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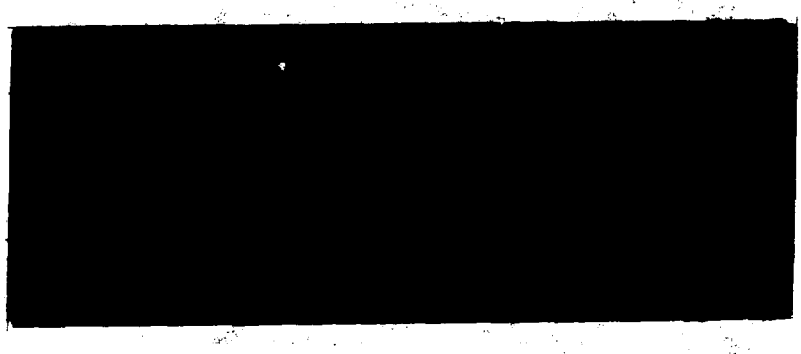

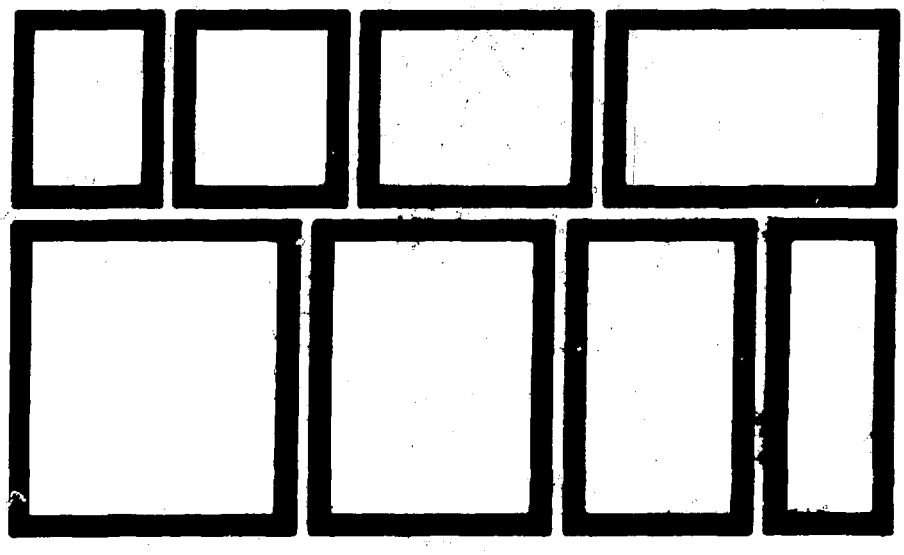

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MALAYSIA

INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF SOIL SAMPLE

by

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INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF SOIL SAMPLE

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Abstract

This paper describes the analysis of soil samples collected from 5 different location around Sungai Lui, Kajang, Selangor, Malaysia. These samples were taken at 22-24 cm from the top of the ground and were analysed using the techniques of Instrumental Neutron Activation Analysis (INAA). The analysis on soil samples taken above 22-24 cm level were done in order to determine if there is any variation in elemental contents at different sampling levels.

The results indicate a wide variation in the contents of the samples. About 30 elements have been analysed. The major ones are Na, I, Cl, Mg, Al, K, Ti, Ca and Fe. Trace elements analysed were Ba, Sc, V Cr, Mn, Ga, As, Zn, Br, Rb, Co, Hf, Zr, Th, U, Sb, Cs, Ce, Sm, Eu, Tb, Dy, Yb, Lu and La.

1. INTRODUCTION

The elements in uncultivated soils come originally from rocks that weathered to form the soil. Basically the elements may be divided into two main categories, that is major elements and trace elements. The major elements in geological samples are Si, O, Al, Fe, Mg, Ca, Na Ie, Ti and P (>1.0%). Any elements with the concentration of less than 1.0% is considered as trace elements (1).

Instrumental Neutron Activation Analysis is the analytical technique for multielemental analysis. Samples and standards were irradiated with thermal neutron for a certain period of time, the activity were counted on the high resolution semi conductor detector for identification and quantification of the elemental contents. The soil contains mostly Silica (SiO_2 >70%) which is not easily activated with thermal neutron (σ = 0.107 barns) offer the most convenient matrix for the INAA. In general, the contents of elements in soil are relatively higher than these in biological sample, thus allows many elements can be determined easily.

This study is part of preliminary work on the main project of utilizing this technique for total elemental analysis of soil and soil solution in various types of Malaysian soil. This technique is chosen because of its sensitivity, non destructive and capability to do multielemental analysis. The application of INAA for soil and soil solution analysis were used by many workers (2,3,4).

2. PREPARATION OF SAMPLES AND STANDARDS

2.1 Collection and preparation of Samples

The samples were collected at five different places as shown in the map marked as F,G,J,K and I, along Sungai Lui's area in Kajang, Selangor. The samples were collected at the depth of 22-24 cm from the surface of the soil. At stations F, J and K, the samples at the depth of 0-20cm were also collected in order to check if there are any variation of the of the elemental contents due to the sampling level. The samples were collected by the method described by campbell et. al (5) and Mc Callan et.al (6). All of the samples were stored in polythere bags. They were dried in an over for 24 hours at 105°C and were then ground using the mortar and pestles. About 1 or 2 g were taken and redried again to a constant weight. About 0.1 to 0.15 g were taken into a clean polythene vial and heat sealed before sending to reactor for neutron irradiation.

2.2. Preparation of Standard

The standard used for the quantification most of the elements are secondary standards, that is IAEA soil-5, IAEA lake sediment SL-1 and NBS coal ash (1632a). The elemental contents in these reference material were taken from their certificates of reperence material, except for the NBS coal ash (1632a), where the elemental contents were from reference 7. The elemental contents in these reference material were further analysed in this laboratory using primary standards prepared by dropping the elemental solution on to specpure SiO_2 and was dried in desicator. The standard reference materials were dried in oven at 105°C for about 24 hours. About 0.1 to 0.15g were taken into a clean polythene vial and heat sealed. The neutron irradiation and the analysis will be discussed in section 3.

Some of the elements in those reference material were analysed by using one or two of the materials as the standards. Table 1, shows the elemental contents in these reference materials obtained in this work and those reported by other workers.

3. IRRADIATION AND COUNTING

Table 2, shows the list of radionuclides which can be detected in the soil sample. For short lived isotopes, the irradiation was performed for 2 to 5 minutes at the flux of about 1×10^{12} n $cm^{-2} S^{-1}$, using the rabbit system of the PUSPATI's Triga Mk II reactor. After 20 minutes of decay interval the elements analysed were Mn, Ti, Mg, Ca, V, Al, Na, Dy, I, Br (^{80}Br) and Cl. After 12-24 hours decay, As, Sb, Sm, K, Na and Br were detected and analysed.

For the medium and longer-lived radionuclides longer irradiation are required. The sample and standard were irradiated in the rotating rack of the PUSPATI's Triga Mark II reactor for about 6 hours at the flux density of about $1x10^{12}$ n $cm^{-2}S^{-1}$. After allowing 3-4 days decay, the following isotopes were detected: Br (^{82}Br), Sm, U, Yb, Ba, Nd, Lu, La, Ce, Sc and Rb. After about 1 month decay interval the radionuclides detected were Eu, Tb, Th, Cr, Zn, Sc, Rb, Fe, Co, Cs, Ta and Ce.

The sample and standard were counted in the polythene vial using the hyperpure germanium semiconductor detector for 5 minutes for short lived isotopes, at a reasonable dead time ($\leq$20%). For longer half-lived isotopes the counting time required are from ½ to 1½ hours. The detail description of the counting and the data acquisition system has been described in the previous paper. The NAA software package from Nuclear Data were used for the elemental quantification.

4. INTERFERENCE

Table 2, shows the list of possible interference which may cause some error in the determination. There are two types of interference to be considered. They are the interference from the secondary reaction and the interference from gamma rays of another radionuclide. The latter could be avoided using another gamma rays of the radionuclide which is free from any interference. For example in the determination of ^{28}Mg, the less intensed photopeak at 1014 keV was chosen instead of the most intense photopeak of 844 keV photopeak, since this peak interfered by the 846 keV of ^{56}Mn.

The interference from the secondary reaction were experimentally determined by irradiating the pure elements of Si, Al, Mg and Fe for 5 minutes in the rabbit system. The standard of Al, Mg, Mn and Na was prepared by dropping solution containing 500 µg of the Al, Mg, Mn and Na on the filter paper. The filter paper was dried in a desicator. From the results shown in Table 3, it is clear that the interference in the determination of Mn, Na and Al are not significant, except for the determination of Mg. In the case of magnesium, if the sample containing 10% Al as much as 2.76% Mg would be produced. The correction for the determination of this element was done using the interference programme of the NAA packages

5. RESULTS AND DISCUSSION

Apart from interference as discussed in section 4, some other factors may cause some errors in this analysis. They are contamination, homogenity, effects of matrices and irregularity in the neutron flux density in the rabbit or in rotating rack systems. The problem in sample homogenity is arised because of only a small portion of the sample were taken for the analysis (0.1 - 0.15g). However this problem can be minimised by randomly taken the sample and carried out more than one analysis. The final results represent the average of each determination. The effect of matrix was not severe, since the IAEA soil-5 and lake sediment SL-1 were used as the standard or reference which are physically and chemically common to the samples. The uncertainty due to flux variations can be reduced by using several standards for the quantification of the elemental contents.

Table 4 shows the list of elemental contents in samples collected from the station F,G,J,I and K. It shows that this method is good for the analysis of most of the elements. However, the relative standard deviation more than 15% are noticed in the determination of Hf, Ce, Cl, I, Zn, K and Cr. The error may be minimized by optimizing the counting or the irradiation time.

Table 5, 6 and 7 show the list of elemental contents at various depths for station F, J and K, respectively. Some of the elements seems to be increased in their concentration as the depths increased (Figure 2,3 and 4). This may be due to the organic matter near the surface of the soil which has dilute the elemental contents.

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Table 1: List of Elemental contents in IAEA's Soil-5, Lake Sediments (LK-1) and NBS Coal ash (1632a)

Elements	Soil-5		Lake sediments SL-1		Coal ash	
	this work	IAEA	this work	IAEA	this work	from ref. 7
Ti	0.38±0.04*	(0.47)	0.53±0.04#	0.517±0.037	0.11±0.009##	0.161±0.00
Al	8.25±0.50	8.19±0.29	9.4±0.7	(8.9)	2.97±0.3	2.94±0.13
Fe	4.82±0.08	4.45±0.14	6.14±0.32	6.74±0.17	1.14±0.11	1.16±0.03
Mg	1.4±0.4*	(1.5)	2.64±0.8#	(2.9)	0.20±0.04	0.13±0.03
Ca	1.93±0.2	(2.2)	1.94±0.22	(0.25)	0.25±0.03	0.23±0.02
Na	1.80±0.1	1.93±0.11	0.175±0.012	0.172±0.012	0.088±0.007	0.085±0.00
K	1.75±0.31*	1.96±0.15	1.5±0.1	(1.5)	0.41±0.03##	0.42±0.02
Mn	840±30	851±37	3550±200	3400±160	30.5±4.0	32±3
Sc	13.9±0.1	14.0±0.6	18.50±1.3	17.30±1.1	7.00±0.5	6.80±0.6
V	140.0±5.0	(151.0)	185±10	170.00±12	48.50±4.0	44.00±3.0
Cr	28.85±1.4	28.9±1.3	104±5	104.0±9.0	31.00±3.0	34.00±2.0
Co	10.0±0.5	11.30±0.70	15.0±1.0	13.80±1.5	6.20±0.3	6.50±0.2
Zn	478.30±30*	368.00±8.2	2?8.00±25.0#	223.00±10.0	-	31.00±6.0
Sb	15.0?±2.0	14.30±0.2	1.75±0.24	1.51±0.14	0.81±0.10	0.60±0.09
As	178.0?±3.6*	138.0±7.4	112.0±?.0#	113.00±11.0	25.00±2.0##	29.00±1.0
Cs	6?.10±5.0*	56.70±3.3	5.50±1.5#	7.01±0.38	-	2.00±0.30
Ba	805.00±?0.0	762.0±53.0	640.0±70.0	639.00±53.0	110.00±7.0	122.00±11.0
Br	2??.0±?.0*	(330.00)	78.60±15#	(?0)	79.90±15##	84.00±9.00
La	30.70±?.1	?8.?±1.5	44.0±4.5	52.60±3.1	18.20±1.3	18.00±?
Ce	6?.00±?.0*	59.70±3.0	?8.50±15#	117.00±17	-	32.00±4
Nd	3?.?0±5.0*	29.?0±1.6	?9.00±3#	43.80±2.?	-	12.10±0.4
Sm	6.80±0.?*	5.41±0.39	8.63±0.4	9.25±0.5?	2.?0±0.3	2.10±0.07
Eu	1.?2±0.??	1.??±0.??	1.?7±0.1?	(1.?)	552.00±35	550.00±30

Tb	0.8±0.1	0.[illegible]5±0.075	–	(1.4)	0.4±0.2##	0.36±0.12
Dy	3.80±1.5*	4.00±1.0	3.20±1.3#	7.46±2.12	2.0±0.4##	2.20±0.3
Yb	2.56±0.4	2.24±0.2	3.40±0.4#	3.42±0.64	–	0.98±0.08
Lu	0.39±0.01*	0.330±0.044	0.44±0.01#	(0.54)	179.0±35##	180.00±30
Zr	216.00±20.0*	(221)	240.00±20#	(241)	50.0±7##	53.00±5.0
Hf	4.97±0.3*	6.30±0.3	4.70±0.7#	4.16±0.58	2.[illegible]±0.10	1.55±0.08
Ta	0.91±0.06*	0.704±0.050	–	(1.6)	380.0±40	400.00±30
I	3.60±0.50*	3.15±0.45	4.05±0.4	4.02±0.32	1.14±0.06	1.2±0.1
Th	14.70±1.8	11.8±0.73	12.30±0.5	14.00±1.0	4.20±0.54	4.8±0.2
Cl	–	–	–	(10)	800.00±80	790.0±20
I	–	(25)	23.0±5.0	(28)	1.50±0.3	1.8±0.2
Br	3.50±1.5*	5.4±1.0	7.00±2.0#	6.82±1.73	44.00± 5##	41.0±4.0
Ga	16.80±2.0*	18.4±1.0	20.00±4.0#	(24)	7.50±0.9##	8.0±0.8
As	106.50±3.0*	23.3±7.5	35.40±4.0#	27.[illegible]±[illegible]	12.0±2.0	10.2±0.5

Note:

( ) – uncertified

* – The value was obtained by using the coal ash (1632a) and Lake Sediment (LK-1) as the standard.

\# – The value was obtained by using the IAEA's soil-5 and NBS Coal ash (1632a) as the standard.

– The value was obtained by using the soil-5 and Lake Sediments (LK-1) as the standard.

Table 5: [illegible] contents in soil samples from station F.

Elements	0-2 m	2-4 m	4-6 cm	6-8 m	8-10 cm	1-10 cm	10-20 cm
% Ti	0.26±0.03	[illegible]	[illegible]	[illegible]	0.17±0.03	0.37±0.03	0.34±0.03
Al	13.73±0.70	[illegible]	[illegible]	[illegible]	14.50±0.70	15.14±0.72	18.7±0.30
Fe	2.00 ±0.12	[illegible]	[illegible]	[illegible]	2.64±0.32	2.46±0.28	2.65±0.33
Mg	0.60±0.21	[illegible]	[illegible]	[illegible]	0.66±0.23	0.66±0.24	0.81±0.30
Ca	-	-	-	-	-	-	-
Na	0.04±0.003	[illegible]	[illegible]	[illegible]	0.05±0.06	0.05±0.005	0.06±0.005
K	1.74±0.17	[illegible]	[illegible]	[illegible]	1.09±0.20	0.98±0.20	1.28±0.50
m Mn	232.11±23.50	[illegible]	[illegible]	[illegible]	264.0±28.0	245.0±26.0	271.0±29.0
Sc	7.50±0.70	[illegible]	[illegible]	[illegible]	11.51±0.77	9.80±0.90	12.29±0.84
V	24.04±2.80	[illegible]	[illegible]	[illegible]	29.34±3.30	22.95±2.90	24.05±3.00
Cr	-	-	[illegible]	[illegible]	16.0±3.10	12.0±4.20	7.80±3.00
Co	1.30±0.20	[illegible]	[illegible]	[illegible]	1.43±0.63	1.68±0.51	1.18±0.25
Zn	-	[illegible]	[illegible]	[illegible]	49.34±11.4	50.30±10.3	30.6±9.50
Sb	1.03±0.20	[illegible]	[illegible]	[illegible]	1.77±0.15	1.97±0.20	1.86±0.16
Rb	781.0±100.0	[illegible]	[illegible]	[illegible]	707.0±80.0	-	708.0±95.0
Cs	27.80±5.00	[illegible]	[illegible]	[illegible]	32.11±7.30	32.20±7.80	32.8±7.60
Ba	-	-	-	-	-	-	-
Sr	-	-	[illegible]	[illegible]	181.30±56.60	-	244.0±77.0
La	15.90±1.20	[illegible]	[illegible]	[illegible]	20.6±2.10	21.20±2.10	20.40±2.10
Ce	70.0±20.0	[illegible]	[illegible]	[illegible]	94.03±23.30	75.0±15.80	89.41±24.84
Nd	-	-	-	-	-	-	-
Sm	4.92±0.20	[illegible]	[illegible]	[illegible]	5.07±0.18	5.13±0.20	5.46±0.20

Continue from Table 5

Elements	0-2 cm	2-4 cm	4-6 cm	6- cm	8-10 cm	14-16 cm	18-20 cm
Eu	0.30±0.03	0.[illegible]	[illegible]	[illegible]	[illegible]	0.50±0.07	0.63±0.07
Tb	-	-	-	-	-	-	-
Dy	3.44±0.65	3.[illegible]	[illegible]	[illegible]	3.85±0.60	2.87±0.70	2.40±0.90
Yb	-	[illegible]	[illegible]	[illegible]	[illegible]	-	6.74±2.50
Lu	1.04±0.20	1.[illegible]	[illegible]	[illegible]	[illegible]	1.65±0.20	0.69±0.10
Zr	289.20±20.0	[illegible]	[illegible]	[illegible]	[illegible]	350±75.00	385.00±30.0
Hf	8.80±3.00	[illegible]	[illegible]	[illegible]	10.65±3.60	10.50±4.0	10.19±3.58
Ta	-	-	-	-	-	-	-
U	19.50±1.60	[illegible]	[illegible]	[illegible]	[illegible]	13.80±1.50	15.90±1.70
Th	60.70±10.0	[illegible]	[illegible]	[illegible]	61.73±8.42	57.90±6.30	61.50±8.50
Cl	75.23±15.0	[illegible]	[illegible]	[illegible]	86.00±16.0	59.80±13.0	66.09±16.0
I	30.50±11.0	[illegible]	[illegible]	[illegible]	[illegible]	20.90±8.00	26.40±10.0
Br	15.40±1.70	[illegible]	[illegible]	[illegible]	[illegible]	18.05±2.00	18.09±2.00
Cs	33.80±3.90	[illegible]	[illegible]	[illegible]	40.08±4.60	39.50±5.00	30.20±3.90
Ac	126.30±7.4	[illegible]	[illegible]	[illegible]	[illegible]	122.80±7.10	120.0±8.50

Table 6: Elemental contents in soil samples from station J.

Elements	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-10 cm	10-12 cm	12-14 cm	14-16 cm	16-18 cm
Ti	0.37±0.08	0.34±0.07	0.30±0.06	0.29±0.07	0.36±0.07	0.43±0.08	0.49±0.09	0.56±0.09	0.54±0.08
Al	3.80±0.40	3.52±0.40	3.31±0.40	2.11±0.20	2.96±0.30	5.13±0.50	5.74±0.60	5.72±0.60	6.86±0.08
Fe	1.61±0.09	2.82±0.13	1.69±0.06	1.70±0.06	1.01±0.14	1.45±0.05	1.49±0.05	1.69±0.08	1.81±0.05
Mg	0.58±0.10	0.63±0.12	0.73±0.15	0.67±0.10	0.76±0.15	0.84±0.20	1.08±0.40	0.93±0.30	0.88±0.25
Ca	-	-	-	-	-	-	-	-	-
Na	0.07±0.001	0.13±0.002	0.1±0.001	0.1±0.01	0.13±0.02	0.1±0.001	0.14±0.001	0.14±0.001	0.13±0.001
K	1.08±0.10	2.11±0.20	1.83±0.15	2.17±0.20	1.68±0.15	1.84±0.15	2.05±0.20	1.85±0.20	1.89±0.21
Mn	171.1±20.0	175.9±21.0	201.6±20.0	168.6±20.0	146±20.0	174.0±20.0	176.0±20.0	186.0±25.0	197.0±25.0
Sc	8.17±0.37	13.70±0.63	11.12±0.73	10.94±0.84	14.6±0.75	9.25±0.61	9.75±0.62	10.79±0.49	11.07±0.73
V	76.7±5.00	77.4±6.50	75.2±5.20	60.5±6.10	79.1±8.10	107.8±10.0	126.9±10.5	120.5±12.0	118.2±11.5
Cr	76.61±15.0	79.27±20.0	71.8±15.0	71.8±15.0	77.50±15.0	81.04±5.0	42.40±6.0	58.90±6.80	68.90±7.50
Co	0.78±0.07	1.36±0.13	0.91±0.1	0.99±0.15	1.0±0.14	0.68±0.13	0.78±0.15	0.84±0.11	0.69±0.16
Zn	-	27.6±4.0	-	-	-	-	101.4±25.9	19.90±2.9	105.0±25.5
Sb	0.26±0.04	0.69±0.07	0.43±0.04	0.64±0.10	0.71±0.10	0.74±0.15	-	0.89±0.20	0.55±0.10
Sb	202.6±30.0	466.5±100	91.22±5.0	78.9±42.0	365.3±87.9	250.0±100	100±100	156.0±30.0	110.0±30.0
Cs	4.27±0.70	7.47±0.50	10.71±1.40	10.3±1.7	8.13±0.50	9.05±1.45	9.13±1.46	9.46±0.66	13.33±2.1
Ba	-	-	-	-	-	98.0±15.0	-	-	99.90±20.0
Sr	-	-	-	-	-	-	-	-	-
La	13.42±2.0	24.15±2.50	20.0±1.80	22.4±2.80	20.8±1.90	18.37±1.80	21.2±2.10	24.25±2.10	22.18±2.0
Ce	52.24±12.5	96.40±10.2	81.7±6.30	41.9±8.10	80.34±5.9	32.93±6.10	46.1±8.40	42.54±2.80	43.65±7.67
Nd	-	-	-	-	-	-	-	-	-
Sm	2.09±0.2	3.65±0.40	2.72±0.30	3.5±0.40	3.60±0.40	2.81±0.30	3.26±0.40	3.53±0.50	3.46±0.80

Elements	0–2 cm	2–4 cm	4–6 cm	6–8 cm	8–10 cm	10–12 cm	12–14 cm	14–16 cm	16–18 cm
Eu	0.37±0.04	0.69±0.07	[illegible]	[illegible]	0.66±0.07	0.28±0.02	0.44±0.03	0.62±0.06	0.54±0.24
Tb	0.53±0.25	0.59±0.35	–	–	0.66±0.29	–	–	–	0.66±0.24
Dy	3.07±0.85	3.09±0.81	[illegible]	3.32±0.5[illegible]	3.67±0.81	3.28±0.31	4.36±0.40	3.36±0.60	3.81±0.50
Yb	4.27±2.0[illegible]	3.55±2.40	[illegible]	[illegible]	5.30±3.00	5.60±3.00		2.37±1.00	2.62±1.07
Lu	0.38±0.03	0.28±0.14	[illegible]	0.30±0.03	0.35±0.04	0.41±0.05	0.48±0.07	0.55±0.10	0.45±0.09
Zr	275.5±30.0	277±20.00	[illegible]	[illegible] 30	275± 30.0	–	234.0± 30		281± 20.5
Hf	8.98±2.30	10.95±1.[illegible]	[illegible]	4.09±1.11	13.40±1.07	4.73±1.01		6.78±0.55	5.29±1.06
Ta	1.66±0.48	1.[illegible]8±0.40	[illegible]	[illegible]6±0.74	[illegible]37±0.69	2.23±0.64	1.82±0.51	1.41±0.41	1.31±0.19
U	–						–	–	–
Th	13.34±1.50	15.26±1.60	[illegible]	7.89±0.83	16.8±1.40	6.91±0.65	8.44±0.75	8.47±0.66	9.19±0.81
Cl	100.[illegible]±20.5	90.00±27.5	78.[illegible]±[illegible].1	61.2±[illegible].1		55.0±25.0	75.0±28.0	86.5±25.6	75.9±20.8
I		–	–	–	–	–	–	–	–
Br	2.81±0.[illegible]8	3.60±1.05	[illegible]±1.[illegible]	3.90±0.81	1.11±1.20	4.21±1.10	3.16±0.98	6.37±1.20	3.19±0.98
Ba	6.95±0.07	7.39±[illegible]	[illegible]±[illegible]	5.99±0.[illegible]	[illegible].34±0.[illegible]	7.56±0.[illegible]	15.2±1.70	18.36±1.80	6.21±0.06
As	2.31±0.[illegible]	3.85±[illegible]	[illegible]±[illegible]	2.96±1.0[illegible]	3.81±0.98	3.48±0.69	4.34±0.40	3.43±0.61	3.36±0.58

[illegible] samples from station K.

Elements	0-2 cm	2-4 cm	4-6 cm	6-8 cm	-10 cm	10-12 cm	12-14 cm	14-16 cm	16-18 cm
Ti	0.19+0.05	[illegible]	[illegible]	[illegible]	[illegible]	0.34+0.03	0.30+0.03	0.32+0.05	0.3[illegible]+0.05
Al	10.9+0.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18.7[illegible]	16.7+0.80	17.9+0.98	18.5+0.95
Fe	2.00+0.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.96+0.20	4.06+0.20	3.54+0.43
[illegible]	1.51+0.44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.63+0.24	0.68+0.30	0.72+0.3[illegible]
Ca	-	-	-	-	-	-	-	-	-
Na	0.06+0.005	[illegible]	[illegible]	[illegible]	[illegible]	0.08+0.006	0.07+0.004	0.07+0.004	0.08+0.00[illegible]
K	1.30+0.13	[illegible]	[illegible]	1.04+0.[illegible]	[illegible]	0.97+0.20	0.89+0.19	1.35+0.20	1.38+0.25
Mn	327.0+25.0	[illegible]	[illegible]	[illegible]	[illegible]+24	345.0+37	268.0+27	320.0+28	350.0+30
Sc	9.64+0.30	[illegible]	[illegible]	[illegible]	[illegible]+0.94	15.79+1.07	16.78+1.8	19.7+1.30	18.2+1.23
V	19.50+[illegible].5	[illegible]	[illegible]	25.90+3.0	[illegible]+3.70	23.60+3.[illegible]	24.15+3.0	25.3+3.50	24.8+4.00
Cr	-	-	-	-	-	-	-	-	-
Co	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]+0.70	4.77+0.36	3.79+1.03
Zn	-	-	-	-	-	-	-	-	-
Sb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]+0.20	1.[illegible]+0.40	1.03+0.50
Rb	[illegible]	[illegible]	[illegible]	[illegible]	733.0+[illegible]	370.0+[illegible]	450.0+95	[illegible]50.0+100	590.0+109
Cs	[illegible].70+6.0	[illegible]	[illegible]	[illegible]	91.0+[illegible]	70.0+7.00	[illegible]0.0+8.10	[illegible]1.60+1[illegible].70	49.93+11.[illegible]
Ba	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]+8.00	79.0+7.[illegible]	[illegible]	97.0+9.70	95.78+8.50
Sr	-	[illegible]	[illegible]	[illegible]7.4+[illegible]	[illegible]	99.5+30.[illegible]	101.0+35.0	180.5+50.5	194.2+66.0
La	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]+2.5	[illegible]+3.0	[illegible]1.30+[illegible].1	23.50+2.50	22.40+[illegible]
Ce	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]8.0+25.0	111.0+29.0	135.2+[illegible]
Sm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].04+0.08	[illegible]	[illegible].02+1.50	3.58+1.50	4.85+2.00
Eu	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]+0.18	0.60+0.19	0.63+[illegible]

Elements	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-10 cm	10-12cm	12-14 cm	14-16 cm	16-18 cm
Eu	-	-	-	-	-	-	-	-	-
Tb	-	-	-	-	-	-	-	-	-
Dy	3.03±0.65	-	[illegible]	[illegible]	.07±0.4	3.42±0.50	3.56±0.68	3.45±0.70	3.41±0.[illegible]
Yb	3.14±1.50	[illegible]	[illegible]	[illegible]	[illegible]7±3.5	7.47±4.10	5.56±1.80	6.74±3.20	9.46±3.10
Lu	0.30±0.04	1.14±0.10	[illegible]	[illegible]	[illegible]±0.03	1.19±0.12	1.20±0.12	1.55±0.16	1.94±0.19
Zr	-	-	-	-	-	-	-	-	-
Hf	9.23±2.80	[illegible]	[illegible]	[illegible]	[illegible]±3.77	10.61±3.7	11.8±4.10	12.57±4.4	11.53±4.04
Ta	-	-	-	-	-	-	-	-	-
U	16.8±1.08	11.39±1.[illegible]	[illegible]	[illegible]	15.5±1.6	14.16±1.4	15.8±1.60	16.20±1.6	11.2±1.10
Th	53.6±[illegible].80	59.[illegible]±[illegible].0	[illegible]	60.[illegible]±[illegible].5	61.91±8.63	71.08±9.8	65.3±10.0	83.90±11.56	85.[illegible]8±12.3
Cl	77.9±15.8	73.7±17.[illegible]	[illegible]	104.4±17	-	80.70±12	75.9±15.0	98.00±16.00	90.8±15.10
I	12.8±4.80	13.0[illegible]±5.[illegible]	[illegible].9±[illegible].8	17.73±7.1	17.[illegible]0±7.1	15.70±7.3	15.3±6.10	16.80±5.8	17.8±6.20
-	22.9±2.[illegible]0	17.70±2.[illegible]	[illegible].6±[illegible].5	16.73±2.8	18.60±2.31	17.7±2.20	18.2±2.80	17.80±3.1	19.2±3.20
[illegible]	36.23±4.2	43.[illegible]±5.[illegible]	[illegible] ±1.[illegible]	[illegible].5±4.[illegible]	41.9[illegible]±5.[illegible]	43.8±5.20	40.1±4.20	39.85±3.95	46.2±5.20
As	180.[illegible]±10.[illegible]	230.[illegible]±13	[illegible] [illegible]±[illegible]	220.5±1[illegible]	[illegible]7.[illegible]±[illegible].2	230.0±13	188±18.20	198±15.20	230±15.80

Table 2 : List of elements, radionuclides, possible interference and gamma ray selected for the analysis, data from ref. 1,8.

1. Short Irradiation (2-5 minutes)

Elements	Isotope	Half-life	∝-energy selected (KeV)	Decay interval	Interference
Titanium	^{51}Ti	5.79m	320.0		
Magnesium	^{27}Mg	9.46m	1014,844		^{30}Si (n,∝) ^{27}Al (n,p) 846(Mn^{56})
Vanadium	^{52}V	3.75m	1434		
Aluminium	^{28}Al	2.32m	1779		^{31}P (n,∝) ^{28}Si(n,p) ^{24}Mg(n,p) ^{27}Al(n,∝)
Sodium	^{24}Na	15.0h	1369,2754		
Dysprosium	^{165}Dy	2.32h	95	20minutes	
Iodine	^{128}I	25.0m	443		
Manganese	^{56}Mn	2.58h	1810,2110,846		^{56}Fe(n,p) 844(^{27}Mg)
Calsium	^{49}Ca	8.8m	3084		
Chlorine	^{38}Cl	37.18m	1642,2167		
Bromine	^{80}Br	17.60m	618		
Manganese	^{56}Mn	2.58h	1810,2110,846		
Sodium	^{24}Na	15.0h	1369,2754		
Bromine	^{82}Br	35.34h	555,775		
Gallium	^{72}Ga	14.10h	834		
Antimony	^{122}Sb	2.70d	564	12-24 hours	559(^{76}As)
Arsenic	^{76}As	26.4h	559		555(^{82}Br)
Samarium	^{153}Sm	46.8h	103		
Potassium	^{42}K	12.4h	1524		

continue from table 2

11. Long Irradiation (6 hours)

Elements	Isotope	Half-life	∝-ray selected	Decay interval	Interference
Europium	^{152}Eu	12.7y	122,1408		
Lutetium	^{177}Lu	6.74d	208		$^{177m}Lu(208)$
Uranium	$^{239}Np(U)$	56.5h	228,278		$^{177m}Lu(229)$
Yterbium	^{131}Yb	4.21d	283,396		
Barium	^{131}Ba	12.1d	216,496	3-4 days	
Neodymium	^{147}Nd	11.1d	91,531		
Lanthanum	^{140}La	40.2h	816,1597		
Cerium	^{141}Ce	32.5d	146		$^{59}Fe(143)$
Rubidium	^{86}Rb	18.7d	1078		

Europium	^{152}Eu	12.7y	122,1408		
Tantalum	^{182}Ta	115d	1221		
Terbium	^{160}Tb	72.1d	880,966		
Thorium	$^{233}Pa(Th)$	27.0d	312,300		$^{160}Tb(300)$
Chromium	^{51}Cr	27.8d	320		
Hafnium	^{181}Hf	42.5d	482		
Strontium	^{85}Sr	64.0d	514	29-30 days	
Zirconium	^{95}Zr	65.5d	757		
Scandium	^{46}Sc	83.9d	889,1120		
Iron	^{59}Fe	45.6d	1099,1292		
Zinc	^{65}Zn	243.0d	1116		$^{46}Sc(1120)$
Cobalt	^{60}Co	5.26y	1173,1332		
Caesium	^{134}Cs	2.06y	604,796		

Table 3 : Interference from the (n,p) and (n,α) reaction.

Nuclear reaction	Radionuclide interfered	Contribution in mg/g isotop
^{28}Si (n,p) ^{28}Al	^{28}Al	3.292 mg
^{31}P (n,α) ^{28}Al	^{28}Al	N.D.*
^{27}Al (n,p) ^{27}Mg	^{27}Mg	279.2 mg
^{31}Si (n,α) ^{27}Mg	^{27}Mg	low (undetected)
^{24}Mg (n,p) ^{24}Na	^{24}Na	1.48 mg
^{27}Al (n,α) ^{24}Na	^{24}Na	low (undetected)
^{56}Fe (n,p) ^{56}Mn	^{56}Mn	0.157 mg

Key to table :- N.D.*, not determined.

Table 4 : Elemental contents form soils at station J, I, G, K and G, around Sungai Lui's area, Kajang, Selangor (samples were taken at 22-24 cm depths)

	Elements	F	G	J	I	K
%	Ti	0.31±0.03	0.43±0.04	0.55±0.09	0.39±0.09	0.35±0.05
	Al	11.9±0.9	6.15±0.70	7.15±0.80	9.36±0.90	19.5±0.95
	Fe	2.29±0.30	2.84±0.40	2.90±0.18	2.34±0.20	3.08±0.43
	Mg	1.51±0.50	0.89±0.60	0.86±0.25	1.15±0.30	0.81±0.31
	Ca	-	-	-	-	-
	Na	0.06±0.005	0.07±0.005	0.13±0.001	0.03±0.001	0.08±0.006
	K	1.31±0.50	0.77±0.48	1.48±0.21	0.41±0.09	1.58±0.31
ppm,	Mn	227±29.0	212.0±25.0	194.0±25	179.0±23.0	380.0±30.5
	Sc	9.64±0.75	8.82±0.80	12.40±0.80	6.72±0.70	19.20±1.25
	U	17.6±2.0	57.9±6.2	115.0±11.5	52.5±5.3	24.0±4.0
	Cr	7.36±3.2	33.94±5.5	80.11±7.5	29.8±2.5	3.8±0.12
	Co	1.75±0.18	1.69±0.17	1.49±0.18	2.23±0.22	4.10±1.21
	Zn	47.06±10.1	38.5±8.5	61.91±20.2	49.8±8.8	38.5±10.8
	Sb	1.85±0.20	1.55±0.20	1.07±0.20	0.48±0.18	1.55±0.30
	Rb	255.3±50.0	85.13±20.8	106.6±28.5	48.2±12.5	598±80.5
	Cs	21.4±6.8	17.60±5.8	8.79±1.8	7.47±2.5	60.5±15.3
	Ba	-	126.2±25.0	157.5±21.0	-	84.8±10.0
	Sr	-	-	-	-	-
	La	20.9±2.1	20.14±2.0	20.1±2.0	21.2±2.0	25.0±2.5
	Ce	50.2±20.1	50.70±7.8	42.0±6.8	40.12±7.5	125.0±30.8
	Nd	-	-	-	-	-
	Sm	4.23±0.21	3.2±0.18	4.23±0.91	3.16±0.85	4.95±2.5
	Eu	0.65±0.08	0.75±0.09	0.56±0.04	0.54±0.05	0.58±0.21
	Tb	-	-	-	-	0.19±0.05
	Dy	3.44±0.95	2.44±0.50	3.44±0.48	2.54±0.50	3.45±0.61
	Yb	5.76±2.1	2.81±2.1	5.76±1.50	2.19±0.75	8.91±3.5
	Lu	0.45±0.15	0.39±0.15	0.37±0.09	0.30±0.09±	0.98±0.09
	Zr	390.0±30.0	389.0±25.0	278.7±25.0	328.1±30.0	427.0±28.0
	Hf	10.01±4.0	9.83±3.7	6.47±1.25	7.02±2.8	9.46±2.1
	Ta	-	-	1.65±0.20	-	-
	U	13.5±1.8	3.76±0.98	-	10.0±1.0	16.8±2.1
ppm,	Th	51.90±7.8	27.06±5.8	10.80±0.85	45.5±7.8	53.8±9.1
	Cl	57.5±13.0	70.2±15.0	80.0±40.1	78.0±30.0	80.9±20.1
	Br	19.07±2.5	25.19±1.8	6.32±1.20	26.12±2.0	15.8±6.2
	I	40.0±10.5	-	-	-	28.8±7.1
	As	91.9±5.8	63.04±6.8	6.45±0.61	18.07±2.1	180.0±20.0
	Ga	39.5±3.8	14.90±0.15	6.21±0.06	25.8±0.18	24.8±4.1

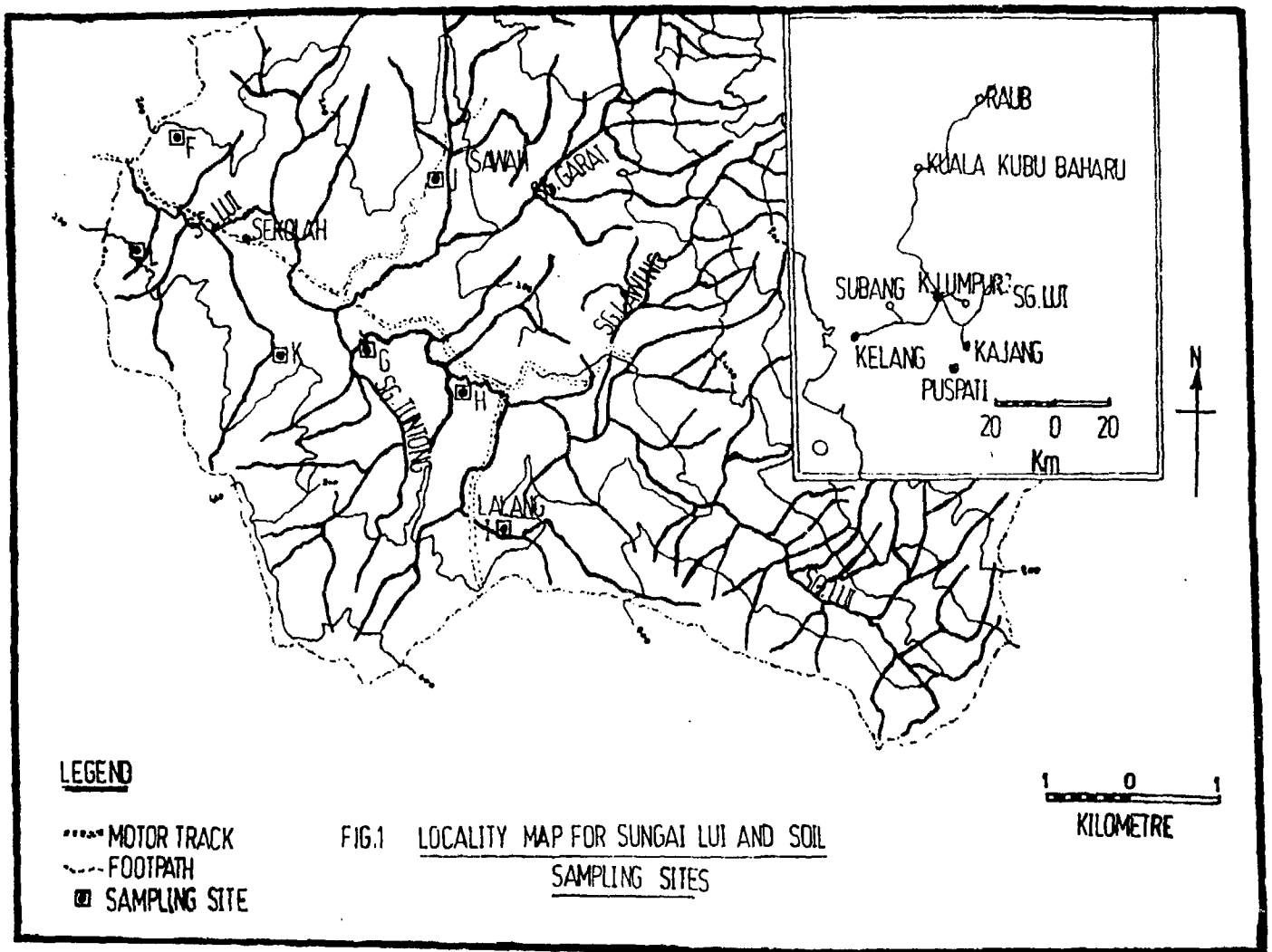

FIG.1 LOCALITY MAP FOR SUNGAI LUI AND SOIL SAMPLING SITES

Figure 2

RELATIVE CHANGE IN CONCENTRATION V.S. DEPT[illegible] (STATE I)

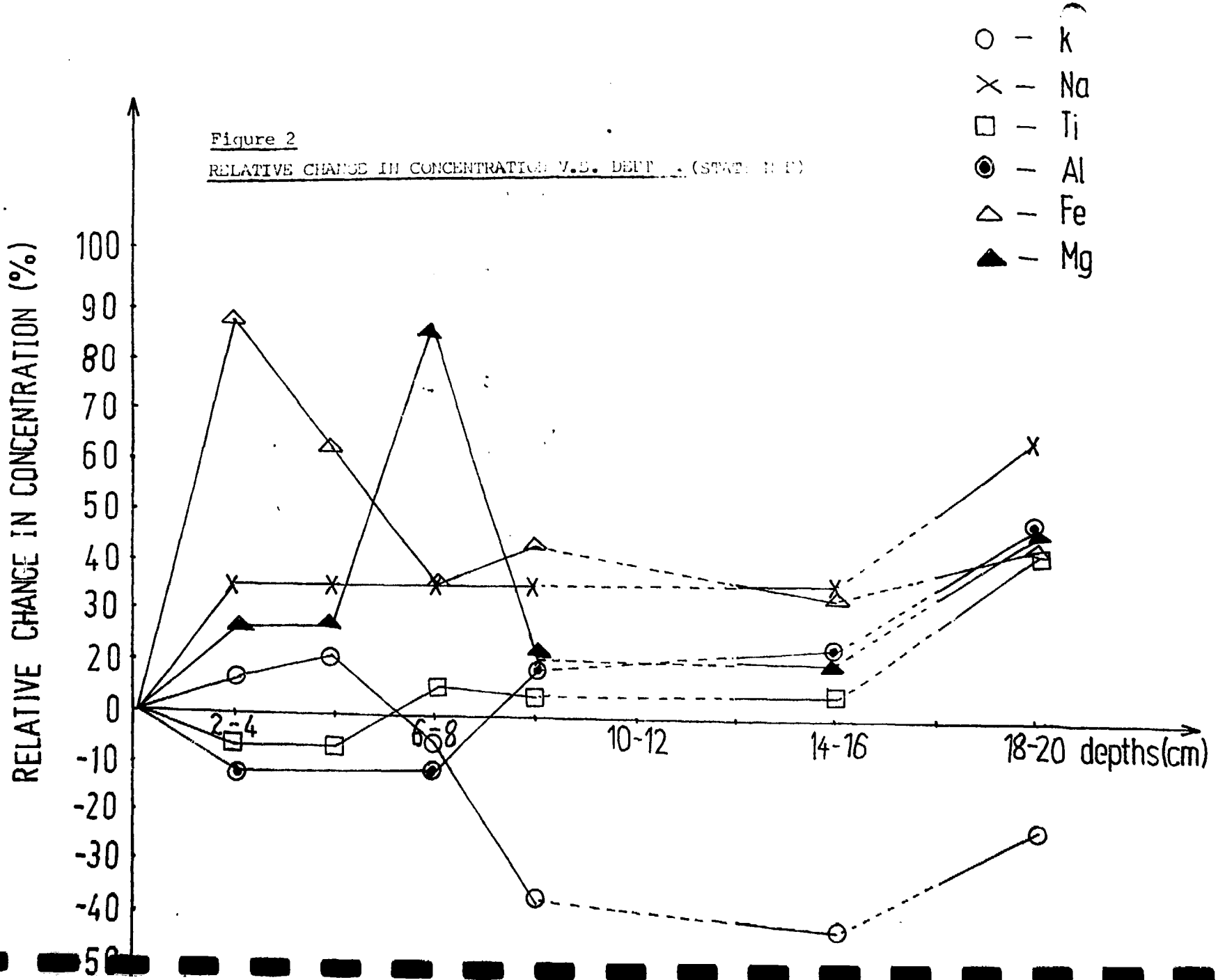

Figure 3

RELATIVE CHANGE IN CONCENTRATION V.S. DEPTH (...)

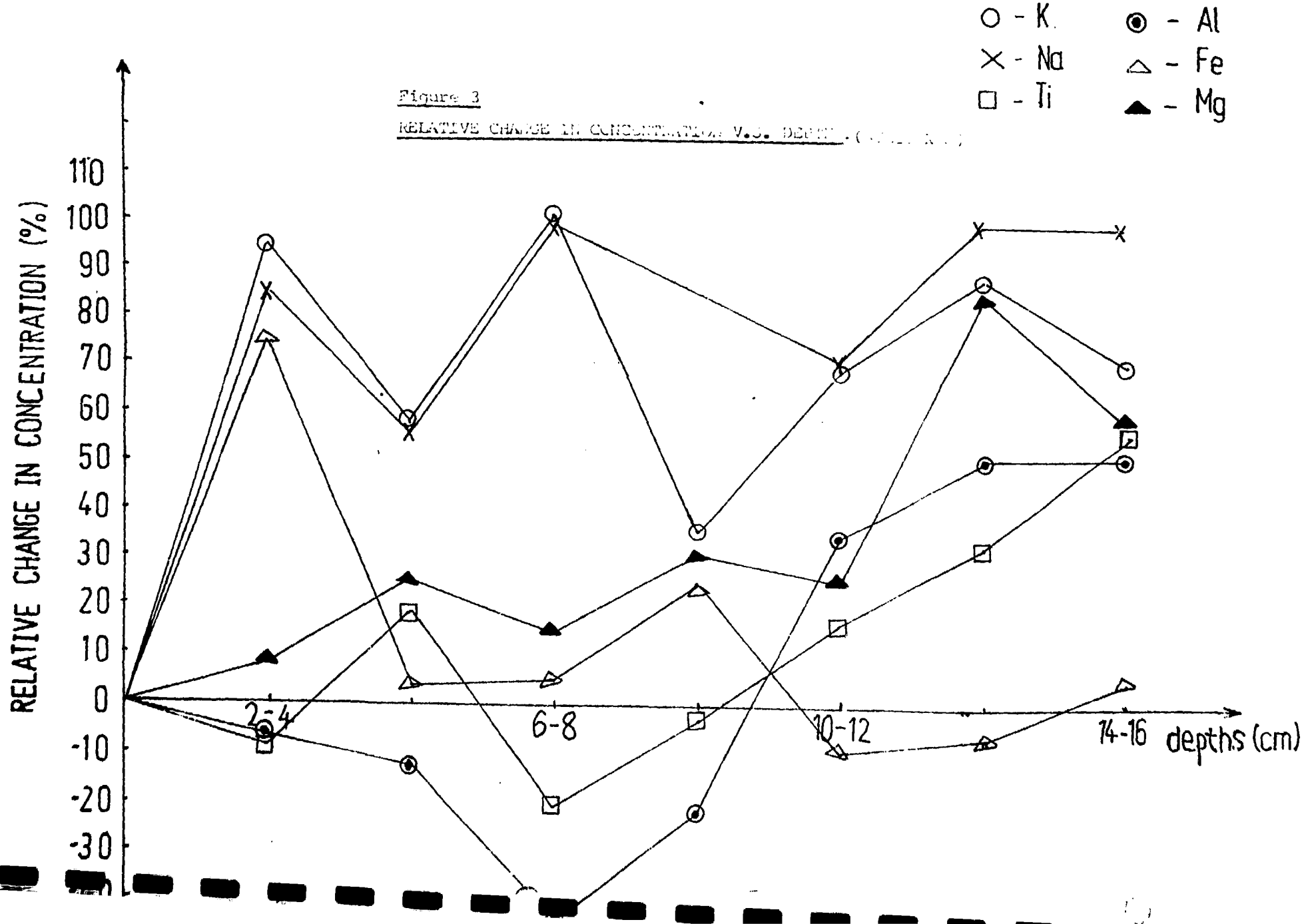

Figure 4

RELATIVE CHANGE IN CONCENTRATION V.S. DEPTHS (STATION K)

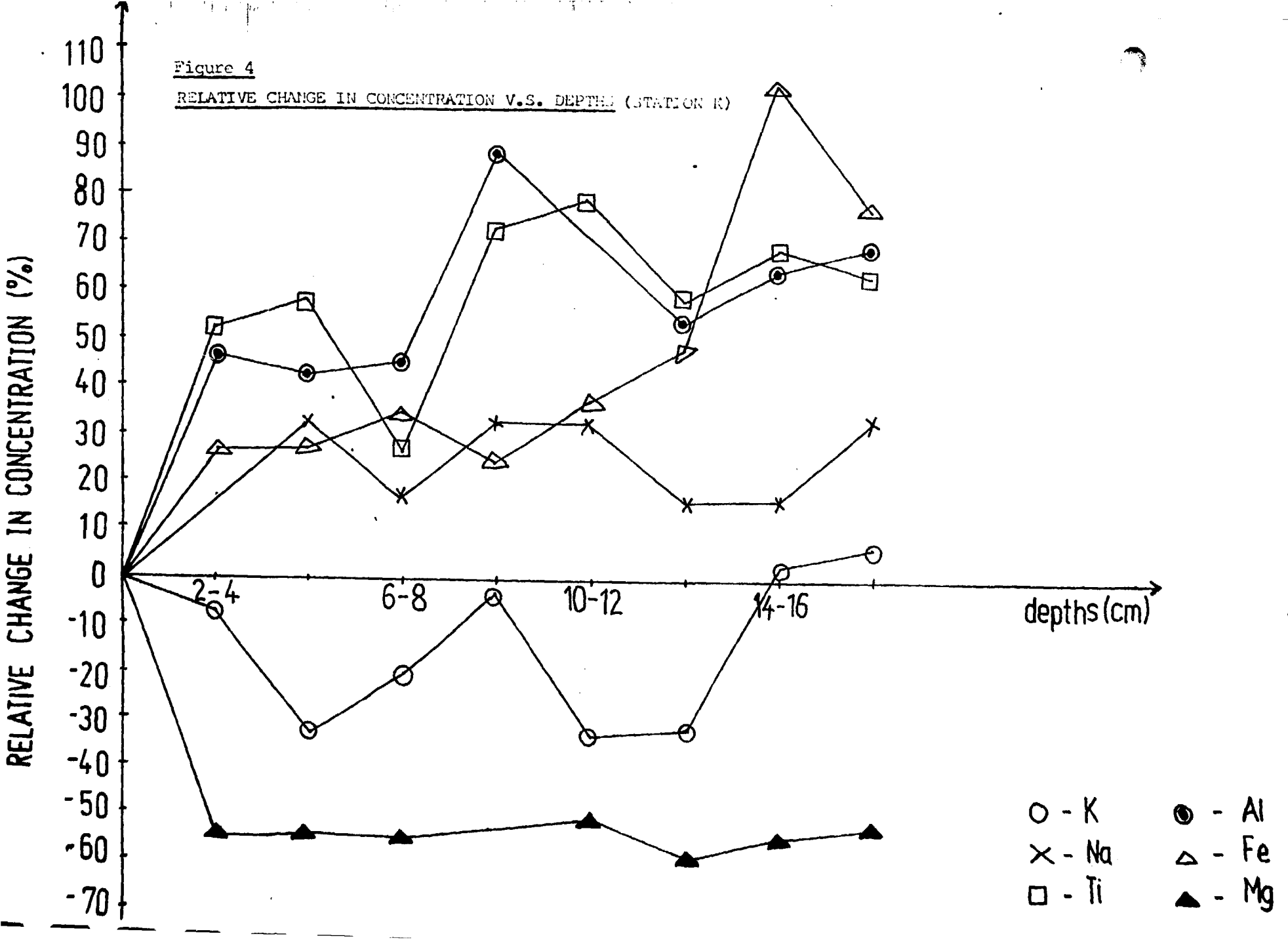

Table 6: Elemental contents in soil samples from station J.

	Elements	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-10 cm	10-12 cm	12-14 cm	14-16 cm	16-18 cm
%	Ti	0.37±0.08	0.34±0.07	0.30±0.06	0.29±0.07	0.36±0.07	0.43±0.08	0.49±0.09	0.56±0.09	0.54±0.08
	Al	3.80±0.40	3.52±0.40	3.31±0.40	2.41±0.30	2.96±0.30	5.13±0.50	5.74±0.60	5.72±0.60	6.86±0.08
	Fe	1.61±0.09	2.82±0.13	1.69±0.06	1.70±0.06	2.01±0.14	1.45±0.05	1.49±0.05	1.69±0.08	1.81±0.05
	Mg	0.58±0.10	0.63±0.12	0.73±0.15	0.67±0.10	0.76±0.15	0.84±0.20	1.08±0.40	0.93±0.30	0.88±0.25
	Ca	-	-	-	-	-	-	-	-	-
	Na	0.07±0.001	0.13±0.003	0.13±0.001	0.14±0.001	0.13±0.001	0.12±0.001	0.14±0.001	0.14±0.001	0.13±0.001
	k	1.08±0.10	2.11±0.20	1.63±0.20	1.17±0.20	1.48±0.15	1.84±0.15	2.05±0.20	1.85±0.20	1.98±0.21
ppm	Mn	171.1±20.0	172.9±20.0	231.0±30.0	164.5±20.0	180±20.0	174.0±20.0	176.0±20.0	186.0±25.0	197.0±25.0
	Sc	8.17±0.37	13.70±0.60	11.1±0.70	10.94±0.60	14.4±0.75	9.25±0.61	9.25±0.62	10.79±0.49	11.07±0.73
	V	76.7±5.00	77.4±5.50	69.5±5.00	69.5±6.10	79.11±8.10	107.8±10.0	126.9±10.5	120.5±12.0	118.2±11.5
	Cr	76.61±15.0	79.2±20.0	72.8±15.0	71.8±15.0	27.50±15.0	31.04±5.0	42.40±6.0	58.90±6.80	68.90±7.50
	Co	0.78±0.07	1.30±0.13	0.94±0.20	0.99±0.15	1.01±0.14	0.58±0.13	0.76±0.15	0.84±0.11	0.69±0.16
	Zn	-	27.6±4.0	-	-	-	-	101.4±25.9	19.90±2.9	105.0±25.5
	Sb	0.26±0.04	0.69±0.07	0.63±0.08	0.64±0.10	0.71±0.10	0.74±0.15	-	0.89±0.20	0.55±0.10
	Rb	202.0±30.0	466.5±60.0	341.7±50.0	78.6±40.0	365.3±37.0	250.0±30.0	300.0±40.0	156.0±30.0	110.0±30.0
	Cs	4.27±0.70	7.17±0.80	10.71±1.00	10.3±1.7	8.13±0.50	9.05±1.45	9.13±1.46	9.46±0.96	13.33±2.1
	Ba	-	-	-	-	-	98.0±15.0	-	-	99.90±20.0
	Sr	-	-	-	-	-	-	-	-	-
	La	13.42±2.0	24.15±3.00	18.4±1.80	19.4±2.80	20.8±1.80	18.37±1.80	21.2±2.10	24.25±2.10	22.18±2.0
	Ce	52.24±10.5	96.40±20.2	84.3±6.30	41.9±8.10	80.34±5.9	32.93±6.10	46.1±8.40	42.54±2.80	43.65±7.67
	Nd	-	-	-	-	-	-	-	-	-
	Sm	3.00±0.2	3.65±0.40	2.72±0.30	3.5±0.40	3.60±0.40	2.81±0.30	3.26±0.40	3.53±0.50	3.46±0.80

Elements	0–2 cm	2–4 cm	[illegible]	6–8 cm	8–10 cm	10–12 cm	12–14 cm	14–16 cm	16–18 cm
Eu	0.37±0.04	0.69±0.07	[illegible]	[illegible]	[illegible]	0.28±0.02	0.14±0.03	0.62±0.06	0.[illegible]±0.24
Tb	0.53±0.25	0.59±0.33	–	–	0.66±0.29	–	–	–	0.66±0.24
Dy	3.07±0.85	3.89±0.81	[illegible]	[illegible]	3.67±0.81	3.28±0.31	4.36±0.40	3.36±0.60	3.81±0.50
Yb	4.27±2.00	5.85±2.10	[illegible]	[illegible]	5.00±3.00	5.60±3.00		2.37±1.09	2.62±1.07
Lu	0.28±0.03	0.28±0.04	[illegible]	[illegible]	0.35±0.04	0.41±0.05	0.48±0.07	0.55±0.10	0.45±0.09
Zr	275.5±30.0	277±20.00	[illegible]	299.0± 30	275± 30.0	–	234.0± 30		281± 20.8
Hf	8.98±2.30	10.9±1.[illegible]	[illegible]	[illegible]	13.40±1.07	4.73±1.01		6.78±0.55	5.29±1.06
Ta	1.86±0.48	1.38±0.40	[illegible]	[illegible]	2.37±0.69	2.23±0.64	1.82±0.51	1.41±0.41	1.31±0.39
U	–	–	–	–	–	–	–	–	–
Th	13.34±1.50	15.2±1.60	[illegible]	[illegible]	16.8±1.40	6.91±0.65	8.44±0.75	8.47±0.66	9.19±0.81
Cl	100.[illegible]±0.5	90.00±27.5	[illegible]	[illegible]		75.0±25.0	75.0±28.0	36.5±25.6	75.0±20.8
I		–	–	–	–	–	–	–	–
Br	2.81±0.98	3.80±1.05	[illegible]	3.96±0.81	4.11±1.20	4.21±1.10	3.16±0.98	6.37±1.20	3.19±0.98
Ga	6.95±0.07	7.39±0.09	[illegible]	6.99±0.09	6.34±0.06	7.56±0.08	15.2±1.70	18.36±1.80	6.21±0.06
As	2.31±0.80	3.85±0.95	3.94±0.98	4.90±1.00	3.81±0.98	3.48±0.60	4.34±0.40	3.43±0.61	3.36±0.58

[illegible] content in soil samples from station K.

Elements	0–2 cm	2–4 cm	[illegible]	[illegible]	[illegible]–10 cm	10–12 cm	12–14 cm	14–16 cm	16–18 cm
Ti	0.19±0.05	[illegible]	[illegible]	[illegible]	[illegible]±0.03	0.34±0.03	0.30±0.03	0.32±0.05	0.31±[illegible]
Al	10.9±[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18.7±0.80	16.7±0.80	17.9±0.98	18.5±0.95
Fe	2.00±0.70	[illegible]	[illegible]	[illegible]	[illegible]	2.75±[illegible]	2.96±0.20	4.06±0.20	3.54±0.43
Mg	1.51±0.44	[illegible]	[illegible]	[illegible].68±[illegible]	[illegible].72±0.16	0.73±[illegible]	0.63±0.24	0.68±0.30	0.72±0.31
Ca	–	–	–	–	–	–	–	–	–
Na	0.06±0.005	[illegible]	[illegible]	[illegible]	[illegible]	0.08±0.006	0.07±0.004	0.07±0.004	0.08±[illegible]
K	1.30±0.13	[illegible]	[illegible]	1.64±[illegible]	[illegible]±0.23	0.[illegible]7±0.20	0.89±0.[illegible]9	1.35±0.20	1.38±0.25
Mn	327.0±25.0	331.[illegible]±3[illegible]	[illegible]±35	[illegible]7.0±3[illegible]	[illegible]±34	345.0±37	268.0±27	320.0±28	350.0±30
Sc	[illegible]	[illegible]	[illegible]	13.63±[illegible]	13.84±0.94	15.79±1.07	16.78±1.8	19.7±1.30	18.2±1.23
V	[illegible]	[illegible]	[illegible]9[illegible]	25.90±3.0	[illegible]±3.70	23.[illegible]±3.[illegible]	24.15±3.0	25.3±3.50	24.[illegible]±4.00
Cr	–	–	–	–	–	–	–	–	–
Co	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.18±0.69	2.25±0.70	4.77±0.36	3.78±1.03
Zn	–	–	–	–	–	–	–	–	–
Sb	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].38	[illegible]±0.20	1.08±0.40	1.03±[illegible]
Rb	[illegible]	[illegible]	[illegible]	[illegible]	733.0±[illegible]	370.0±[illegible]	450.0±95	550.0±100	590.0±[illegible]
Cs	2[illegible].7±6.0	[illegible]	[illegible]	35.20±[illegible]	[illegible]	73.0±7.00	[illegible]0.0±3.10	51.60±11.70	49.[illegible]±11.[illegible]
Ba	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70.0±7.00	[illegible].60	97.0±9.70	95.79±[illegible].50
Sr	–	[illegible]	[illegible]	237.4±92	77.4±3[illegible]	9[illegible].5±30.[illegible]	101.0±35.0	190.5±50.5	194.2±[illegible]
La	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].90±3.0	[illegible]1.30±2.1	23.50±2.50	22.40±[illegible]
Ce	[illegible]	[illegible]	[illegible]	[illegible]0±[illegible]	[illegible]±21.7	[illegible]±27.0	38.0±25.0	111.0±29.0	135.2±[illegible]3.90
Sm	[illegible]	[illegible]	[illegible]	[illegible]±0.08	1.01±0.08	[illegible]±1.[illegible]	[illegible].02±1.50	3.53±1.50	4.85±2.00
Eu	[illegible]	[illegible]	[illegible]±0.20	0.61±0.[illegible]	0.53±0.21	0.66±0.25	0.59±0.18	0.60±0.19	0.63±0.21

Elements	0-2 cm	2-4 cm	4-6 cm	6-8 cm	8-10 cm	10-12cm	12-14 cm	14-16 cm	16-18 cm
Eu	-	-	-	-	-	-	-	-	-
Tb	-	-	-	-	-	-	-	-	-
Dy	3.03±0.55	-	[illegible]	[illegible]	[illegible]	2.42±0.50	3.56±0.68	3.45±0.70	3.41±0.65
Yb	3.14±1.50	[illegible]	[illegible]	[illegible]	6.37±3.5	7.47±4.10	5.56±1.80	6.74±3.20	9.46±3.1[illegible]
Lu	0.80±0.04	[illegible]	[illegible]	[illegible]	[illegible]	1.19±0.12	1.20±0.12	1.55±0.16	1.94±0.19
Zr	-	-	-	-	-	-	-	-	-
Hf	9.[illegible]3±2.80	[illegible]	[illegible]	[illegible]	10.66±3.77	10.61±3.7	11.8±4.10	12.57±4.4	11.53±4.04
Ta	-	-	-	-	-	-	-	-	-
U	16.8±1.08	11.39±1.[illegible]	[illegible]	15.01±1.5	15.5±1.6	14.16±1.4	15.8±1.60	16.20±1.6	11.2±1.10
Th	53.6±8.80	59.[illegible]±0.0	[illegible]	60.80±8.5	61.91±8.63	71.08±9.8	65.3±10.0	83.90±11.56	89.[illegible]±12.3
Cl	77.9±15.[illegible]	78.7±17.[illegible]	[illegible]	[illegible]	-	80.70±12	75.9±15.0	98.00±16.00	90.8±15.10
I	12.8±4.80	[illegible]	[illegible]	17.73±7.1	17.[illegible]0±7.1	18.70±7.3	15.3±6.10	16.80±5.8	17.8±6.20
Br	22.9±2.[illegible]	[illegible]	[illegible]	16.73±2.9	18.60±2.31	17.7±2.20	18.2±2.80	17.80±3.1	19.2±3.20
Ba	36.[illegible]±4.[illegible]	[illegible]	[illegible]	[illegible]	41.9[illegible]±5.0	43.8±5.20	40.1±4.20	39.85±3.95	46.2±5.20
As	180.[illegible]±[illegible]	[illegible]	[illegible]	220.5±[illegible]	[illegible]17.5±12	230.0±13	188±18.20	198±15.20	230±15.80

Table 2 : List of elements, radionuclides, possible interference and gamma ray selected for the analysis, data from ref. 1,8.

1. Short Irradiation (2-5 minutes)

Elements	Isotope	Half-life	∝-energy selected (KeV)	Decay interval	Interference
Titanium	^{51}Ti	5.79m	320.0		
Magnesium	^{27}Mg	9.46m	1014,844		^{30}Si (n,∝) ^{27}Al (n,p) 846(Mn^{56})
Vanadium	^{52}V	3.75m	1434		
Aluminium	^{28}Al	2.32m	1779		^{31}P (n,∝) ^{28}Si(n,p)
Sodium	^{24}Na	15.0h	1369,2754		^{24}Mg(n,p) ^{27}Al(n,∝)
Dysprosium	^{165}Dy	2.32h	95	20minutes	
Iodine	^{128}I	25.0m	443		
Manganese	^{56}Mn	2.58h	1810,2110,846		^{56}Fe(n,p) 844(^{27}Mg)
Calsium	^{49}Ca	8.8m	3084		
Chlorine	^{38}Cl	37.18m	1642,2167		
Bromine	^{80}Br	17.60m	618		
Manganese	^{56}Mn	2.58h	1810,2110,846		
Sodium	^{24}Na	15.0h	1369,2754		
Bromine	^{82}Br	35.34h	555,776		
Gallium	^{72}Ga	14.10h	834	12-24 hours	
Antimony	^{122}Sb	2.70d	564		559(^{76}As)
Arsenic	^{76}As	26.4h	559		555(^{82}Br)
Samarium	^{153}Sm	46.8h	103		
Potassium	^{42}K	12.4h	1524		

continue from table 2

11. Long Irradiation (6 hours)

Elements	Isotope	Half-life	∝-ray selected	Decay interval	Interference
Europium	^{152}Eu	12.7y	122,1408		
Lutetium	^{177}Lu	6.74d	208		$^{177m}Lu(208)$
Uranium	$^{239}Np(U)$	56.3h	228,278		$^{177m}Lu(229)$
Yterbium	^{131}Yb	4.21d	283,396		
Barium	^{131}Ba	12.1d	216,496	3-4 days	
Neodymium	^{147}Nd	11.1d	91,531		
Lanthanum	^{140}La	40.2h	816,1597		
Cerium	^{141}Ce	32.5d	146		$^{59}Fe(143)$
Rubidium	^{86}Rb	18.7d	1078		
Europium	^{152}Eu	12.7y	122,1408		
Tantalum	^{182}Ta	115d	1221		
Terbium	^{160}Tb	72.1d	880,966		
Thorium	$^{233}Pa(Th)$	27.0d	312,300		$^{160}Tb(300)$
Chromium	^{51}Cr	27.8d	320		
Hafnium	^{181}Hf	42.5d	482		
Strontium	^{85}Sr	64.0d	514	29-30 days	
Zirconium	^{95}Zr	65.5d	757		
Scandium	^{46}Sc	83.9d	889,1120		
Iron	^{59}Fe	45.6d	1099,1292		
Zinc	^{65}Zn	243.0d	1116		$^{46}Sc(1120)$
Cobalt	^{60}Co	5.26y	1173,1332		
Caesium	^{134}Cs	2.06y	604,796		

Table 3 : Interference from the (n,p) and (n,α) reaction.

Nuclear reaction	Radionuclide interfered	Contribution in mg/g isotop
^{28}Si (n,p) ^{28}Al	^{28}Al	3.292 mg
^{31}P (n,α) ^{28}Al	^{28}Al	N.D.*
^{27}Al (n,p) ^{27}Mg	^{27}Mg	279.2 mg
^{30}Si (n,α) ^{27}Mg	^{27}Mg	low (undetected)
^{24}Mg (n,p) ^{24}Na	^{24}Na	1.48 mg
^{27}Al (n,α) ^{24}Na	^{24}Na	low (undetected)
^{56}Fe (n,p) ^{56}Mn	^{56}Mn	0.157 mg

Key to table :- N.D.*, not determined.

Table 4 : Elemental contents form soils at station J, I, G, K and G, around Sungai Lui's area, Kajang, Selangor (samples were taken at 22-24 cm depths)

	Elements	F	G	J	I	K
%	Ti	0.31±0.03	0.43±0.04	0.55±0.09	0.39±0.09	0.35±0.05
	Al	11.9±0.9	6.15±0.70	7.15±0.80	9.36±0.90	19.5±0.95
	Fe	2.29±0.30	2.84±0.40	2.90±0.18	2.34±0.20	3.08±0.43
	Mg	1.51±0.50	0.89±0.60	0.86±0.25	1.15±0.30	0.81±0.31
	Ca	-	-	-	-	-
	Na	0.06±0.005	0.07±0.005	0.13±0.001	0.03±0.001	0.08±0.006
	K	1.31±0.50	0.77±0.48	1.48±0.21	0.41±0.09	1.58±0.31
ppm,	Mn	227±29.0	212.0±25.0	194.0±25	179.0±23.0	380.0±30.5
	Sc	9.64±0.75	8.82±0.80	12.40±0.80	6.72±0.70	19.20±1.25
	V	17.6±2.0	57.9±6.2	115.0±11.5	52.5±5.3	24.0±4.0
	Cr	7.36±3.2	33.94±5.5	80.11±7.5	29.8±2.5	3.8±0.12
	Co	1.75±0.18	1.69±0.17	1.49±0.18	2.23±0.22	4.10±1.21
	Zn	47.06±10.1	38.5±8.5	61.91±20.2	49.8±8.8	38.5±10.8
	Sb	1.85±0.20	1.55±0.20	1.07±0.20	0.48±0.18	1.55±0.30
	Rb	255.3±50.0	85.13±20.8	106.6±28.5	48.2±12.5	598±80.5
	Cs	21.4±6.8	17.60±5.8	8.79±1.8	7.47±2.5	60.5±15.3
	Ba	-	126.2±25.0	157.5±21.0	-	84.8±10.0
	Sr	-	-	-	-	-
	La	20.9±2.1	20.14±2.0	20.1±2.0	21.2±2.0	25.0±2.5
	Ce	50.2±20.1	50.70±7.8	42.0±6.8	40.12±7.5	125.0±30.8
	Nd	-	-	-	-	-
	Sm	4.23±0.21	3.2±0.18	4.23±0.91	3.16±0.85	4.95±2.5
	Eu	0.65±0.08	0.75±0.09	0.56±0.04	0.54±0.05	0.58±0.21
	Tb	-	-	-	-	0.19±0.05
	Dy	3.44±0.95	2.44±0.50	3.44±0.48	2.54±0.50	3.45±0.61
	Yb	5.76±2.1	2.81±2.1	5.76±1.50	2.19±0.75	8.91±3.5
	Lu	0.45±0.15	0.39±0.15	0.37±0.09	0.30±0.09±	0.98±0.09
	Zr	390.0±30.0	389.0±25.0	278.7±25.0	328.1±30.0	427.0±28.0
	Hf	10.01±4.0	9.83±3.7	6.47±1.25	7.02±2.8	9.46±2.1
	Ta	-	-	1.65±0.20	-	-
	U	13.5±1.8	3.76±0.98	-	10.0±1.0	16.8±2.1
ppm,	Th	51.90±7.8	27.06±5.8	10.80±0.85	45.5±7.8	53.8±9.1
	Cl	57.5±13.0	70.2±15.0	80.0±40.1	78.0±30.0	80.9±20.1
	Br	19.07±2.5	25.19±1.8	6.32±1.20	26.12±2.0	15.8±6.2
	I	40.0±10.5	-	-	-	28.8±7.1
	As	91.9±5.8	63.04±6.8	6.45±0.61	18.07±2.1	180.0±20.0
	Ga	39.5±3.8	14.90±0.15	6.21±0.06	25.8±0.18	24.8±4.1

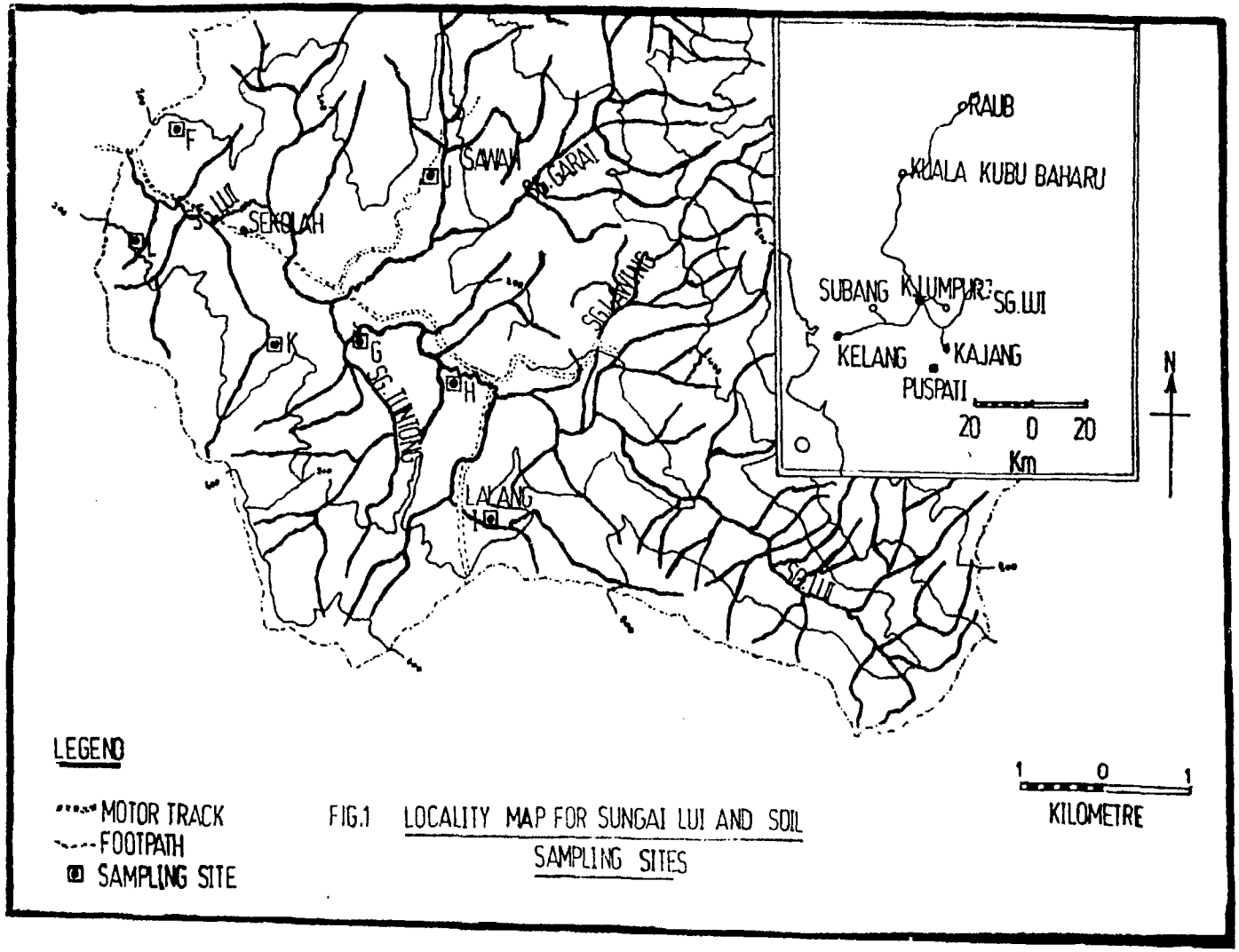

FIG.1 LOCALITY MAP FOR SUNGAI LUI AND SOIL SAMPLING SITES

Figure 2

RELATIVE CHANGE IN CONCENTRATION V.S. DEPT[illegible] (STN[illegible])

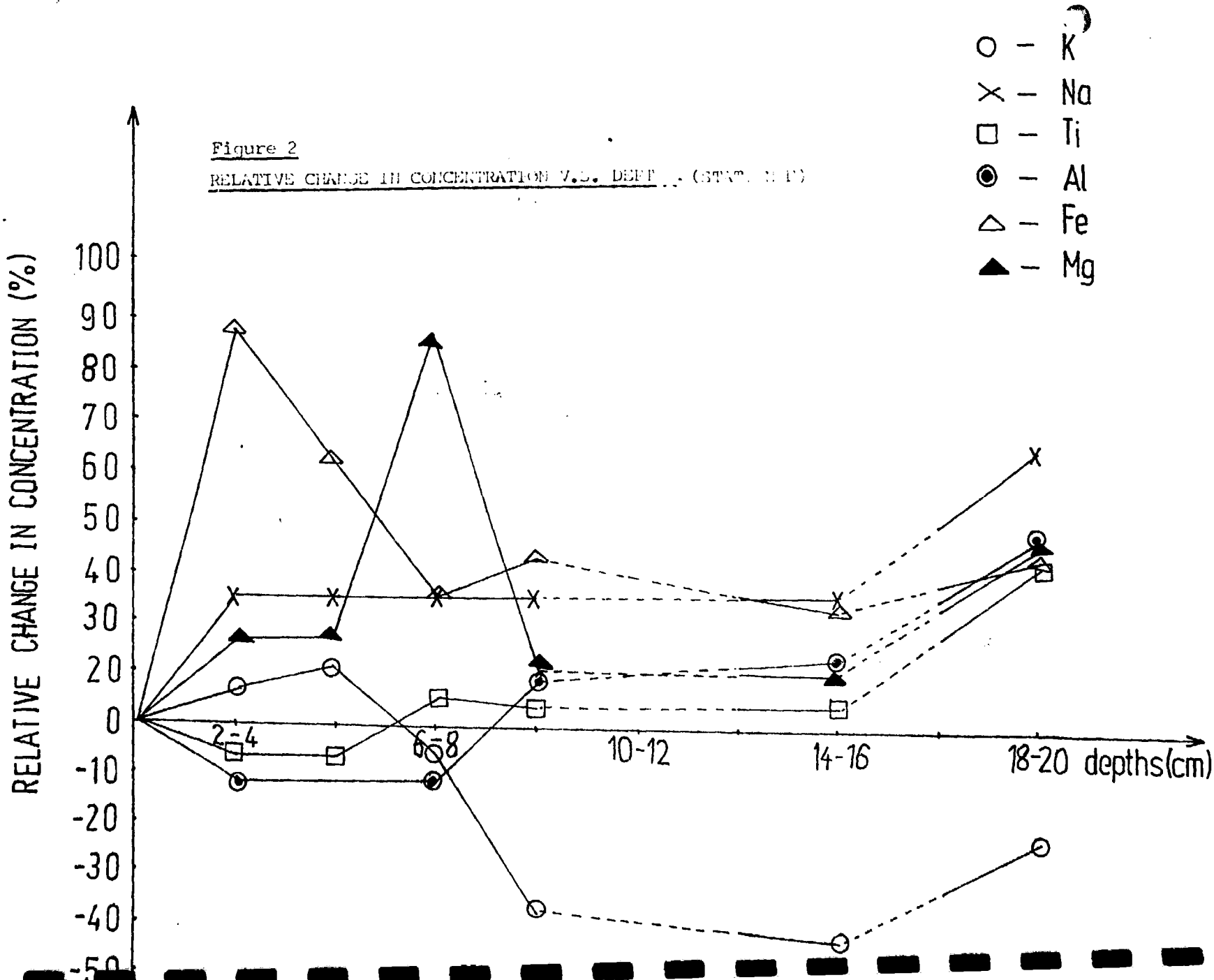

Figure 3

RELATIVE CHANGE IN CONCENTRATION V.S. DEPTH (...)

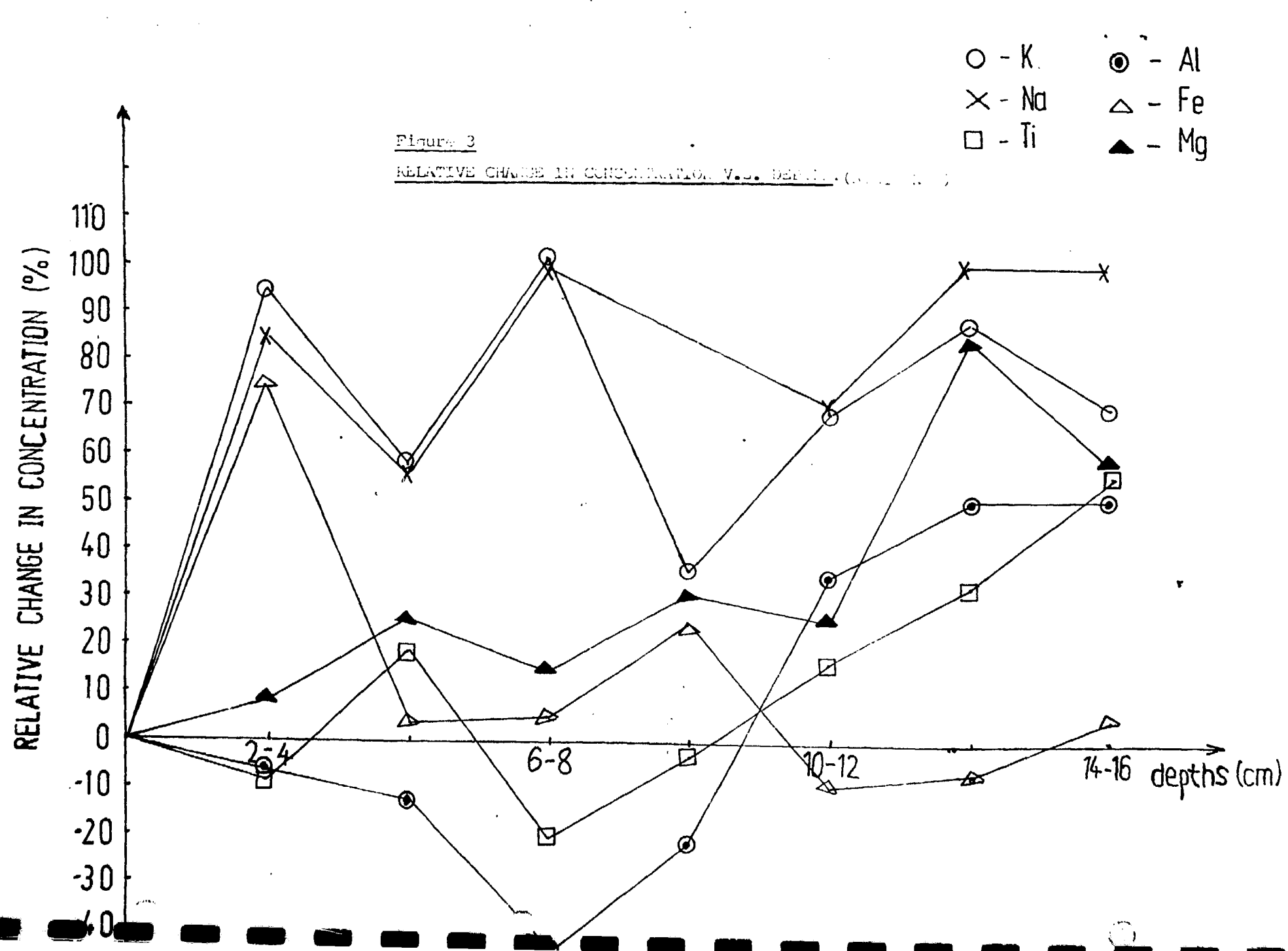

Figure 4

RELATIVE CHANGE IN CONCENTRATION V.S. DEPTH (STATION K)