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The relation between Pb-pollution along mainroads and the trace element-composition in soil and vegetation (Examination of section rectangular to M 3 mainroad)

By

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Abstract: The thesis treats the lead pollution along mainroads and the trace element composition of Zn, Mn, Cu in the upper two meters of the soil as well as in vegetation living on it. It reveals a novel connection between pH, carbonate content, organic material content and soluble trace-element content. It shows not only the environment--polluting effect of the road, but also the regularity of the phenomena. The examinations were carried out in the Department of Petrology and Geochemistry at the Faculty of Sciences of Eötvös Loránd University in the course of 1980-81.

Introduction

On of the greatest problems of our time is environmental pollution. A significant role is played in this by lead, coming from the exhaust fumes of cars. Lead is harmful to every living being including humans. This metal gets into the atmosphere predominantly in the form of Pb-tetraetile and Pb-tetrametile. The petrol used in Europe and in Hungary contains 0,4 g Pb/l. In Australia the Pb content of petrol is almost twice as much: 0.78 g Pb/l. It is obvious that pollution there is considerably higher, and the big industrial towns of Britain and of the USA are only slightly less polluted (Birmingham: 1700 ppm, Manchester: 940 ppm, USA: 1800 ppm on the average, considering dust alongside roads).

It has been proved that this pollution may cause serious nerve and arterial diseases even a degeneration of muscles (BONTA et al. 1969). Its toxic effect has been detected in the simplest living organisms, in bacteria, and in plants of higher order. One per cent of lead caused fifty per cent inhibition in bacteria and fungi. In flowering plants (young barley) 35 mg/kg proved to be the highest critical level (DAVIS & BECKETT 1978). In fully developed plant tissues 10-30% Pb-level has been shown. Considering that lead accumulates in living organism i.e. it is not discharged from time to time even small quantities are extremely dangerous. It is an appaling fact that our normal daily diet contains 220-280 ug lead (DAY 1977). According to the data of the World Health Organization, the oral intake of lead by an adult person is even higher: 430 ug/day. To lead inhaled usually less significance is attributed in spite of its high adsorption. Thus, along roads, but mainly in cities that can play a significant role, too. Data from Australia show that the quantity of lead in dust along busy roads reaches 3100 ppm, medium traffic produces 1400 ppm, and alongside less busy roads it is 830 ppm. Even green belts contain considerable Pb-level. Thus in city playgrounds 700 ppm was measured, while in suburban areas only 40 ppm. The lead-content in the dust of some busy roads reaches 5000-6000 ppm (DAY 1977). The effect of lead is

even more harmful for children. According to data of the World Health Organization the daily lead consumption of children is 300 ug/day. This is the upper limit which their organism can still tolerate although not without dangerous effects. Lead gets integrated in the biochemical system of the body, inhibits the functioning of p-amino levulin acid dehidrataze (ALAD) enzime, and interfers with the hemoglobine structure. Normally the Pb-level of the blood is 0.25 ppm; in polluted areas this may rise significantly. Researches so far have been confined mainly to the indication of lead and this is the stage researches in Hungary have reached till today. Other tests refer to the changes in human organisms, caused by the harmful effect of lead, a third group goal is to clarify in what processes lead has a role to play and with what consequences.

Our present examinations, in addition to the detection of lead, try to find explanation for the relations of lead to other trace elements, to the pH, the organic material content, clay mineral and carbonate content. Within these examinations we attempted to explain the factors influencing the trace element composition as well as the reasons for changes and connections. These examinations are predominantly of agrogeological significance. The trace element content of soils is always in connection with the plants living in them. It is not irrelevant what kinds of factors control what quantities of trace elements can be integrated, and regularities of their changes. The examination of some plant samples may reveal the connection between the soil and the trace element-composition of plants. We took samples from a section at right angle to the mainroad. Thus in this study first of all the "road-effect" is demonstrated which exerts its harmful influence not only by means of lead pollution but also by its influence on a great number of other parameters. Its destructive role can be empirically observed in the must susceptible natural vegetation and in the fauna. A scientific explanation makes it possible through the knowledge of these effects to protect them against it. This is of special significance today, when conservation areas, forests and fields are broken by an ever increasing number of highways. These roads change the geochemical environment, thus fundamentally changing the outward appearance of the area can be the cause of the perishing of rare and protected plants.

I. Sampling and Testing Methods

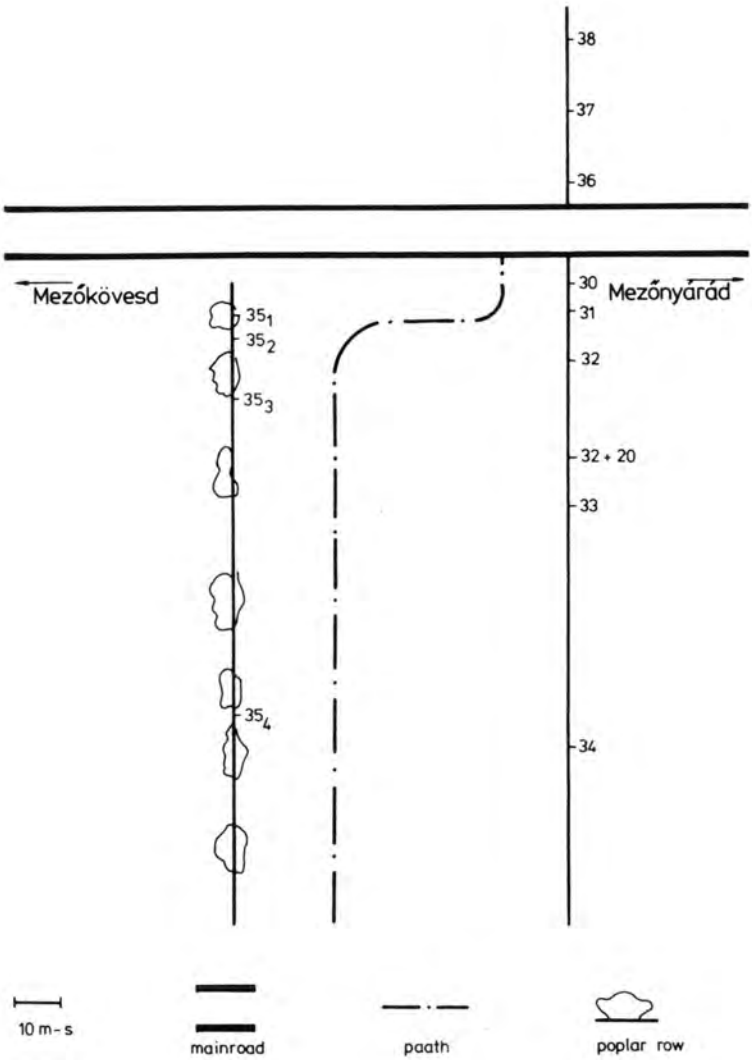
The sampling area is the M 3 mainroad, between Mezőkövesd and Mezőnyárád. Geographically this territory belongs to the Great Hungarian Plain, and is situated near the Downs of the Bükk. Geologically it is an extremely complex territory bordered by great tectonic lines and its deeper structure having not been fully penetrated yet.

1. Sampling

In order to clarify the role of the soil-section and the bedrock we took samples from 2-meter-deep sections (holes dug in the soil). The sampling holes were dug in right angle to the M 3 road at a point on either side of the road between Mezőkeresztes and Mezőnyárád (Fig. 1). This method was chosen because the direction of the wind may influence the areal distribution of the lead coming from the exhaust fumes. The sampling sites were selected so as to show whether the quantity of lead altered while getting further away from the road, and if so, what the measure of the change was. The relatively distant sampling points could give an estimate of the background trace element-distribution of the area. The samples were taken from each hole at spaces of 20 cm, they were put into nylon bags and numbered, and written records were made of the observations. Our area is flat, slightly sloping to the south at larger distances. Nearby flows the Tardi brook which crosses the road not far from our sampling lines. The furthest sampling points were 35 m north of the road and 106 m to the south from the surface of the road. The area has lost its natural vegetation since on either side of the road, at a distance of about 20-40 m the land is cultivated. To the north, about 10-30 m away from the road there is a wide patch of shrubs. Apart from some natural species, the vegetation consists of planted and adventive species such as Celtis, Amorpha fruticosa. From these and some others samples were taken. This belt of shrubs and trees is parallel with the mainroad. In right angle

Fig. 1.

Schematic map of the sampling points



to it, parallel with our section there is a row of planted poplars which were also sampled. The grass along the mainroad cannot be considered native grass cover because agricultural cultivation and mainroad building left only such a narrow place for it, that mostly cosmopolitan roadside species thrive in it. It does not contain natural plant assemblages. The whole of the plantage shows antropogene influence partly through tree plantation, partly through agricultural cultivation.

Sampling from plants

For the examination of the trace element composition of surface vegetation, samples from several species were collected and classified also according to organs. The plants selected for examination were partly cultured, partly wildgrown. (Several plant samples coming from each soil-section have been specially numbered.)

6. Lawn sheared with scissors from beside the sampling hole No.30, washed during sample preparation.
6.a. Same, unwashed.
7. Lawn cut from area two meters south of hole No.30, washed while preparing sample.
7.a. Same, unwashed.
8. Washed fruit of Rosa canina collected from the vicinity hole No.31.
9. Washed leaf of rosa canina from the vicinity of hole No.31.
10. Washed grass collected 1.5 m south of hole No.31.
11. Washed root of maize, collected near hole No.32.
12. Washed stalk of same.
13. Washed leaf of same.
14. Washed corn of same.
14.a. Unwashed leaf of same.
15. Washed root of maize collected 20 m south of hole No.32.
16. Washed corn of same.
17. Washed stalk of same.
18. Washed leaf of same.
19. Washed ear of same.
20. Washed corn of maize collected at hole No.33.
20.a. Unwashed corn of above sample.
21. Washed root of above sample.
22. Washed stalk of above sample.
23. Washed leaf of above sample.
24. Washed corn of maize collected at hole No.34.
24.a. Unwashed corn of above sample.
25. Washed root of above sample.
26. Washed stalk of above sample.
26.a. Unwashed stalk of above sample.
27. Washed leaf of above sample.
27.a. Unwashed leaf of above sample.
28. (Row of poplars as sampling point 35)
Washed leaf of poplar belonging to the row of poplars 13 m from the road.
29. Washed leaf of poplar 18 m from the road.
30. Washed leaf of poplar 30 m from the road.
31. Washed leaf of poplar 94 m from the road.
32. Washed branch of poplar 13 m from the road.
33. Washed branch of poplar 18 m from the road.
34. Washed branch of poplar 30 m from the road.
35. Washed branch of poplar 94 m from the road.
36. Washed grass cut from around hole No.36.
37. Washed grass cut 5 m north of hole No.36.
38. Washed leaf of Amorpha fruticosa 5 m north of hole No.36.
39. Washed crop of Amorpha fruticosa 5 m from hole No.36.

40. Washed leaf of maple near hole No.37.
40.a. Unwashed leaf of above sample.
41. Washed leaf of Celtis near hole No.37.
41.a. Unwashed leaf of same.

2. Methods of examination.

2.1. Preparation of Samples

The wet samples collected from the soil and bedrock were placed on filter paper, left to dry, then made homogenious and quartered. This quartered sample was used in the further tests, partly directly, e.g. determination of grane size distribution, determination of removable trace element content; partly through further preparation. The samples were ground in a mill with achate balls. Soil samples thus prepared were tested by means of derivatograph, and of atomic absorption in order to determine all the Cu, Zn, Mn, Pb as well as spectrum analysis. Here grain size distribution tests spectroanalysis as well as micromineralogical examinations are not dealt with since these did not essentially contribute to the solution of our main problems.

2.2. pH-measurements

20 g of each averaged and aerodry sample were measured on balance, then kept in fifty ml of destilled water for about six hours. The chemical reaction of the suspension obtained in this way and stirred several times was measured on an O.P. 107 portable pX-meter.

2.3. Derivatographic measurements

From all the averaged samples and in case of separated samples from every part smaller than 0.063 mm derivatogramms have been made. 1000 mg of aerodry samples were measured by MOM derivatographic equipment. The apparatus equipped with a photoemulsion registration equipment was heated to a maximum temperature of 1000°C, at a rise of 10°C per minute. TG was set at 200 mg, the sensitivity of DTG and DTA was set to 1/10. The other apparatus equipped with registration facilities was heated to a maximum 100°C with the TG set at 200 mg; the sensitivity of the registration DTG was 2.5 mV that of DTA was 250 μV.

In the interest of quicker proceedings both apparatuses were used. Part of the samples was measured in one of them, the other part of the samples in the other. Given the same samples, fractions under 0.063 mm were measured always on the apparatus which was used earlier for the examination of the average sample.

2.4. Atomabsorption examinations

2.4.1. The determination of the full element contents of the soil by means of digestion

The aerodry samples pulverized in achate ball and tube mill were dried in a drying cupboard at 105°C, then 0.4000 g were added to 15 ml digestion acid. The digestion acid was

produced by mixing 150 ml cc. $HClO_4$ solution and 500 ml cc. H_2F_2. Distilled on waterbath until the substance losts its smell, it was washed into a 100 ml wessel, with tridistilled water poured up to sign. The samples thus prepared were measured by atomic absorption spectrophotometer. The measurements of all the samples of soil section No.30 were made for Mn, Zn, Cu, Pb elements. The data were measured to µg/g in the following manner: The parallel results were averaged then the value of the blind sample measured for checking was substracted. The result was divided by 0.4. The quantitative data of respective elements were correlated with the data of the spectroanalysis. To determine the full-element contents of the rest of the sections the values obtained by spectroanalysis and corrected were used.

2.4.2. The determination of the soluble trace element contents of soils by means of EDTA--shaking

The aerodry and homogeneous samples were dried at 105°C then 15.0 g soil was measured to 75 ml EDTA. (EDTA-solution was made from 104.64 g EDTA with 5 l tridistilled water.) The chemical reaction of the suspension was measured to pH 7, then shaken in shaking mashine for one hour. Then the suspension was centrifuged for 20 min., the supernatant part poured off, and filtered into adequately preparated polyethylene flasks. The measurements were made using the previous apparatus. The results were calculated into µg/g in the following way:

The parallel measurements were averaged, the value of the control blind sample was substracted and the results thus obtained multiplied by 75/15. Mn, Zn, Cu, Pb were measured in the samples of each soil section.

2.4.3. The determination of trace element contents of plants by digestion methods

The plant samples collected were thoroughly clean with distilled water. This is necessary because certain parts of the plant, especially the leaf absorb on their surface some elements, so Pb in great quantities. This quantity is not actually integrated in the plant tissues (KLINCSEK 1976). Some similar samples were prepared for examinations, both washed and unwashed. All the samples were dried at 105°C, then pulverized in mill. Of the plant fragments thus obtained a quantity of 1.0000 g was measured. This was distilled with 15 ml cc. HNO_3 then 5 ml cc. H_2O_2 solution was poured over it. With this it was distilled again. This latter procedure was twice repeated. The resulting four times distilled substance was suspended in 5 ml 4 per cent HNO_3, while being heated, then washed into a 25 ml vessel pouring tridistilled water on it up to the sign. The samples were stored in polyethylene flasks, and measured with the above mentioned apparatus. In this way the full Mn, Zn, Cu, Pb contents of the plant samples were determined.

II. Examination results

1. The comprehensive characterization of soil sections

Comparing the different data of measurement given below a comprehensive characterization of our soil sections will be provided.

Section No.30 (Fig. 2)

The lower limit of the uppermost, so-called A-level can be fixed at a depth of about 20 cm on the basis of field obsevations and of data measured; the lowest layers of B and C are at 120

cm. The chemical effect of the soil is never acidic within the section, it is alkolescent with pH values between 7.5 and 8.5. The organic content of the section is the highest in the layer between 20 and 40 cm, hardly exceeding 3%. The organic material content is the smallest in the lowest layer as well as in the layer between 100 and 120 cm, where it is between 1.7-1.8%. Clay mineral contents (Illite) increases first in the layer between 40 and 60 cm, then with slight recession it reaches the value of 36% similar to the above, between 80 and 100 cm. Between 160 and 180 cm there is a remarkable recession, then under this in the lowest sample of the section the Illite-content reaches its maximum in the section. The upper 60 cm of the section contains no demonstrable quantity of carbonate minerals. In the sample between 60 and 80 cm less than 2% carbonate mineral has been measured. It is missing again in the next 20 cm layer, then its quantity increases reaching its maximum about 14% between 160 and 180 cm. After that slight decrease can be seen.

Of the trace elements the changes of the soluble quantities of manganese, zinc, copper and lead were examined. Manganese is present in the largest quantity. Its concentration is greater by one or two as related to the corresponding value of copper and lead and three in relation to zinc, magnitude. The soluble trace element content shows a decreasing tendency for all the elements examined. In addition to Mn, Pb, and then Cu can be found in greatest quantitites. Zn is present in the smallest quantity. Its soluble concentration is significantly higher in the highest layer than in the lower layers. In the middle layers between 80 and 100 cm, remarkable increase of soluble element contents can be observed which in case of Mn and Cu approximates the value of the first layer, but remains under this value in case of Pb and Zn.

Section No.31 (Fig. 3)

The A-level of the soil-section is in the upper 20 cm, followed by B-level down to 140 cm. The chemical reaction of the soil never falls within the acidic interval. In the upper layer the pH is almost neutral (7.25), which shows a regular and gradual increase downwards. It reaches its maximum 8.4 pH value at a depth of 160 cm under which the pH was found constant to the bottom of our section. The changes in organic material contents can be called also relatively constant, its maximum 4.2% is in A-level, with unmistakable decrease from there on. It shows a slight increase in the layer between 60 and 80 cm which, however, is far from the one, seen in the first two layers.

The clay mineral content of the section is rather variable, alternating between 21% and 34%. The Illite content of the part between 160 and 180 cm is the highest. It reaches a constant value of 30% in the lower part of the B-level. In the layer between 60 and 80 cm, where the increase of organic material can be seen, the quantity of Illite considerably devreases. This tendency characterizes the whole of the section i.e. where there is a decrease in organic material, the Illite content increases. The $CaCO_3$-content of the soil gradually increases after the upper third (60 cm) of the B-level until its maximum of 13%, which it reaches in the layer between 160 and 180 cm. It is present in the A-level only in very small quantity and it can not be seen at all in the next 40 cm.

The soluble Mn, Zn, Cu, Pb content, like in the previous section, shows an unmistakable decrease towards the deeper layers. Each reaches its maximum in the A-level. Cu decreases the most evenly, unlike Zn and Pb. The concentration of both of these elements decreases to a great extent after the first level, while the decrease of Mn becomes gradually less and less in the upper 80 cm-s and shows a sudden drop after that. It remains on this low level further on with the exception of its new but small increase between 140 and 160 cm.

Section No.32 (Fig. 4)

The A-level of the section is from 0-20 cm, its B-level to 120 cm. The chemical reaction of the soil changes within a much wider interval than so far. The A-level is characterized by a mild acid almost 6 pH, then in the next 40 cm it is near neutral but still under pH 7. At 60 cm the pH changes from acidous into alkaline and from here its even increase can be observed. At its highest point - between 160 and 180 cm -, it almost reaches the value of pH 8.5. Organic material contents of the section reaches its near 5% maximum in the A-level. After that it shows a very quick decrease until under B-level, where it reaches its minimum. After that between 140 and 160 cm it increases again to about the level of the value between 60 and 80 cm, then it decreases again. The Illite reaches its minimum in the A-level, after that its quantity suddenly

Fig. 2.

30. Soil-section

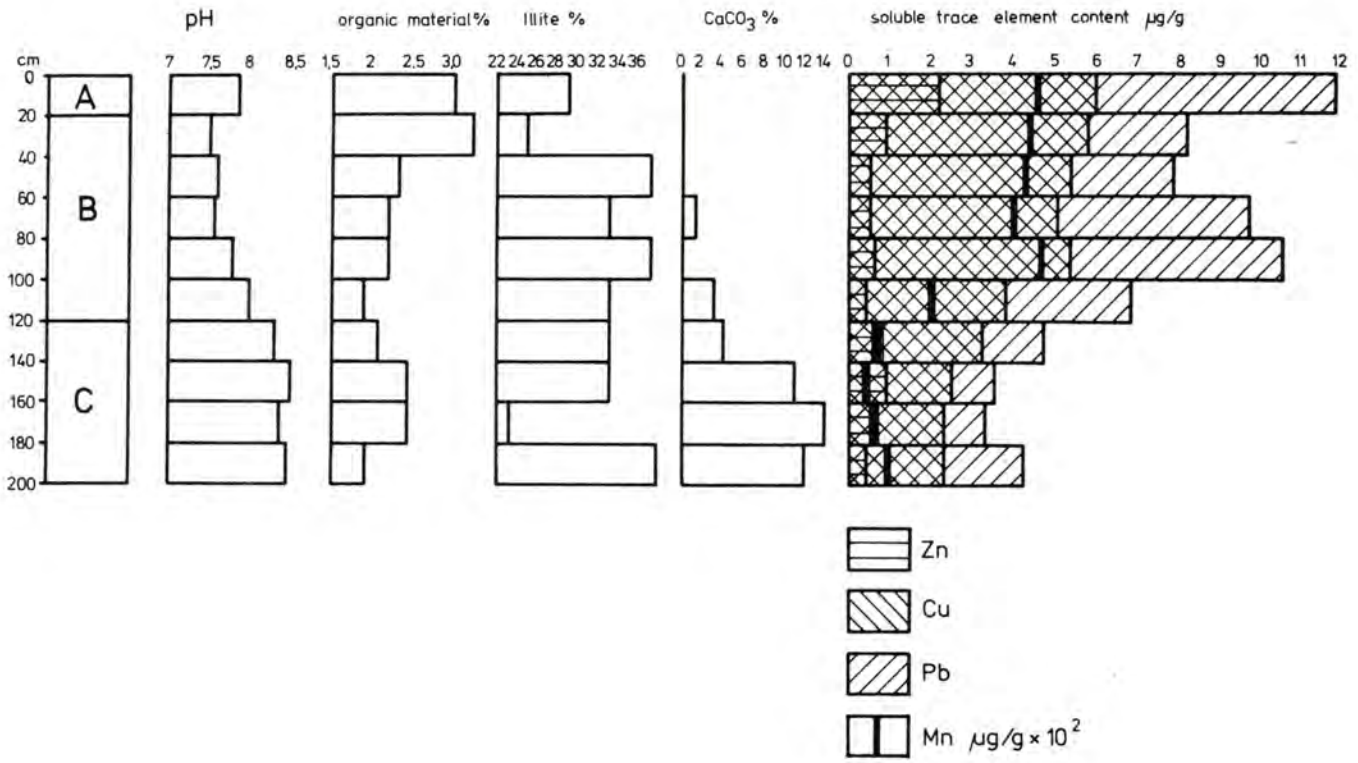


Fig. 3.

31. Soil - section

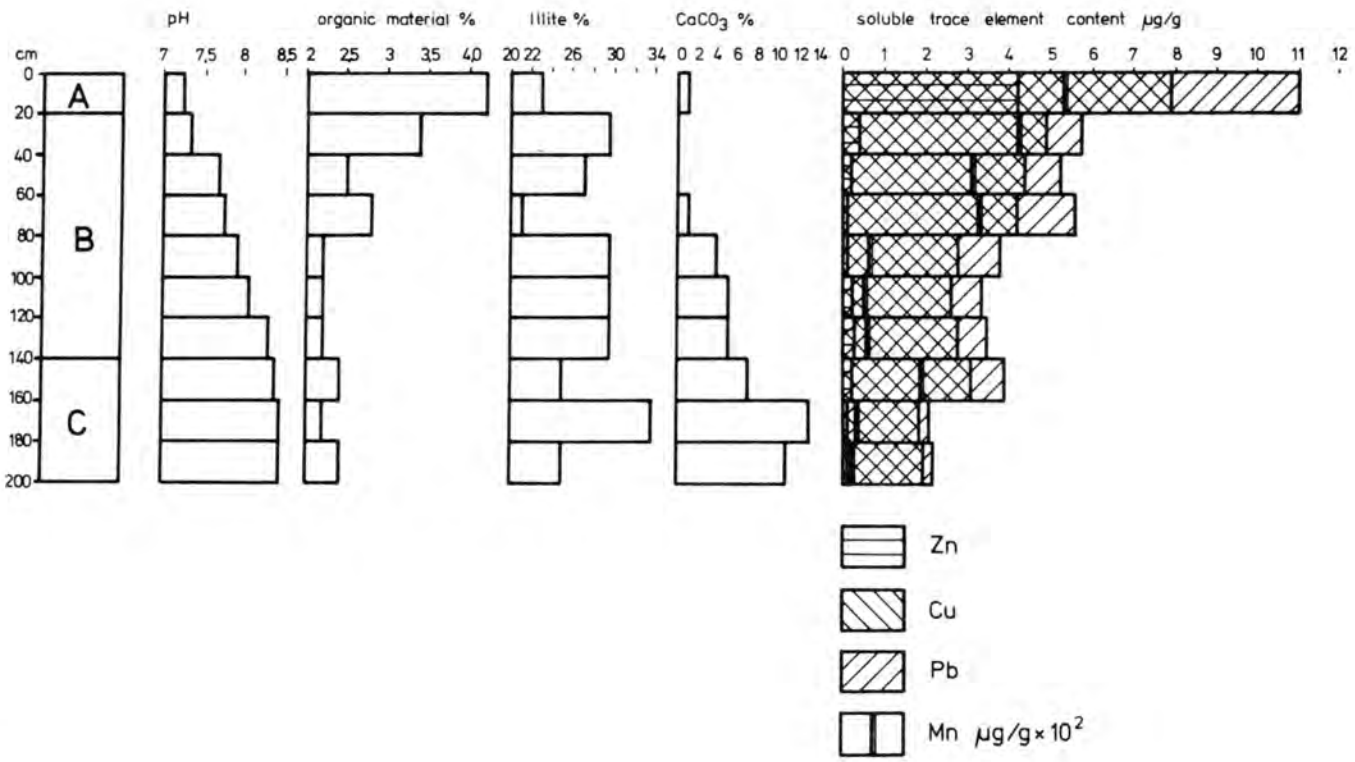


Fig. 4.

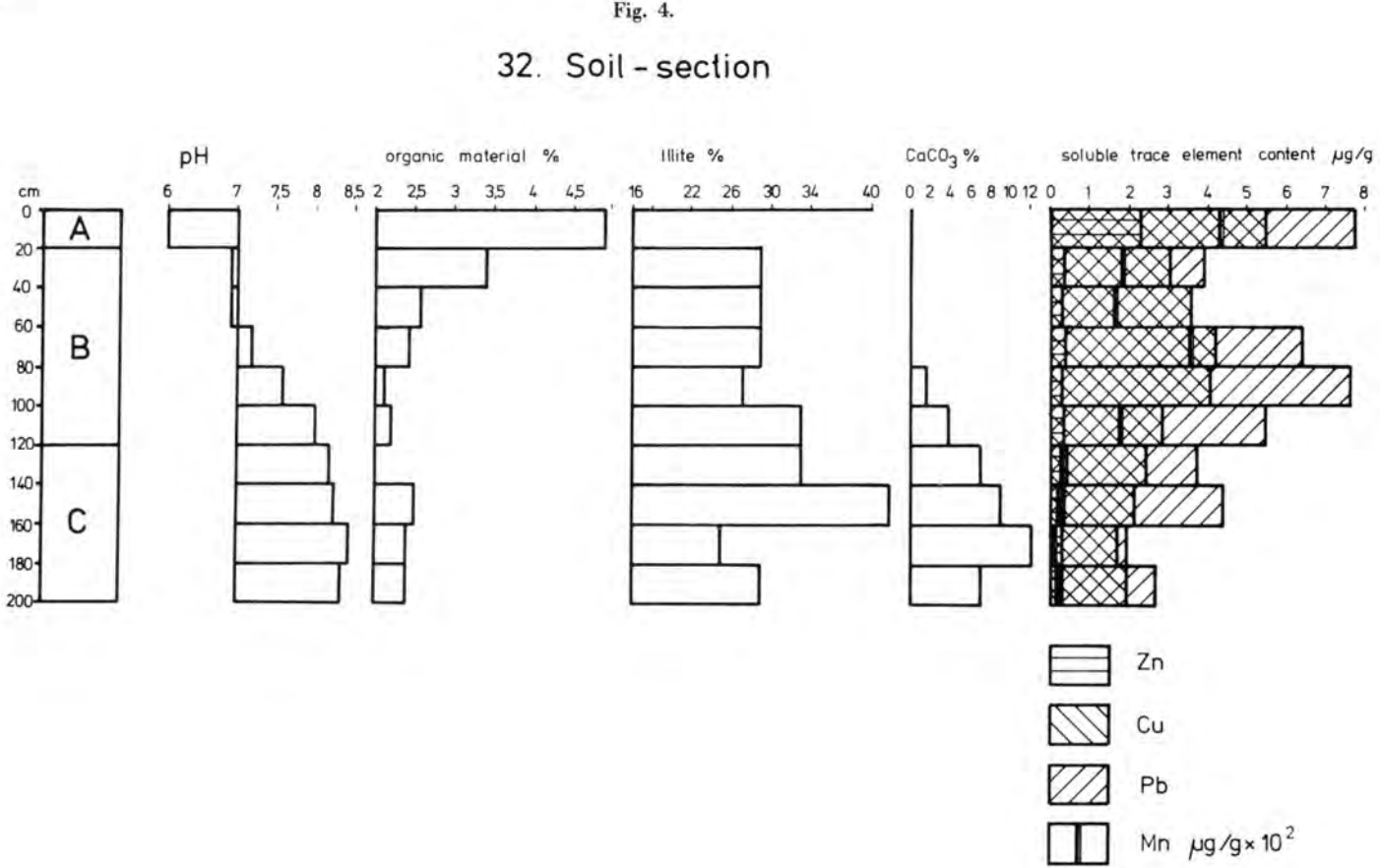
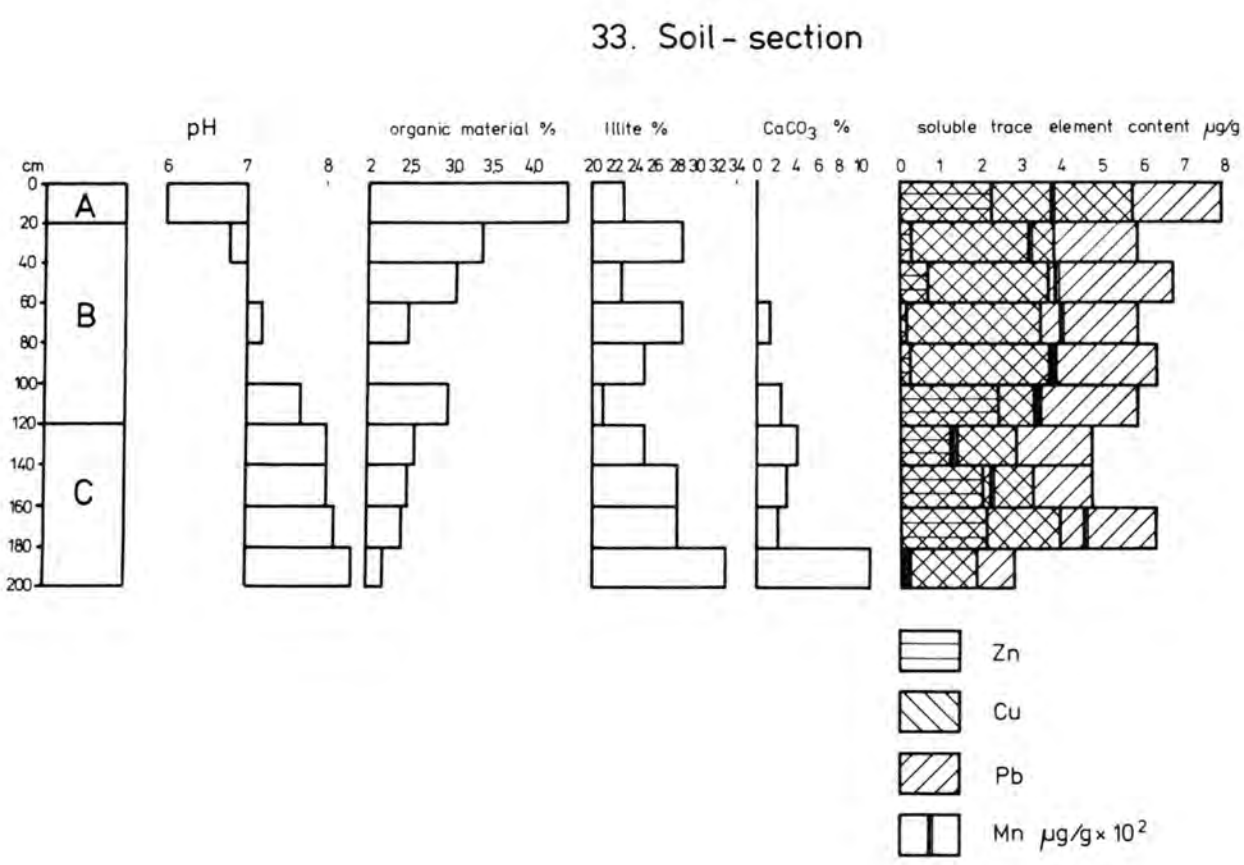

32. Soil - section
pH
organic material %
Illite %
$CaCO_3$ %
soluble trace element content µg/g
cm
A
B
C
Zn
Cu
Pb
Mn µg/g × 10^2

Fig. 5.


33. Soil - section
pH
organic material %
Illite %
$CaCO_3$ %
soluble trace element content µg/g
cm
0
20
40
60
80
100
120
140
160
180
200
A
B
C
6 7 8
2 2.5 3.0 3.5 4.0
20 22 24 26 28 30 32 34
0 2 4 6 8 10
0 1 2 3 4 5 6 7 8
Zn
Cu
Pb
Mn µg/g × 10^2

increases and remains at medium value almost still the bottom of B-level. At the depth of 1 m it increases but it reaches its maximum only between 140 and 160 cm. After that its quantity suddenly decreases and in the lowest sample it starts increasing again.

Section No.32 is free of carbonate in its upper 80 cm. After that a gradual and even increase of the carbonate contents can be observed until its maximum of about 12% (160 and 180 cm), after which its value decreases again. The tendency of the changes in the soluble Mn, Zn, Cu, Pb can not be marked by decrease according to depth. Although all the elements show the highest concentration in the uppermost level, the level between 80 and 100 cm is also very near the above values. Zn is the element whose quantity suddenly decreases below A-level and remains on this low level to the bottom of the section with minor variations. Also in this section it is Cu which shows a downward decrease most evenly. It is interesting to note the variations of the values in lead and manganese, which show similar changes. These suddenly decrease after their highest values in A-level, increasing significantly at 60 cm and almost reaching their maximum in A-level between 80 and 100 cm. After that they show a gradual and then a quick decrease in quantity.

Section No.33 (Fig. 5)

The A-level is between 0 and 20 cm, B-level is between 20 and 120 cm. Like with the previous section, the pH covers almost two and a half pH intervals, A-level is milder acidic and shows sudden decrease after its 6 pH, although it remains within acidic interval, it is already near neutral chemical reaction. Between 40 and 100 cm it is neutral. Though once it shows alkaline reaction. Under 1 m it suddenly increases and shows steady increase further on to its 8.5 pH maximum between 180 and 200 cm. The decrease in organic material content towards the deeper layers shows two stages. It is present in largest quantities in A-level, then gradually decreases to its minimum between 80 and 100 cm. It increases again to its previous quantity in about 40 and 60 cm. From here it shows steady decrease to the bottom of the section.

The quantities of Illite within the section change rather capriciously, but the changes show no outstanding values. Illite appears in the section at 21-33%. It shows even changes only in the C-level, where it increases steadily from the top to the bottom of the section. Almost to the depth of 1 m the section is free of carbonate, smaller quantities of carbonate occur between 60 and 80 cm. Its quantity is relatively constant under 100 cm and shows a sudden increase in the lowest sample level (190 cm).

The changes in the soluble trace element content are highly different from those in the previous section. Although copper and lead are enriched the most in the A-level, zinc reaches its maximum at the bottom of B-level (100-120 cm), and manganese reaches its maximum in the C-level (160 and 180 cm). It is to be noted, however, that they almost reach these values also in the A-level. Zn shows the most unepected results. In the sections so far presented it remained at constantly low values under the A-level. Here this applies only to a depth of 1 m. Between 100 and 120 cm it increases again to a higher value than in A-level and occurs in a relatively high concentration in the following 60 cm. Its concentration shows again significant decrease.

Section No.34 (Fig. 6)

The depth of this section is half of the previous ones (1 m). A-level is between 0 and 20 cm, beneath that the whole section is B-level. The majority of the sampling levels fall within acidous pH intervals. The 5.25 pH of A-level can be said acidic enough. Under 20 cm it is mildly acidic, at 80 cm it is very near neutral, but shows alkalescent character (7.2 pH). In this section the organic material content shows very regular variations. The maximum of A-level (4.8%) is followed by a gradual decrease with a more marked decrease under 60 cm while it reaches 2% minimum between 80 and 100 cm. Within 21 and 25% Illite changes irregularly. No carbonate mineral was present in the full length of the section.

In the soluble Mn, Zn, Cu, Pb quantities, a decreasing tendency according to depth can be observed. It is remarkable, however, that while so far the order was Mn Pb Cu Zn, now Cu and Zn change places. Besides Zn is enriched not in A-level but between 40 and 60 cm, and it decreases to its usual quantity only between 80 and 100 cm under 1 ppm. To the end of the section copper occurs only in a very small quantity.

Section No.36 (Fig. 7)

As opposed to previous values an increase of A-level can be observed from 0 to 40 cm. Thus B-level decreases between 40 and 100 cm. Under this C-level reaches to the bottom of the section. pH is in the neutral-alkalescent and is within very small interval: 7.5-8. The change of the organic material content is very even. It gradually decreases from its maximum in the level (4.1%) to a minimum of 1.8%, which it reaches in the lowest 40 cm. Illite shows rather even increase with occasional minor regressions. It reaches its maximum in the lowest 20 cm of the section. The $CaCO_3$-content of the soil is within a narrow, 1-7% interval thus it can be regarded rather constant. It is rather from C-level onwards that higher values can be found. In the relation to the element contcentrations, two generally even decreases can be observed here. Mn - which, as compared to the other elements, occurs in greater quantities also here - is on the whole constant in the upper 100 cm, reaches its maximum between 100 and 120 cm. After that it shows a rapid decrease to the bottom of the section. Lead - after its decrease in A-level -, similarly to manganese is enriched again between 100 and 120 cm, then shows a greater decrease than previously to the bottom of the section.

The changes in the quantities of soluble copper and zinc are noteworthy. In A-level Zn is present in considerably larger quantities than before, exceeding copper, which is present in its usual quantity (around 5 ppm). Copper is relatively constant in the upper 120 cm, then shows gradual decrease. Zinc shows much greater extremes. After its 9.8 ppm in A-level, it greatly decreases then with its considerable decrease at 40 and 60 cm it remains at its usual level under 1 ppm to the end of the section.

Section No.37 (Fig. 8)

This is a thin section only 60 cm deep. Its A-level is thick, 40 cm beneath that only 20 cm of B-level have been revealed. pH is neutral, mildly acidic. The organic material content shows rapid decrease downwards from its five weight per cent maximum in the upper most 20 cm. At the top Illite is about 17%, then its quantity significantly increases (25%), and later it decreases again. No carbonate was found in the examined depth of 60 cm. The change of Mn, Zn, Cu, Pb in the section is very even; downwards each decreases in about the same proportion. However, the quantities of Mn and Cu completely change places in relation to the first sections, thus the order will be Mn$\gg$ Pb$>$ Zn$>$ Cu.

Section No.38 (Fig. 9)

A-level, similarly to the first sections here, too, is 20 cm. B-level reaches until 120 cm, where C-level starts. Chemical reaction here yields one of the most beautiful changes. With the neutral pH acting as axle the change produces an S curve. Chemical reaction gradually grows from mildly acidic pH to the acidic. It reaches its acid maximum between 40 and 60 cm. After that it evenly decreases towards the neutral interval. The change from acidic to alkaline reaction occurs at 120 cm. From here on, it gets always more and more alkaline till it reaches 8.3 pH maximum at the bottom of the section. The organic material content culminates not in the highest level but between 40 and 60 cm. After that it shows an even decrease, remaining approximately constant under 120 cm. Illite is present in the upper section of the section in more or less the same small quantity. It increases at 100 cm, then it decreases reaching its maximum (about 40%), in the lowest 20 cm (180-200 cm). The section is free of carbonate to a depth of 140 cm. Carbonate appears here, then gradually increases to the bottom of the section, but its quantity hardly exceeds 4%. The changes in trace element content occur differently from those in the previous sections. It was shown earlier (30, 31, 36 sections), that at maximum element concentrations of 0-20 cm an outstanding value appears in the lower levels, which produces maximum of at least approximately maximum values.

Here the level of 40-60 cm, is the zone containing the highest soluble concentrations. From here the trace element content of the rest of the levels shows almost symmentrical values in both directions. The order of the concentrations is Mn$\gg$ Pb$>$ Cu $>$ Zn. Unlike in previous cases Cu and Pb change places between 80 and 120 cm. Zn appears in the lower 80 cm with its usual small concentration. Cu after its maximum shows the usual gradual decrease. This explains also the fact that between 80 and 120 cm it "precedes" lead since this shows a rapid decrease after a depth of 80 cm.

Fig. 6.

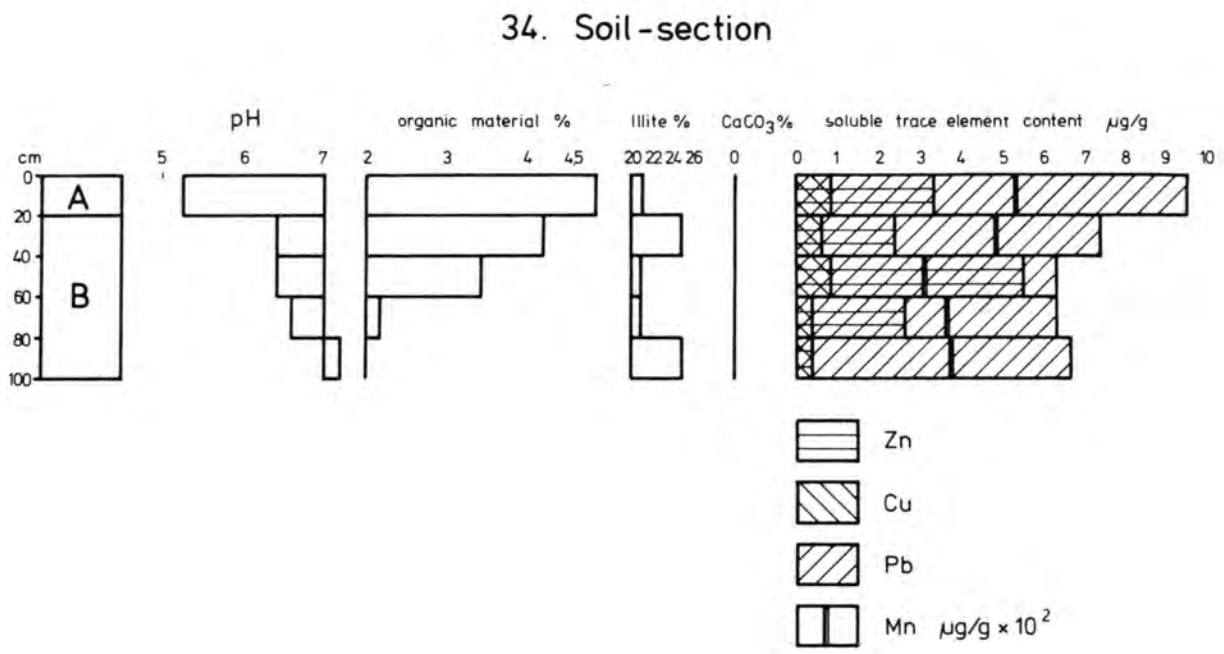

34. Soil-section
pH
organic material %
Illite %
$CaCO_3$ %
soluble trace element content µg/g
cm
A
B
Zn
Cu
Pb
Mn µg/g × 10^2

Fig. 7.

36. Soil - section

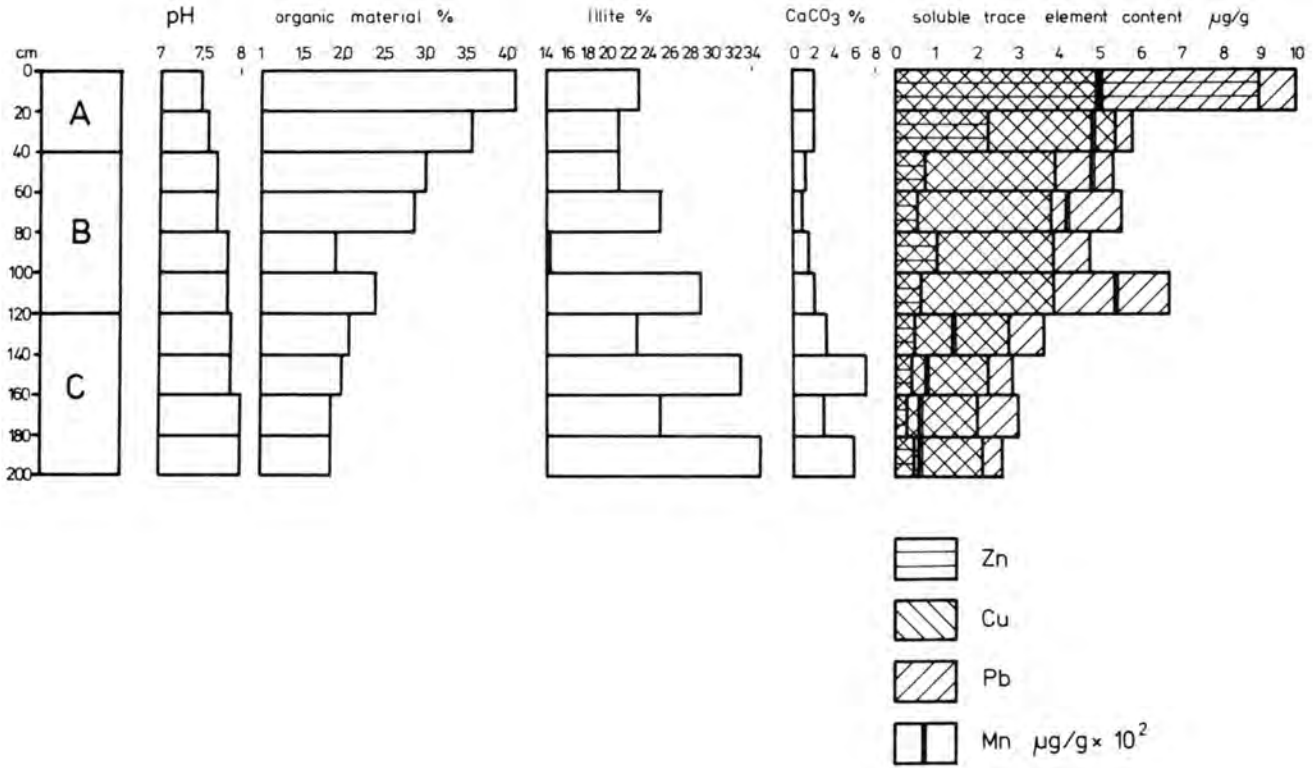


Fig. 8.

37. Soil-section

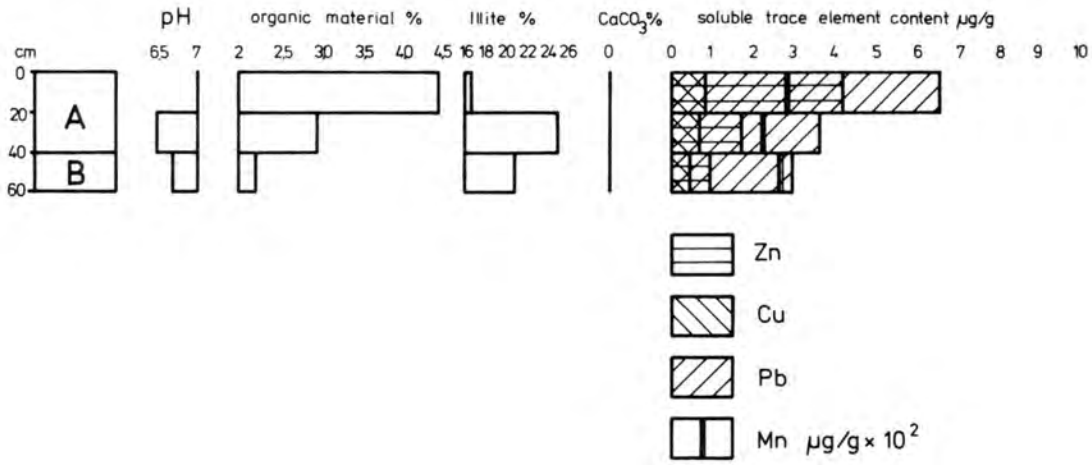
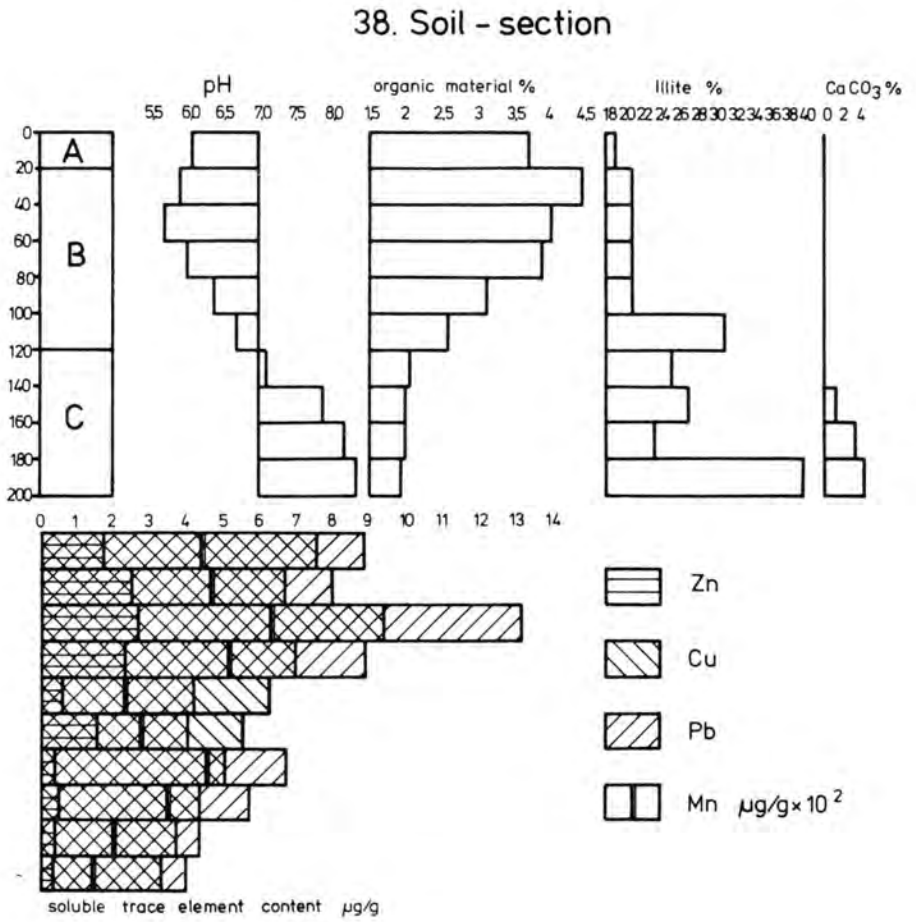


Fig. 9.


38. Soil - section
pH
5,5 6,0 6,5 7,0 7,5 8,0
organic material %
1,5 2 2,5 3 3,5 4 4,5
Illite %
18 20 22 24 26 28 30 32 34 36 38 40
CaCO3 %
0 2 4
0
20
40
60
80
100
120
140
160
180
200
A
B
C
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Zn
Cu
Pb
Mn µg/g × 10 2
soluble trace element content µg/g

2. Organic material, clay mineral and carbonate in the soils (The results of derivatographic examinations)

Our derivatogramms made it possible to distinguish four major curve stages, resulting from the presence of water, organic material, clay mineral and carbonate. The first endotermic peak and the accompanying loss of weight results from the loss of water in the organic material built into the colloid fraction adsorbtively. After that the DTG curve reaches its balance at about 200-240°C. This is the interval where the line can be drawn between the loss of water and the burnout domain of the organic material. Following this all the graphs show a great exotherm peadk of the organic material. In the DTA curve this peak shows between 200-240 and 500°C, thus is hides several phenomena within this domain. Of these the most significant one is the invisibility of the endothermic peaks of ferri-oxi-hydroxids and of the siliceous colloids. These latter ones do not indicate loss of weight, thus all the losses of weight in this domain were calculated for the organic material. When the organic material was not humus, i.e. a relatively homogenious fraction, but contained also undecomposed, fragments or organs, the DTA peak of the organic material spread wider. In certain cases this can effect the clay mineral interval, the reason for which is that the decomposition temperature of the inhomogenious organic fraction (root, chitin armour etc.) is different in each. In this case the exothermic peak of the burnout of the organic material and the endothermic DTA-peak of the clay mineral partly neutralize each other, in the interval around 500°C. In such cases the limit of the weight losses arising from these reactions has been determined at 540°C. The weight per cent of the organic material was calculated on the basis of the weight loss of the interval mentioned.

The exothermic DTA-peak of the organic material shows three smaller peaks in most cases. First we supposed it to be pyrite, later it turned out to be the result of the inhomogenity of the organic material. The fact that our soil samples did not contain pyrite was proved by the following experiment: HCl was added to the soils, than the opening of the test tube was covered with filter paper soaked in Pb-acetate. If pyrite were present, HCl would release H_2S. This, reacting to Pb-acetate would yield black PbS precipitation. The smallest quantity of pyrite demonstrable by this reaction is 10^{-12} g and this can be regarded as highly sensitive (ERDEY 1970). None of our samples yielded this reaction, so the presence of pyrite can be excluded.

The third interval of the graphs is between 500 and 600°C, with variabilities. The exothermic peak produced by the organic material continues in the endothermic peak of the clay minerals. In almost all cases even this becomes flat and almost asymmetrical, which indicates that the Illite is not clean, but mixed with Montmorillonite, i.e. there is a transition of Illite-Montmorillonite. This is proved also by the break at the endothermic peak of the sorptive water, which is characteristic of smectites; water is released in two stages: between 120 and 140°C, and 140 and 280°C. This is also proved by data from literature according to which Montmorillonite crystallizes looser in the soil and thus its endothermic peak appears at 600°C (NEMECZ 1973). On closer observation of the DTA curve it can be seen that at about 900°C usually the exothermic peak is low, which also indicates Montmorillonite. All these indicate that our soil samples contain Illite and Montmorillonite together or mixed structures. A more precise solution of the problem requires closer examinations.

The fourth important section of the DTA curve is determined by the character of the carbonates. The endothermic peak of the carbonates contains an indefinite section with low temperature on one hand and a well-marked section with higher temperature on the other. This can be observed on the DTG curve as well: after 600°C a sloping flat "peak" can be observed, and only after that does the curve fall more markedly.

As a result of a more intensive treatment of the samples with acid the mildly sloping peak preceding the strong endothermic peak disappeared, which proves its relation to carbonate minerals. This allows for the supposition that above 600°C carbonates of mild crystallization which, occasionally may from a colloid film begin to leave. This can be assumed to be the cause of the mild sloping at the carbonate peak. The characteristic carbonate peak around 800°C is already the result of crystallized carbonate grains.

In a few cases around 700-750°C we find a smaller endothermic peak preceding the high endothermic peak of Calcite. This arises from a higher $MgCO_3$ content, and, occasionally shows such marked presence as indicating Dolomite in addition to Calcite. The isolation of these carbonate varies would demand changes in methodology, so quantitative data here were calculated as $CaCO_3$.

The interval between 600 and 750°C may contain smaller Montmorillonite and even Chlorite peaks, these, however, could not be evaluated. Thus the small loss of weight which may appear here and can be related to the Phillosilicates, should be calculated as part of the carbonate content. From the above it follows that the weight per cent values calculated with the help of derivatograms, are only approximative values obtained from an average sample. The derivatograms of the fraction below 0.063 mm made the evaluation easier in some cases. For particular samples the changes in organic material-, carbonate-mineral and clay-mineral content were dealt with in chapter II.1.

Table 1. Soluble Mn, Zn, Cu, Pb content and the geochemical factors of the soil

Sample	Mn ppm	Zn ppm	Cu ppm	Pb ppm	pH	H_2O %	organic material %	clay mineral %	$CaCO_3$ %
30. 1.	446.1	2.18	5.99	11.85	7.7	4.0	3.0	29.4	-
30. 2.	446.2	0.86	5.80	8.10	7.5	3.6	3.2	25.2	-
30. 3.	430.0	0.51	5.30	7.80	7.65	4.7	2.3	37.8	-
30. 4.	409.5	0.50	5.06	9.65	7.6	5.2	2.2	33.6	1.5
30. 5.	463.9	0.63	5.32	10.50	7.8	6.0	2.2	37.8	-
30. 6.	207.2	0.45	3.86	6.80	8.0	6.2	1.8	33.6	3.1
30. 7.	71.6	0.63	3.25	4.75	8.3	5.5	2.1	33.6	3.9
30. 8.	44.17	0.92	2.50	3.55	8.5	5.8	2.4	33.6	11.0
30. 9.	51.8	0.59	2.46	3.44	8.4	5.0	2.4	23.1	13.8
30.10.	93.9	0.48	2.34	4.25	8.4	5.2	1.8	37.8	11.8
31. 1.	538.3	4.23	7.92	11.05	7.25	3.3	4.2	23.1	1.3
31. 2.	425.0	0.40	4.87	5.74	7.3	4.6	3.4	29.4	-
31. 3.	318.3	0.21	4.43	5.24	7.7	4.7	2.5	27.3	-
31. 4.	326.6	0.14	4.22	5.55	7.75	5.2	2.8	21.0	1.3
31. 5.	72.7	0.14	2.79	3.80	7.9	5.8	2.2	29.4	3.9
31. 6.	52.1	0.22	2.64	3.39	8.1	4.8	2.2	29.4	4.8
31. 7.	57.2	0.26	2.77	3.48	8.3	5.2	2.2	29.4	4.8
31. 8.	182.3	0.22	3.02	3.92	8.35	4.6	2.4	25.2	6.8
31. 9.	30.4	0.17	2.06	1.86	8.4	4.2	2.2	33.6	12.7
31.10.	18.6	0.16	1.96	2.19	8.4	4.6	2.4	25.2	10.5
32. 1.	438.4	2.33	5.47	7.75	6.1	3.4	4.8	16.8	-
32. 2.	148.7	0.38	3.94	3.00	6.9	4.6	3.4	29.4	-
32. 3.	162.3	0.24	3.58	3.59	6.9	4.4	2.6	29.4	-
32. 4.	353.5	0.35	4.16	6.41	7.2	5.8	2.4	29.4	-
32. 5.	435.0	0.31	4.03	7.65	7.6	4.6	2.1	27.3	1.7
32. 6.	180.0	0.38	2.88	5.24	8.0	5.8	2.2	33.6	3.9
32. 7.	32.0	0.43	2.44	3.71	8.2	4.6	2.0	33.6	7.4
32. 8.	27.6	0.38	2.14	4.43	8.25	5.2	2.5	39.9	8.8
32. 9.	8.3	0.31	1.73	1.95	8.4	4.0	2.4	25.2	12.3
32.10.	22.8	0.27	1.90	2.63	8.4	4.8	2.4	29.4	7.4
33. 1.	371.6	2.36	5.64	7.88	6.0	3.2	4.4	23.1	-
33. 2.	323.3	0.36	3.75	5.71	6.8	4.6	3.4	29.4	-
33. 3.	381.6	0.67	3.65	6.69	7.0	4.3	3.1	23.1	-
33. 4.	396.6	0.24	3.43	5.87	7.2	4.3	2.5	29.4	1.5
33. 5.	371.6	0.29	3.81	6.36	7.0	4.2	2.0	25.2	-
33. 6.	340.0	2.48	3.41	5.87	7.7	4.0	3.0	21.1	2.2
33. 7.	142.6	1.42	2.88	4.62	8.0	4.2	2.6	25.2	3.9
33. 8.	231.6	2.03	3.28	4.69	8.0	4.5	2.5	29.4	2.8
33. 9.	450.0	2.15	3.96	6.25	8.15	3.6	2.4	29.4	2.2
33.10.	7.1	0.35	1.88	2.84	8.3	5.2	2.2	33.6	11.0

(Table 1. cont.)

Sample	Mn ppm	Zn ppm	Cu ppm	Pb ppm	pH	H_2O %	organic material %	clay mineral %	$CaCO_3$ %
34. 1.	530.0	3.37	0.93	9.50	5.25	3.1	4.8	21.1	-
34. 2.	490.0	2.44	0.59	7.43	6.4	4.0	4.2	25.2	-
34. 3.	315.0	5.5	0.82	6.47	6.4	4.2	3.4	21.1	-
34. 4.	363.3	2.65	0.49	6.47	6.65	4.2	2.2	21.1	-
34. 5.	368.3	0.44	0.46	6.77	7.2	4.4	2.0	25.2	-
36. 1.	506.6	8.92	5.03	9.82	7.5	3.2	4.1	23.1	2.2
36. 2.	483.3	2.25	5.47	5.79	7.6	3.4	3.6	21.1	2.2
36. 3.	475.0	0.78	3.96	5.30	7.7	3.6	3.0	21.1	1.7
36. 4.	416.6	0.58	3.82	5.48	7.7	4.0	2.8	25.2	1.3
36. 5.	495.0	1.05	3.95	4.72	7.8	2.5	1.9	14.7	1.9
36. 6.	546.6	0.69	3.97	6.67	7.8	4.6	2.4	29.4	2.2
36. 7.	141.3	0.53	2.70	3.65	7.9	5.4	2.1	23.1	3.5
36. 8.	73.6	0.47	2.24	2.86	7.9	5.0	2.0	33.6	7.4
36. 9.	60.4	0.35	2.09	3.06	8.0	4.3	1.8	25.2	3.1
36.10.	65.9	0.42	2.15	2.69	8.0	4.4	1.8	35.7	6.1
37. 1.	285.0	4.13	0.82	6.54	7.0	3.6	4.4	16.8	-
37. 2.	224.8	1.73	0.78	3.62	6.5	4.4	2.9	25.2	-
37. 3.	263.3	0.93	0.47	2.96	6.7	4.2	2.2	21.1	-
38. 1.	445.0	1.80	7.65	8.92	6.1	3.1	3.7	18.9	-
38. 2.	473.3	2.53	6.85	8.09	5.8	3.6	4.4	21.1	-
38. 3.	635.0	2.61	9.49	13.26	5.7	3.4	4.0	21.1	-
38. 4.	516.6	2.41	7.07	8.95	6.0	3.4	3.8	21.1	-
38. 5.	246.6	0.63	6.39	4.13	6.4	4.0	3.2	21.1	-
38. 6.	273.3	1.50	5.53	4.04	6.7	3.8	2.6	31.5	-
38. 7.	453.3	0.34	5.08	6.75	7.15	4.6	2.1	25.2	-
38. 8.	345.0	0.41	4.38	5.65	7.8	4.5	2.0	27.3	1.7
38. 9.	198.1	0.37	3.58	4.34	8.2	4.7	2.0	23.1	3.7
38.10.	144.2	0.37	3.34	3.91	8.3	5.0	1.9	39.9	4.6

3. The soluble element content of soil-sections and the examination of the geochemical factors influencing it

The soluble element content was measured after shaking in EDTA by means of atomic absorption device. The quantity of these in µg/g us shown in Table 1. Direct conclusions can not be drawn from the values of the soluble element content of different sections, therefore correlation has been calculated for the examined element of each section as well as between its element and the examaned parameters. Correlation was calculated on the basis of the following formule:

$$r = \frac{SP}{\sqrt{SQ_x \cdot SQ_y}}$$

$$\pm SP = \sum xy - \frac{\sum x \cdot \sum y}{n}$$

$$SQ_x = \sum X^2 - \frac{/\sum X^2/}{n}$$

$$SQ_y = \sum Y^2 - \frac{/\sum Y^2/}{n}$$

n: the number of the samples
r : correlation coefficient

SQ_x and SQ_y can stand for only positive number, because the sum of the correlation to be substracted can be smaller than the square of the differences. SP can be either positive or negative. The sign of the correlation coefficient is always identical with the sign of SP. Its value may range from -1 to +1 depending on whether there is a positive or a negative correlation between the quantities examined. The closer the value of r is to $\pm$ 1, the closer the correlation is. The values of r were calculated by means of the linear regression programme made for the PTK 1072 pocket calculator. The data of identical units can be substituted for the x and y values of the above formula. If their units are not measurable with each other, e.g. concentration and pH, the data have to be standardized previously. In such cases the average and the standard deviation of the series have to be individually calculated, then the average is substracted from each sample and is divided by the standard deviation.

$$x_{ST} = \frac{x - \bar{x}}{S}$$

$\bar{x}$: the average of the samples
S: the standard deviation of the samples
x: the value of the original sample
x_{ST}: the value of the standardized sample

The values of x_{ST} and y_{ST} obtained through the above transformation can be substituted into the r formula.

Table 2. Correlation between of the soluble Mn, Zn, Cu, Pb contents and of the geochemical factors

Sample		Mn	Zn	Cu	Pb	pH	organic material	clay mineral	$CaCO_3$
30.	Mn	-	0.33	0.98	0.93	-0,96	0.49	0.08	-0.87
	Zn	0.33	-	0.41	0.48	-0,21	0.68	-0.32	-0.25
	Cu	0.98	0.41	-	0.93	-0.96	0.57	-0.02	-0.93
	Pb	0.93	0.48	0.93	-	-0.86	0.40	0.13	-0.85
31.	Mn	-	0.65	0.94	0.91	-0.94	0.90	-0.05	-0.76
	Zn	0.65	-	0.85	0.88	-0.58	0.84	-0.38	-0.29
	Cu	0.94	0.85	-	0.99	-0.88	0.94	-0.50	-0.70
	Pb	0.91	0.88	0.99	-	-0.85	0.92	-0.55	-0.69
32.	Mn	-	0.52	0.91	0.90	-0.74	0.05	-0.57	-0.79
	Zn	0.52	-	0.65	0.54	-0.65	0.88	-0.70	-0.31
	Cu	0.91	0.65	-	0.76	-0.94	0.68	-0.61	-0.89
	Pb	0.90	0.54	0.76	-	-0.62	0.32	-0.34	-0.59
33.	Mn	-	0.19	0.73	0.88	-0.53	-0.53	-0.44	-0.86
	Zn	0.19	-	0.42	0.29	0.09	0.39	-0.43	-0.13
	Cu	0.73	0.42	-	0.88	-0.80	0.73	-0.52	-0.77
	Pb	0.88	0.29	0.88	-	-0.79	0.61	-0.67	-0.88

(Table 2. cont.)

Sample		Mn	Zn	Cu	Pb	pH	organic material	clay mineral	$CaCO_3$
34.	Mn	-	-0.17	0.38	0.88	-0.70	0.78	0.16	-
	Zn	-0.17	-	0.73	0.04	-0.50	0.45	-0.72	-
	Cu	0.38	0.73	-	0.66	-0.87	0.80	-0.58	-
	Pb	0.88	0.04	0.66	-	-0.87	0.79	-0.47	-
36.	Mn	-	0.41	0.90	0.80	-0.82	0.66	-0.59	-0.79
	Zn	0.41	-	0.59	0.83	-0.72	0.78	-0.22	-0.24
	Cu	0.90	0.59	-	0.83	-0.94	0.86	-0.58	-0.69
	Pb	0.80	0.83	0.83	-	-0.88	0.85	-0.36	-0.61
37.	Mn	-	0.60	-0.04	0.65	0.96	0.54	-0.98	-
	Zn	0.60	-	0.77	1.00	0.80	1.00	-0.73	-
	Cu	-0.04	0.77	-	0.73	0.23	0.81	-0.12	-
	Pb	0.65	1.00	0.73	-	0.84	0.99	-0.78	-
38.	Mn	-	0.76	0.84	0.94	-0.48	0.71	-0.63	-0.71
	Zn	0.76	-	0.84	0.78	-0.87	0.92	-0.49	-0.59
	Cu	0.84	0.84	-	0.86	-0.94	0.88	-0.67	-0.76
	Pb	0.94	0.78	0.86	-	-0.71	0.72	-0.57	-0.51

3.1. Correlation between the certain trace-elements

To calculate the correlation between the trace elements the data calculated for µg/g has been used directly without standardization. Correlation has been calculated in each soil-section separately between the elements. The correlation values are shown in Table 2. The correlation between the elements in certain cases is remarkably good as for instance with Mn-Pb. In case of Mn-Zn no correlation can be demonstrated. With Mn-Cu there is strong correlation in some sections, in other cases there is no correlation at all. With Zn-Cu, Zn-Pb the correlation is good, in other cases there is no correlation. Cu-Pb generally show strong connection. To detect the causes of differences in certain element pairs in the sections, I used the following calculations and ideas. To establish the connections, it is apparently not sufficient to take two factors into consideration. As a first step I tried to find out the connection between the changes in element-pairs. The connections of the pair correlation of each element pairs shown in Table 3. Grouping these and marking the mutual elements of element pairs the existing correlations are indicated (Table 4.). Viewing this latter table the following statement can be made:

If one member of each element pair is

a. Zinc (Zn), there is a correlation between the two element pairs independently from the two other elements in the pair being Mn, Cu; Mn, Pb; or Cu, Pb i.e. any of the elements examined.
b. Copper (Cu), correlation exists between the two element pairs if the other element in the pair is Mn, Pb. No correlation can be demonstrated if the two other elements are Zn, Mn; or Zn, Pb; i.e. if one of the elements is Zn.
c. Manganese (Mn), there is correlation between the two element pairs if the two other elements in them are Cu and Pb. There is no correlation if Zn, Cu or Zn, Pb; i.e. if one of the elements is Zn.
d. Lead (Pb), correlation exists if the two other elements in the pair are Mn and Cu. There is no correlation if Zn, Cu and Zn, Mn respectively are the additional elements of the element-pair.
e. There is no correlation in the absence of mutual elements in two pairs.

From the above it is to be seen that the differences in the correlation are caused mainly by zinc. An explanation of this is given in chapter titled Conclusion.

Table 3. Correlation between the element pairs

MnZn	- MnCu	r =	-0.17
MnZn	- ZnCu	r =	0.96
MnZn	- MnPb	r =	-0.04
MnZn	- ZnPb	r =	0.76
MnZn	- CuPb	r =	-0.10
MnCu	- MnZn	r =	-0.17
MnCu	- ZnCu	r =	-0.25
MnCu	- MnPb	r =	0.89
MnCu	- ZnPb	r =	-0.45
MnCu	- CuPb	r =	0.68
ZnCu	- MnZn	r =	0.96
ZnCu	- MnCu	r =	-0.25
ZnCu	- MnPb	r =	-0.16
ZnCu	- ZnPb	r =	0.80
ZnCu	- CuPb	r =	-0.09
MnPb	- MnZn	r =	-0.04
MnPb	- MnCu	r =	0.89
MnPb	- ZnCu	r =	-0.16
MnPb	- ZnPb	r =	-0.55
MnPb	- CuPb	r =	0.66
ZnPb	- MnZn	r =	0.76
ZnPb	- MnCu	r =	-0.45
ZnPb	- ZnCu	r =	0.80
ZnPb	- MnPb	r =	-0.55
ZnPb	- CuPb	r =	-0.20
CuPb	- MnZn	r =	-0.10
CuPb	- MnCu	r =	0.68
CuPb	- ZnCu	r =	-0.09
CuPb	- MnPb	r =	0.66
CuPb	- ZnPb	r =	-0.20

Table 4. Correlation between the element pairs

MnZn	- MnCu		ø
MnZn	- ZnCu		1
MnZn	- MnPb		ø
MnZn	- ZnPb		1
MnZn	- CuPb		ø
MnCu	- MnZn		ø
MnCu	- ZnCu		ø
MnCu	- MnPb		1
MnCu	- ZnPb		ø
MnCu	- CuPb		1
ZnCu	- MnZn		1
ZnCu	- MnCu		ø
ZnCu	- MnPb		ø
ZnCu	- ZnPb		1
ZnCu	- CuPb		ø
MnPb	- CuPb		1
MnPb	- MnZn		ø
MnPb	- MnCu		1
MnPb	- ZnCu		ø
MnPb	- ZnPb		ø
ZnPb	- MnZn		1
ZnPb	- MnCu		ø
ZnPb	- ZnCu		1
ZnPb	- MnPb		ø
ZnPb	- CuPb		ø
CuPb	- MnZn		ø
CuPb	- MnCu		1
CuPb	- ZnCu		ø
CuPb	- MnPb		1
CuPb	- ZnPb		ø

ø no correlation
1 correlation

3.2. The relation between soluble trace element content and pH

Correlation calculation has been made also for the connection between soluble element content and pH. The calculations have been made for Mn, Zn, Cu, Pb and the pH separately for elements and sections. For these calculations all out data had to be standardized. The standardized data are shown in Table 5, the values of r are shown in Table 2. The connection of the soluble trace element content and the pH shows that pH has a relatively high correlation to all the elements. An exception is Zn, which in most cases does not show correlation with pH.

Table 5. Standardized values to the calculation of the correlation

Sample	Mn total	Mn soluble	Zn total	Zn soluble	Cu total	Cu soluble	Pb total	Pb soluble	pH
30. 1.	1.28	1.04	-0.35	2.70	0.02	1.22	0.20	1.58	-0.74
30. 2.	1.41	0.94	1.39	0.16	2.31	1.10	0.20	0.34	-1.26
30. 3.	1.11	0.85	1.49	-0.51	-0.66	0.76	2.60	0.24	-0.87
30. 4.	0.20	0.74	0.78	-0.52	0.72	0.59	-0.16	0.85	-1.00
30. 5.	0.11	1.03	0.06	-0.28	-0.97	0.77	-0.55	1.14	-0.47
30. 6.	-0.44	-0.32	0.06	-0.63	0.34	-0.22	-0.55	-0.09	0.05
30. 7.	-0.33	-1.04	-0.04	-0.28	-0.94	-0.64	-0.55	-0.77	0.84
30. 8.	-1.07	-1.18	-0.96	0.28	0.33	-1.15	-0.55	-1.17	1.37
30. 9.	-1.26	-1.14	-1.57	-0.34	-0.66	-1.18	-0.55	-1.20	0.97
30.10.	-1.03	-0.92	-0.86	-0.52	-0.48	-1.26	-0.55	-0.93	1.11
31. 1.		1.80		2.85		2.37		2.46	-1.59
31. 2.		1.19		-0.17		0.67		0.43	-1.48
31. 3.		0.62		-0.31		0.42		0.24	-0.57
31. 4.		0.66		-0.37		0.31		0.36	-0.45
31. 5.		0.28		-0.37		-0.49		-0.31	-0.11
31. 6.		-0.80		-0.31		-0.58		-0.47	0.34
31. 7.		-0.77		-0.28		-0.50		-0.44	0.80
31. 8.		-0.11		-0.31		-0.37		-0.27	0.91
31. 9.		-0.92		-0.35		-0.90		-1.06	1.02
31.10.		-0.98		-0.36		-0.96		-0.93	1.02
32. 1.		1.49		2.84		1.85		1.51	-1.91
32. 2.		0.001		-0.25		0.59		-0.79	-0.88
32. 3.		-0.13		-0.47		0.29		-0.51	-0.88
32. 4.		0.99		-0.30		0.77		0.86	-0.50
32. 5.		1.47		-0.37		0.66		1.46	0.01
32. 6.		-0.03		-0.25		-0.29		0.29	0.53
32. 7.		-0.89		-0.18		-0.65		-0.45	0.78
32. 8.		-0.92		-0.25		-0.90		-0.10	0.85
32. 9.		-1.03		-0.37		-1.24		-1.30	1.04
32.10.		-0.95		-0.43		-1.10		-0.97	0.94
33. 1.		0.52		1.19		2.20		1.61	-1.95
33. 2.		0.16		-0.92		0.19		0.02	-0.85
33. 3.		0.59		-0.59		0.08		0.74	-0.58
33. 4.		0.70		-1.04		-0.15		0.14	-0.30
33. 5.		0.52		-0.99		0.26		0.50	-0.58
33. 6.		0.28		1.31		-0.17		0.14	0.38
33. 7.		-1.17		0.20		-0.73		-0.77	0.79
33. 8.		-0.52		0.84		0.31		-0.73	0.79
33. 9.		1.09		0.96		0.41		0.42	1.00
33.10.		-2.17		-0.93		-1.80		-2.07	1.21
34. 1.		1.27		0.27		1.29		1.70	-1.59
34. 2.		0.84		-0.24		-0.32		0.09	0.03
34. 3.		-1.07		1.44		0.75		-0.67	0.03
34. 4.		-0.55		-0.13		-0.83		-0.67	0.38
34. 5.		-0.49		-1.34		-0.98		-0.43	1.15
36. 1.		0.85		2.78		1.24		2.21	-1.71
36. 2.		0.74		0.25		1.61		0.36	-1.12
36. 3.		0.70		-0.31		0.35		0.14	-0.53
36. 4.		0.43		-0.39		0.23		0.22	-0.53
36. 5.		0.80		-0.21		0.34		-0.13	0.06
36. 6.		1.04		-0.35		0.36		0.77	0.06
36. 7.		-0.88		-0.41		-0.70		-0.62	0.65

(Table 5. cont.)

Sample	Mn total	Mn soluble	Zn total	Zn soluble	Cu total	Cu soluble	Pb total	Pb soluble	pH
36. 8.		-1.20		-0.43		-1.09		-0.98	0.65
36. 9.		-1.26		-0.48		-1.21		-0.89	1.24
36.10.		-1.23		-0.45		-1.16		-1.06	1.24
37. 1.		0.90		1.12		0.69		1.14	1.08
37. 2.		-1.08		-0.32		0.45		-0.40	-0.92
37. 3.		0.18		-0.80		-1.16		-0.74	-0.12
38. 1.		0.46		0.52		0.89		0.70	-0.73
38. 2.		0.64		1.26		0.47		0.42	-1.03
38. 3.		1.67		1.34		1.84		2.13	-1.13
38. 4.		0.92		1.13		0.59		0.71	-0.83
38. 5.		-0.81		-0.68		0.24		-0.88	-0.42
38. 6.		-0.64		0.20		-0.21		-0.91	-0.12
38. 7.		0.51		-0.98		-0.44		-0.02	0.33
38. 8.		-0.18		-0.91		-0.81		-0.38	0.99
38. 9.		-1.12		-0.95		-1.22		-0.81	1.39
38.10.		-1.46		-0.95		-1.34		-0.95	1.49

3.3. The connection between soluble trace element and organic material content

The organic material content of the samples was calculated from the derivatograms. I calculated correlation between organic material and soluble element content for each element (Table 2.). In accordance with the data available the special literature the highest correlation with the organic material content was in case of Zn, which on one occasion reached even the maximum of 1. Cu generally showed good correlation while the connections between Mn and Pb were rather variable. In some cases the correlation is very close, in other cases it is so low that no connection can be assumed. (This will be explained in Chapter titled Conclusion.)

3.4. Connection between soluble trace element content and clay-mineral content

The clay mineral content was determined also by means of derivatograms. The clay-mineral was mainly Illite and to lesser degree a mixed structure of Montmorillonite-Illite. Close negative correlation was found in the soluble Mn-content and clay-mineral content of only one section. In the majority of cases no correlation whatsoever could be found. With some elements in some samples low negative correlation was found. On the whole it can be concluded that no linear correlation exists between the clay-mineral quantity and the soluble concentration of Mn, Zn, Cu or Pb (Table 2.).

3.5. The connection between soluble trace-element content and carbonate content

The carbonate content was determined by means of thermoanalysis, by derivatograph. In the connections calculated for carbonate content and soluble element content the highest value was obtained for Mn with relatively good negative r values for all the sections. Zn showed no connection at all, while copper and lead - with the exception of a few cases - showed fairly good negative correlation with the carbonate content (Table 2.). An explanation for the above is given in "Conclusion".

Table 6. Mean element concentration (ppm) of soil levels

Soil level		30.	31.	32.	33.	34.	36.	37.	38.
	Mn	446.1	538.3	438.3	371.6	530.0	494.9	254.9	445.0
	Zn	2.18	4.23	2.33	2.36	3.37	5.58	2.93	1.81
A	Cu	5.99	7.92	5.47	5.64	0.93	5.25	0.80	7.65
	Pb	11.85	10.05	7.75	7.88	9.50	7.81	5.08	8.92
	pH	7.7	7.25	6.1	6.0	5.25	7.55	6.75	6.1
	Mn	391.4	208.7	263.1	362.6	384.2	483.3	263.3	429.0
	Zn	0.59	0.23	0.33	0.81	2.76	0.77	0.93	1.94
B	Cu	5.07	3.62	3.72	3.61	0.59	3.92	0.47	7.06
	Pb	8.57	4.53	5.17	6.1	6.78	5.54	2.96	7.69
	pH	7.71	7.84	7.32	7.14	6.66	7.75	6.75	6.12
	Mn	65.4	77.1	22.7	207.8	-	85.3	-	285.2
	Zn	0.65	0.18	0.35	1.48	-	0.44	-	0.37
C	Cu	2.64	2.35	22.05	3.00	-	2.29	-	4.09
	Pb	4.00	2.66	3.18	4.60	-	3.06	-	5.16
	pH	8.39	8.38	8.29	8.11	-	7.95	-	7.86

Table 7. Standardized values to the calculation of the correlation

Soil level		30.	31.	32.	33.	34.	36.	37.	38.
	Mn	0.28	1.06	-0.02	-0.74	0.98	0.60	-2.00	0.06
	Zn	-0.73	0.90	-0.61	-0.58	0.22	1.97	-0.13	-1.03
A	Cu	0.38	1.09	0.19	0.25	-1.49	0.11	-1.51	0.99
	Pb	1.47	1.09	-0.46	-0.40	0.36	-0.43	-1.72	0.09
	pH	1.28	0.76	-0.56	-0.68	-1.54	1.10	0.18	-0.56
	Mn	0.46	-1.48	-0.90	0.15	0.38	1.44	-0.90	0.86
	Zn	-0.53	-0.94	-0.83	-0.28	1.97	-0.32	-0.13	1.02
B	Cu	0.72	0.05	0.10	0.05	-1.35	0.19	-1.40	1.64
	Pb	1.48	-0.78	-0.42	0.10	0.48	-0.21	-1.66	0.99
	pH	0.89	1.10	0.26	-0.03	-0.81	0.95	-0.74	-1.68
	Mn	-0.58	-0.47	-1.01	0.84	-	-0.38	-	1.61
	Zn	0.15	-0.85	-0.49	1.91	-	-0.30	-	-0.45
C	Cu	-0.14	-0.53	-0.93	0.35	-	-0.61	-	1.82
	Pb	0.22	-1.14	-0.61	0.84	-	-0.73	-	1.41
	pH	1.00	0.96	0.57	-0.22	-	-0.91	-	-1.30

Table 8. Correlation between the soluble Mn, Zn, Cu, Pb contents and pH in the soil levels

		Mn	-	0.39	0.40	0.77	0.06
		Zn	0.39	-	-0.07	-0.03	0.41
	A	Cu	0.40	-0.07	-	0.53	0.38
		Pb	0.77	-0.03	0.53	-	0.27
		Mn	-	0.45	0.37	0.64	-0.17
		Zn	0.45	-	-0.20	0.36	-0.75
	B	Cu	0.37	-0.20	-	0.61	0.04
		Pb	0.64	0.36	0.61	-	-0.10
		Mn	-	0.36	0.95	0.86	-0.72
		Zn	0.36	-	0.19	0.50	-0.10
	C	Cu	0.95	0.19	-	0.90	-0.63
		Pb	0.86	0.50	0.90	-	-0.53

3.6. The examination of areal variations of soluble trace element content

So far the vertical changes within the section and of the soluble trace element content, their relations have been examined. With view to the whole area calculations have been made with the aim of examining whether there is a linear connection between the soluble element content of the different elements within the same soil level of different places. The basis for these calculations was the previously designated A, respectively B, and C levels. The average of the elements of the different levels were separately calculated (Table 6.) and further the correlation between the soluble element contents of the different levels were calculated with regard to these. The values thus obtained are shown in Table 8. It is to be seen that there is hardly any correlation within level A. With Mn and Pb the values are somewhat higher, but do not reach the criterion of correlation. The situation is similar in level B. It is Mn and Pb as well as Cu and Pb which show very low positive correlation, but these values are so little that strictly speaking they cannot be accepted as correlation. Only in level C do we find closer positive correlation between Mn-Cu, Mn-Pb, Cu-Pb.

The connection between soluble element content and pH was examined also here. For the new arrangement the data to be calculated had to be standardized anew. The standardized data are contained in Table 7., the correlation values in Table 8. No element in level A shows any horizontal connection with the change in pH. This applies to level B, as well. In level C only Mn shows acceptable negative correlation with pH while with the other elements this value is too small to be acceptable. It was previously seen that pH shows significant connection with almost all the elements within the sections, i.e. vertically. This is why it is surprising that horizontally just the opposite is shown. An explanation of these results will be given in the "Conclusion".

4. The chemical reaction of soils

The analysis of the chemical reaction of the soils proved to be of basic significance in making decisions about all the problems. By means of pH-analysis of samples it was possible to draw general conclusions as to the chemical reaction of the soils in the area; at the same time careful observation of pH-changes made it possible to draw futher conclusions concerning the area. The pH values measured in the sections analysed range between 5.25 and 8.5. Analysing the areal variations of values, it was remarkable that while in some places alkaline values of almost 8 pH can be found already between 0 and 20 cm, in other places pH is 5.25 in the some depth. The sampling places are not so far away from each other, that such great difference should exist between the pH-s of levels of the same depths.

It can be seen most distinctly in the pH-diagram of Section No.38 (Fig. 9) that from mildly acidic pH it changes gradually into more acidic, then it becomes weak again moving into alkalescent interval, then its alkalinity grows gradually again. After that close observation of the rest of the sections shows similar regularity. Sections No.37 (Fig. 8) and No.34 (Fig. 6) are incomplete, but both show this tendency, especially No. 34 in which pH produces even alkaline chemical reaction. Sections No. 32 (Fig. 4), No. 33 (Fig. 5) also show the same regularity although at different vertical levels. Sections No. 30 and 31 have only alkaline parts. Arranging our samples in linear order: No. 34, 33, 32, 31, 30, road, 36, 37, 38; the following can be observed:

The upper layer of section No. 34 is alkaline, with 5,25 pH at the beginning and changes from acidic into alkaline at the depth of 80 cm. Section No. 33 has pH = 6 as a starting point which at the previous one was between 20 and 40 cm. The unequivocal change from acidic into alkaline pH also occurs 20 cm deeper than in the previous section, i.e. at the depth of 100 cm. There is a significant difference between section No. 32 and No. 33. Section No. 31 has its starting point already in alkaline interval. As compared to section No. 34 the position similar to the above is obtained with a shift of 80 cm. Section No. 30 has to be shifted by 20 cm in relation to 31, and by 100 cm in relation to the starting 34 in order that their pH-s should be the same. The opposite side of the road offers the same situation. It can be clearly observed that 37 has to be shifted by 60 cm in relation to 38, 36 has to be lowered by 130 cm. In Fig. 10

our sections are measured on a neutral pH-axes. The metric scale does not refer to the depth of the soil, – all starting from the surface, but indicates only their relation to each other on the pH = 7.

In Fig. 11 the sections are shown in their original position, starting from the surface with the line of the neutral pH marked. Upwards from this the pH is acidis downwards it is alkaline. The pH-line demonstrates best the character of the "road-effect". It can be seen that the road unbalances the acidic and alkaline intervals, "drawing" the alkaline pH up to a higher level than it was. Its effect on the two sides of the road is not even. At the side of the section No. 30, the original balance is regained relatively nearer to the surface (at a depth of 60 cm). Section No. 34, which is about 106 m from the road, is regarded intact.

At the other side of the road (in the wall of hole No. 36), this effect can be observed much deeper. At 35 meters from the road there is no equipoise at the depth of 120 cm. Where it sets in at this side, can not be observed, because of the absence of further sampling. It is to be seen that in the close neighbourhood of the road, alkaline pH can be found, already on the surface. Neutral pH surfaces are so high here that their presence can actually be excluded.

III. Conclusion

The road effect on the chemical reaction, trace element composition of the soil, as well as the relations there of to the parameters examined, and to the vegetation with special regard to lead content.

The recognition of the effect of the road on the pH and the pH curve thus obtained will be the basis of the further explanation of all the results. As it was mentioned in Chapter II. 4. in the vicinity of the mainroad, the soil turns alkaline in a wide and deep zone (Fig. 11). The reason for this alkalization is certainly caused by the "road effect". There must be several factors contributing to this. The most effective alkalization is the consequence of the sprinkling of salt on roads in winter, when man introduces a very great amount of Na^+ into the soil. The asymmetry of pH = 7 curve shown in Fig. 11. Should be put down to the fact that the deeper side – received Na^+ then can be ascribed the road shows inclination upwards, and the grassy patch of the northern side lies somewhat deeper than the other side – or there were such differences in the composition of the soil, as facilitating the sinking of Na^+ into a deeper level. The verification of these suppositions needs further experiments.

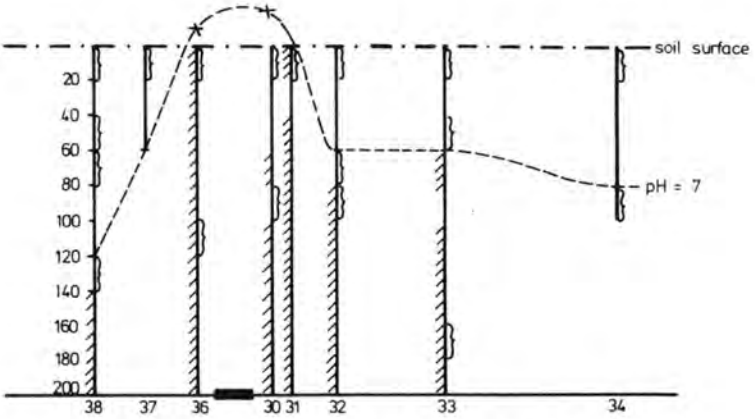
The alkalization occuring through the effect of salting is a doubtless fact. This can be regarded as a primary effect, which upsets the pH-balance of the soil and causes further equilibrium disturbance.

Fig. 11 presents our sections at their normal right from the surface of the soil downwards, indicating the points, where carbonate content appears. It is to be seen that this level greatly varies even with relatively near sampling places. No. 36 contains carbonate already at the surface, while section No. 37 at a distance of 15 m is free from carbonate till the depth of 60 cm, at a distance of 20 m in section No. 38 carbonate mineral can be found only at a depth of 140 cm. In normal cases such extremes can not occur. Placing our sections on neutral pH (Fig. 10), the carbonate containing levels – logically –, fall to the alkaline interval. This can be clearly seen in Fig. 11 which presents the course of the pH-curve. From about a depth of 60 cm original carbonate content can be found, which accompanied the soil formation, this is shown by sections No. 32, 33.

On the far side of the mainroad, where the pH = 7 curve slopes, carbonate can be observed only at a depth of 140 cm. The carbonate in the upper layers of sections No. 31 and 36 is probably a later effect, that is the results of a posterior precipitation in addition to the alkaline pH produced by the road effect. This supposition is supported also by the derivatographic examination (Chapter II. 2.), which indicates these precipitations appear at lower temperatures with endothermic peaks. This was experimented in the above two sections, and more marked calcite-peaks were observed only with deeper layers which is the result of carbonatification produced by natural circumstances in the process of soil formation. The change of the pH in such direction explains enrichment level of the soluble trace elements. Using the figures, in Fig. 11 those levels were marked which yielded higher trace element concentration after EDTA-shaking in relation to the total of all the trace elements examined. In Fig. 11 most of the values fall within.

Fig. 11.

Enrichment - levels of soluble trace elements,
$CaCO_3$ -content and pH change in the soil - section



Placing of the soil sections on the neutral pH - line

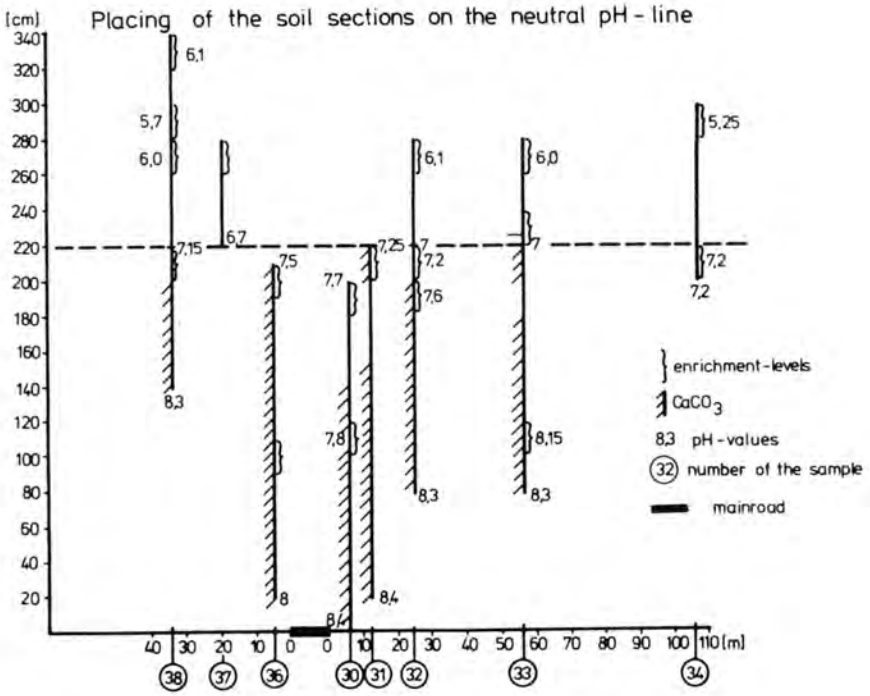


Fig. 10.

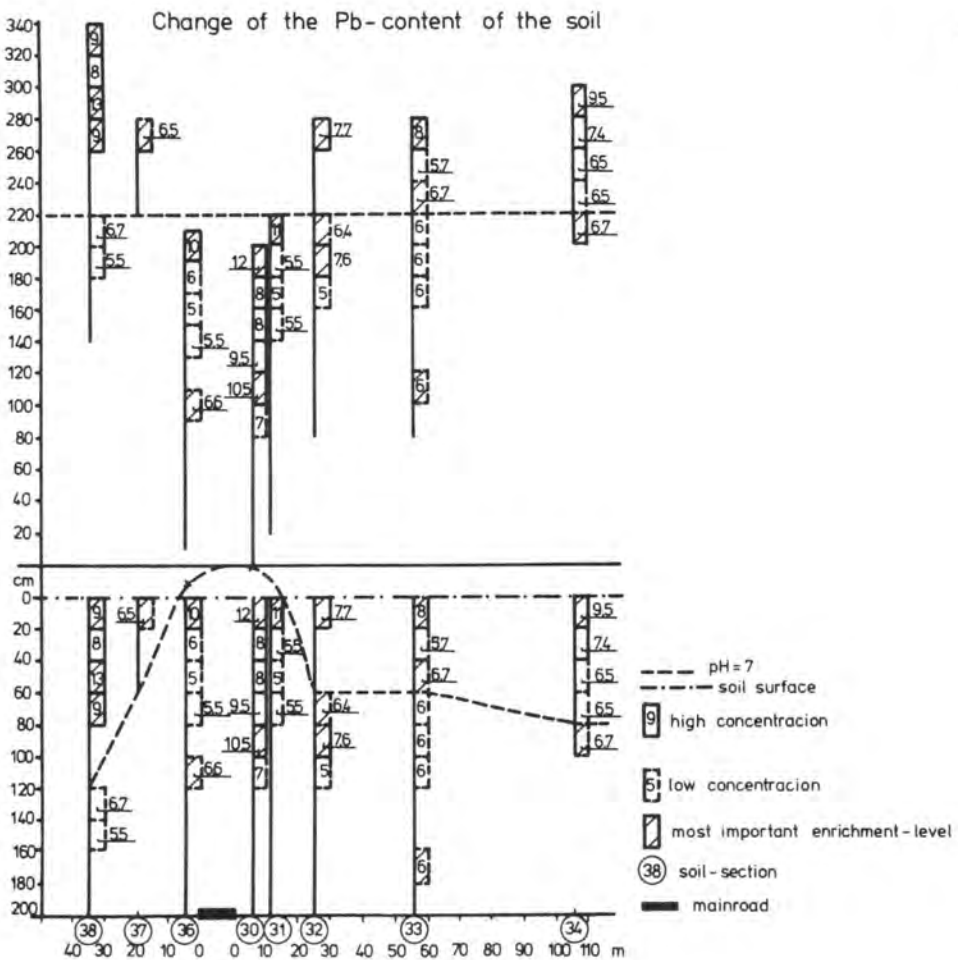

Change of the Pb-content of the soil
cm
pH = 7
soil surface
high concentracion
low concentracion
most important enrichment-level
soil-section
mainroad
m

Fig. 12.

Zone 0-20 cm, that is the first sampling level. It is clearly seen in Figures 2-9 that the soluble trace element content of all the elements (Mn + Zn + Cu + Pb) is almost always high. This phenomenon could suggest that the enrichment occurred under surface effect thus it is bound up with organic materials. This is refuted by the fact that it is only Zn which shows constantly good correlation with the organic material content. Fig. 10 clearly shows that the accumulation levels are grouped around certain pH-levels independently of their position in depth. Thus a significant level is formed around the neutral pH-interval (at ± 7.5 pH), then in two directions from this at around 8 pH and in the level of 6 pH. In an interval more acidic than that at 5.5 pH significant accumulation can be found. Section No. 38 is a good proof of the fact that this element enrichment is governed not by depth but by chemical reaction. In this section the enrichment is the highest at level 3 (between 40 and 60 cm) at 5.7 pH. Thus enrichment in the first level corresponds to the level of enrichment is pH 6 interval. This shows the analogous origin of surface enrichments in the different samples. Enrichment levels are the results of the following: Section No. 38: pH = 5,5, section No. 37: pH = 6, section No. 36, 30, 31: pH = ± 7.5, section No. 32 and No. 33: pH = 6, No. 34: pH = 5.5, as in the first one. From the above it directly follows why no good correlation results were obtained horizontally when the relations of levels A, B, C were being examined (Chapter II. 3. 6.). It is to be seen that identical depths from the surface mark geochemically very different levels. This is the reason why there was no correlation between the different elements or between the elements and pH.

Correlations calculated according to depth indicated that there is close connection between soluble element content and organic material content only in case of Zn (Chapter II. 3. 3.). At the same time Zn was the only element showing no close correlation with pH (Chapter II. 3. 2.). This can be explained by the above model. Zn appears bound to organic material, so it is contained in the greatest quantity by the upper soil level. At the same time we know that this soil level means different pH-values in different samples. While the rest of the elements follow the pH, to a certain extent independently of depth Zn follows mainly the organic material. Those correlations which in certain cases were obtained for Pb and Mn are the results of accidental coincidence. In Chapter II. 3. 1. some correlational relationship has been established concerning the changes of the different element pairs. This demonstrated that actually it is Zn that shows divergence, Mn, Pb, Cu on the whole changed according to identical rules. This likeness to regularity can also be explained by the above facts. Zn follows the organic material, its soluble quantity is enriched not according to pH, but the other three elements change first and foremost with pH.

On the basis of our model it is possible to explain the correlations between element content and carbonate content. Given different sections of identical elements in some cases the correlation is good, in others there is no correlation. Zn never showed connection with the change of carbonate content. The former explanation applies to this, too. The concentration of Zn changes in connection with the organic material while the carbonate content depends on pH. This statement, however, does not explain why the quantity of the other trace elements examined (Mn, Cu, Pb) shows occassional good correlation with the carbonate content and why there is no correlation in other cases. This phenomenon can be explained by the fact that - as already seen - the above elements have more than one enrichment level, out of which two are in the acidic interval. Here carbonate is absent. When the carbonate content and the enrichment levels are jointly present, there is a correlation, but no correlation can be found where the section enters the acidic interval. Thus the connection between carbonate content and Mn, Cu, Pb is realized with pH, i.e. it is a secondary phenomenon.

The dependence of the quantity of soluble lead on different parameters has previously been given since our findings related also to this. As lead has harmful biological effect it is worthwhile demonstrating it on its own.

The separation of natural lead and pollution lead presents the greatest difficulty. If, however, the general element enrichment levels are known it can be detected where lead concentration is the result of different components and where lead exists in its natural form.

Fig. 12 demonstrates that the concentration of lead changes as follows:

At 5 m from the road it is 10 ppm, at 20 m it is 6.5 ppm, and at 35 m it is 9 ppm. This shows that there is no linear proportion between the decrease in the quantity of lead and the increase of distance. This shows that there is no linear proportion between the decrease in the quantity of lead and the increase of distance. This phenomenon has two reasons. On one hand 9 ppm lead content of section No. 38 at a distance of 35 m is within a high enrichment area while the 6.5 ppm of section No. 37 nearer the road is within a low enrichment zone. This explains

why section No. 32 contains less Pb than the upper layer of section No. 34. (Soluble concentration was measured.) Both of them are on the enrichment levels which, however, are not equal. The upper sample of 32 is part of the pH = 6 enrichment level whereas that of 34 is part of pH = 5.5 enrichment level.

The relatively lower value of the lead content of section No. 37 can be explained by the vegetation "catching" the polluting lead. This sampling place is right in the middle of the roadside patch of bushes and trees. Anomalies exist not only in relation to distance from the road, but also to depth. The decrease in lead in relation to depth can be explained in different ways. In the figure only the values greater that 5 ppm are shown. From this it can be seen that downwards the Pb concentration decreases. Then between 80 and 100 cm it reaches a value below 5. Between 100 and 120 cm, however, it is high again and appears in a concentration higher even then 20-40 cm. This can not be the result of pollution. As pointed out this is an element enrichment level notably in this depth there is a pH = 8 level. From this it can be seen that with different elements the enrichment levels are not equal. Lead more thoroughly examined yielded more extreme pH values, the two extreme enrichment levels were pH = 5.5 and pH = 8. This is probably due to the amphoteric nature of lead which is the reason why with lead pH = 6 and 7.5 seems to be on a weaker level. The lead content of plants will be dealt with separately since its toxic effect is directly harmful to humans. In Hungary lead content of leaves and of the upper 10 cm layer of soil has been tested (KOVÁCS, M. & PODANI, J. & OPAUSZKY, I. & KLINCSEK, P. & DINKE, M. in the Botanical Research Institute of the Hungarian Academy of Sciences, in Vácrátót).

Our examinations extended to the different organs of plants (Table 9). It was held by scientific circles but without the basis of adequate tests - that in trees more lead accumulates in the lignificated stalk than in the leaf which falls at the end of the vegetational period. This seems to be logical, but measurements indicate that it is otherwise.

The row of poplars we examined and where the samples were taken from different trees at different distances, show that the leaves contain more lead than the stalks. Only one sample, No. 35_3 taken at 30 meters from the road shows the same lead concentration in the leaf and the stalk, but the Pb-content of the stalk does not exceed that of the leaf even here (Fig. 13). It can not be decided then, which organ of a plant accumulates lead in highest concentration. This accumulation probably varies according to species. In may samples both in case of yearling and of woody plants it was the leaf which seemed to be the most suitable for accumulation. The stalk was in second place, then the root, and at last the fruit. My samples, however, are not numerous enough to allow general conclusions to be drawn. It has been pointed out that in some cases there are very great differences between the washed and unwashed control samples, while in other cases there is no substantical difference. This probably depends on the adsorption of different plant organs. The statement concerning the Pb-intake of plants is of much greater importance. According to a widespread theory plants take up lead from the air. Our data contradict this statement. If lead was built into plant organism only from the air, the lead concentration in plants would decrease proportionally with the increase of the distance. Our samples do not agree with this model unequivocally. In the samples taken from the poplar-row 13-94 meters away from the road, lead is almost on the level both in the stalk and the leaf. Plant samples from our main section line were examined with the following results:

For the examination, such a species is selected which serves for sampling several times, at different distances. This with the purpose of excluding species-dependence. The plant easiest to examine is maize (Zea mays), which is present 25 m away from the road, (at section No. 32) at 45 m, 56 m (soil-section No. 33) and at a distance of 106 m (soil-section No. 34). In addition, it was possible to examine all the organs of this plant (except its flower). Figure 13 shows the lead concentration of maize separately for the different organs and in relation to distance. The accumulation was highest in the leaf. Tracing the changes in the lead concentrations of maize-leaves in relation to distance, we experience no unequivocal decrease. The quantity of lead is 20 ppm at 55, 9 ppm at 45 and 32 ppm at 56 meters away from the road. So far it really shows decrease. But at a distance of 106 meters, the ppm rises to almost 11, so the leaf contains more Pb than that only 45 m away from the road. This can not be attributed to the lead pollution of the air, so air can not be regarded the only source of lead intake by plants. Looking back to the accumulation levels of lead in the soil, the above phenomenon can be given a geochemical explanation Fig. 13).

Table 9. Mn, Zn, Cu, Pb content of the plants

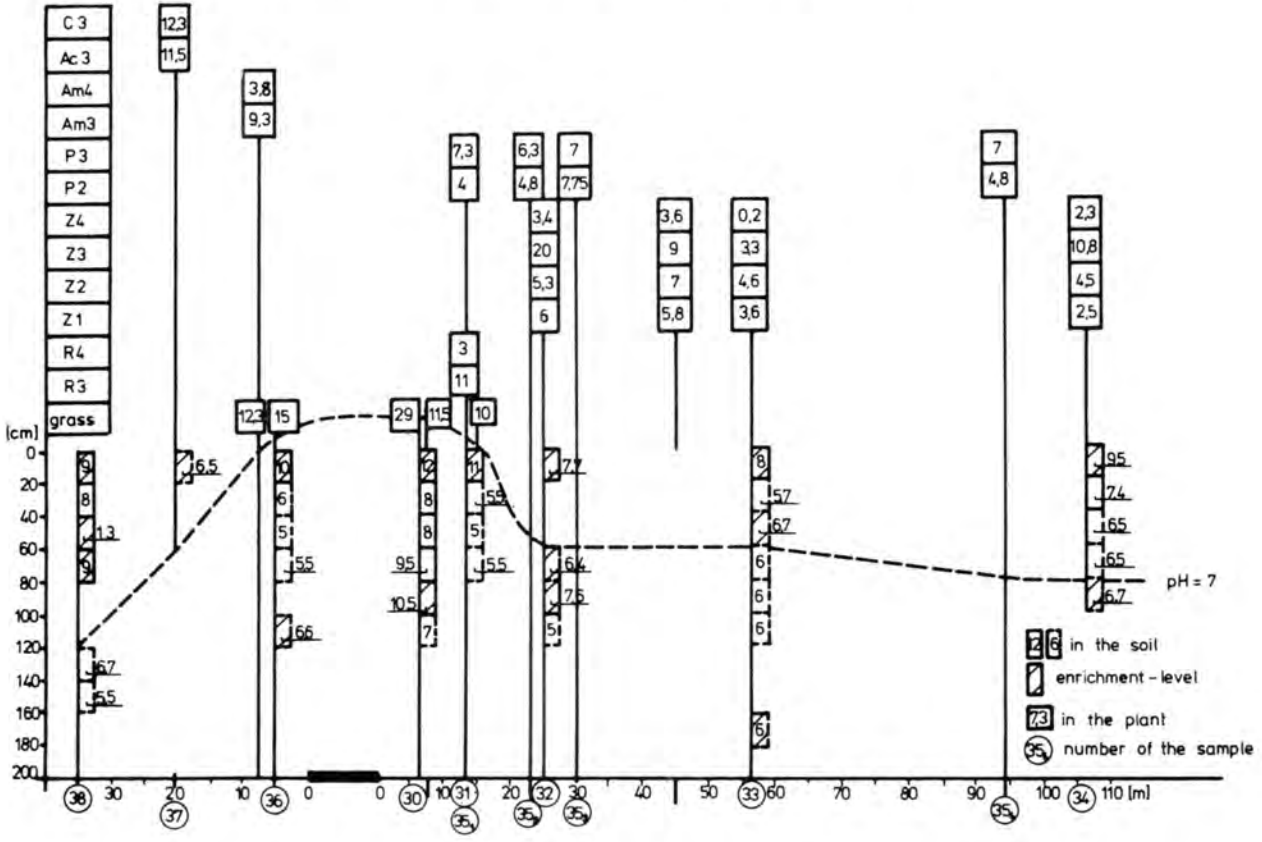
Number of the sample and name of the plant	Mn ppm	Cu ppm	Zn ppm	Pb ppm
6. 30. grass	45.87	0.97	0.75	28.88
6.a. 30.^{x} grass	36.50	0.80	0.80	33.46
7. 30. + 2m grass	27.37	0.45	0.67	11.40
7.a. 30.^{x} + 2m grass	56.12	0.45	0.42	15.89
8. 31. Rosa canina (corn)	150.00	0.42	0.17	3.18
9. 31. Rosa canina (leaf)	38.4	0.75	0.50	11.32
9.a. 31.^{x} Rosa canina (leaf)	60.75	1.22	0.50	11.40
10. 31. + 1.5m grass	33.87	0.50	0.50	10.02
11. 32. Zea mays (root)	48.00	0.40	0.32	5.88
12. 32. Zea mays (stalk)	24.5	0.60	0.27	5.29
13. 32. Zea mays (leaf)	160.32	1.37	0.50	20.05
14. 32. Zea mays (corn)	4.57	0.12	0.42	3.37
14.a. 32.^{x} Zea mays (corn)	4.40	0.20	0.42	8.57
15. 32. + 20m Zea mays (root)	200.00	0.52	0.47	5.75
16. 32. + 20m Zea mays (corn)	4.15	0.15	0.47	6.51
17. 32. + 20m Zea mays (talk)	4.32	0.40	0.07	7.23
18. 32. + 20m Zea mays (leaf)	56.32	0.65	0.25	9.21
19. 32. + 20m Zea mays (corn)	4.00	0.10	0.40	3.59
20. 33. Zea mays (corn)	4.25	0.60	0.42	0.20
20.a. 33.^{x} Zea mays (corn)	7.57	0.10	0.47	1.39
21. 33. Zea mays (root)	63.07	0.50	0.65	3.60
22. 33. Zea mays (stalk)	14.40	0.80	0.12	4.62
23. 33. Zea mays (leaf)	35.82	0.47	0.17	3.25
24. 34. Zea mays (corn)	6.17	0.12	0.45	2.26
24.a. 34.^{x} Zea mays (corn)	6.17	0.12	0.42	11.25
25. 34. Zea mays (root)	96.82	0.52	0.40	2.50
26. 34. Zea mays (stalk)	22.32	0.90	0.22	4.50
26.a. 34.^{x} Zea mays (stalk)	22.07	0.42	0.20	4.00
27. 34. Zea mays (leaf)	209.57	2.02	0.50	10.75
27.a. 34.^{x} Zea mays (leaf)	112.50	1.02	0.37	7.00
28. 35. 1. 13m Populus (leaf)	121.00	0.95	2.72	7.25
29. 35. 2. 18m Populus (leaf)	157.40	0.77	4.05	6.25
30. 35. 3. 30m Populus (leaf)	137.75	0.92	3.30	7.00
31. 35. 4. 94m Populus (leaf)	122.50	1.15	4.05	7.00
32. 35. 1. 13m Populus (stalk)	18.07	0.42	1.05	4.00
33. 35. 2. 18m Populus (stalk)	22.57	0.35	0.85	4.75
34. 35. 3. 30m Populus (stalk)	18.75	0.35	0.77	7.75
35. 35. 4. 94m Populus (stalk)	16.25	0.27	0.75	4.75
36. 36. + 1m grass	74.82	0.50	0.67	15.00
37. 36. + 5m grass	50.32	0.67	0.70	12.25
38. 36. + 5m Amorpha fruticosa (leaf)	43.75	0.32	0.37	9.25
39. 36. + 5m Amorpha fruticosa (corn)	17.50	0.62	0.45	3.75
40. 37. Acer (leaf)	98.90	0.32	0.40	11.50
40.a. 37.^{x} Acer (leaf)	78.50	0.35	0.32	11.25
41. Celtis (leaf)	127.25	1.12	0.52	12.25
41.a. 37.^{x} Celtis (leaf)	111.65	1.05	0.47	11.05

x: unwashed sample

The upper layer of soil-sections No.32 and 33 (and so presumably that of the area between them), fall into the pH = 6 enrichment level, therefore here only distance is a decisive parameter. This is proved by the even decrease of the Pb-content of all the organs of the plant. The upper

Fig. 13.

Change of the Pb-content of the soil and the vegetation
in several distance from the meinroad and in several deph



level of section No. 34, 106 m from the road, belongs to the enrichment zone, pH = 5.5. As already mentioned with lead, this is one of the main enrichment levels, while the pH = 6 zone has less significance from the point of view of Pb. Thus the examination shows that where lead enrichment takes place in the soil, the same occurs in the vegetation living on it. This explains why the Pb-concentration of maize can rise again at a great distance from the road. It can be concluded that plants take up Pb not only from the air but also from the soil; their lead concentration depends not only on distance from the road, but also on the geochemical characteristics of the soil.

Summary of the results obtained in course of the investigation

1. The primary effect of the road is manifested in the alkalescence of the pH of the soil, which can be detected down to a depth of 60–140 cm and to a distance of almost 100 m on both sides.

2. The enrichment-levels of the soluble trace element content (Mn, Cu, Pb) depend on pH, accompany the pH changing under the influence of the road to some extent independently of depth.

3. The soluble Zn-content depends on organic material content and is connected with the organic material and not with the pH.

4. The alkaline pH arising under the influence of the road causes subsequent carbonate production.

5. The most important enrichment levels of the soluble lead content shift towards the more alkaline and the more acidic pH of a given environment.

6. The Pb-content of the soil in the vicinity of the road does not show linear decrease in proportion to depth and to distance from the road.

7. In identical organs of different species and the different organs of the same individuum, the identical trace elements and so lead, too, accumulate in different measures.

8. The Pb-content of plants does not decrease in linear proportion with the distance from the road. According to geochemical characteristics (element enrichment levels), the value of Pb can increase even farther away from the road.

9. Plants take in lead not only from air, but also from the soluble Pb-content of the soil.

10. The Pb, Mn, Cu content of plants can not be directly related to the upper level of the soil.

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