77

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INTERNATIONAL SYMPOSIUM

Environmental health aspects of lead

Die gesundheitlichen Aspekte der Umweltverschmutzung durch Blei

Les problèmes sanitaires posés par le plomb présent dans l'environnement

E N V I R O N M E N T A L   L E A D   I N   T H E   N E T H E R L A N D S

SECTION A

STATUS REPORT ON THE OVERALL SITUATION

b y

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SECTION B

APPRAISAL OF LEAD EXPOSURE IN CUSTOMS OFFICERS AND POLICEMEN
AT A HIGHWAY FRONTIER STATION

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Environmental Lead in The Netherlands

Status report on the overall situation in The Netherlands, and appraisal of lead exposure in custom officers and policemen at a highway frontier station.

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The TNO Research Institute for Public Health Engineering has performed a number of studies on lead in the environment. These comprise pollution patterns in urban, rural, and residential areas, as well as along highways, in tunnels, and at frontier crossings.

Besides the lead content in petrols, rainwater, and drinkingwater is measured rather regularly too.

Results will be presented as frequency distributions, as well as in terms of daily, weekly and seasonal trends. The influence of meteorological parameters, traffic density, and sampling location will be discussed.

A number of observations has been made at the Dutch-German frontier station "Bergh Autoweg" (highway E 36).

Because of complaints issued by members of the personnel on duty, attention was not paid only to the uptake of lead, but rather to an appraisal of the working conditions in general and especially the pattern of exposure to various components of vehicle exhaust under normal and extreme conditions. Five times a group of about fifteen people was screened for a.o. lead content of the blood, concentration of δ-amino levulinic acid (ALA) and coproporphyrin in urine, and the activity of the enzyme ALA-dehydratase in erythrocytes.

Although there exists a seasonal fluctuation in traffic density on the spot, no clear-cut trend could be found in the lead exposure parameters. A greater part of the investigated persons demonstrated phenomena of increased lead uptake (decrease of ALA-dehydratase activity).

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Section A

Introduction

Exhaust from gasoline-fueled vehicles accounts for almost all of the airborn lead in The Netherlands.
No standards for maximum concentration of lead in gasoline exist in this country.
Average concentrations of lead in some brands of gasoline and their aromatic content are given in Table 1. Because lead addition to gasoline is dependent on many factors no trends should be deduced from the table.

Lead alkyl compounds are introduced into the atmosphere by evaporation from gasoline tanks, from carburator vents, and during filling at service stations. The lead alkyl compounds are converted in the internal combustion engine to lead particulates, lead oxides, lead halides, lead oxyhalogenates, and complex lead-ammonia-halogen compounds.
70-80% of that lead is emitted as particulates from the tailpipe. It can be estimated that over 1971, $2.5.10^3$ tons of lead were emitted into the atmosphere. The lead-halogen compounds are converted into lead oxides, lead carbonates, and lead sulphates by photolysis, microdiffusion of halogens and other chemical reactions in the atmosphere.

The percentage of lead in exhaust is just as the other toxic components occurring in exhaust gas, among other things, dependent on the time-velocity relationship of the driving pattern. For stagnant traffic, CO-levels are relatively high, while lead-levels are relatively low. For free-flowing traffic just the opposite is the case.
Over relatively long periods, however, a correlation between these two pollutants, of which the source is identical, may be expected.

Atmospheric surveillance

There are presently some surveillance programs for determining anorganic lead in ambient air in The Netherlands. These are carried out by the Research Institute for Public Health Engineering TNO, the municipalities of Rotterdam, Amsterdam, and The Hague, and finally the Service of Environmental Hygiene of the "Zaan-area".

- Results of very -

Results of very many measurements carried out in the Netherlands can be found in a report drafted by the European Community which will be presented at this conference.
Results of some measurements carried out by TNO in 1970 and 1971 are presented in Table 2. It is interesting to note that, at least in the western part of The Netherlands, "remote stations", which are stations located away from important traffic movements (e.g. No. 11 and No. 13), are still considerably influenced by surrounding urban areas and highways.
The average lead concentration varies with the season; values in winter are usually higher than summer values. This, however, may vary with sampling locality. For sites located very near traffic arteries or in tunnels, there seems to be a very close correlation between traffic density and lead concentration, and levels are far less influenced by other parameters.
A frequency distribution of data obtained at the monitoring stations in the residential area and the centre of The Hague is given in fig. 1.

Apart from the aforementioned observations, special surveys are carried out. These include:

- Surveys regarding the daily trend of the lead concentration.

  These are conducted at several localities and since 1968, on a routine basis, near Delft at about 150 m west of the national highway No. 13 running from The Hague to Rotterdam.
  For 1968 and 1969 the trend of the lead concentration over the week in the summer and winter seasons is given in fig. 2. From the graphs of fig. 2 the difference in average concentration between summer and winter season is quite apparent. This is caused by meteorological differences between the two seasons and not by differences in traffic density as follows from traffic counts.
  In fig. 3 the average lead concentration as a function of the wind direction is given for the same station. The highest concentrations occur when eastern wind directions prevail. This means that lead levels are considerably influenced by the nearby highway, running east of the measuring station.

- Measurements in tunnels.

  Fig. 4 gives the daily trend of the lead concentration in a tunnel with separate ducts near Amsterdam. The total length of the tunnel is about 1300 m of which about 600 m is covered. During rush hours traffic intensity amounts to over 2000 cars hr^{-1}.
  Maximum hourly lead concentrations up to 32 $\mu g/m^3$ were recorded.

- Measurements near border crossings.

  Because of complaints issued by members of the personnel on duty, a survey of the level of air pollution, to which the officials were exposed, was carried out in 1969 and 1970.
  Results of this survey will be discussed more in detail in section B of this paper. Lead measurements showed that, dependent on the traffic intensity and prevailing meteorological conditions, lead concentrations ranged from 5 - 20 $\mu g/m^3$. Maxima up to 71 $\mu g/m^3$ (two hour average) were recorded.

Summarizing we may state that in big cities in The Netherlands people may be exposed to lead levels of $< 1 - 2$ $\mu g/m^3$ over longer periods of time. Exposure over shorter periods to concentrations of up to 8 $\mu g/m^3$ is also possible. Special groups of the population, such as chauffeurs, non residents travelling by car, policemen, border personnel, streetmakers, and tunnel workers may be exposed to much higher concentrations.

The influence of highways on the immediate surroundings

Preliminary evidence from limited studies of crops growing near highways suggests that lead residues decrease exponentially with the distance from the highway.
Little research has been done on this subject in The Netherlands.
Results of some investigations on lead contamination of grass, as might occur along highways, is given in Table 3.

- Grass which has -

Grass which has not or hardly not been contaminated seems to have a lead content of 5 mg/kg dry weight.
Along highways the lead content may be 8-70 times as high, while the lead content of grass growing on the middle bank of the highway may even be 100 times as high.
Even at a distance of more than 150 m from the highway lead contamination of the grass caused by the traffic is still noticable. It concerns lead residues which can be removed for the greater part by washing the grass with detergents.

There also seems to be an accumulation of lead in soils in the vicinity of highways as can be seen in the same table.
The uptake and mobilization of lead by plants through their rootsystem, however, remains a point of discussion.

<u>The lead content of water</u>

The lead content of rainwater is usually low i.e. 10 µg/l or less.
There are, however, indications that the lead content is influenced by adjacent traffic arteries.
Results of measurements are given in Table 4 .
The ratio of non water soluble lead to non water soluble particulates in the samples amounted to 0,05%.

The lead content of untreated surface waters which served as drinking water supply is given in Table 5. It has been estimated that each year the river Rhine transports near Lobith a lead burden of 1500-2600 tons.

In reservoirs and treatment plants the lead content generally does not exceed a 5 µg/l level. From this we may conclude that most lead in surface waters is non-soluble lead that is removed by filtration.
For surveillance programs most samples are taken from or near water plants.
Although, after the Second World War, lead pipes have not been used any more in exterior and interior plumbing, the water quality of drinking water as the consumers get it from the tap may be quite different from that which the water plants produce.

- For this reason -

For this reason, samples taken from consumers' taps would more reflect the real lead levels of drinking water which is consumed by the public. Although the Research Institute for Public Health Engineering TNO is more interested in ambient air quality data, lead levels of tap samples have been determined on a limited scale for the western part of The Netherlands.
For post-war houses lead levels ranged from 17-62 μg/l with an average of 20 μg/l. Rameau (TNO-Nieuws 23 1968) also mentioned levels of 29 μg/l for another part of The Netherlands.
For pre-war houses with lead pipes still in use, levels of 60-300 μg/l with maxima up to 1000 μg/l can be found.
The use of lead pipes is generally relatively harmless with most water supplies, although soft waters are known to be very corrosive, especially with respect to lead plumbing.
Lately there seems to exist vague plans to build central water softening plants in order to combat water pollution by phosphates. If this will be effectuated, there is the possibility that lead levels in drinking water, especially for older houses with lead pipes, will become a problem.

Absorption and excretion of lead by adults living in the big cities

Under ordinary circumstances about 10% of the lead ingested daily is absorbed from the gastrointestinal tract. From the inhaled lead 30-50% is absorbed.
Although no data are available for the average lead content of food in The Netherlands, a value of 150 μg/kg would probably be a right guess. Cigarette smoking contributes to an increased body burden of lead, since tabacco also contains some lead, i.e. up to about 7 μg/cigarette. Although most lead remains in the ash of the cigarette, our experiments have shown that about 0.7 μg of lead/cigarette is inhaled by cigarette smoking.
Based on these values an estimation of lead absorption for adults living in the big cities in The Netherlands is given in Table 6.

It is interesting to note that for non-smokers only 30% of the absorbed lead comes from inhalation of contaminated ambient air. For smokers this figure amounts to about 50%.
Because the biological half-life time for the body as a whole is estimated at 1460 days, this means that the greater part of absorbed lead indeed accumulates in the body, especially in the bones. This amounts to about 10 mg/year.

Pb-content (in g Pb/L) and aromatic content (in % g/v) of some brands of gasoline sold in the Netherlands

Pb-content	1969	1971	1972 (February/March)
Chevron	*	0.70	0.70
BP	0.46	0.44	0.44
ESSO	0.78	0.75	0.70
Shell	0.67	0.47	0.33

Aromatic content of samples Febr/March 1972	Chevron			BP			ESSO			Shell		
Benzene	2.0	2.0	2.4	4.2	4.1	3.5	5.2	5.4	5.7	2.6	2.6	2.9
Toluene	8.4	8.8	8.2	10.9	10.8	11.1	4.2	4.2	4.1	9.3	9.3	10.2
Ethyl benzene	2.3	2.4	2.5	3.1	2.8	2.7	1.6	1.9	1.8	2.2	2.2	2.0
p + m-Xylene	7.1	7.3	7.1	7.7	7.2	7.3	2.8	3.1	2.7	8.8	8.8	8.2
o-Xylene	2.8	3.0	3.1	3.1	3.0	3.0	2.1	2.4	2.3	3.5	3.6	3.2
other aromatics	9.3	11.3	9.0	3.8	3.9	3.7	18.6	16.9	17.1	5.7	5.6	6.4
Total	31.9	34.8	32.3	32.8	31.8	31.3	34.5	33.9	33.7	32.1	32.1	32.9

Table 1.

Monthly average and maximum daily average lead concentration ($\mu g/m^3$) for several localities

1970

Station No.	J	F	M	A	M	J	J	A	S	O	N	D
1		1.2(3.4)	1.2(4.2)	0.9(2.5)	1.1(2.9)	1.4(3.7)	1.1(2.6)	1.0(2.8)	1.6(5.5)	1.4(5.1)	1.3(5.0)	1.6(4.9)
2		0.5(1.5)	0.4(1.5)	0.2(0.6)	0.3(0.7)	0.3(0.8)	0.3(0.9)	0.4(0.6)	0.5(1.9)	0.4(1.6)	0.4(1.3)	0.4(1.5)
6									1.0(2.6)	1.2(2.6)	1.1(2.7)	1.1(1.7)
7									0.9(2.0)	0.6(1.7)	0.4(1.0)	0.3(0.9)
8									0.5(1.8)	0.3(1.5)	0.4(1.4)	0.4(1.)
12									0.3(1.0)	0.3(1.2)	*	*
13									0.3(0.8)	0.3(1.1)	*	*

1971

Station No.	J	F	M	A	M	J	J	A	S	O	N	D
1	2.3(7.8)	1.2(3.8)	1.2(3.3)	1.4(4.7)	1.4(3.2)	0.7(2.4)	0.3(1.1)	0.4(1.1)	1.5(3.1)	1.4(3.2)	1.2(5.6)	1.5(5.2)
2	0.6(1.7)	0.4(1.1)	0.3(0.7)	0.3(0.9)	0.3(0.7)	0.2(0.6)	0.3(0.6)	0.3(1.4)	0.5(1.3)	0.6(1.8)	0.4(1.2)	0.5(1.5)
6	1.5(2.7)	1.2(2.5)	* *	0.5(1.2)	0.5(0.9)	* *	* *	0.6(1.1)	0.8(1.8)	1.1(3.1)	0.8(1.6)	* *
7	0.5(1.7)	0.5(1.7)	0.3(1.1)	0.3(1.1)	0.4(0.9)	0.3(0.8)	0.3(0.6)	0.4(0.9)	0.6(1.3)	0.6(1.9)	0.5(1.5)	0.5(1.2)
8	0.6(1.6)	0.4(1.3)	0.2(0.8)	0.2(1.1)	0.3(0.5)	0.2(0.4)	0.2(0.6)	0.2(0.3)	0.4(0.9)	* *	* *	* *
9	*	*	*	0.4(1.1)	*	0.3(0.7)	0.4(0.8)	0.3(0.8)	0.6(1.3)	0.6(2.0)	0.4(1.3)	0.5(1.5)
10	*	*	*	0.3(0.9)	*	0.3(0.5)	0.3(0.6)	0.3(0.7)	0.4(1.0)	0.5(1.2)	0.4(1.2)	0.5(1.3)
11	*	*	*	0.4(2.0)	*	0.3(0.8)	0.2(0.4)	0.2(0.4)	0.3(0.7)	0.4(1.0)	0.3(0.9)	0.3(1.0)
14	0.9	0.6	0.4	0.4	0.6	0.3	0.5	0.4	0.7	0.7	0.4	0.4

1 The Hague (Centre)
2 The Hague (Residential area)
6 Amsterdam (Christiaan Huygensstr.)
7 Bleiswijk
8 Gouda
9 Heinenoord
10 Piershil
11 Strijen
12 Leeuwendorp
13 's Heerenhoek
14 Delft (Zuid Polder)

* no data available

Table 2

Lead content of grass (mg/kg dry weight) and lead content of soils (mg/kg) along highways

Locality	Highway E 36 N		Amsterdam-scheweg		Highway Arnhem-Emmerich near the Dutch-German border crossing			National highway no. 13 Ascent near Delft	Highway Groningen Delfzijl (Ten Post)
					1969		1970		
	grass	soil	grass	soil	grass	soil	grass	grass	grass
Middle bank	550	130*	108	43*	376	380	348		
Side bank	135	365			75	200	202	350	30 - 60
25 m distance	110	40							
50 m distance							61		
70 m distance					36				
130 m distance	38	27							
160 m distance									

* Data from J.Th. Rameau TNO-Nieuws <u>23</u> (1968) 54

Table 3

Lead content of rainwater ($\mu g/L$)

. no data available

Locality	Nov. '71	Dec. '71	Febr. '72	March '72	April '72	May '72	June '72
Delft (10)	20	50	10	10	30	< 10	20
Delft (11)	< 10	10	< 10	< 10	20	10	10
Delft (12)	90	20	60	60	50	20	10
Nieuwe Waterweg (1)	10	40	.	< 10	< 10	< 10	10
Nieuwe Waterweg (2)	< 10	10	10	< 10	20	10	< 10
Nieuwe Waterweg (7)	10	10	10	20	< 10	10	10
Rotterdam (3)	30	10	30	< 10	< 10	20	< 10
Zuid-Hollandse eil.(3)	20	10	10	< 10	< 10	10	< 10
Westland (10)	30	.	20	< 10	20	< 10	.

Table 4

Lead content of untreated riverwater in µg/L

River	Sampling site	Year	Pb *
Lek	Jutphaas	1967/1968	18 - 64
Lek	Bergambacht	1967/1968	15 - 40
The New Meuse	Honingerdijk	1967	33
The Old Meuse	Berenplaat	1968	$<$ 4 - 7
The Old Meuse	Oud Beyerland	1967/1968	23 - 49
Rhine	Nijmegen	1971	29 - 78

* Data from The National Institute for Public Health

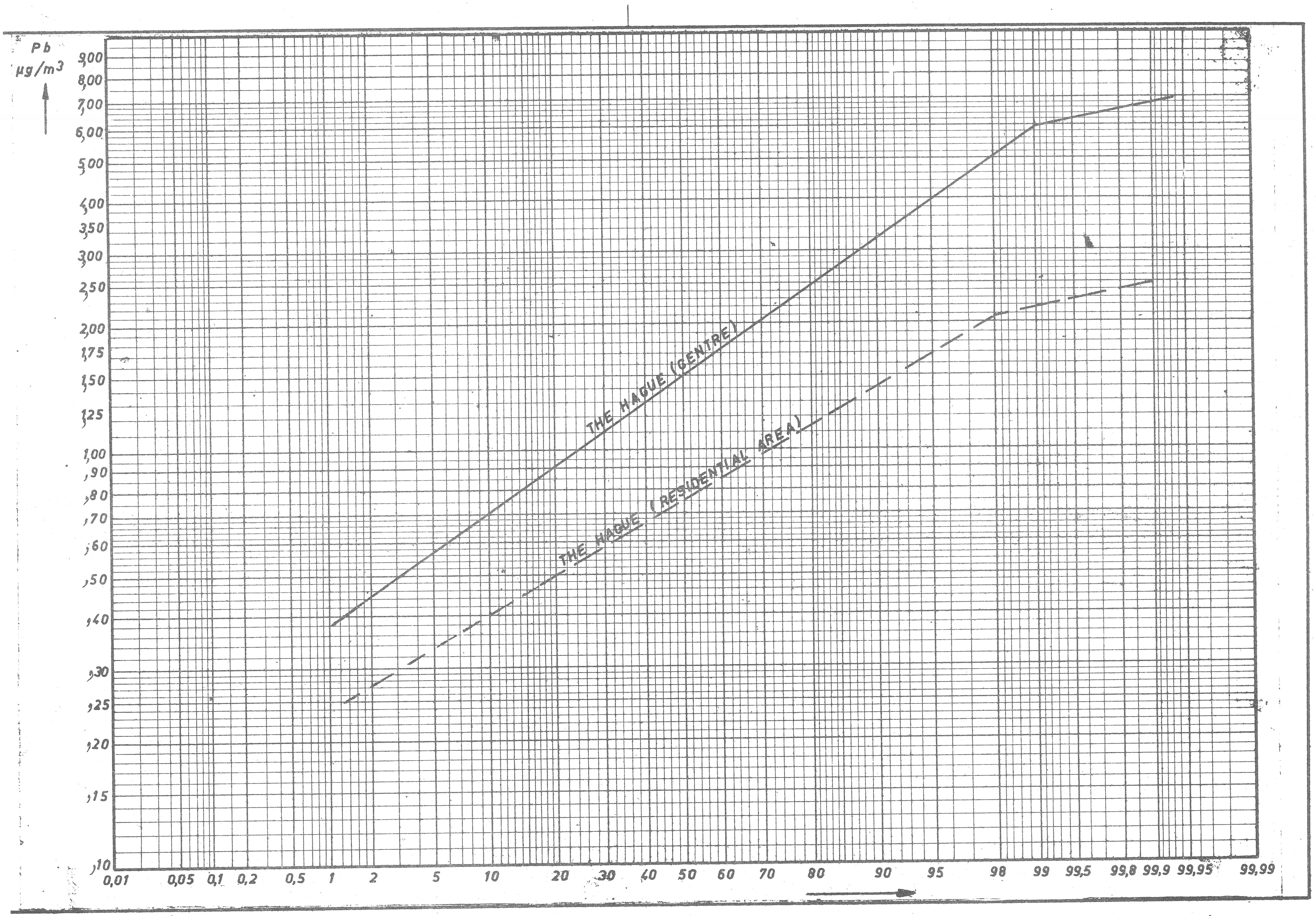
Table 5.

Ingestion and absorption of lead

Substance	Daily intake	Pb concentration	Pb intake μg/day	Pb absorbed %	Pb absorbed μg/day
Food	2 kg	150 μg/kg	300	5	15
Water	1 L	20 μg/L	20	10	2
Urban air	20 m^3	1 $\mu g/m^3$	20	40	8
				Total	25 μg
Smokers 30 cigarettes per day			21	40	8
				Total	33 μg

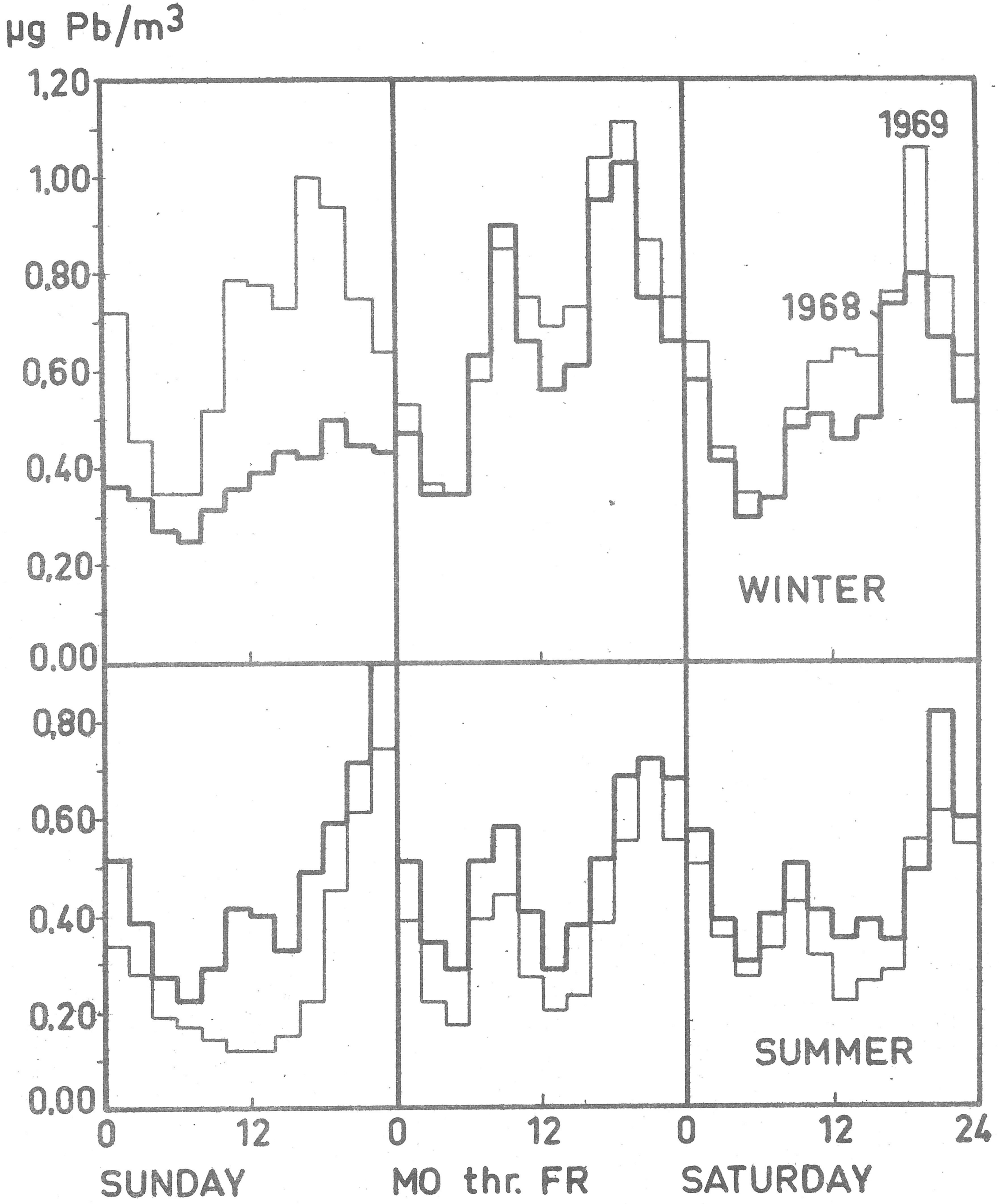
Cumulative frequency distribution of 24-hour measurements over 1971.

Fig. 1



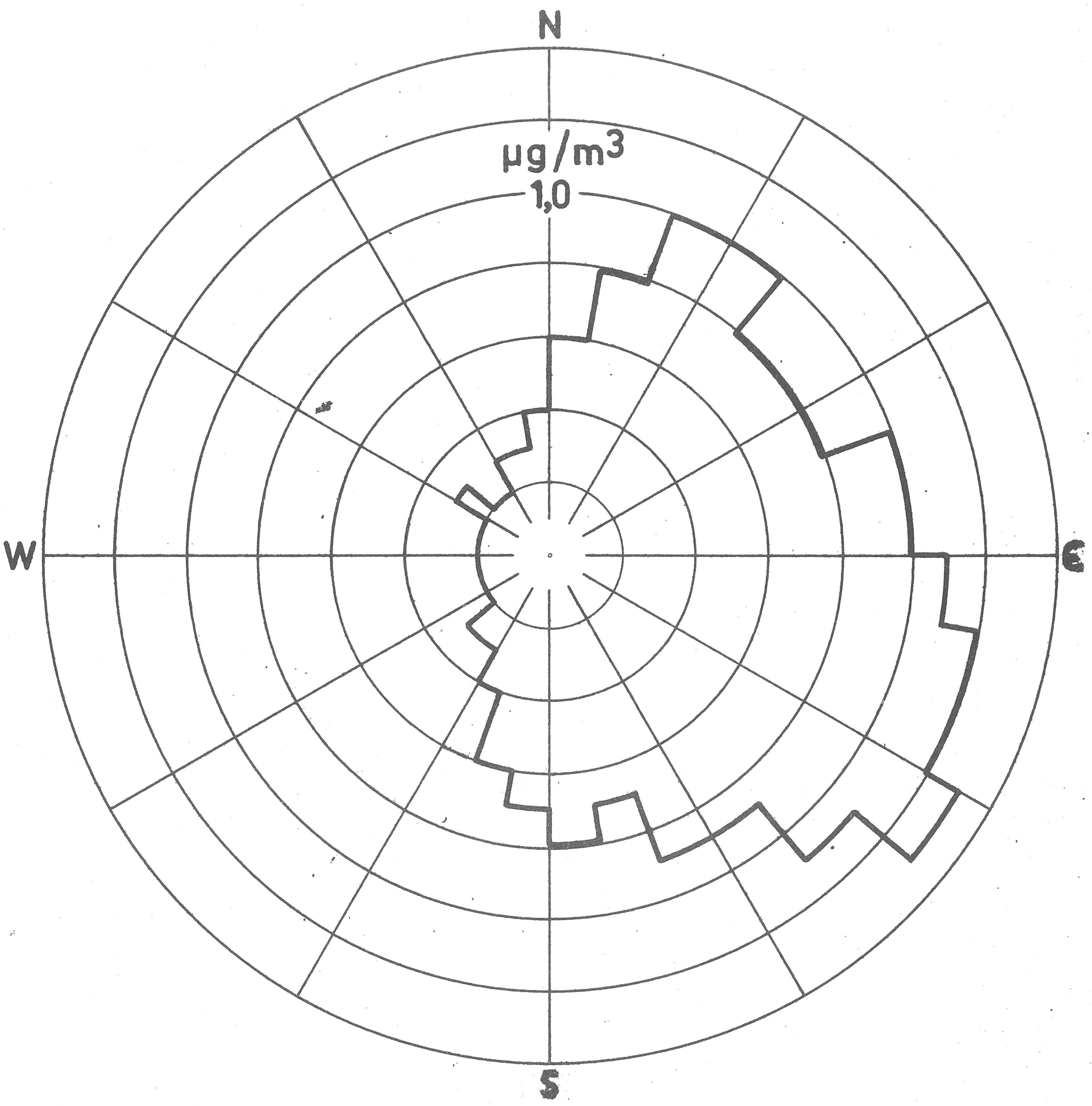
Percentage of observations under a definite value.

Fig. 2

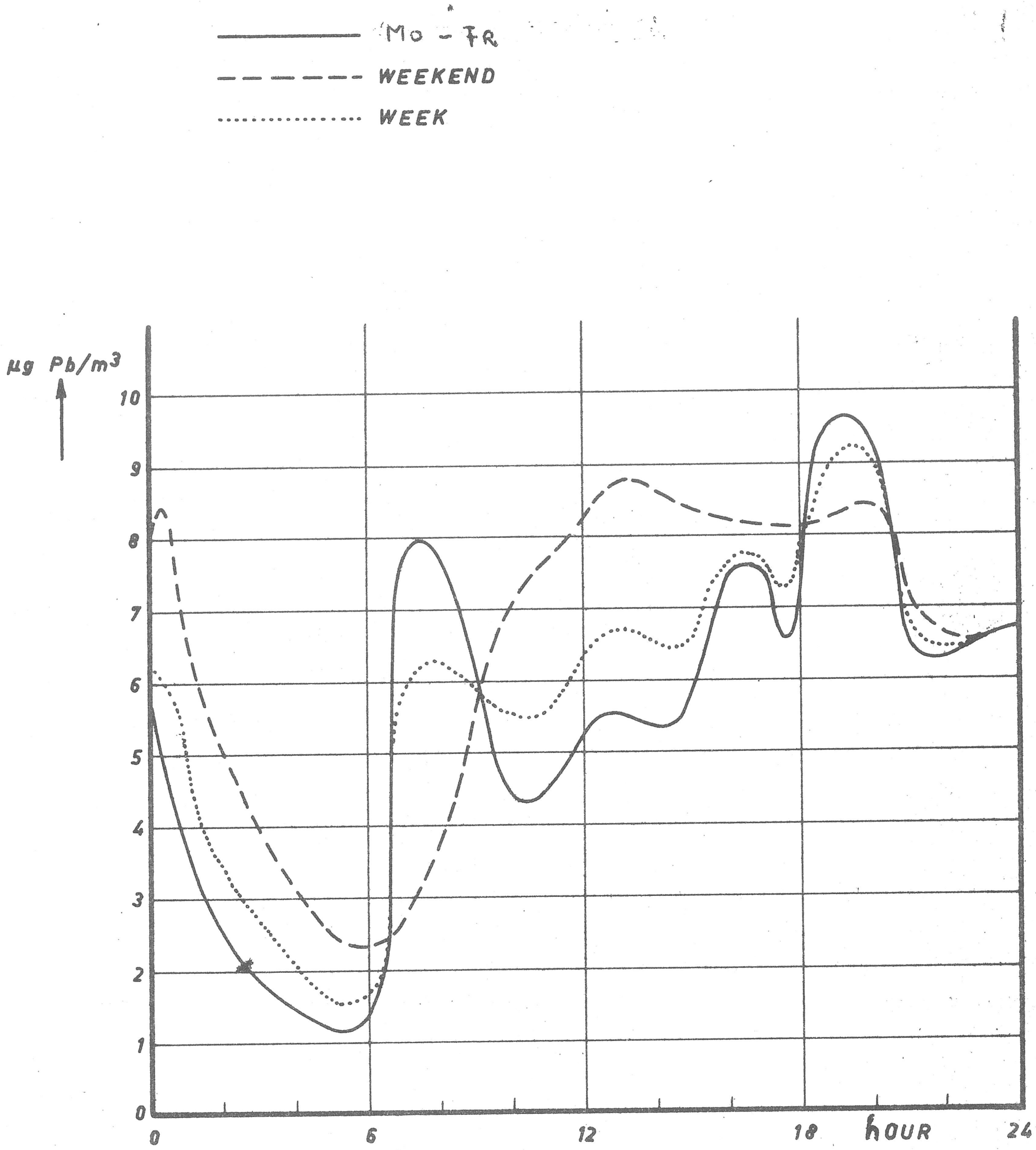


Trend of the lead concentration over the week

Fig. 3



Average lead concentration as a function of the wind direction



Daily trend of the lead concentration in a tunnel

Section B

Introduction

In north-west Europe highway E 36 represents the artery that connects Holland with the Ruhr-area in Germany. Both commercial and private traffic along that route belong to the most dense of their kind. Where the road crosses the Dutch-German frontier a large customs office is situated between the main artery and a number of sidings that are reserved for goods traffic. In both directions three lanes are available for passenger control. This arrangement is not unnecessary if one imagines the density of traffic on high days (in the order of 2000 per hour and direction). Although the barrier, the sidings and the buildings cover a large surface area, the local micro-climate is somewhat influenced by a wall of wood and small elevations in the terrain, surrounding the place to more than half extent.

In the years 1969 and 1970 a number of measurements on the spot has been made in the frame of an inventory of atmospheric pollution by motor vehicle exhaust under varying conditions and at different locations. Components that have been estimated are OECD standard smoke, carbon monoxide, lead, nitrogen dioxide, aldehydes, saturated and non--saturated (C_2 ... C_4) as well as polynuclear hydrocarbons.

In 1970 the five appraisals of the state of air pollution were combined with a screening of a small number of customs officers and policemen who wished to participate as volunteers after both parties had expressed wishes to an appraisal of the local situation from the health point of view. Notwithstanding the great interest of both groups, only a very small contigent has participated. During the season motivation faded, whilst continuity of participation was further interfered by absence (holidays) and moving workshifts. So the gathered data represent a far from optimal mixture of transversal and longitudinal approach.

In this paper only the parameters refering to lead exposure will be dealt with.

Subjects

The group examined consisted of 29 customs officers and 16 policemen. Of these 45 persons the participation pattern was as follows: once at any examination: 18; twice: 18; three times: 6 and four times: 3. This amounts to a total number of 84 observations. The distribution of the number of participations over the five examinations was random. The number of participants per examination was 20, 21, 17, 11 and 15 respectively. The screening took place during the morning shift (6 - 14h) at intervals of about 8 weeks from March through November, 1970.

Because of subjective complaints the work regimen for both customs officers and policemen is fractioned. Customs officers are on duty at the barrier each time for one hour, with two hours interval, during which they perform clerical work or duties at a distance from the focus of pollution. Policemen represent only a small group in comparison so that their scheme of activities is more comprehensive and confined to duties on the spot. Their regimen is 50% outdoor service and 50% indoors in their office, next to the main artery.

Exposure could be expressed in terms of the product of the measured concentrations of lead in the air in the near surroundings of the officers on duty, and the percentage of time that they are active on the spot. For the policemen the exposure pattern is consistent, for customs officers it varies, a.o. in dependence of age, the young performing a more intensive barrier service than the elder ones do.

The persons were examined by an industrial health officer (J.d.V.) at their first participation. Each time they gave also a subjective appreciation of their health condition by means of a score (range 0 - 100%).

Blood and urine samples were collected during the morning shifts, between 6 and 11 a.m. Most people had previously voided their bladder at about 5 a.m.

Lead in the atmosphere

Lead concentrations in the atmosphere were estimated by means of an AISI-smoke sampler with Whatman paper filter. The apparatus was located on the edge of the main lane in use, near to the officers on duty, in dependence of the climatic conditions. Every hour a sample was taken, during 24 hours, each time. The lead content of the samples was determined by atomic absorption spectrometry (Bikker and Den Tonkelaar, 1971).

Human lead parameters

A limited number of biological parameters, related to the uptake of lead in the human body, was estimated.
In blood: haemoglobin (Hb), haematocrit value (Ht), lead(PbB) and activity of aminolaevulinic acid-dehydrase (ALA-D). In urine: copro--porphyrine (CPU) and aminolaevulinic acid (ALAU).

PbB was determined spectrophotometrically according to an inversed dithizone method.

Assay of ALA-D in whole blood was made by direct colorimetric estimation of the amount of porphyrobilinogene produced from added ALA after incubation for one hour (Bonsignore, Calissano and Cartosegna, 1965).
The activities reported were caculated from the formula:

$$E = 1000 \times 12.5\ (A_{60} - A_0) \div \%Ht$$

ALAU was determined by the method of Mauzerall and Granick (1956).
CPU by the method of Zondag and Van Kampen (1956). Both compounds were estimated in terms of weight per gram creatinine and calculated per liter of urine.

Results and comment

The concentrations of lead in the atmosphere demonstrated a definite seasonal pattern. The five sampling days through the season yielded the following averages over 8 hours during the morning shift:

	March(1)	May(2)	July(3)	September(4)	November(5)
Pb $\mu g/m^3$	6,6	12,8	10,0	2,8	2,4

During the nights, previous to the respective morning shifts, the concentrations were considerably lower. There was a weak correlation with the number of passing vehicles (not significant) and there was some correspondence between the number of passing vehicles per hour and the recorded lead in the atmosphere. It may be assumed that part of these discrepancies can be attributed to unstable micro-climate conditions on the spot.

On the basis of estimates of the uptake of carbon monoxide, simultaneously made among non-smokers, it can be postulated that the recorded lead levels in the air are between 50% and 100% of the concentrations actually inhaled by personnel on duty. Taking a correction factor of this order into account the only statement could be that the exposure levels under the working conditions remain far below concentrations regularly met in industry. Once, at another occasion, a concentration of 71 $\mu g/m^3$ has been recorded during two early morning hours at the occasion of an exodus of holiday-makers when the barriers were opened to give free passage to a column of many kilometers length. In comparable sense, the second and third examination represent days of relatively high traffic density, but they are also representative for the overall increase of traffic during the summer.

The exposure parameter (Pb $\mu g/m^3$ times percentage of time on duty at the barrier) shows to be correlated with some of the human lead parameters (Table 1 and Figures 1 - 4). The exposure ranges from 2.4 $\mu g/m^3$ x 5% to 12.8 $\mu g/m^3$ x 50%. It is assumed that every personnal observation represents a sample which could display the balance at that time between seasonal mean exposure at one hand and bodily uptake and excretion of lead on the other.

It is most interesting to observe that at exposures which are still very modest, a clear-cut relationship exists between lead uptake and CPU excretions, whereas ALAU excretion does not bear any relevancy. Further, ALA-D activity does not discriminate between the varying exposures. But what one should observe too, is the fact that ALA-D activity was reduced to a level below 50% of the normal value (113 ± 13 units) found among non-exposed men (De Bruin and Hoolboom, 1967). At the atmospheric levels of lead, found at the barrier and, in consequence, at much lower concentrations in the area where customs officers and policemen are commonly performing their duties, the PbB neither exhibits a significant relationship to possible uptake of lead, if the latter is well represented by the exposure parameter. The more astonishing is it that a rather rough parameter, like Hb content of the blood in this case, gives an indication of response to lead exposure, a sign that is strengthend by the significant negative correlation with Ht value.

Table 2 reflects the differences according to the regression formulae between extreme groups, with minimum and maximum exposure. It is clear that CPU can indeed be used to discriminate between groups with different exposures in this low range of concentrations and exposure times.

TABLE 2

Extreme group values according to regression formulae

Exposure	Hb	Ht	CPU_1	CPU_2
minimum	16,0	48,0	14	20
mean	15,8	47,5	18,7	29,4
maximum	15,5	46,4	31	54

Legend: table 1

Table 3 and Figures 5 - 11 display, the (non-)existence of interrelationships between the various parameters. All correlations and regressions were calculated. Only a limited number of these, that could be of interest from a theoretical or practical point of view, are shown in the table. Those missing have correlation coefficients in the order of zero.

Although the exposure parameter does not correlate too well with a number of biological lead parameters (Table 1), there exists various interrelationships between the latter (Table 3). But the mutual relationships are not universal. Multiple regression or factor analysis could have revealed the most significant of these parameters in view of its predictive capacity for the others. This has not been done. But looking at the data in Table 3 it is tempting to postulate that both CPU and ALA-D are sensitive signs of an exposure to lead in dependence of the PbB content. But the missing relation between CPU and ALA-D indicates that each bears its own significance and does mean something different. A conclusion could be that interference of ALA-D activity at these low PbB levels does not at all influence CPU excretion, the latter being a phenomenon that stands on its own. This observation is stressed by the fact that neither ALAU and CPU are correlated significantly, whereas ALA-D and ALAU well display an interdependency (as would be expected). Further there remains an indication of Ht dependency on CPU.

Conclusion could be that ALA-D is a still too sensitive parameter to discriminate between differences in the uptake of lead at exposure levels that are common in people who are regularly exposed to motor-vehicle exhaust. CPU remains to have more discriminating capacity and is a useful tool for screening purposes. On the other hand reflects ALA-D rather well PbB content, which is an indicator of the body burden or the level at which the body keeps the balance between uptake and excretion.

This aspect of ALA-D, as an indicator of steady state or level of balance, is forwarded in a very recent communication by Hernberg a.o. (1972). They put the question how accurately ALA-D can predict PbB in a definite lead balance, steady state or body burden. The regression of PbB on ALA-D is very poor in our case, so that it must be concluded that PbB does predict pretty well ALA-D activity but ALA-D has no predictive capacity as to PbB in the range PbB < 40 µg/100 ml.

Another phenomenon, that could be observed in the longitudinal study of persons examined more than once, bears on the intra-individual fluctuation of the lead parameters. The above clearly indicates the significance of inter- and intra-individual fluctuations of exposure through the season. But what about the reflection of day by day changes in the exposure pattern and uptake of lead?

At the planned date in July a mass exodus was expected on the basis of definite holiday schedules, as these are practized in The Netherlands for some occupational groups. Therefore a second examination of the same personnel was performed four days later, after the week-end. Prime interest was the behaviour of ALA-D activity.

In contrast to what seemed predictable and, by the way, was expected, the flux of holiday-makers at that time spread itself over a number of days, probably on account of an intensive propaganda not to leave at earliest convenience. So the week-end and the four days between both examinations were relatively quiet. We had hoped to be able to demonstrate a decrease of ALA-D activity by intensive exposure during the exodus.

But our primary disappointment turned into satisfaction as we were confronted with the data of the small group of nine recidivists that showed a significant increase ($0{,}02 < P < 0{,}05$) of ALA-D activity after four days of only intermediate traffic density (Figure 12). No exact data are available. Our impression and conclusion are based on statements by local staff.

This observation indicates that at these exposure levels, resulting in PbB concentrations in the order of 15 - 20 μg/100ml, ALA-D activity still is in rather quickly reversible equilibrium with the body burden of lead. One should take into account the fact that the regimen of activity of the examined personnel is not directly comparable with workers in industry so that it is not wise to translate the exposure parameter into terms that are applicable to other working conditions. Yet it can be postulated that the observed phenomena will scarcely be met in practice and that these are typical for an occupation like the job of customs officers or policemen on duty in lane traffic.
To some extent the findings are comparable with early exposure data presented by Hernberg a.o. (1972) in their study on the time course of ALA-D inhibition.

Finally, in view of the appreciation of the environmental conditions from the occupational health point of view, it must be said that no symptoms or signs were observed that could bear relevance as to lead being the specific agent that evokes the complaints forwarded by the staff. A significant correlation, indeed, was found between exposure and number and intensity of a.o. the following symptoms: general weakness, apathy, tiredness, dry throat, bad taste, coughing or respiratory distress, nervousness and a feeling of inadequate approach to the public. But all of these fit well to the whole amalgam of environmental conditions that exerts a definite stress. Although each agent or component in the atmosphere was far below industrial threshold limit values, one should not forget that carbon monoxide, nitrogen dioxide, lead, hydro-carbons, noise and the necessity of maintaining a high level of alertness hidden by poker-face and politeness, all together carry an intensive workload. The contribution and the consequences of lead exposure are probably rather small.

So, in conclusion, the significance of lead uptake by the examined personnel can only be estimated by means of comparison with criteria and guides from other sources. In Table 4 some of these are presented. Checking these with the mean group data leads to the conclusion that the lead uptake is within the boundaries of what is estimated as normal or below the upper limit of normal.

Yet, the findings may raise some questions as to the vital significance of the observed changes in sensitive parameters as CPU and ALA-D activity among population groups with border-line exposures.

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Greater part of the analytical work on biological lead parameters was done in the Coronel Laboratory for Occupational Hygiene, University of Amsterdam, and the State Institute of Public Health at Bilthoven/Utrecht. A grant was given by the Environmental Sanitation Division of the Governmental Health Authority.

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TNO, Sept. 26, 1972
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TABLE 1

CORRELATION BETWEEN EXPOSURE (x) AND LEAD PARAMETERS (y)

x	y	n	$\bar{x} \pm s$	$\bar{y} \pm s$	r	p
EXPOSURE	Hb	76	197.5 ± 191.3	15.8 ± 0.8	−0.173	$0.05 < p < 0.1$
id.	Ht	76	197.5 ± 191.3	47.5 ± 2.3	−0.220	$0.025 < p < 0.05$
id.	CPU 1	63	183.2 ± 187.6	18.7 ± 13.1	+0.401	$p \ll 0.005$
id.	CPU 2	63	183.2 ± 187.6	29.4 ± 23.4	+0.439	$p \ll 0.005$
id.	ALAU 1	67	189.4 ± 188.8	1.78 ± 0.92	−0.048	n.s.
id.	ALAU 2	67	189.4 ± 188.8	3.21 ± 3.69	−0.063	n.s.
id.	ALA-D	59	206.4 ± 207.7	47.9 ± 13.7	−0.040	n.s.
id.	PbB	74	201.5 ± 192.3	17.1 ± 12.1	+0.070	n.s.

LEGEND: Hb IN g/100ml, Ht IN %, CPU 1 IN µg/g CREATININE, CPU 2 IN µg/l, ALAU 1 IN mg/g CREATININE, ALAU 2 IN mg/l, ALA-D IN E/ml RBC, PbB IN µg/100 ml, EXPOSURE IN TERMS OF % TIME x µg Pb/m^3; n.s. MEANS NON SIGNIFICANT, $p \gg 0.05$

TABLE 3

INTERRELATIONS OF A NUMBER OF LEAD PARAMETERS

x	y	n	$\bar{x} \pm s$	$\bar{y} \pm s$	r	p
PbB	CPU 1	61	16.7 ± 12.7	19.0 ± 13.2	+0.319	< 0.01
PbB	CPU 2	61	16.7 ± 12.7	29.8 ± 23.6	+0.230	< 0.05
PbB	ALAU 1	65	16.9 ± 12.6	1.8 ± 0.9	+0.210	0.05
PbB	ALAU 2	65	16.9 ± 12.6	3.2 ± 3.7	+0.051	n.s.
PbB	ALA-D	57	14.6 ± 6.6	48.1 ± 13.2	−0.276	< 0.025
CPU 1	Ht	63	18.7 ± 13.1	47.6 ± 2.2	−0.194	< 0.1
CPU 2	Ht	63	29.4 ± 23.4	47.6 ± 2.2	−0.242	0.025
CPU 1	ALAU 1	60	19.0 ± 12.9	1.7 ± 0.9	+0.044	n.s.
CPU 2	ALAU 2	60	29.7 ± 22.9	2.7 ± 1.8	+0.165	n.s.
ALA-D	ALAU 1	50	47.7 ± 14.6	1.6 ± 0.9	−0.306	< 0.05
ALA-D	ALAU 2	50	47.7 ± 14.6	2.7 ± 1.9	−0.262	< 0.05
ALA-D	CPU 1	52	48.0 ± 14.4	17.6 ± 13.8	−0.001	n.s.
ALA-D	CPU 2	52	48.0 ± 14.4	28.1 ± 24.5	+0.039	n.s.

LEGEND: Hb IN g/100 ml, Ht IN %, CPU 1 IN µg/g CREATININE, CPU 2 IN µg/l, ALAU 1 IN mg/g CREATININE, ALAU 2 IN mg/l, ALA-D IN E/ml RBC, PbB IN µg/100 ml, EXPOSURE IN TERMS OF % TIME x µg Pb/m^3; n.s. MEANS NON SIGNIFICANT, $p << 0.05$

TABLE 4

Comparison of guides and findings

Criteria	PbB $\mu g/100ml$	CPU $\mu g/l$	ALAU mg/l	ALA-D E/h/mlRBC	Pb-air $\mu g/m^3$
Sweden 1967	50		1.5		
Amsterdam 1968	70	300	10		150
Brit.Med.J.1968	40(80)	150(500)	6(20)		
Selander a.o.1970	40		6		
Stanković 1971	40(60)	90(180)	4.5(10)		
de Bruin a.o.1967				113 ± 13	
Haeg.Arons a.o.1971				121 ± 32	
Findings hoc.loco	17 ± 12	29 ± 23	3.2 ± 3.7	48 ± 14	<25

Legend: Numbers refer to safe upper limits. Figures in brackets indicate slightly abnormal environmental exposure.

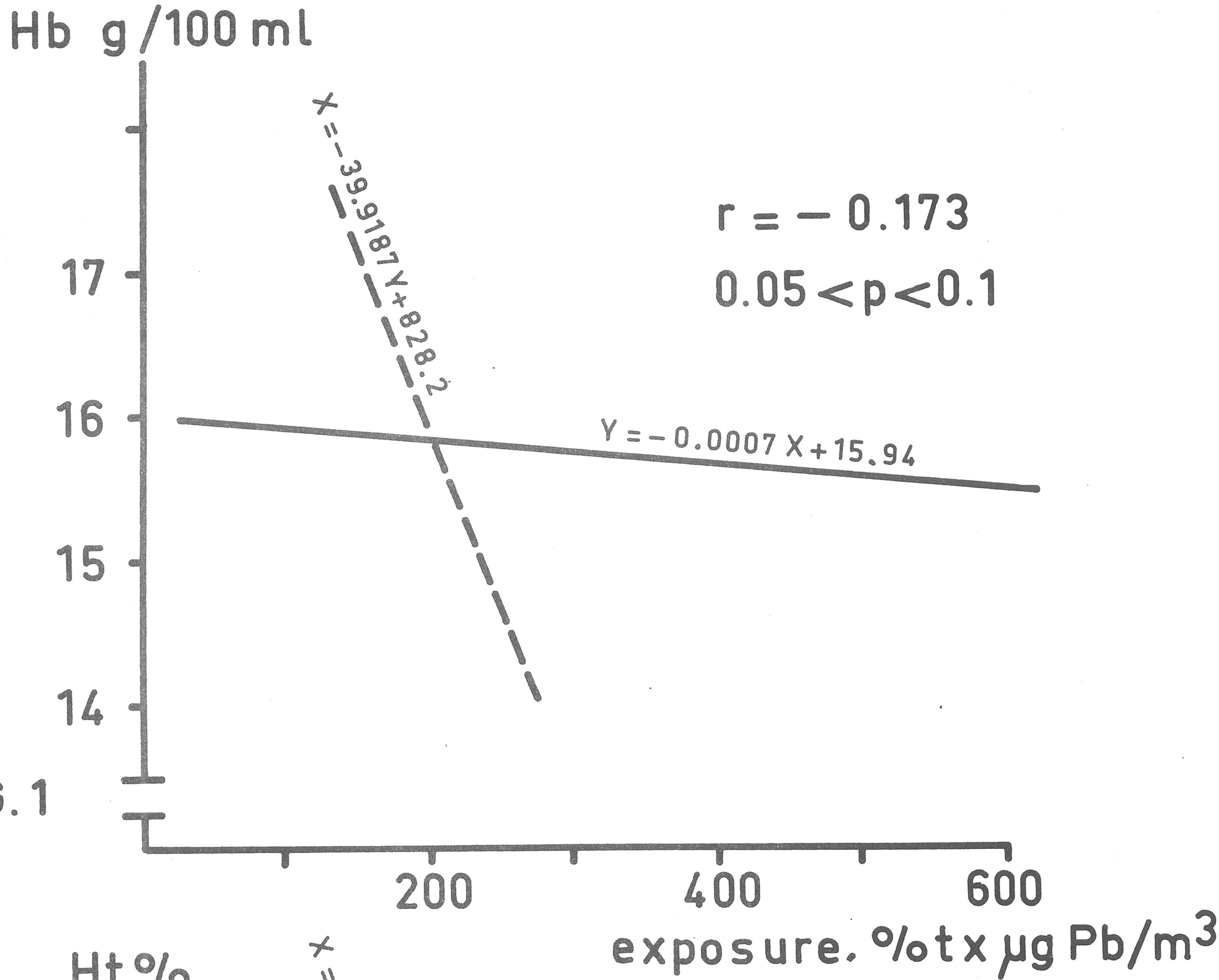

Hb g/100 ml
17
16
15
14
X = -39.9187 Y + 828.2
r = − 0.173
0.05 < p < 0.1
Y = − 0.0007 X + 15.94
200
400
600
exposure. %o t x µg Pb/m3

FIG. 1

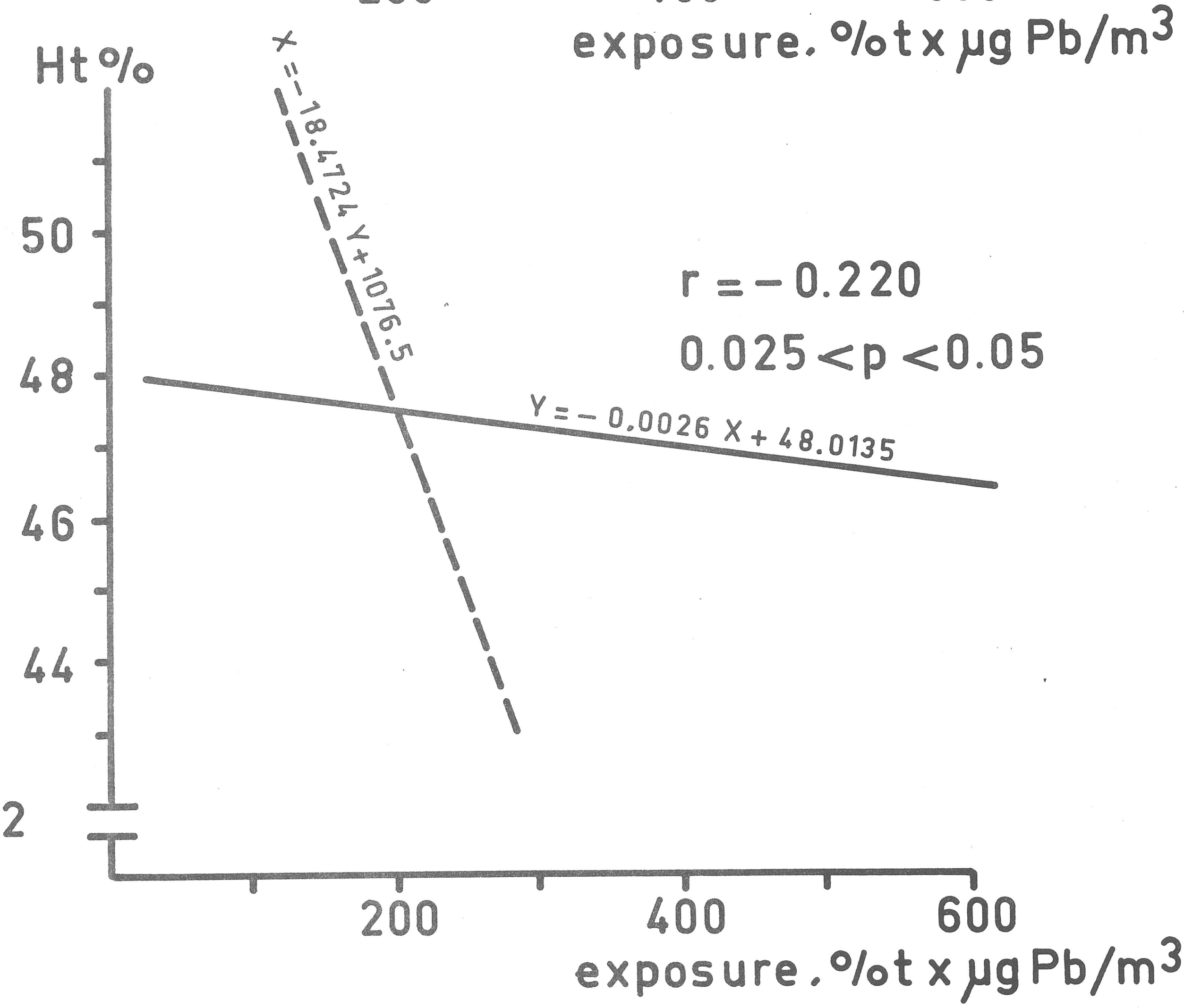

Ht %
50
48
46
44
X = -18.4724 Y + 1076.5
r = − 0.220
0.025 < p < 0.05
Y = − 0.0026 X + 48.0135
200
400
600
exposure. %o t x µg Pb/m3

FIG. 2

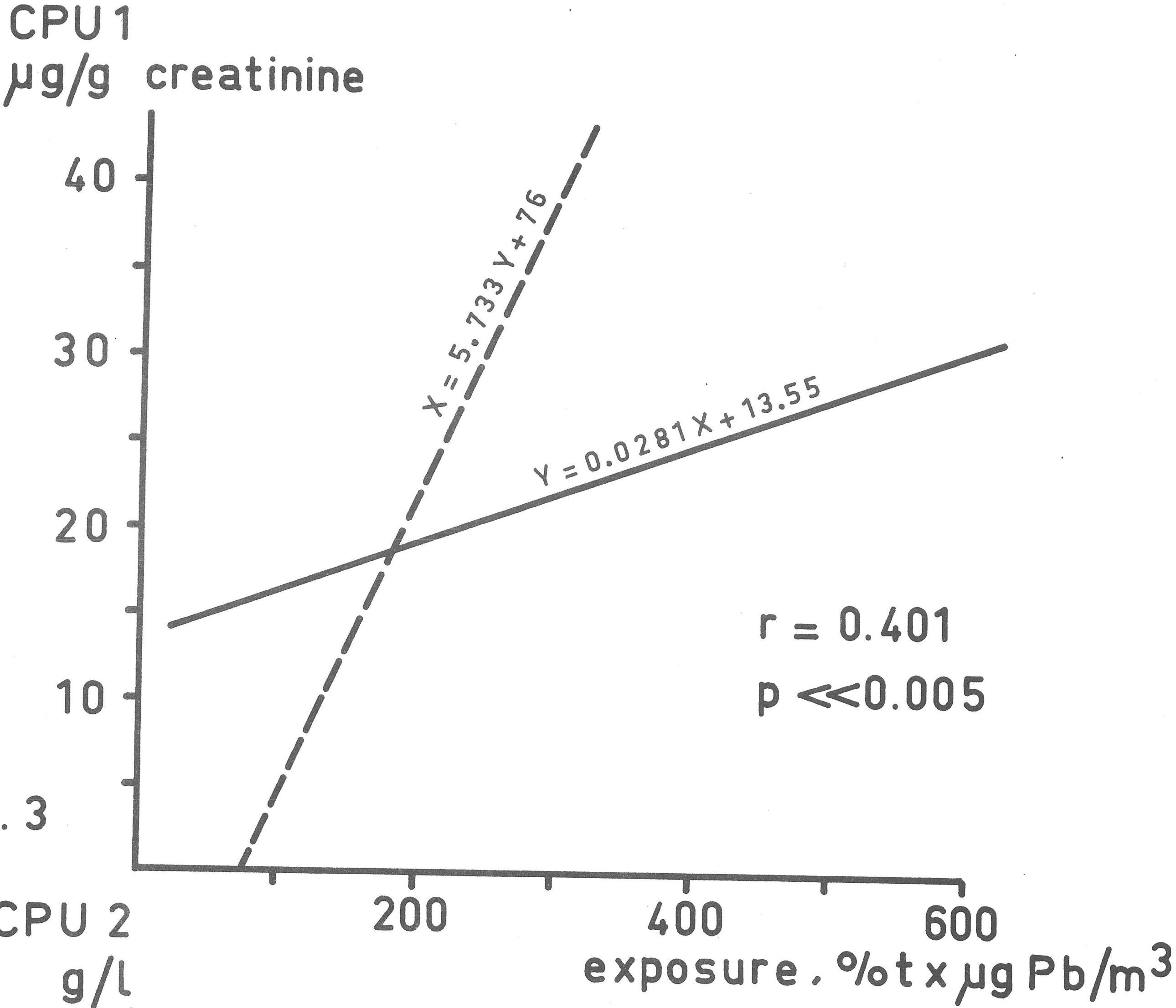

CPU 1
µg/g creatinine
40
30
20
10
200
400
600
exposure, %t x µg Pb/m³
X = 5.733 Y + 76
Y = 0.0281 X + 13.55
r = 0.401
p << 0.005

FIG. 3

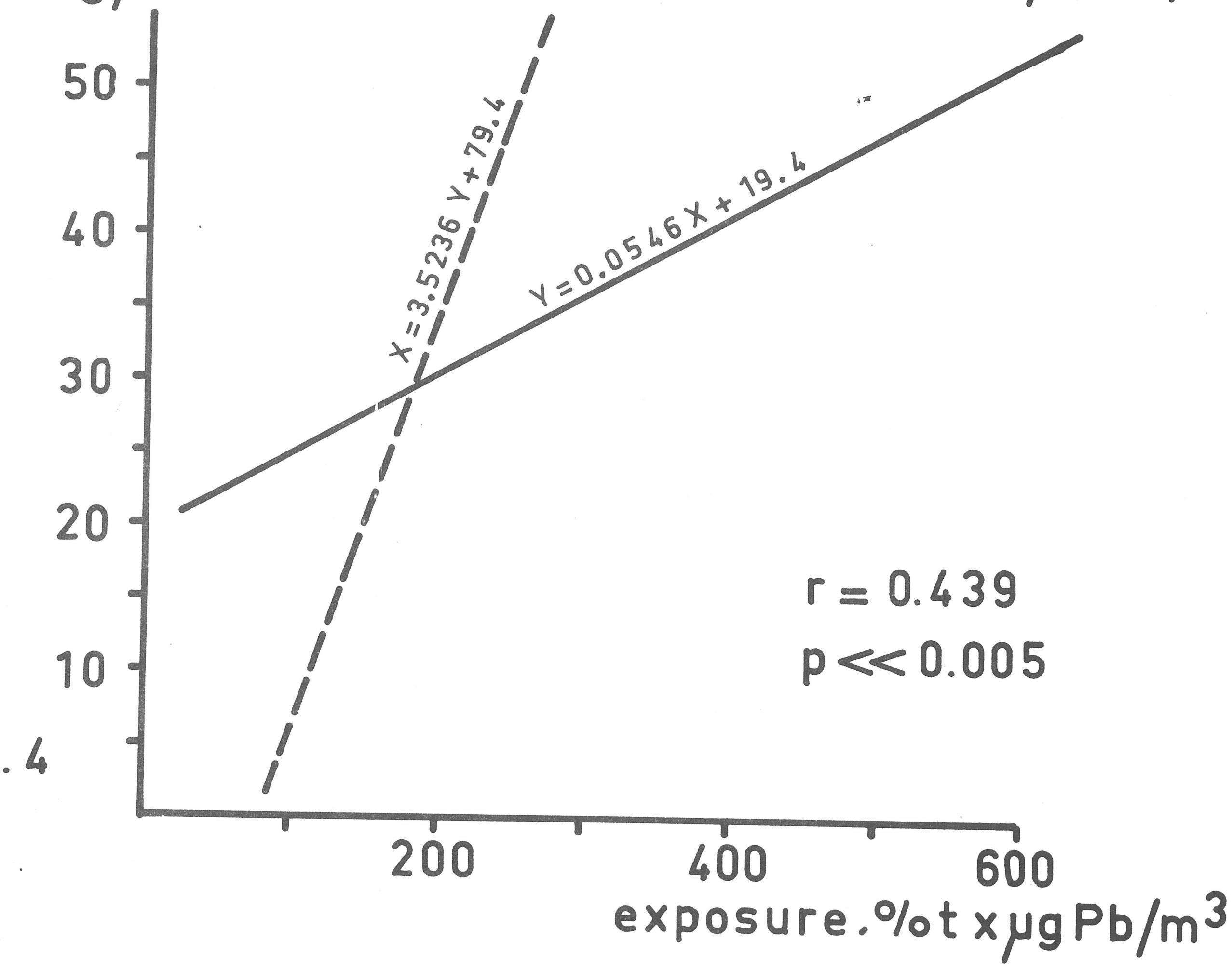
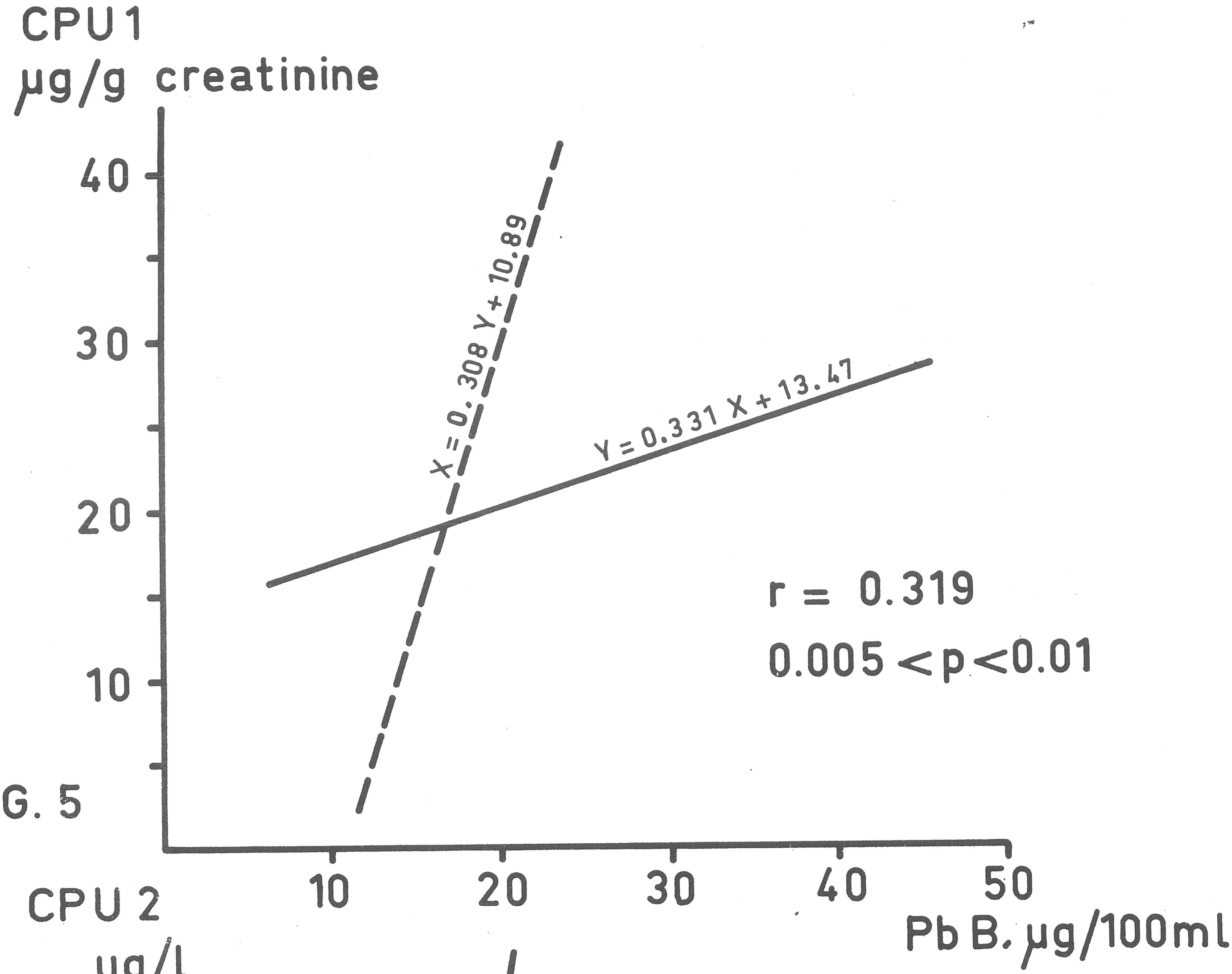
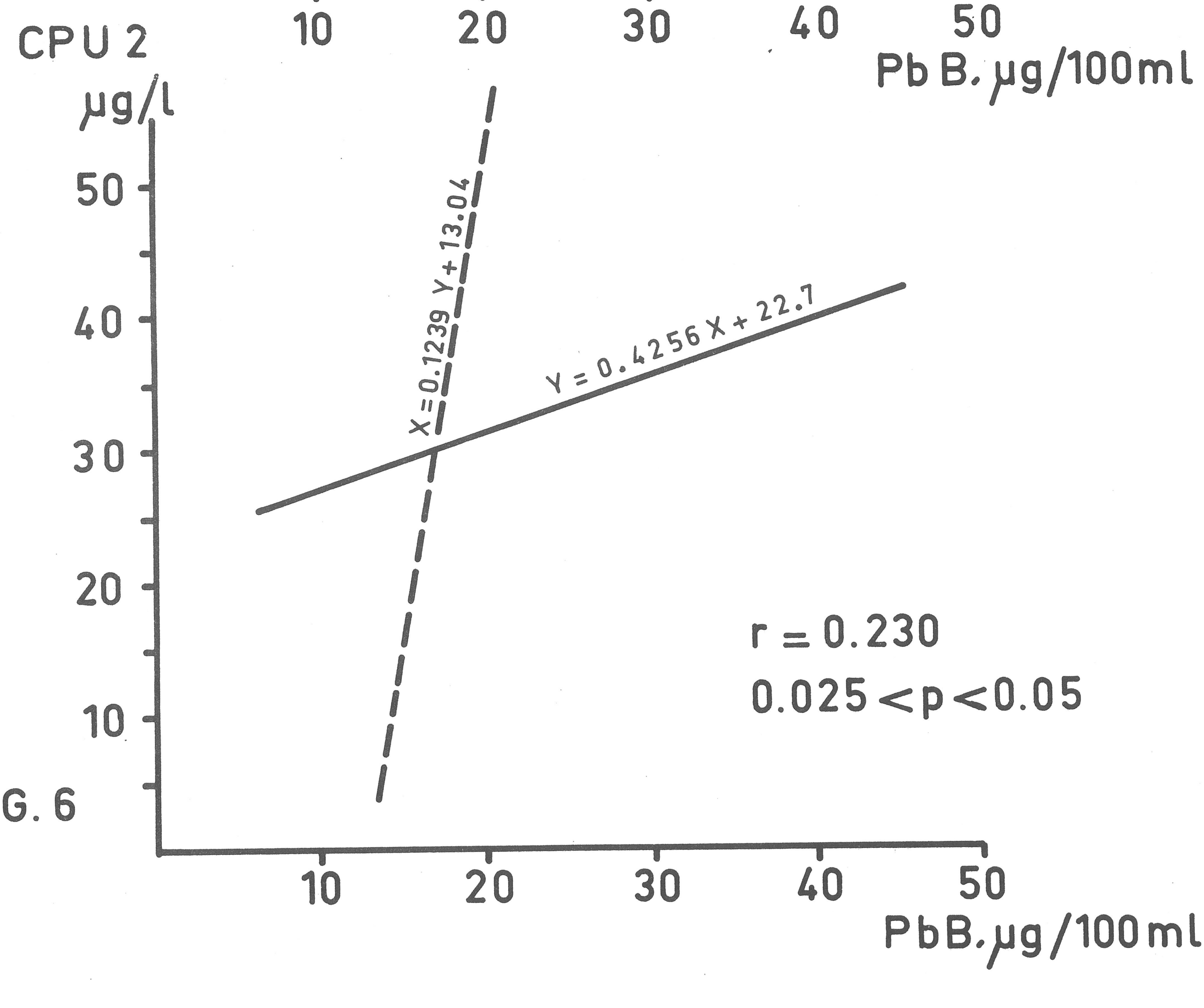

CPU 2
g/l
50
40
30
20
10
200
400
600
exposure. %t x µg Pb/m³
X = 3.5236 Y + 79.4
Y = 0.0546 X + 19.4
r = 0.439
p << 0.005

FIG. 4



CPU 1
µg/g creatinine
40
30
20
10
X = 0.308 Y + 10.89
Y = 0.331 X + 13.47
r = 0.319
0.005 < p < 0.01
10
20
30
40
50
PbB, µg/100ml

FIG. 5



CPU 2
µg/l
50
40
30
20
10
X = 0.1239 Y + 13.04
Y = 0.4256 X + 22.7
r = 0.230
0.025 < p < 0.05
10
20
30
40
50
PbB, µg/100ml

FIG. 6

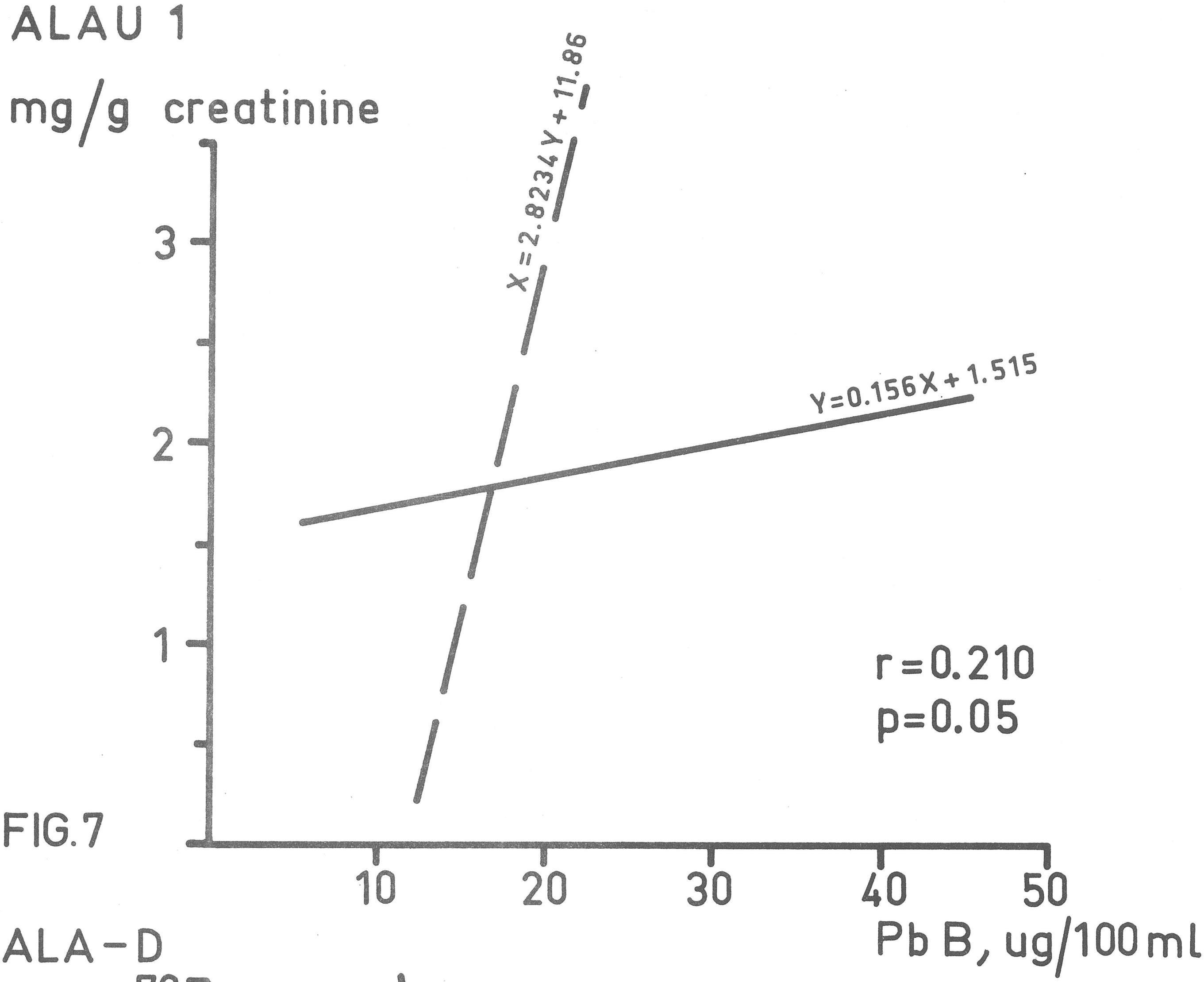

ALAU 1
mg/g creatinine
3
2
1
X=2.8234Y+11.86
Y=0.156X+1.515
r=0.210
p=0.05
10
20
30
40
50
PbB, ug/100ml

FIG.7

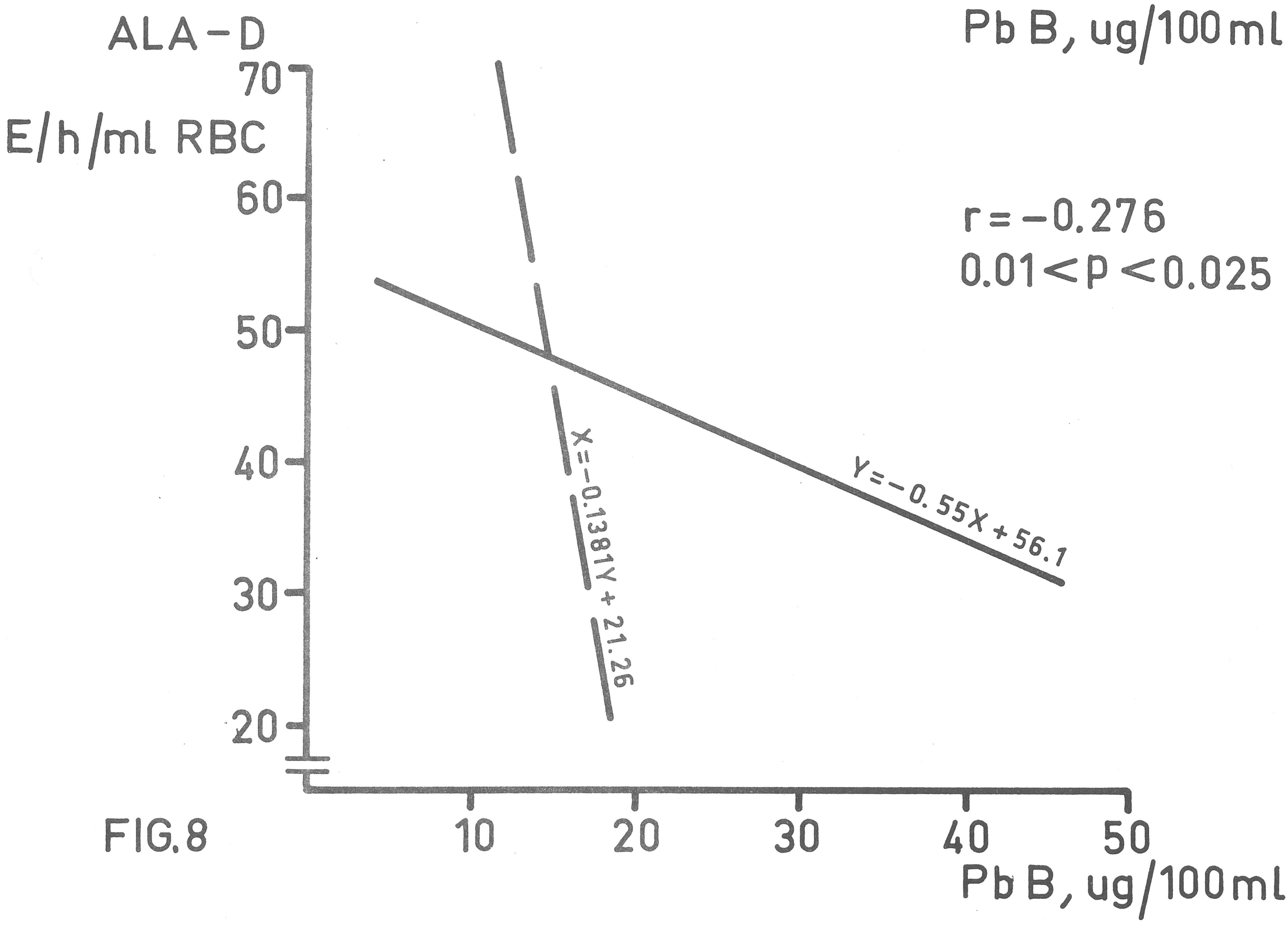

ALA-D
E/h/ml RBC
70
60
50
40
30
20
r=-0.276
0.01<P<0.025
X=-0.1381Y+21.26
Y=-0.55X+56.1
10
20
30
40
50
PbB, ug/100ml

FIG.8

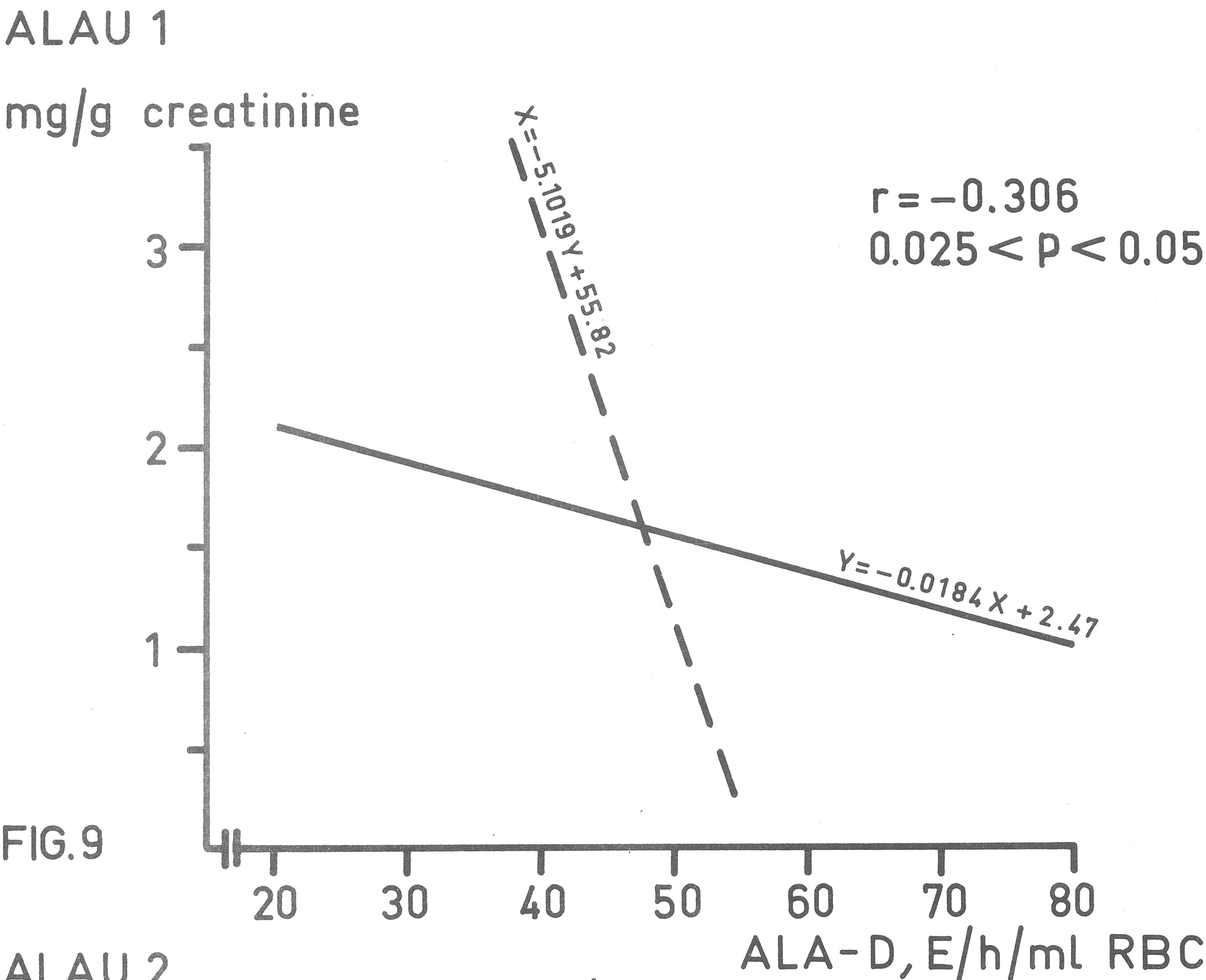

ALAU 1
mg/g creatinine
X=-5.1019Y+55.82
r=-0.306
0.025<P<0.05
Y=-0.0184X+2.47
3
2
1
20
30
40
50
60
70
80
ALA-D, E/h/ml RBC

FIG. 9

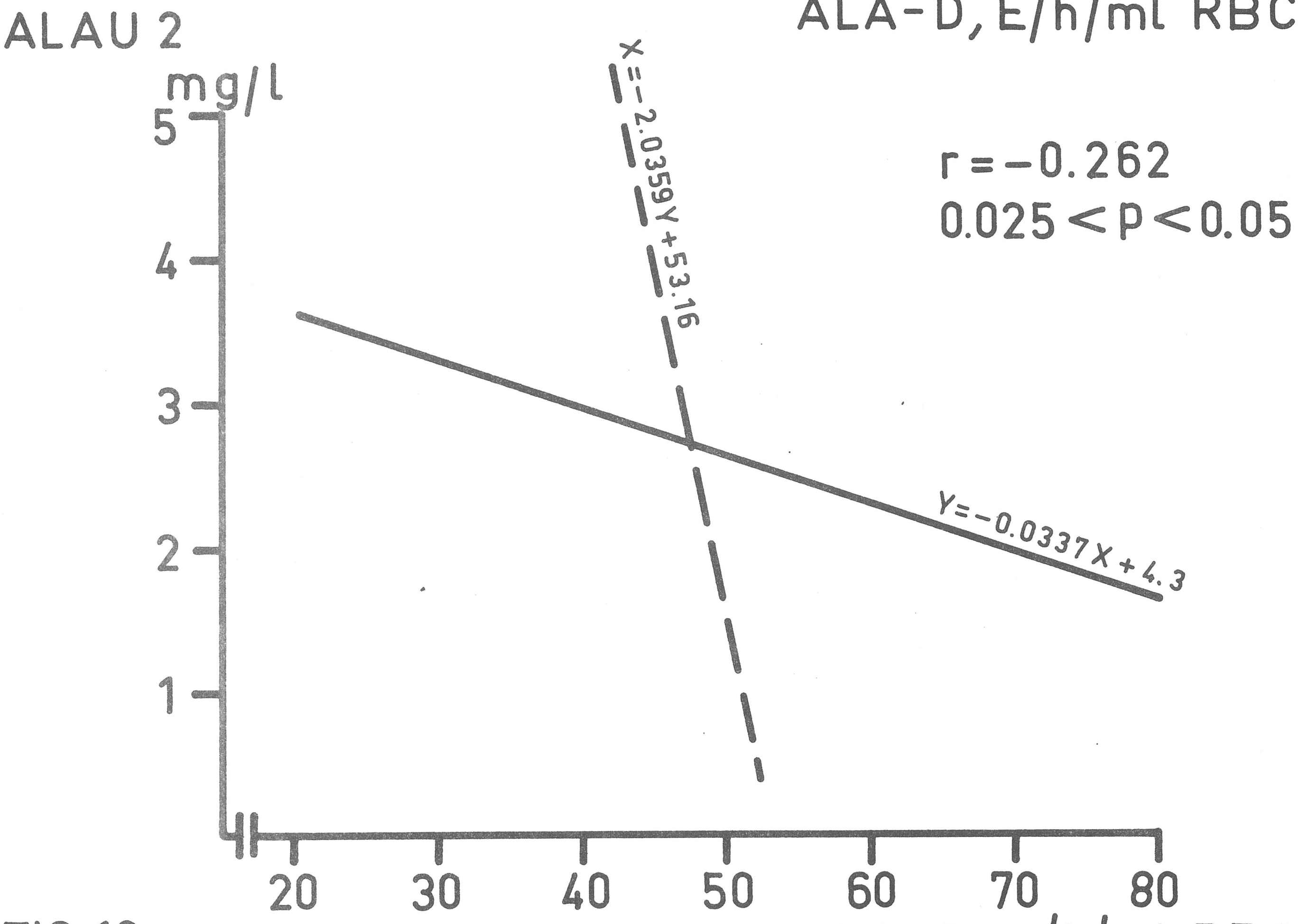

ALAU 2
mg/l
X=-2.0359Y+53.16
r=-0.262
0.025<P<0.05
Y=-0.0337X+4.3
5
4
3
2
1
20
30
40
50
60
70
80
ALA-D, E/h/ml RBC

FIG. 10

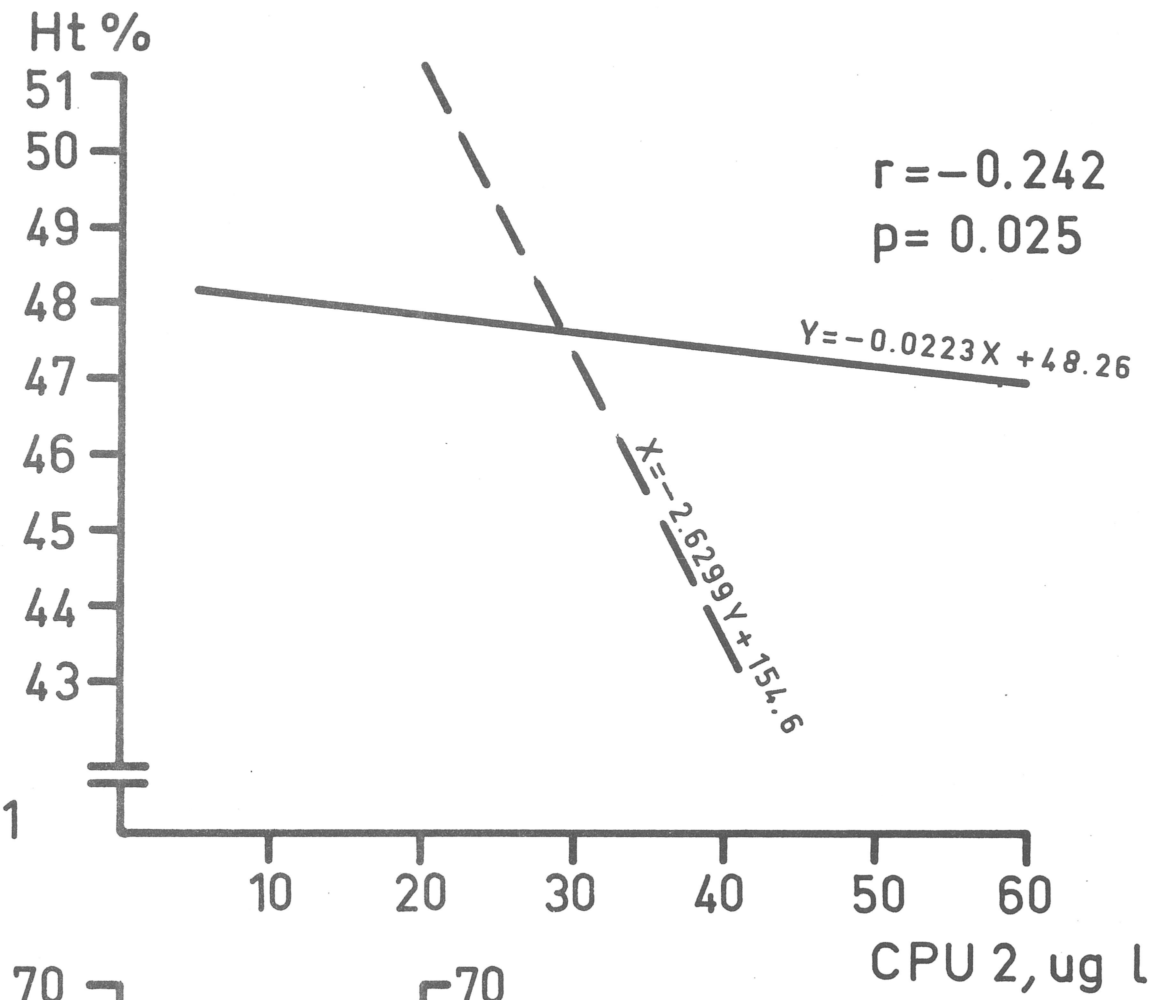

Ht %
51
50
49
48
47
46
45
44
43
r =−0.242
p= 0.025
Y=−0.0223X +48.26
X=−2.6299Y+154.6
10
20
30
40
50
60
CPU 2, ug l

FIG. 11

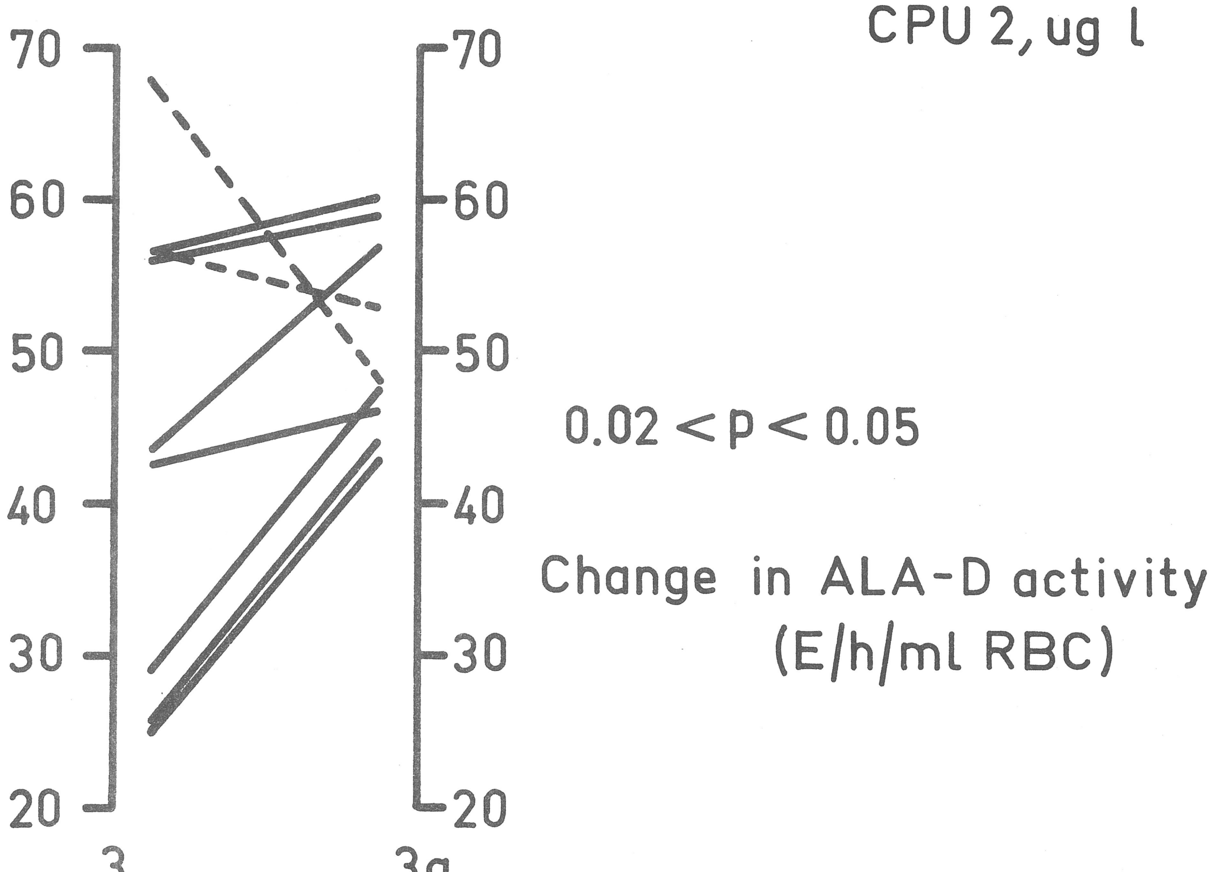

70
60
50
40
30
20
3
3a
0.02 < p < 0.05
Change in ALA-D activity
(E/h/ml RBC)

FIG. 12