materials apparatus required and costs involved. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966 c, 471-481.

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 radioaktiver 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 C^{14}-markierter Huminsäuren). Z. Pflanzenernähr., Düng., Bodenkunde 96, 11-34 (1962).

SCHARPENSEEL, H.W. and K.H. MENKE: Radiochromatographie mit schwachen ß-Strahlen. 1. Mitt. Z. analyt. Chem. 180, 81-92 (1961 a).

SCHARPENSEEL, H.W. and K.H. MENKE: Radiochromatographie mit schwachen ß-Strahlen (^{35}S, ^{14}C, ^{3}H). 2. Mitt. Radiosäulenchromatographie mit Hilfe des Flüssigkeits- und Scintillations-Spektrometers. Z. analyt. Chem. 182, 1-10 (1961 b).

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

SCHEFFER, F. and R. KICKUTH: Chemische Abbauversuche an einer natürlichen Huminsäure. I. Z. Pflanzenernähr., Düng., Bodenkunde 94, 180-188 (1961 a).

SCHEFFER, F. and R. KICKUTH: Chemische Abbauversuche an einer natürlichen Huminsäure. II. Z. Pflanzenernähr., Düng., Bodenkunde 94, 189-198 (1961 b).

SCHEFFER, F. and B. ULRICH: Lehrbuch der Agrikulturchemie und Bodenkunde. III. Teil. Humus und Humusdüngung 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).

SCHEFFER, F., W. ZIECHMANN and H. SCHLÜTER: Über die Sedimentation von Huminsäuren in der Ultrazentrifuge. Kolloid Z. 160, 1-7 (1958).

SCHLICHTING, W.: Die Beeinflussung der Nährstoffaufnahme durch Huminstoffe, Mitt. d. Dtsch. Bodenkundlichen Gesellsch. 8, 165-167 (1968).

SCHMID, G.: Bericht über die Tätigkeit der Forschungsanstalt für Landwirtschaft, Braunschweig-Völkenrode, 12-13, (1962), 13-14 (1963), 15 (1964).

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 S.I.M. SKINNER: Organo-metallic interactions in soils: 1. Reactions between a number of metal ions and the organic matter of a podzol E_h-horizon. Soil Sci. 96, 86-93 (1963 a).

SCHNITZER, M. and S.I.M. SKINNER: Organo-metallic interactions in soils. 2. Reactions between different forms of iron and aluminium and the organic matter of a podzol B_h-horizon. Soil Sci. 96, 181-186 (1963 b).

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. 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 über die Umwandlung von Weizenstrohlignin im Laufe der Verrottung.- Dissertation, ETH Zürich (1958).

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

SEIFERT, K.: Die chemische Veränderung der Holzzellwand-Komponenten unter dem Einfluß pflanzlicher und tierischer Schädlinge. II. Abbau von Pinus sylvestris L. durch Coniophora cerebella Pers. Holzforschung 16, 102-113 (1962).

SHMUK, A.A.: The chemistry of soil organic matter. Trudy kuban. s.-kh. Inst. 1, 2 (1924), (russ.).

SHMUK, A.A.: The chemical nature of soil organic matter. Byull. Pochvoveda 5-7 (1930), (russ.).

SHOREY, E.: Some organic soil constituents. U.S. Dept. Agric. Bureau of Soils Bull. 88, 5-41 (1913).

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

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

SIMONART, P. and J. MAYAUDON: Étude 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: Étude 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).

SLYKE, D.D. van, D.A. MacFADYEN 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).

SMIDOVA, M.: Über den Einfluß von Na-Humat auf die Oxydations-Reduktions-Prozesse in den Wurzeln von Winterweizenpflanzen.- Studies about Humus. Symp. Humus and Plant, Praha and Brn. 28.9. - 6.10. 1961.

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.: Zur Erfassung der bei der Strohrotte gebildeten Ligninabbauprodukte: Kennzeichnung durch UV-Spektren. Landbauforsch. Völkenrode 11, 13-15 (1961 a).

SÖCHTIG, H.: Inwieweit können Strohrotteprodukte das Pflanzenwachstum beeinflussen? Über Veränderungen von Ligninabbauprodukten. Landbauforsch. Völkenrode 11, 16-18 (1961 b).

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.: Auftrennung von Huminstoffen durch Gelfiltration. Mitt. Dt. Bodenk. Ges. 4, 297-300 (1965).

SÖCHTIG, H.: Zur Fraktionierung von Humusstoffen durch Gelfiltration. 1. Mitt. Das Verhalten von anorganischen Ionen aus der Asche und den Lösungen von Humusstoffen auf Sephadex-Gelen. Landbauforsch. Völkenrode 16, 25-30 (1966).

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

SÖCHTIG, H.: Zur Charakterisierung von Humusstoffen durch Gelfiltration. Dtsch. Bodenkundl. Ges. 8, 137-140 (1968).

SÖCHTIG, H.: Über den Einfluß 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. and H. HARMS: Über den Einfluß von Torf auf Keimung und Anfangswachstum von Pflanzen.-Landw. Forsch. 26/II (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.

SÖCHTIG, H., H. HARMS and K. HAIDER: Uptake and transformation of ^{14}C-labelled phenolic acids by wheat seedling. 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. International Atomic Energy Agency, Vienna 1968, S. 531-540.

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 of 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.: 1. Farbtiefe und Farbcharakter von Humusextrakten in ihrer Abhängigkeit von der Alkalikonzentration, zugleich ein Beitrag zur Kenntnis der Humustypen.- Z. Pflanzenernähr., Düng., Bodenkunde 34, 1-14 (1934).

SPRINGER, U.: Der heutige Stand der Humusuntersuchungsmethodik mit besonderer Berücksichtigung der Trennung, Bestimmung und Charakterisierung der Huminsäuretypen und ihre Anwendung auf charakteristische Humusformen. Bodenkunde und Pflanzenernähr. 6, 312-373 (1938).

SPRINGER, U.: Stoffabbau und Humusaufbau untersucht an einem Strohmist und Strohligninmist (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 aeroben 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 Kompostbereitung auftretenden stofflichen Veränderungen. Mit Ergebnissen eines dreijährigen Gefäßversuches. Bayr. Landw. Jahrbuch 38, 250-300 (1961).

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

STANIER, RIY.: Simultaneous adaption: A new technique for the study of metabolic pathways. J. Bact. 54, 339-48 (1947).

STANIER, 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 natürlicher Huminsäuren. Dissertation TH Braunschweig (1956).

STEWART, B.A., L.K. PORTER and D.D. JOHNSON: Immobilization and mineralization of nitrogen in several organic fractions of soil.- Soil Sci. Soc. Amer. Proc. 27, 302 (1963).

STOKES, G.G.: On the theories of internal friction of fluids in motion and the equilibrium and motion of elastic solids.- Trans. Cambridge Phil. Soc. 8, 287 (1849).

STÖCKLI, A.: Über den Abbau von Lignin, Cellulose und Hemicellulose durch Pilze. Versuche mit Streumaterialien, Holz und Ligninsulfonsäure. Promotion ETH Zürich (1952).

SULLIVAN, J.D. and G.T. FELBECK: A study of the interaction of s-triazine herbicides with humic acids from three different soils.- Soil Sci. 106, No. 1, 42-52 (1968).

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

SVEDBERG, T.: Die Molekulargewichtsanalyse im Zentrifugalfeld. - Kolloid Z. 67, 2-16 (1934).

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, 191-201 (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 protocatechuic acid. Biochem. J. 76, 9p (1960).

TROJANOWSKI, J., A. LEONOWICZ and B. HAMPEL: Exoenzymes in fungi degrading lignin. II. Demethoxylation of lignin and vanillic acid. Acta Microbiol. Polon. 15, 17-22 (1966).

TROJANOWSKI, J., A. LEONOWICZ and M. WOJTAS: Exoenzymes in fungi degrading lignin. III. The effect of peroxidase on veratric acid. Acta Microbiol. Polon. 15, 215-222 (1967).

TYURIN, I.V.: Die organischen Stoffe der Böden. Selchosgis Moskau (1937) (russ.).

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).

WALTERS, E.H.: The isolation of p-hydroxy-benzoic acid from soils. J. Amer. Chem. Soc. 39, (1917).

WELTE, E.: Zur Konzentrationsmessung von Huminsäuren. Z. Pflanzenernähr., Düng., Bodenkunde 74, 219-227 (1956).

WHITEHEAD, D.C.: Identification of p-hydroxybenzoic, vanillic, p-coumaric and ferulic acids in soils. Nature 202, 417-418 (1964).

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

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

WILZBACH, K.E.: Tritium-labelleing by exposure of organic compounds to tritium gas.- J. Amer. Chem. Soc. 79, 1013 (1957).

WILZBACH, K.E.: IAEA Tritium Symposium paper TTS/83, Vienna (1961).

WINTER, A.G.: Untersuchungen über die Aufnahme von Penicillin und Streptomycin durch die Wurzeln von Lepidum sativum und ihre Beständigkeit in natürlichen Böden. 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, 120-127 (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).

ZELLER, A., H.E. OBERLÄNDER and F. HIEMER: A growth chamber for raising ^{14}C-labelled plants. In: The use of isotopes in soil organic matter studies. Report of the FAO/IAEA Technical Meeting. Pergamon Press. Ltd. Oxford 1966, 401-413.

ZELLER, A., H.E. OBERLÄNDER, K. ROTH and I. STADLER: The humification of carbon-14 labelled mycelium in soil. In: The use of isotopes in soil organic matter studies. Pergamon Press. Ltd. Oxford 1966, 275-279.

ZELLER, A., H.E. OBERLÄNDER and K. ROTH: A field experiment on the influence of cultivation practices on the transformation of 14C-labelled farmyard manure and 14C-labelled straw into humic substances. In: Isotopes and radiation in soil organic matter studies. International Atomic Energy Agency, Vienna 1968, 265-274.

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

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

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

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).