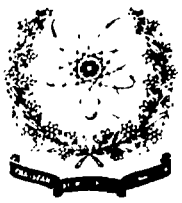

Pakistan Institute of Nuclear Science and Technology
ISLAMABAD

TECHNICAL REPORT

Approved by:

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Analytical Chemistry Group of Nuclear Chemistry Division at [illegible] has been participating in IAEA Intercomparison programme of analytical quality control since 19[illegible]. So far fifteen samples of a variety of materials received from the Agency have been analyzed for different minor and trace elements. Mostly destructive and non-destructive neutron activation analysis techniques have been used for elemental analysis. In this report the description of the samples and the experimental procedures employed have been mentioned. The results of elemental analysis have been reported and compared with IAEA values which are based on the average computed from the results of different participating laboratories.

1. INTRODUCTION

For technological development in scientific research in many areas of human activity the need for well characterized materials is rapidly increasing. Reference materials with accurately known composition and properties are often required to calibrate instruments and analytical techniques particularly for the measurement of trace element concentrations. The identification and the determination of minute amounts of chemical impurities in high purity materials is important as many of the properties of solids depend directly upon the trace element concentrations. Accurate measurement of trace elements in biological materials is also of vital concern as these elements play an important role in bio-chemical processes. Therefore, the preparation and characterization of the reference materials has received a considerable attention during the last decade.

Chemical characterization of reference materials involves measurement of major and minor constituents employing sensitive and accurate analytical techniques. The reliability of such measurements depends on the precision and accuracy of the analytical methods employed. The scatter in the measured values which indicates the precision of an analytical method can easily be determined by multi determinations of the sample and statistical treatment of the data whereas the accuracy which indicates the agreement of the measured values with the true value can be determined by analysing a well characterised standard reference material and comparing the measured value

with the certified value. The deviation of the measured value will indicate the magnitude of the systematic errors of the analytical method.

Standard reference materials not only provide analytical data to be refered to a common base but also a basis for the comparison of the measurements and to control the quality of the industrial products. These materials besides being useful for calibration of instruments can also be employed to improve the compatibility of the measurements in the critical areas and to control certain sensitive properties to improve the performance of the materials.

The certification of the reference materials can be achieved by analysing the materials employing as many different techniques, individuals and instruments as possible. There are some limitations of this procedure of certification because all types of instruments and techniques may not be available in one laboratory. Moreover, this procedure is comparatively more expensive. Alternatively, this can be achieved through the participation in an interlaboratory comparison programme. The average value obtained from the statistical evaluation of all the results from different laboratories reflect the most probable true value. The agreement of the results from a particular laboratory with the true value is also a measure of the

accuracy for the type of analysis under investigation.

International Atomic Energy Agency has launched an intercomparison programme in Analytical Quality Control in early sixties. The agency is distributing not only standards and reference materials but also samples for intercomparison to be used in the determination of elements in environmental and biomedical research and other substances of interest in nuclear fuel technology, isotope hydrology and nuclear safety control. The purpose of this programme is to help the laboratories of IAEA member states to achieve reliable measurements in the fields of nuclear technology and isotope utilization with adequate precision and their necessary improvement[1].

The samples provided by IAEA belong to a variety of materials such as environmental materials (air filter, water, soil and lake sediment), animal materials (animal muscle, animal bone and milk powder), plant materials (wheat flour, potato and sea plant) and materials of marine origin, (oyster, fish soluble, fish flesh, and copepod homogenate).

Analytical Chemistry Group at PINSTECH is participating in the IAEA Intercomparison Programme of Analytical Quality Control since 1972. So far fifteen samples have been received from the Agency for analysis. These samples were analyzed for a number of different minor and trace elements using various

analytical techniques such as destructive and non-destructive neutron activation analysis, atomic absorption spectrometry and spectrophotometry. This report describes the preparation of the samples, the methods employed for analysis and the results obtained.

2. DESCRIPTION OF THE SAMPLES

2.1 Animal Bone A-3/1 (1972)

Fresh cattle bone was ashed and milled. After milling, the material was sieved to obtain the grains of the same size. The grains collected were mixed uniformly and distributed for analysis. The homogeneity was also checked by analysing ^{90}Sr and manganese content in 50 different samples. The variation among the values obtained was not more than 5% from the mean.

2.2 Milk Powder A-8(1972)

The sample was prepared from industrially manufactured fresh skim-milk by spray drying. The sample was homogenised by stirring the original liquid milk as well as by thorough mixing of the powdered material.

2.3 Wheat Flour V-2/1 (1972).

Wheat Flour sample was made from commercially available wheat flour. The homogeneity was achieved by thorough mixing. The particular structure of flour causes an inhomogenity on a

microlevel, therefore more than 100 mg sample was recommended to be used for analysis.

2.4 Mashed Potato V-4 (1972)

The fresh potatoes were mashed and dried. The homogeneity was achieved by mixing before distribution.

2.5 Fresh Water W/3 (1973)

Three 4 ml solutions of sixteen trace elements in glass ampoules were provided. The glass ampoules were made of chemically inert glass towards exchange and adsorption reactions. Two of them contained certain trace elements in strongly acidified solution whereas one was slightly alkaline containing other trace elements. Each portion was diluted to 5 litres according to the method given below. This diluted solution was very similar to an average fresh water.

To a 5 litre container about 200-500 ml doubly distilled water and 50 ml concentrated nitric acid (AnalaR grade) were added. After removing the labels from three ampoules, they were washed from outside first with dilute nitric acid then with doubly distilled water and introduced into the container. The ampoules were crushed with a long glass rod and the volume was made upto 5 litre with doubly distilled water and mixed uniformly. The diluted solution was not stable therefore it was prepared just before analysis.

Using the same batch of nitric acid and doubly distilled water, two blank solutions were made upto 5 litre. From these solutions containing same amount of nitric acid used for preparing water samples, appropriate aliquots were analysed for the elements measured in W-3 water samples.

2.6 Fish Soluble A-6(1973)

The sample consists of air-dried fish serum prepared from commercially available fish solubles. The dried material was thoroughly mixed to achieve homogeneity but due to a particular structure of fish solubles this can not be achieved on microscale even after applying mechanical processes. Always more than 100 mg aliquot of the sample was used for analysis to ensure a homogeneous sample as recommended by IAEA.

2.7 Oyster Homogenate MA-M-1 (1975)

The sample was homogenized, sieved and freeze-dried oyster tissue. After lyophilization and grinding the resultant product was doubly sieved and the fraction passing 500 µm and 63 µm was retained to prepare the sample. The homogeneity of the sample was tested by analysing few elements by atomic absorption spectrometry and neutron activation analysis. The standard deviation of ± 10% was obtained for many elements at sample weight of 100 mg. Since many elements may be lost from the sample if dried at 105 - 110°C, the dry - weight of the

sample was determined separately and the results were corrected on the basis of the dry - weight. To minimize the biodegradation of the sample, it was stored in the dark in a refrigerator until the time of analysis.

2.8 Air - 3 Filter (1975)

Commercially available filter papers (Schleicher and Schüll No.589-2 Weissband) with a 5.5 cm diameter and an ash weight of 20 µg were moistened with 50 µl of the appropriate solution containing trace elements by an Eppendor pipette and then air-dried. The moistened spot did not form a regular shape and the solution was not taken up uniformly by the filter paper. A group of ten filters sandwitched between polythene sheets were distributed in a plastic envelope. The filters for blank determinations were also supplied in different envelops.

The total error introduced in sample handling was very much smaller than 2% which is the estimated uncertainty of the concentration of the spiking solution.

2.9 Animal Muscle H-4 (1976)

The sample was prepared from 80 kg of fresh meat. The meat was cut into small pieces with a commercially pure titanium knife and freeze-dried on plastic trays. The dried material was finely powdered in an agate ball mill, passed

through a nylon sieve of 125 μm mesh and finally mixed in bulk in a rotatory plastic drum. ^{24}Na was measured by neutron activation analysis to check the homogeneity. The relative standard deviation was found to be ± 1% for the sample of 100 mg.

2.10 Soil-5 (1976)

The soil sample was collected at the Agricultural Experimental Station, La Molina, Lima, Peru (20 cm top soil depth) and ground. The material was sieved and the fraction which passed through a seive of 0.16 mm was collected. This portion was mixed thoroughly in a rotating plastic drum for 48 hours and 50 g portions were distributed for analysis in the plastic bottles.

The homogeneity was tested by measuring the contents of cesium, cobalt and iron in different bottles selected at random. It was observed that results do not differ significantly and the sample can be considered homogeneous for samples of weight ≥ 100 mg. The moisture content was determined by drying it for 22 hours at 105°C in a separate sub-sample and all the results were reported on dry-weight basis.

2.11 Lake-Sediment SL-1 (1977)

The lake sediment samples were collected at Sardis Reservior, Panola County, Mississippi, U.S.A at the water depth

of 15 meters. They were dried in an oven at 50°C for seven days and ground to obtain the fraction passing through a 0.1 mm. This fraction (60 kg) was homogenised in IAEA Seibersdorf Laboratory by mixing in a rotating plastic drum for about 60 hours. Approximately 25 g portions were distributed for analysis in plastic bottles. The homogeneity was tested by determining several elements by instrumental neutron activation analysis in samples taken from bottles chosen at random. The results have shown that material is homogeneous as long as the weight is more than 100 mg. The content of moisture was established by drying it at 105°C for 48 hours in a separate aliquot and all the results are quoted on dry-weight basis.

2.12 Fish Flesh IAEA-A-2(1978)

The sample was freeze-dried, ground and sieved through a 500 µm mesh of nylon. The product was then homogenized mechanically. The homogeneity was further checked by determining several trace elements using different analytical techniques. For most of the elements measured, the standard deviations were less then ± 10% at the sample weights of 200 mg. The sample was stored in the dark, under refrigeration until the time of analysis to reduce the biodegradation of the material.

In all these samples no spiking with active or inactive material was done. The concentrations of elements to be determined are those which are naturally present in the samples. Trace amount

of foreign substances may have been added to the samples during technical processes in their preparation.

3. EXPERIMENTAL

3.1 Chemicals

All the reagents employed in this study were either C.P. or Analar grade. The solutions were prepared using doubly distilled deionised water. Spec-pure metals or their corresponding compounds used as standards were procured from Johnson & Mathey Co, England. Buffer solutions of pH 4.5 were prepared by mixing appropriate amounts of 0.2M sodium acetate and acetic acid or 1M sodium acetate and hydrochloric acid, whereas 0.2M boric acid, potassium chloride and sodium hydroxide were used for buffers of pH 9 and 10.

3.2 Instruments

The neutron irradiations of the samples were performed in the Research Reactor PARR-I of PINSTECH. A Pye model 79 pH meter was used for pH measurements. A Nuclear Data computerized multichannel analyzer model ND-4410 coupled with a 30 cm^3 Ge(Li) detector (Canberra) having a resolution of 3.0 keV at 1.332 MeV was employed for gamma spectroscopy and radiometric assay. ^{60}Co and

^{137}Cs sources were used for energy calibration whereas the precise energies of the photopeaks were determined using a previously calibrated research pulser. Spectrophotometric measurements were carried out with a Beckman DU-2 Spectrophotometer. Atomic absorption spectrometric determinations were made with a Zeiss Atomic Absorption Spectrometer model AAD-3.

3.3 General procedure for the non-destructive determination of Manganese, Cobalt, Chromium Cesium and Zinc[2]

For manganese determinations the samples and the standards were sealed in polypropylene vials and irradiated for 5 to 30 sec at a neutron flux of $2x10^{13}$ n cm^{-2} sec^{-1}. The irradiated samples were allowed to cool for 100 minutes for the decay of ^{27}Mg. The samples, for arsenic determination, were irradiated for one hour and cooled for 24 hours. For other elements the samples and the standards were sealed in quartz vials and irradiated along with a flux monitor for 10 hours to 3 days and cooled for one to two weeks, for the decay of the short-lived radioisotopes. After appropriate cooling the gamma-ray spectra of the samples were recorded and the activities of the desired elements were measured by integrating the areas under the relevent full energy peaks. The standards were dissolved in nitric acid and an appropriate aliquot was radioassayed under similar conditions.

The amount of the desired element was calculated using the following equation.

$$\frac{A_x}{A_s} = \frac{W_x}{W_s}$$

Where A and W represent the activity (count rate) and weight of the element; x and s stand for samples and standard respectively.

3.4 General method for the destructive determination of Copper, Manganese and Zinc[3].

The irradiated samples were digested with (10 - 15ml) perchloric acid for about 40 - 60 minutes till a wet or clear solution was obtained. After cooling, 5 ml of 10% sodium citrate solution was added to mask iron present in the samples. The solution was then neutralized with 4N sodium hydroxide solution and 15 ml of a buffer solution of pH 10 was added and finally pH was adjusted to pH 9.5 to 10 with sodium hydroxide. Later 5ml of 2% hydrogen peroxide solution was added to oxidize manganese to a higher valence state and the contents were heated at 150°C for 15 - 20 minutes to dissolve $Al(OH)_3$ (if any) formed at alkaline pH. The solution was constantly stirred during heating. The appearance of hydrogen peroxide bubbles coming out ensures the complete oxidation of manganese. The solution was transferred to a separatory funnel

and 5 ml of 0.1% 1-(2-pyridylazo)-2-naphthol (PAN) solution in absolute ethanol was added. After 10 minutes metal chelates of copper, manganese and zinc formed with PAN, were equilibrated for 5 minutes with 30 ml of chloroform. The organic phase containing the metal chelates was mixed with 40 ml of pH 4.5 buffer and agitated for 10-12 minutes to strip manganese and zinc into aqueous solution. The organic phase was assayed for copper whereas aqueous phase was counted for manganese. After an over night cooling, when ^{56}Mn had completely decayed, zinc was measured in the aqueous phase.

3.5 Spectrophotometric assay of Iron in Air Filter[4].

Iron was determined spectrophotometrically in Air-3 filter. The impregnated and blank filter papers were digested in per-chloric acid at 80°C. The solution was taken into 6M hydrochloric acid. Iron was extracted quantitatively in diethyl ether. The organic phase containing iron was heated to dryness to remove ether, then 1-10, phenanthroline was added to make an iron(II) complex. This complex was extracted into chloroform and the absorbance was measured at 510 nm against a blank. The iron(III) complex with the reagent does not absorb at the above wave length, therefore it is necessary to ensure the complete reduction of iron(III) into iron(II) before the addition of 1,10 phenanthroline. Hydroxylamine hydrochloride was employed for the reduction

of iron(III). A calibration curve was drawn with known amounts of iron (10 - 50 µg/ml). Beer's law was obeyed through out the entire concentration of iron used.

3.6 Atomic absorption spectrometric measurement of Manganese and Zinc[5] in Soil-5.

A 100 mg aliquot of Soil-5 was mixed with 0.5 ml water then 10 ml of 65% nitric acid was added carefully in a covered beaker. This mixture was heated at 100°C for 2 hours on a hot plate. After cooling for 15 minutes, 3 ml of 30% hydrogen peroxide was added dropwise. The contents were heated for another hour with occasional stirring. After cooling, it was filtered and volume was made upto 100 ml. A 10 - 100 times dilute digestate was taken for analysis. Specpure standards of respective metals were treated similarly for comparison.

3.7 Atomic absorption spectrometric measurement of Iron[6] in Soil-5.

To a 100 mg sample, ten drops of deionised water and 5 ml of hydrofluoric and perchloric acid were added at an ambient temperature in a teflon beaker and left for 16 hours. The contents of the beaker were heated to dryness on a sand bath at 50-60°C. After adding 5 ml of each acid the contents were again heated to dryness. Then 2-5 ml of perchloric acid was added and heated till the complete elimination of hydrofluoric acid. The remaining residue was further heated with

25 ml of deionised water and 5 ml of hydrochloric acid till complete dissolution. Lanthanum nitrate solution was added and the volume was made up to 100 ml. Similarly specpure iron standard was treated and its solution was made for comparison.

4. RESULTS AND DISCUSSION

4.1 Determination of weight loss in the samples.

Most of the biological materials contain certain amount of moisture. The content of moisture was determined by drying the samples at 90°C for 20 hours or at the temperature for an appropriate time as suggested by the Agency. Since some elements might be lost from the samples during drying, therefore these measurements were carried out in separate aliquots and all the results are quoted on dry weight basis. The amount of the moisture determined in each sample is given in table I. The moisture content varies from sample to sample.

4.2 Elemental Analysis

To calibrate the instruments and methods to be employed for the analysis of reference materials of IAEA for minor and trace elements, Standard Reference Material No. 1571 (orchard leave) from NBS (U.S.A.) was analyzed for its sodium, manganese, copper and zinc contents. The results are compared in table II with the NBS certified

values which are based on 250 mg dried weight of the material. Our results for most of the elements are wit' in 5% deviation from the certified quoted values. It is evident from table II that the techniques used are fairly accurate and precise.

Most of the elements in th. samples were measured radiometrically by neutron activation analysis. These determinations were carried out via certain radionuclides. The relevent nuclear data of these radionuclides are given in table III. All the radionuclides listed in table III were not necessarily measured in all the samples. In few cases the results were also checked by atomic absorption spectrometry. The results of the analysis of the materials for copper, manganese, zinc and iron are recorded in table IV. The average values determined and their standard deviations along with IAEA values based on the average computed from the results of different participating laboratories are reported. However, IAEA values for fish flesh and lake sediment are not yet available for comparison.

Cobalt was also determined in soil, sea plant, lake sediment and in fish flesh. Chromium was measured in lake sediment and fish flesh whereas cesium was assayed in lake sediment. The amount of cobalt was found to be 17.8 ± 1.5, 3.16 ± 0.22, 20.3 ± 0.8 and $(6.97 \pm 0.24) \times 10^{-2}$ µg/g in soil-5, sea plant, lake sediment and fish flesh

respectively. The corresponding IAEA values for cobalt were 14.8 ± 2.3 and 3.8 ± 0.04 μg/g in soil-5 and sea plant respectively. The concentration of chromium in lake sediment and fish flesh were 120.2 ± 3.4 and 2.1 ± 0.16 μg/g whereas the amount of cesium determined in lake sediment was 9.8 ± 0.6 μg/g. It is evident from these results that in most of the analyses, our results are in a reasonable agreement with the probable values as reported by IAEA.

The amount of manganese in copepod homogenate and zinc in sea plant are somewhat low. The amount of manganese is although in the same order of magnitude as that of IAEA value but still it is four times less. This error may be attributed to the partial oxidation of Mn(II) to its higher oxidation state. In such cases, the extraction of manganese with PAN would be incomplete and would lower the results of manganese estimation. In the gamma spectrum of sea plant different peaks arising from the presence of bromine were also observed. These peaks offered some difficulties in the radiometric assay of the sample. The low estimation of zinc in sea plant may possibly be due to the interference caused by bromine present in the matrix.

The dissolution of lake sediment was somewhat difficult and the following method was employed for its dissolution. The sample was first treated with 5 ml

hydrofluoric acid, evaporated to dryness then 10 ml nitric acid was added and again was heated to dryness. This process was repeated three times after the addition of hydrofluoric and nitric acid alternatively. The remaining residue was later taken into 6N hydrochloric acid and iron being present in large amounts, was removed by extracting it with diethyl ether. Later, few drops of perchloric acid were added to the aqueous solution and the usual extraction procedure with PAN was followed. In this material, the interference of scandium in the determination of zinc was also noticed.

Animal muscle degrades and decomposes with the passage of time. This sample does not seem to be a suitable standard reference material because concentration of the elements in this matrix may vary due to its decomposition.

4.3 Estimation of standard deviation (S) and statistical error (σ) due to counting.

The errors quoted in the results (Table III and IV) is the standard deviation showing a 68.3% confidence level. The standard deviation was evaluated from the following relationship.

$$S = \sqrt{\frac{(\bar{X} - X)^2}{n - 1}} \qquad (1)$$

where $\bar{X}$ is the mean value of 'n' measurements and X indicates any individual determination.

The percent statistical error ($\%\sigma$) due to counting in the measurements carried out radiometrically is determined from the equation.

$$\%\sigma = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \sigma_4^2 + \ldots} \qquad (2)$$

where σ_1, σ_2, σ_3 and σ_4 etc. represent individual counting errors expected from 'A' count rate in different measurements of samples and standards.

$$\%\sigma_i = \pm \frac{\sqrt{A_i}}{A_i} \times 100 = \frac{100}{\sqrt{A_i}} \quad - - - - \qquad (3)$$

A particular element was determined in three different aliquots along with a standard, there could be a certain counting error in each radiometric assay of the aliquots and standard. All these individual counting errors were taken into account to calculate the overall statistical error ($\%\sigma$) by equation (2).

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Table I

Weight Loss in the Samples

S.No.	Sample	IAEA Reference No.	% Weight Loss
1.	Animal Bone[a]	A-3/1 (1972)	Nil
2.	Milk Powder[a]	A-8 (1972)	4.9
3.	Wheat Flour[a]	V-2/1 (1972)	10.1
4.	Mashed Potato[a]	V-4 (1972)	6.1
5.	Oyster Homogenate[b]	MA-M-1(1975)	7.4
6.	Soil-5[c]	Soil-5(1976)	0.74
7.	Copepod Homogenate[a]	MA-A-1(1977)	4.2
8.	Sea Plant[a]	SP-M-1(1977)	8.2
9.	Lake Sediment[d]	SL-1 (1977)	2.7
10.	Fish Flesh[b]	MA-A-2(1978)	3.3

a. Heated at 90°C for 20 hours.

b. Heated at 105°C till constant weight.

c. Heated at 105°C for 22 hours.

d. Heated at 105°C for 48 hours.

Table II

Analysis of NBS Standard reference material 1571 (orchard leaves)

Element	NBS quoted value (μg/g)	Our Results (μg/g)
Sodium	82 ± 3*	72 ± 5.8*
Manganese	91 ± 2	94.5 ± 1.9
Copper	12 ± 0.5	10.4 ± 0.5
Zinc	25 ± 1.5	24.2 ± 2.4

*Quoted errors stand for one standard deviation

Table III

Radionuclides used for measurement and their relevent data

Nuclide	Half - life[7]	Abundance of stable Nuclide[8] (%)	Thermal cross section for (n,r)[8] (Barn)	Prominent energies (keV)[7]	Relative Intensites[7]
^{51}Cr	27.72 d	4.35	15.9	320.078*	= 100
^{56}Mn	2.587 hr	100	13.3	846.751*	= 100
				1810.665	28.7
^{59}Fe	44.6 d	0.31	1.15	1099.224*	= 100
				1291.564	77
^{60}Co	5.268 y	100	17	1173.208*	= 100
				1332.491	= 100
^{64}Cu	12.78 hr	69.1	4.5	511.006*	= 100
^{65}Zn	243.7 d	48.9	0.78	1115.518*	= 100
^{69m}Zn	13.9 hr	18.6	0.072	438.634*	= 100
^{76}As	26.32 hr	100	4.3	559.068*	= 100
				657.02	14.0
^{134}Cs	2.06 y	100	26.5	569.35*	15.3
				604.73*	= 100
				795.84	87.0

* Gamma energies used for measurements.

Table IV

Results of elemental analyses

Metal	Copper µg/g		Manganese µg/g	
Name of the Sample & Reference No.	Our Results	IAEA Values	Our Results	IAEA Values
Animal Bone A-3/1 (1972)	3.1±0.2	6.8±0.3	39.9±1.9	32±5
Milk Powder A-8 (1972)	1.4±0.1	2.0±0.5	4.4±0.3	4.9±0.9
Wheat Flour V-2/1 (1972)	3.7±0.2	5.8±1.1	39.2±2.1	35±6
Mashed Potato V-4 (1972)	4.2±0.1	4.2±1.1	2.7±0.2	2.4±0.5
Fresh Water V-3 (1973)	$(1.4\pm0.1)10^{-2}$	$(1.4\pm0.2)10^{-2}$	$(1.4\pm0.2)10^{-3}$	$(7.7\pm1.5)10^{-3}$
Fish Soluble A-6 (1974)	4.6±0.2	5.25±0.64	3.9±0.2	4.73±0.56
Oyster Homogenate MA-M-1 (1975)	336±6.9	311±9	75±6	68±2
Air-3 (1975)	4.33±0.15	3.34±0.76	3.82±0.15	4.03±0.8
Animal Muscle H-4 (1976)	3.1±0.2	3.92	0.63±0.26	0.52
Soil-5 (1976)			995±52 849±18*	852±31
Copepod Homogenate MA-A-1 (1977)	8.5±0.7	12±4	0.8±0.1	3.2±0.4
Sea Plant SP-M-1 (1977)	15.7±1.2	13±1	55.6±2.9	61±3
Lake Sediment SL-1 (1977)	30±2.6	-	3056±879	-
Fish Flesh MA-A-2 (1978)	3.8±0.3	4.6 ± 0.4	1.1±0.05	1.0 ± 0.1

* Atomic absorption spectrometric results

Continued Table IV

Metal	Zinc µg/g		Iron µg/g	
Name of the Sample & Reference No.	Our Results	IAEA Values	Our Results	IAEA Values
Animal Bone A-3/1 (1972)	171±7	183±12		
Milk Powder A-8 (1972)	32.8±1.6	39±7		
Wheat Flour V-2/1 (1972)	31.8±1.0	33±5		
Mashed Potato V-4 (1972)	10.3±0.5	11.9±1.3		
Fish Soluble A-6 (1974)	17.3±0.8	18.9±1.3		
Oyster Homogenate MA-M-1 (1975)	2722±277	2700±100		
Air-3 (1975)	69.3±4.4	71±8	186.9±5.8	200±13.8
Animal Muscle H-4 (1976)	101.8±2.4	85.6		
Soil-5 (1976)	362±16	367±25	$(474\pm8.8)\times10^2$ $(446\pm7)\times10^{2*}$	$(446\pm68)\times10^2$
Copepod Homogenate MA-A-1 (1977)	162±7.5	220±70	67±3.5	69±6
Sea Plant SP-M-1 (1977)	15.6±1.6	66±5	1967±53	1790±70
Lake Sediment SL-1 (1977)			$(581\pm18)\times10^2$	
Fish Flesh MA-A-2 (1978)	34.1±1.13	36 ± 3	67.7±4.5	61 ± 4

* Atomic absorption spectrometric results