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Institut für Medizin

CONCENTRATIONS OF 15 TRACE ELEMENTS IN SOME SELECTED ADULT HUMAN TISSUES AND BODY FLUIDS OF CLINICAL INTEREST FROM SEVERAL COUNTRIES: RESULTS FROM A PILOT STUDY FOR THE ESTABLISHMENT OF REFERENCE VALUES

by
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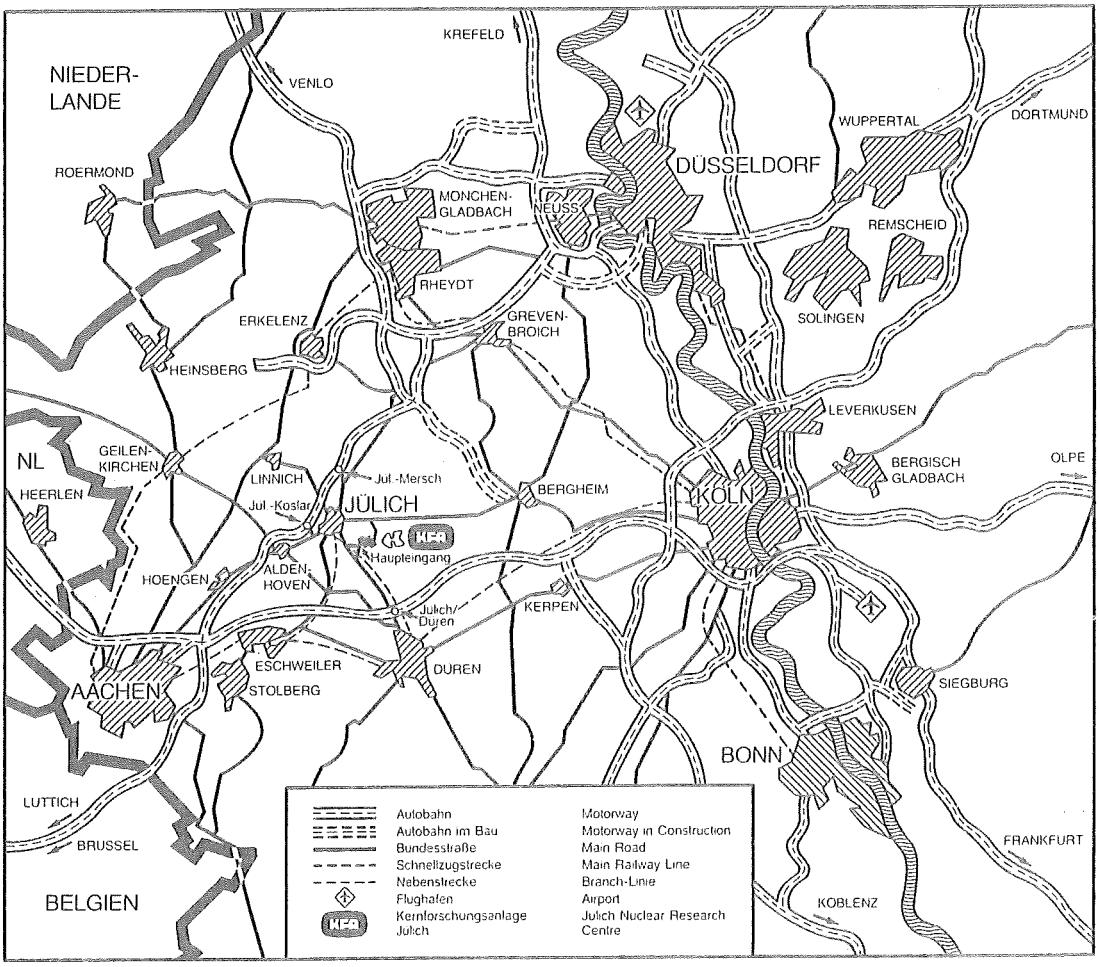

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PREFACE

This is an unusual compilation in the sense that over 6o investigators from more than 4o countries have contributed the data as active participants. It was emphasized that the collaborators should give due consideration to the analytical quality of the results before making any definitive recommendations. Because of this, in several cases it is possible to identify consistent tendencies in the reported findings, thus enabling meaningful interpretation of the data. Therefore, to a great extent, the compilation differs from the already existing ones.

Often, simultaneous analysis of different specimens from the same subject is required to obtain a more reliable picture of trace element deficiency or toxicity. Therefore, where only a single type of specimen is analysed and some identification of trace element imbalance has been observed, it is desirable to follow up and obtain more information on additional samples. This compilation is useful in identifying such situations. It contains a certain amount of well represented information and provides valuable hints for planning future investigations.

For some countries information was rather scanty. Nevertheless such inputs have been included as tentative values.

In grouping the countries together, both geographical and social aspects were considered. Thus, because of socio-historical moorings Turkey appears among middle east countries, though in a sense it falls in the European orbit from a geo-political view point.

The present compilation inspite of its limitations has brought into light two revealing features:

1) The existence of clear lacunae in reliable data for some elements
2) The virtual absence of any basic information for even some common elements as Cu, Fe and Zn from some of the developing countries.

Therefore, it is time for some of the International Agencies to step in and initiate measures to exploit the prophylactic properties of the essential trace elements for the benefit of human health, especially in the malnourished populations of the world. Such efforts are worthwhile and can be productive at little cost and much benefit. The task of assembling data, generating relevant information and even initiating well defined projects legitimately belong to one or more International Organizations and UN Agencies.

SUMMARY

Over 6o investigators, many of them with an outstanding international reputation as analysts were requested for reliable data from their countries on elemental concentrations in normal adult human samples of clinical interest.

A set of samples consisting of whole blood, blood serum, erythrocytes, urine, milk, liver and hair were chosen and considered for 15 elements of biological significance: As, Cd, Cr, Co, Cu, F, I, Fe, Pb, Mn, Hg, Mo, Ni, Se and Zn. The results represent wholly or partially data received from 4o countries of the global regions of Africa, Asia, Europe, North, South and Central Americas, Australia and New Zealand.

This survey even if qualitative, has been useful in demonstrating certain trends of the trace element scenario around the world. It is of course recognized that both diet and environment exert a strong influence on the distribution pattern of several elements such as As, Cd, Mn, Pb, Se and Zn. A limited comparison of the available information on soil status of different countries revealed interesting associations for elements such as Mn and Zn.

Importantly, this study revealed that only a few countries were in a position to supply a reasonable amount of data on samples requested for this project. Regretably, for a number of countries, any dependable data for even such essential elements as Cu, Fe and Zn were not available.

In view of the nutritional importance of many elements, the time is ripe for concerted efforts by International Organizations and Agencies to initiate investigations or commission task forces/projects to generate reliable reference data for selected global regions, which sadly lack data of any kind at present.

Section 1

INTRODUCTION

Literature data on the so called "normal levels" for elemental concentrations in biological systems, especially for trace elements, are full of controversial findings (1). Therefore, there are several problems in using such information for evaluating human health and related questions.

At this stage it is well to ponder on the expression "normal value" itself which is being used somewhat indiscriminately in the world of elemental composition of biological systems. For example, the same expression is used for Pb and Cd as well as for Cu and Zn. Strictly speaking, true normal values for Pb and Cd, e.g. in human blood, should be close to zero. However, environmental and other factors have contributed to the entry of these two elements into biological systems, and what one means in this case is an acceptable tolerance limit. On the other hand, elements such as Cu and Zn are absolutely essential for life and are homeostatically regulated. Therefore, under ideal conditions, their levels may be expected to fluctuate within narrow limits for a given species, thereby justifying the usage of normal levels.

It is highly desirable to establish such normal levels in human tissues and body fluids so that alterations during disease conditions can be detected. However, in practice it is a tough task requiring consideration of and compensation for a number of possible concurrent phenomena, and correlations are very complex. Thus baseline values can be deceptive and the question as to what is normal may not be very easy to answer. Therefore, it is more meaningful to establish reference ranges of values for different populations, taking the essential regional features such as dietary habits, environmental aspects and geochemical factors into consideration.

Sources of errors in literature values

In dealing with literature data, sometimes gross errors involving several orders of magnitude are not uncommon. These often stem from the use of an inappropriate analytical methodology. In some cases, however, it is evidently due to the failure in procuring valid samples for analysis. In this context it should be recognized that obtaining specimens that satisfy both biological and analytical criteria is governed by the presampling factors on one hand (2), and the demand for quality assurance in sampling, sample preparation, preservation and storage of the specimens, on the other (3-5).

Experience has revealed that even when adequate attention is shown to overcome the above mentioned factors, one still encounters difficult situations during data handling and data interpretation, arsing from such simple things as sketchy documentation. An additional handicap is that results are seldom accompanied by information on quality control by way of analysing certified or standard reference materials.

Because of this situation it has become difficult to identify reliable analytical results. Generally speaking, irrelevantly high or low and unreasonable analytical findings may be discarded as errors or artifacts. Yet, one is frequently faced with a difficult state of judgement where the analytical results fall within acceptable limits but there is no assurance for the reported accuracy. Unfortunately, this situation is rather common as seen from the bulk of literature data (1,6,7).

The workshop on Research needed to improve data on mineral content of human tissues sponsored by the American Institute of Nutrition in 1980 has dealt with some of the shortcomings of the existing literature data (8). The present report also shares the same concern and a pilot effort is made to have a better grip on the voluminous mass of published information.

The purpose of this report is to identify reliable analytical results for the elemental concentrations in selected tissues and body fluids and to examine the possibility of evaluating some reference values,

DATA BASE

The chief objective was not to collect a large quantity of data but to focus on the quality of the input, as much as possible.

Approach and selection of data

A number of analysts from different countries were requested to identify reliable data from their countries for adult human samples. It was emphasized that the analytical quality of the results was crucial.

A set of 7 samples of clinical interest, namely, whole blood, blood serum, erythrocytes, urine, milk, liver and hair were considered for 15 elements of biological significance: As,Cd,Co,Cr,Cu,F,I,Fe,Pb,Mn,Hg,Mo,Ni,Se and Zn.

For the selection of data 2 modes were followed:

1). Collaborating investigators' own results submitted with a qualifying statement concerning the analytical quality, and
2). Screened results from the literature undertaken by the present author in order to include as many countries as possible.

Over 6o investigators participated directly by sending their results. These were accepted as sent. The names of the participants are shown in Table 1.

Some of the collaborators did not provide extensive data but recommended selected sources and these were followed up by the author. Thus, taking all the input into consideration, the results cover over 55 countries. However, the extent of coverage of the information with respect to each country varies widely ranging from just one element in one of the requested samples to several elements in many of the specimens sought. Thus, the overall coverage of the countries includes,

Austria, Australia,
Bangladesh, Belgium, Botswana, Bulgaria,
Canada, Chile, China, Cuba, Czechoslovakia,
Denmark,
Egypt,
Finland, France,
Germany FRG, Germany GDR, Greece, Greenland, Guatemala,
Holland, Hong Kong, Hungary,
India, Iran, Iraq, Ireland, Israel, Italy,
Japan,
Kenya,
Luxembourg,
Mexico,
Nepal, New Zealand, Nigeria, Norway,
Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland,
South Africa, Spain, Sweden,
Thailand, Thaiwan, Turkey,
Uganda, UK, USA, USSR,
Venezuela, Vietnam,
Yugoslavia,
Zaire and Zambia.

Reliability of the data base

The concept that the analyst is the most important part of any analytical system forms the back bone. Some of the participants of this study are outstanding investigators of international reputation. Some of them have analysed standard reference materials (e.g. NBS bovine liver, IAEA animal muscle and milk powder) during the course of their analytical work to assess the accuracy and precision of the results. In some of the international collaborative studies from which data are extensively quoted in this report (e.g. Cd and Pb in blood, multielement multination study of human milk), extensive quality control steps were initiated using both the available reference materials and also by developing in-house standards. However, it must be pointed out that some of the crucial reference materials (e.g. blood serum) are still not avialable and that in such cases the discretion of the analyst or the participants forms the sole basis for inclusion of the results.

Extensiveness of the data

This collection is not a systematic compilation and is deemed to serve merely as a pilot study exploring the means to improve the quality of data collected. For a few elements in some specimens the input was scarce and therefore, only a couple of countries are listed with values. Hence, in some cases paucity of information reflected in this report may not necessarily indicate the real situation.

Presentation of the data

The elemental concentration values are tabulated in Tables 11 to 87. The data are grouped under African, American, Asian, Australian and European regions. Whereever information was available on the number of subjects, sex, analytical techniques used, Median, Mean and Standard Deviations of the Mean and the Ranges of the reported results, these are shown in the Tables. Comments if any, and sources of the information are also listed under the remarks column. Analytical techniques are abbreviated in Table 2.

Interpretation of the data

In section 2 under results and discussion an attempt has been made to interpret the results gathered during this survey. In this context it should be recognized that the data included here are from literature sources that are filtered to varying extents by the participants to reflect a measure of analytical reliability. Barring a few exceptions no new experiments were undertaken particularly to provide the information sought. Based on these back ground circumstances, gross comparisons of the concentration levels are made between different populations and a few conclusions are drawn. However, the differences reflected should be seen as merely qualitative indicators warranting fresh grounds for further investigations.

An attempt is also made to link the elemental concentrations of the tissues and fluids to the elemental status of the soil from the respective countries, where information was readily available. It may be mentioned that a definite conclusion based on such a comparison may not necessarily be valid, and any correlations observed should be regarded as qualitative markers.

The author recognizes the difficulties in directly relating the status of the soil to tissue levels. Besides such factors as extractability of an element from the soil, to what extent the locally grown food is consumed by the subjects and the bioavailability of the elements in such foods as reflected by the gastrointestinal absorption (Table 3), collectively influence the situation. Thus, for example, rural populations, especially from the developing countries, may generally be expected to subsist on local food products.

Whereas, urban populations (from cities such as Tokyo) are prone to the impact of food imports. Obviously, origin of such foods is crucial in this context. In spite of all such difficulties involved, the data reveal certain characteristic differences which are discussed under each element in section 2. Trace element status of soils from a few countries derived from a recent FAO report (9) is shown in Table 4.

LITERATURE CITED

1. Iyengar G.V., Kollmer, W.E. and Bowen, H.J.M.
The Elemental Composition of Human Tissues and Body Fluids
Verlag Chemie, Weinheim, FRG, 1978

2. Iyengar G.V.
Presampling factors in the elemental composition of biological systems
Anal. Chem. 54(1982)554A-558A

3. Iyengar, G.V.
Human health and trace element research: Problems and prospects
Sci. Total Environ. 19(1981)1o5-1o9

4. Iyengar, G.V.
Preservation and preparation of biological materials for trace element analysis: Quality assurance considerations, In Quality Assurance in Biomedical Neutron Activation Analysis, Report of an IAEA Advisory Group, IAEA-TEC-DOC (in press), IAEA, Vienna, 1984

5. Iyengar G.V. and Sansoni, B. & Sansoni, B. and Iyengar, G.V.
Chapters 5 and 6, Elemental Analysis of Biological Materials, Current Problems and Techniques with special reference to Trace Elements, Technical Report Series No. 197, IAEA, Vienna, 1980, 73-101,

6. Iyengar, G.V.
The Elemental Composition of Human and Animal Milk: A Review
IAEA-TEC-DOC 269, Vienna, 1984

7. Versieck, J. and Cornelis, R.
Normal levels of trace elements in human blood serum or plasma
Anal. Chim. Acta 116(1980)217-54

8. Research needed to improve data on mineral content of human tissues: Workshop Proceedings
Fed. Proc. 40(1981)2111-2158

9. Sillanpaa, M.
Micro nutrients and the nutrient status of the soils: A global study
FAO Soils Bulletin 48, Rome, 1982

Table 1

List of participants

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Table 2

Abbreviations for the analytical techniques (indicated as Meth.)

AAS	Atomic Absorption Spectrometry
AES	Atomic Emission Spectrometry, also ICP-AES[a]
ISE	Ion Selective Electrode Method
MS	Mass Spectrometry
NAA	Neutron Activation Analysis, also PAA[b]
POL	Polarography, ASV = Anodic Stripping Volatameetry
SAS	Solution Absorption Spectrometry
SFS	Solution Fluorescence Spectrometry
XRF	X-Ray Fluorescence Spectrometry also PIXE[c]

a) Inductively coupled plasma
b) Photon activation analysis
c) Proton induced X-ray emission

Units for expressing the concentration data

Fluids are expressed in mg or /ug/L. Occasionally they are also expressed as mg or /ug/kg. Urine is also given in /ug/24 hours in some cases. The solid specimens are expressed in their wet weight status under mg or /ug/kg.

Section 2

DISCUSSION

Only a few countries were in a position to supply reasonable amount of data for all the samples requested. A few comments are summarized in the following paragraphs.

The results of trace element concentrations for different tissues and body fluids are shown under "Frequent values" as observed in several countries. Deviations if any, from the frequent values are expressed as "relatively high" or "relatively low" values. For elements such as As, Hg and Se that are easily absorbed from the diet, the reported values are subject to variations depending upon the dietary status of these elements. Therefore, it may not always be possible to define frequent values in these cases. Similarly, for toxic elements such as Pb and Cd, frequent values may not necessarily mean tolerance levels since the overall expectation is to have as low levels as possible for such pollutant elements. Human milk is an example in this context (Jensen 1983).

Arsenic

Sample type	Unit	Frequent values	Relatively high values	relatively low values
Whole blood	/ug/L	2 - 7	Japan (Urban) = 15 Taiwan (Teipei) = 23	-
Milk	/ug/L	o.25 - 3.o	Philippines (Manila) = 24	-
Liver	/ug/kg	5 - 15	Japan and New Zealand (Urban areas) = 5o	-
Hair	/ug/kg	15o - 3oo	Canada (Urban), India (Bombay) & parts of U.K. = 4oo - 7oo	-
Urine	-	See	general	remarks

General remarks: Since As is one of the elements that is strongly influenced by its own abundance in the food, variations observed in many of the tissues and body fluids directly reflect the differences in the dietary intake of this element. Consistently high As values seen in blood (Japan & Taiwan), milk (Philippines) and liver and hair (Japan and India) presumably reflect the As status of the geochemical belt of that part of Asia.

Hair is known to be a good accumulator of As and therefore, depending upon the level of exposure true variations in the concentrations are possible. Carefully carried out experiments are of great value in this context.

For urine, only 2 results were received; Belgium = 1o and Denmark = 3o /ug/L.

Cadmium

Sample type	Unit	Frequent values	Relatively high values	Relatively low values
Whole blood	/ug/L	o.3 - 1.2 (non-smokers)	1 - 4 (smokers)	-
Milk	/ug/L	Few values, ≤1	Guatemala (city), Nigeria (Ibadan) & Philipinnes (Manila) = 2 - 5	-
Liver	mg/kg	≤1 - 2	Japan (Urban) = 3 - 4	-
Hair	mg/kg	o.4 - 1	Canada (Urban), Kenya (Nairobi) & Nigeria (Ibadan) 2 - 2.4	-
Urine	/ug/L	≤1?	(See general remarks)	

General remarks: Cd resembles Pb in its capacity to bind exclusively to RBC. However, it is difficult to demonstrate the sex difference as seen in the case of Pb because of the low concentration and subsequent analytical difficulties involved. Almost all of the 25 sets of the results for blood received from 15 countries fall within the range of o.3 to 1.2, for non-smokers. This is quite remarkable in view of the low concentration involved and speaks for the increasing awareness of quality control in many laboratories.

Urinary Cd values were received for only 5 countries. Of these, Germany (FR), USA and Belgium show less than 1 /ug/L, while Venezuela and Japan show 2 and 4.7 /ug/L, respectively.

Chromium

Sample type	Unit	Frequent values	Relatively high values	Relativaely low values
Blood serum	/ug/L	o.1 - o.2 (few results)	(See general remarks)	
Milk	/ug/L	1.o - 1.5 (few results)	Nigeria (Ibadan) and Philipinnes (Manila) = 4	-
Liver		(See	general	remarks)
Hair	mg/kg	o.3 -o.8	Bangladesh (Dacca), Chile (Santiago), Iran (Bagdad) & Pakistan (Islamabad)= 1.4 - 4	Egypt (several parts), Finland (Urban), Thailand (Bangkok) and USA (Denver) o.1 - o.2
Urine	/ug/L	o.2 -o.5? (few results)	Germany (FR, Urban) & New Zealand (Urban) = 1 - 2	-

General remarks: Generally speaking, not many laboratories are in a position to analyse Cr at low levels of concentration. Among the available results following

comments may be made.

Among the reported values for Cr in whole blood, lowest value has been from Canada = 2o /ug/L, followed by 28, 3o and 45 from Egypt, U.K. and Japan, respectively.

Of the 9 sets of results received for liver, values from the U.K. are the lowest showing 8 /ug/kg. There are variations reported within the country too, e.g. Japanese values show 12 to 66 /ug/kg, while values from 3 different regions of the U.S.A. namely Baltimore, Mineapolis and Seattle are quoted to be 11o ± 12o.

A total of 8 results are available for Urine. Of these, 6 of them are in the range of o.2 to o.5 /ug/L. For Germany and New Zealand the results are somewhat higher and fall between 1.1 to 1.8 /ug/L.

Cobalt

For blood serum 3 results were received with values of o.11, o.12 and o.46 /ug/L from Belgium, Germany FR and Italy, respectively. In whole blood a value of 4o /ug/L has been reported form Canada. One result from Belgium suggests a concentration of 16 /ug/kg of RBC while the Italian group has quoted 46 /ug/kg.

Results for milk show a mixed pattern. The WHO study group countries (Guatemala), Hungary, Nigeria, Sweden, Philippines and Zaire) show a range of o.3 /ug/L (Sweden) to 1.6 /ug/L (Philippines).

The variations seen for Co in liver are rather wide. They range from 6 /ug/kg in Japan to 151 /ug/Kg in New Zealand. Since liver being a store for vitamin B_{12}, such differences are propably not surprising. The contrasting values seen for Japan and New Zealand may well reflect the differences resulting from food intake.

Hair Co concentrations cover a wide range over 3o /ug/kg in Czechoslovakia to 5oo /ug/kg in Germany and Canada. It is not possible to assign any particular grouping for the distribution of Co in hair.

In urine, it appears that the concentration is between 1 and 2 /ug/L.

Although several variations are noted in the concentration of Co in various tissues and body fluids, the changes by themselves may not be of any significance since only a small part of the total inorganic Co found in the specimens is biologically active in the form of Vitamin B_{12}.

Copper

Sample type	Unit	Frequent values	Relatively high values	Relatively low values
Whole blood	mg/L	o.8 - 1.1 (males) 1.o - 1.4 (females) (same levels in serum and erythrocytes)	Aboriginals (Australian settlements) and Tokelau Islanders (New Zealand) 1.4 - 1.8	-
Milk	mg/L	o.25 - o.4	Australia (Geelong), New Zealand (Dunedin), Greece (Athens), Finland (Helsinki) & Turkey o.5 - o.7	Hungary (Budapest, Sweden (Uppsala), U.S.S.R. (Urban) & Zaire (Lwiro) ≈ o.2
Liver	mg/kg	5 - 8	Japan (Urban) = 1o	Bulgaria (Vratsa)=3
Hair	mg/kg	15 - 25	Australia (Brisbane) = 39	Bangladesh (Dacca), Botswana, Pakistan (Islamabad), Turkey (Istanbul) and parts of Nigeria and New Zealand = 1o
Urine	/ug/L	3o - 6o	-	-

General remarks: Finland and Turkey show highest concentrations of Cu in milk. Yet, from the point of view of soil, they are classified as normal or normal to low (Table 4, Ref. 9 from section 1). However, among countries grouped under low concentration (e.g. Hungary, Sweden & Zaire), the soil status of Hungary is known to be deficient (Table 4, Ref. 9 from section 1).

Concentrations of Cu in hair from Kenya, Australia and to some extent in New Zealand are high. As for soil, only for New Zealand the status of Cu is known and is quoted to be normal to high. Pakistan, Turkey, Nigeria, Thailand, Bangladesh, East Germany and Tokelau Islands (NZ) show low levels in hair. The official soil status in the first 4 countries is given as normal to low in the FAO report (Table 4, Ref. 9 in section).

For urine, part of the results are quoted as concentration and the remaining ones are expressed as 24 hour clearance. Since no figures were provided to convert these values to a single base, no comparisons are feasible.

Fluorine:

No results were received for any of the requested specimens with the exception of milk.

Of the 8 results received for milk, based on median values, the concentration measured for the Philippines is the highest being 118 /ug/L. Finland and Zaire show low values of the order of about 7 /ug/L. The remaining results fall in the range of 9 to 17 /ug/L.

Iodine

Very few results were received for I in whole blood, serum or urine. Typically, in blood serum the concentration appears to be between 5o and 7o mg/L.

In milk, with the exception of Zaire, median values for all other countries fall in the range of 4o to 8o mg/L. Zaire, a country known to be having I deficiency problems shows 15 mg/L.

Only one result was received for I in liver from U.K. showing o.2 mg/kg.

In hair, with the exception of Nigeria and India which show values exceeding 3 mg/kg, most other countries show a relatively narrow range of o.4 to 1 mg/kg.

Iron

Sample type	Unit	Frequent values	Relatively high values	Relatively low values
Whole blood	mg/L	425 - 5oo	-	Bangladesh (Dacca), Iran (Teheran and U.S.S.R. (Urban) = 3oo - 34o
Blood serum	mg/L	o.8 - 1.2	-	-
Milk	/ug/L	35o - 6oo	Chile (Santiago), Italy (Rome), Philippines (Manila), Turkey (Istanbul) & Zaire (Lwiro) = 7oo - 17oo	Germany (FR) and and some parts of U.S.A. = 2oo - 26o
Liver	mg/kg	15o - 25o	(See general remarks)	
Hair	mg/kg	3o - 6o	Botswana (Bushman subjects), Kenya (Nairobi), South Africa (Bantu subjects), parts of Egypt and Iraq = 1oo - 9oo	Australia (Victoria), Iran (Teheran), Turkey (Istanbul) and Vietnam (Urban) = 5 - 2o
Urine	/ug/L	1oo - 15o? (few results)	-	-

General remarks: In liver, variations are seen for different sets of results from the same country. Also, livers from female subjects contained lower concentrations than those from males. For example, results from Canada show mean values between 46 and 116 mg/kg for females of 55 years of age and above, while ranges of mean values for males varies from 132 to 262 mg/kg. Also, low values of 115 mg/kg are reported for subjects from Cuba aged 2o to 46 years.

Concerning Fe in milk, several factors are involved and the results should be evaluated carefully (Iyengar 1982, Ref. 6 in Section 1, Lonnerdal et al 1981).

No notable associations are seen for soil Fe status and the tissue concentration levels.

Lead

Sample type	Unit	Frequent values	Relatively high values	Relatively low values
Whole blood	µg/L	9o - 15o	India (Bangalore), Italy (several cities), Mexico city, parts of U.S.A. and Canada = 2oo or more	China (Peking), parts of Japan & Sweden = 5o - 8o Nepal and some remote parts of Venezuela = 8 - 3o
Milk	-	(See	general	remarks)
Liver	µg/kg	35o - 55o (few results)	New Zealand (some parts) and U.K. (Urban) = 1ooo - 2ooo	-
Hair	-	(See	general	remarks)
Urine	-	(See	general	remarks)

General remarks: In milk, high values are found in the Philippines, Spain, Sweden and Hungary extending up to 17 µg/L. In the U.S.A. a range of 12 to 26 µg/L has been reported from Cincinnati area. Nigeria, Zaire and Guatemala have reported concentrations of about 3 to 5 µg/L.

In hair, high levels are seen in samples from Nigeria = 52, Kenya = 42, some parts of the U.S.A. = 19 to 45 and Canada = 17 mg/kg. Countries such as India (rural), Bangladesh and Iran represent some of the low exposure areas with values around 3 to 5 mg/kg. No results were received for any of the European countries. The reader may refer to other compilations (Pankhurst & Pate 1979, Jenkins 1979) which have listed some of the findings. The reader may also consult another source (Grandjean 1979) which illustrates the differences in the accumulation of Pb in hair due to low level and occupational exposures resulting in accumulations up to 5 mg/kg in non exposed persons and up to 1oo mg/kg in exposed populations.

Only a few results were received for Pb in urine. These values show typically 6 to 12 µg/L for Japan and Belgium, for example. Control of external contamination is a major problem in handling urine for Pb analysis and extreme precautions are necessary to obtain dependable results.

A few other points concerning the environmental impact of Pb has been dealt with in section 3 of this compilation.

Manganese

Sample type	Unit	Frequent values	Relatively high values	Relatively low values
Whole blood	/ug/L	8 - 12	India (Bombay), Japan & Canada (Urban) = 18 - 28?	-
Blood serum	/ug/L	o.5 - 1.o	-	-
Milk	/ug/L	3 - 6	Nigeria (Ibadan), Philippines (Manila) & Zaire (Lwiro) = 11 - 4o	-
Liver	mg/kg	1.1 - 2.1	-	Sweden & U.K. (Urban) = o.5
Hair	mg/kg	o.5 - 1.5	Marginally high in India (Bombay), Nigeria (Ibadan), Pakistan (Islamabad) & Thailand (Bangkok) = 3 - 4, high in Kenya (Machakos District) = 15	-
Urine	-	Very few results, see Table 43		

General comments: Considerable number of results available for Mn in milk allow some comparisons to be made. The high values seen in samples from Philippines and Nigeria match the Mn profile of the soil (Table 4, Ref. 9 from section 1). As for New Zealand, which shows high values in urine (3 - 19 /ug/24 hours), soil status is recorded as moderately high. Soil status of Zaire (high Mn in milk) is unknown to the author. However, high values seen in hair from a number of countries do not always correlate with the soil Mn status.

Mercury

Sample type	Unit	Frequent values	Relatively high values	Relatively low values
Blood	-	(See	general	remarks)
Milk	/ug/L	1 - 3	Nigeria (Ibadan), U.S.A. (Alaska) & Zaire (Lwiro) = 5	-
Liver	/ug/kg	3o - 15o	Japan & U.K. (Urban) = 25o - 5oo	-
Hair	mg/kg	o.5 - 2	Japan (Urban), Kenya Machakos District), Italy (Rome) & parts of U.S.A. = 3 - 12	-
Urine	-	(See	general	remarks)

General remarks: The picture for Hg in blood is confusing. 3 sets of Japanese values range from 2o to 59 /ug/L. 2 sets of results from the U.S.A. (Eskimos) and one set each from Italy and Venezuela have values between 13 and 2o /ug/L. Other results range from o.6 /ug/L in Germany to 1o /ug/L in parts of the U.S.A.

Hg resembles As in its absorption from foods and therefore, variations in tissue and fluid levels are indicators of the intake of this element.

For urine, not many results were received. Of the reported results, Japan and Italy show high values of about 6 to 7 µg/L. In Belgium and Germany (FR), the concentration reported is about 1 µg/L. On a 24 hour clearance basis, values for the U.S.A. and Denmark show up to 2o µg.

Molybdenum

Only a few results were received for this element in blood, urine and hair.

In milk, the spread of values range from about 1 µg/L in Hungary and Sweden to about 4 µg/L in Guatemala, Nigeria and Zaire. Both India and the Philippines show high values of 9 and 2o µg/L, respectively.

Of the 7 sets of results received for liver, with the exception of the Belgian value = 36o µg/kg, all others fall in a close range of 5oo - 8oo µg/kg.

Nickel

Results received for this element are too few for any meaningful comparisons.

In milk, results for Germany (GD) show highest values of 39 µg/L. Low values are reported from Finland = 1.5 µg/L. For a number of other countries, the results are spread between 1o and 2o µg/L.

In hair, the variations observed between countries are too great.

Selenium

Sample type	Unit	Frequent values	Relatively high values	Relatively low values
Whole blood	µg/L	9o - 13o	Canada (Hamilton), U.S.A. (Wyoming) & Venezuela = 16o - 24o	China (Keshan area), parts of Egypt & Finland, Italy (Amiata area) & New Zealand = 2o - 6o (whole blood or blood serum)
Blood serum	µg/L	75 - 12o		
RBC	mg/Kg	1oo - 18o	-	
Milk	µg/L	15 - 25	Chile (Santiago) & Philippines (Manila) = 33 - 62	Parts of Australia, Finland & New Zealand & U.S.A. ≈ 1o
Liver	µg/kg	25o - 4oo	Parts of Japan & U.S.A. = 5oo - 7oo	Bulgaria (Vrasta) & New Zealand = 6o-19o
Hair	mg/kg	o.5 - 1.o	Parts of Japan & U.K. = 2.2 - 4.o	Parts of Finland & Germany (GD), China (Shan Xi area) & Italy (Amiata area) = o.2 - o.3 and China (Keshan area) & parts of Greece = < o.1
Urine	µg/L	25 - 5o	parts of Canada & Japan = 125 - 16o	Italy (Amiata) and New Zealand = 7 - 13

General remarks: For blood and liver there are two sets of results from U.K. one covering Glasgow area and the other a general survey of the country. These values differ from each other significantly.

As seen from the results presented, several countries have reported low Se values in one or more tissues or fluids. The FAO soil study report does not give information on Se. However, it is known from other sources that countries such as New Zealand, Finland and China (some parts) have Se deficient soils. Since Se levels in tissues and body fluids are known to be extremely susceptible to changes in dietary intake and reflect even short term variations in input, changes in Se levels of biological samples should be interpreted carefully.

Zinc

Sample type	Unit	Frequent values	Relatively high values	Relatively low values
Whole blood	/ug/L	6 - 7	Japan (Hokkaido) & U.S.A. (Illinois) = 9	Bangladesh (Dacca) & India (Bombay) = 4 - 5
Blood serum	/ug/L	o.8 - 1.1	-	Parts of Turkey ≈ o. o.55
RBC	mg/kg	1o - 13	-	-
Milk	mg/L	1.5 - 2	Chile (Santiago), Finland (Urban), Guatemala city, Italy (Rome) & New Zealand = 3 - 7.2	Hungary (Budapest), Sweden (Uppsala), Turkey (Istanbul) & Yugoslavia (Ljubljana) = o.8 - 1.3
Liver	mg/kg	4o - 6o	-	-
Hair	mg/kg	15o - 25o	Poland (Warsaw) = 32o	Bangladesh (Dacca), parts of Egypt, Kenya (Machakos District), S.Africa (Bantu subjects), Turkey (Istanbul) & parts of U.S.A. = 1oo - 14o
Urine	/ug/L	4oo - 6oo	Information scarce	Information scarce

General remarks: Based on the picture of relatively low values of Zn in blood, milk or hair, countries such as Bangladesh, Egypt, Hungary, India, Kenya, Sweden, Turkey and Yugoslavia, etc, fall into one group.

Of these, Hungary, Sweden and Yugoslavia show low values only in milk. This condition may not necessarily reflect the deficiency if any, in the mother, but its significance to the infant during the breast feeding stage is self explanatory. For example, depressed concentration of serum Zn is known in malnourished children (Panday et al 1983). Other examples are also known (Murzan 1976).

The list of Zn deficient groups would have been certainly longer if results were available from more countries. A further discussion of Zn deficiency and its probable association with soil Zn status is discussed under section 3.

Section 3

SOME SALIENT FEATURES OF THIS COMPILATION

1. For a few elements such as Zn, data were available from a number of countries and therefore, some comparisons were possible. For example, as shown in Tables 4 and 5, an association between the Zn status of the soil and the Zn status of some tissues and fluids was reflected and in some cases it appeared to be consistent. Turkey is one example in this context.

   Keeping in mind the limitations mentioned under interpretation of data, a few such comparisons are possible for elements such as Cu, Fe, Mo and Mn, whose soil status is summarized in Table 4.

2. Distinct regional variations on a global level are clearly demonstrated for Pb in whole blood (Table 6).

   Comparison of the blood Pb levels reveals that men have about 2o to 3o per cent more of this element in their blood than women. This is confirmed in several studies and in many countries. Since almost all of the Pb in blood is known to be associated with RBC, a substantial part of the sex difference in concentration is explained by the hematocrit. The remaining part of the difference can be related to the variability in the working environment and food consumption (quantity). Therefore, expressing the concentration of Pb on the basis of RBC weight is more helpful in identifying other factors that influence the concentration of this element in blood. Smoking elevates blood Pb only to a small extent whereas, consumption of wine (e.g. Italy) may elevate the level by a factor of about 1.5 (Table 48).

   Such indisputable inforamtion is required for many elements in context of environmental health.

3. Cd offers yet another example revealing the variations arising out of habits, such as smoking tobacco. The data convincingly show that smokers have more Cd in their blood than non-smokers (Table 6). In view of the known deliterious effects of this element on human health, data such as these, provide compelling evidence for pregnant mothers to abstain from smoking, to quote one example.

4. The data on milk summarized for the 6 countries in Tables 7 (concentration) and 8 (calculated mean daily intake by the infants), are self explanatory. They clearly expose toxic and deficient situations and provide a great step forward in establishing firm dietary allowances for trace elements in order to maintain optimal health. Figure 2 illustrates the case of Mn in this context (Iyengar 1984, Parr 1984).

5. Until now, it was seldom possible to appreciate the true inter-sample variability taking both analytical and biological variations into consideration due to basic flaws in the accuracy of the analytical results. However, results from very carefully conducted studies are now available that facilitate the understanding of such differences in concentrations in similar samples drawn from different regions of a country. An excellent example is given in Figure 2, which shows clear cut regional differences in liver from 3 areas of the USA (Baltimore, Mineapolis and Seattle). Se varies by a factor of 2 between these cities. This study was under rigid quality control supervision right from the planning stage of the investigation (Zeisler et al 1984).

6. A number of elements occur at rather low concentration levels in several body fluids (Table 9) and their accurate determination has always been a problem. However, it is encouraging to note that the accuracy for reported data on trace elements in tissues and body fluids is improving day by day. This compilation has for example, fairly consistent values for elements such as Co, Cr, Mn and Mo, which are considered as difficult elements to determine at the level they are present in blood serum.

   In some other cases too there are methodological problems and unacceptable results still appear. For example, a study, recently conducted by the International Union of Pure and Applied Chemistry (IUPAC) in which the present author also participated, revealed that for Se some methods tended to give rather low or highly dispersed results (Figure 3). However, many of these analytical difficulties are better understood now, and with more and more quality control procedures being introduced, the picture is becoming more optimistic.

7. Finally, some more effort is still needed to characterize the sample precisely before the analysis is taken up. "Validity" of the specimen is very important since even "Status at sampling" may have considerable influence on the concentration of trace elements in a typical clinical specimen such as blood (Table 1o). These and other aspects of choosing a specimen and accounting for the presampling factors are dealt with in detail (Iyengar 1982, Iyengar 1983, Iyengar 1984).

Table 3 Normal dietary intake, gut absorption and urinary excretion in human subjects (median values from literature)

Element	Absorption [a] (per cent of injested dose)	Dietary [b] intake (mg per day)	Urinary [b] excretion (mg per day)
B	high (60–100%)	1.3	1
BR		4	4
F		2	1.7
I		0.2	0.17
MO		0.2	0.1?
TL		0.015	0.0008
		0.02	0.02
AS	medium (10–50%)	0.1	0.05
CO		0.02	0.001?
CU		2.5	0.05
FE		16	0.2
HG		0.01	0.004
PB		0.3	0.05
SE		0.15	0.05
SR		1.5	0.24
ZN		13	0.44
AL	low (<10%)	10	0.1
CD		0.04	0.001
CR		0.05	0.001
MN		4	0.0004
NI		017-0.4	0.01
SN		1	0.02?
V		0.01	0.002

[a] Iyengar 1984, [b] Bowen 1982 (personal communication)

Table 4. The nutrient status of soils from selected countries

Country	Cu	Fe	Mn	Mo	Zn	Remarks
Belgium	N[a)]	N-H	N	N	EH	Generally acidic, mostly coarse in texture, medium organic matter content and low cation exchange capacity
Egypt	N-H	N	N-L	N-H	N-L	Fine textured, highly alkaline, medium organic matter content and high cation exchange capacity
Finland	N-L	H	N	N	H	Generally acidic, widely varying texture, high organic matter and relatively high cation exchange capacity
Hungary	L	L	L	L	L	Vary widely in regard to texture, pH and cation exchange capacity, somewhat lower organic matter content
India	N	L-N	L	H	L	Relates to northern States, coarse texture, alkaline, low in organic matter content and low cation exchange capacity
Iraq	N	N	L	H	L-VL	Medium to fine textured, highly alkaline, low in organic matter content and medium cation exchange capacity
Italy	EH	N	L	H	N-L	Vary greatly in texture, alkaline pH, medium organic matter content and medium cation exchange capacity
New Zealand	L-H	H	N-H	L	L-H	Cu and Zn are low in north and south island and high Tonga and Rarotonga, Medium textured, severe to moderately acidic and high organic content
Nigeria	N-L	N-L	H	N-L	L-H	Coarse in texture, low in organic matter content, varying pH and low cation exchange capacity
Pakistan	N	N	L	H	L	Coarse to medium texture, low in organic matter and cation exchange capacity
Philippines	EH	H	H	N	H	Wide variations in soil properties
Thailand	N	N	N	N	L	Heavy to medium textured, varying pH, relatively high organic matter and high cation exchange capacity
Turkey	N	L	L	N	L-VL	Alkaline, low in organic matter and relatively high in cation exchange capacity
Zambia	VL	N-L	VH	VL	L-N	Mostly acidic, coarse to medium textured, low in organic matter content and low in cation exchange capacity

[a)] L low, N normal, H high, EH exceptionally high, VL very low, VH very high and L-H varying from low to high

Table 5. Some examples of countries showing different values for Zinc (mg/L or kg) in 3 specimens compared with known soil status

Specimen	Zn level	Soil Zn status	Countries	Remarks
Whole blood	8 – 8.5	?	Japan	Hokkaido region
	6 – 7		several countries	
	4 – 5	?	Bangladesh	
		very low	India	
Blood serum	0.50	very low	Turkey	Some parts
Milk	> 3	high	Finland	
		high	New Zealand	
		?	Chile	
	2 – 3	?	Guatemala	
		high	Phillipines	
		Normal - high	Italy	
	< 1.5	very low	Hungary	
		?	Yugoslavia	
		?	Japan	urban area
		?	Russia	
	< 1	very low	Turkey	
		?	Sweden	
Scalp hair	> 250	?	Poland	
	160 – 250		several countries	
	< 160		S. Africa	Bantu subjects
		very low	India	
		?	Bangladesh	
		?	Panama	
		?	Egypt	
	< 130	very low	Kenya	Machakos district
		very low	Turkey	

Table 6

Lead and Cadmium in Whole Blood

	Groups	/ug/L
Lead	Frequent values covering many countries	9o-15o
	High values in India (Bangalore), Italy (many cities), Mexico city, U.S.A. (Los Angeles) & Canada (Halifax)	17o-24o
	Intermediate values in China, Japan and Sweden	5o-8o
	Low values in Nepal & remote parts of Venezuela	8-3o
Cadmium	Non-smokers	o.3-1.2
	Smokers	1.o-3.7
	Factor between Smokers & Non-smokers =	3-12

Table 7 . Median concentrations (ug/L) of selected elements in milk samples from 6 different countries, ( ) = number of samples

Country	Zn	Se	I	Ni	As	F
Philippines	198o	33.2	57.4	16.1	19	118
	(65)	(65)	(1o)	(62)	(14)	(32)
Nigeria	168o	24.2	61.6	12.2	1.8	26.4
	(65)	(65)	(7)	(14)	(6)	(7)
Zaire	192o	19.3	14.8	4.9	o.26	7.5
	(69)	(69)	(18)	(59)	(2o)	(46)
Guatemala	261o	19.2	59.8	12.9	o.3o	9.1
	(84)	(84)	(23)	(74)	(26)	(23)
Hungary	12oo	13.9	63.8	14.4	o.24	14.5
	(71)	(71)	(31)	(74)	(11)	(52)
Sweden	7oo	13.1	55.7	11.o	o.55	17.o
	(32)	(32)	(16)	(31)	(8)	(1o)

Table 8. Measured daily intakes of elements through milk (median concentration x median volume) and comparison with WHO and NAS recommendations

Element	Unit	Measured intake in study areas						Recommended intake	
		Phi	Nig	Zai	Gua	Hun	Swe	WHO[a]	NAS[b]
Co	ug/d	0.91	0.38	0.22	0.16	0.10	0.22	-	-
Cr	"	2.20	2.60	0.60	0.80	0.50	1.20	-	0-40
Cu	"	173	167	120	173	136	149	480	500-700
F	"	76	16	4.4	6	10	14	-	100-500
Fe	"	460	314	334	228	244	357	-	10 000
I	"	37	43	6.1	39	44	44	-	40
Mn	"	25	9.5	6.7	2.5	2.7	2.6	-	500-700
Se	"	21	14	12	13	9.3	11	-	10-40
Zn	mg/d	1.3	1	1.2	1.7	0.8	0.6	3.1-12.5[c]	3

a) Trace Elements in Human Nutrition, WHO Report 532 (1973)

b) Recommended Dietary Allowances, National Academy os Sciences, Washington (1980)

c) varying according to different assumptions about fraction absorbed

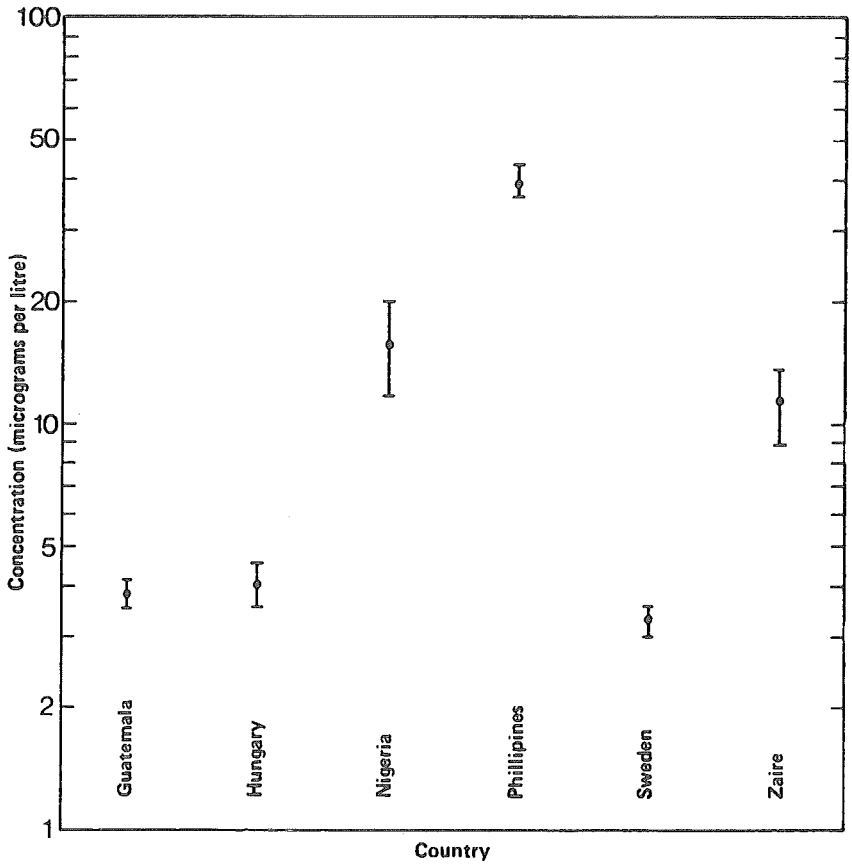


Figure 1. Manganese concentrations in human milk from different countries. The values plotted are the median concentrations ± one SD of median. Note that the concnetration scale is logarithmic. (By permission of Dr. Parr), Parr 1983

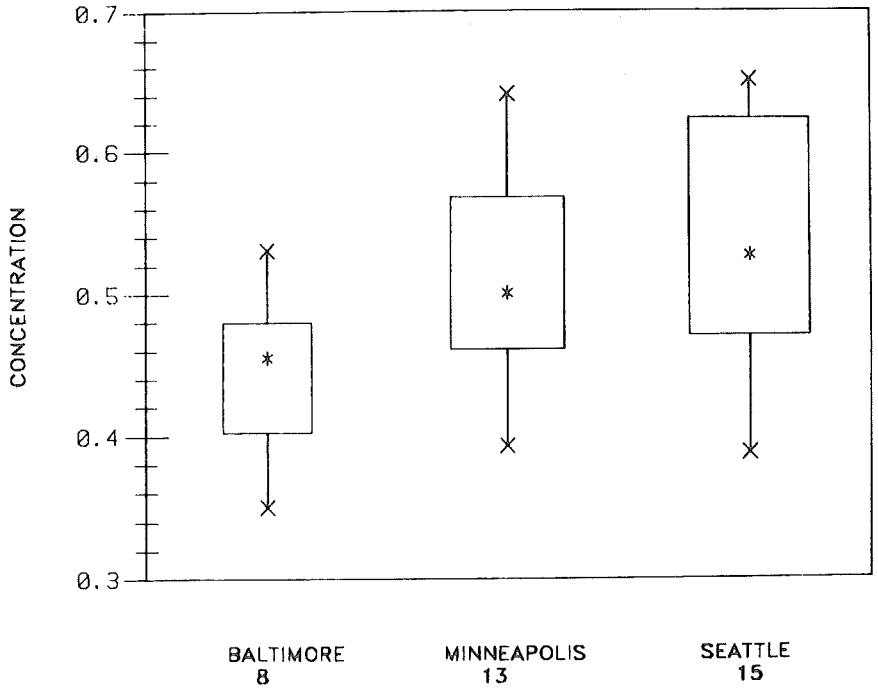
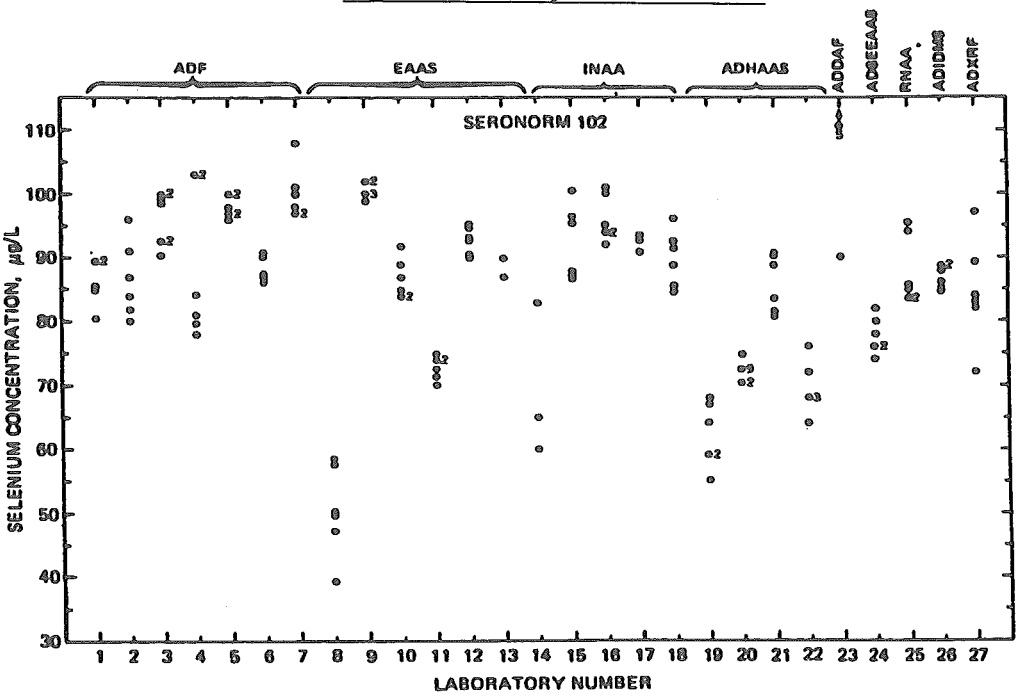


Fig. 2 , Mean concentrations (μg/g fresh weight) of selenium in liver specimens from three geographical locations. X, range of values; *: mean concentration. Rectangles represent 50% of the values.

Figure 3

IUPAC study on Performance of Analytical Methods in absence of a certified reference material for human serum (1983)

Element investigated : Selenium



Method	Entire lab population No. of labs	No. of Obs.	Mean concn. ± SE, µg/L	After Exclusion of labs No. of labs	No. of Obs.	Mean concn. ± SE, µg/L
ADF	7	42	91.8 ± 2.2	6	36	92.4 ± 2.6
EAAS	6	32	81.2 ± 7.7	4	20	92.8 ± 3.4
INAA	5	24	89.8 ± 4.2	4	21	92.7 ± 1.4
ADHAAS	4	30	72.3 ± 3.9	1	6	85.9 ± 1.8
ADDAF	1	6	149 ± 18	–	–	–
ADSEEAAS	1	6	77.7 ± 1.2	–	–	–
RNAA	1	6	87.8 ± 2.2	1	6	87.8 ± 2.2
ADIDMS	1	6	86.6 ± 0.6	1	6	86.6 ± 0.6
ADXRF	1	6	84.5 ± 3.4	1	6	84.5 ± 3.4

Methods

ADF = Acid decomposition-fluorometry
EAAS = Electrothermal Atomic Absorption spectrometry
INAA = Instrumental Neutron Activation Analysis
RNAA = Radiochemical "

ADHAAS = Acid Decomposition Hydride generation AAS
ADSEEAAS = " Solvent extraction AAS
ADDAF = " Dry ashing Fluorometry
ADIDMS = " Isotope Dilution Mass Spec.
ADXRF = " X-ray Fluorescence Spec.

TABLE 9

SOME EXAMPLES OF ANALYTICALLY CRITICAL CONCENTRATION LEVELS ENCOUNTERED IN ANALYSIS OF BODY FLUIDS (VALUES IN µG/L)

ELEMENT	URINE	SERUM	BLOOD
AL	≤ 1	≤ 1	≤ 1
AS	≤ 10	LOW AND VARIABLE	≤ 1 LOW & VARIABLE
CD	≤ 1	< 0.05	1(?)
CO	1(?)	< 1	< 1(?)
CR	< 1	< 1	< 1 (?)
HG	< 2	?	≤ 2
MN	< 1	< 1	5-20
MO	?	< 1	?
NI	≤ 2	< 2	< 2
PB	≤ 10	< 2	30-300
V	?	≪1	?

TABLE 10

Influence of "status at sampling" on the concentration of selected elements in human subjects: Some examples

Sample	Element	Condition	Influence	Remarks
Serum	Zn	Fasting	Elevated	Even over night fasting
		After food	Lowered	Low in first few hours
		Stress	Elevated	Sampled while standing
		+ sea food	Elevated	e.g. Oyster
		Low Zn intake	Lowered	Rather sudden effect
		Pregnancy	Lowered	Progressive decline
Serum	F	Fasting	Normal	Over night fasting
		After food	Variable	If sampled immediately
		+ Tea	High	"
		Low F intake	Lowered	Over a few days
Serum	I	High I intake e.g. Sea food, excess intake of iodinated salts, etc.,	Elevated	Level declines slowly since the uptake is rapid and biological halflife is about 2.5 weeks.
Serum	As	Shrimp consumption	Normal	No absorption of As from this source
		Fish consumption	Elevated	Well absorbed and declines over a few days
Blood	Cd	Smoking	Elevated	Remains chronically high in smokers
	Pb	Alcohol	Elevated	E.g. Wine consumption

CONCLUDING REMARKS

Although analytical awareness has been the basis for the results presented here, they must be used with caution. This is because there are still some unresolved analytical problems related to trace element analysis of the biological specimens.

Nevertheless, this survey has been useful in demonstrating certain trends in the trace element picture around the world, at least qualitatively. Both diet and environment exert strong influence on the trace element distribution pattern in tissues and fluids as seen for several elements, e.g. As, Cd, Mn, Pb, Se and Zn. These and other factors should be considered while evaluating literature data before rejecting the findings that show substantial variations, unless there are strong reasons to support that the entire variation is arising from analytical errors.

This study also revealed the paucity of data in some regions of the world. In view of the nutritional importance of several elements the time is ripe for international organizations to intervene and help to produce some reference data for selected global regions which lack data of any kind. Analysis of merely whole blood samples to start with can generate a wealth of information to monitor the status of some of the key elements such as Cu, Fe, Se and Zn. Such data can serve as a regional reference bank until each country develops its own data base.

In choosing the reference group of subjects for a data base, a set of healthiest persons from a given country should be chosen. Fresh army recruits are a good example in this context. The results from these groups should be used for comparison when random populations of that country are studied. Notable deficiencies or excesses, if any, in the reference group, can be identified by comparison with reliable literature data.

Most of the data in this review cover only urban parts which are not ideal study areas in terms of trace element influences on human health. Therefore, more rural populations should be studied.

ACKNOWLEDGEMENTS

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Section 4

Tables with individual results

This section contains data that were received from various investigators listed on page 8. In addition it also contains results screened by the present author. The approach and selection of data are mentioned on page 4. The reliability of the data base is discussed on page 5.

Table 11. Regional values for the concentration of Arsenic in whole blood and serum (ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA					Whole blood		
ASIA							
India		8	NAA		6.0 ± 4.0	(3-14)	Bombay, Dang et al 1983
Japan		330	AAS		21	(1-99)	Urban, Ikeda et al 1979
	F	211	AAS		20.0 ± 20.0		Urban, Usagimoto et al 1980
	M	135	AAS		23.0 ± 21.0		" " " "
EUROPE							
Denmark			NAA		2.5 ± 0.5		Roskilde, Heydorn 1970, Heydorn 1980
Sweden		8	NAA		4.0 ± 1.2		Stockholm, Brune et al 1966
NORTH AMERICA							
U.S.A.	F	52	AAS		3	(0.2-24.6)	Charlotte, Kagey et al 1977
	F	49	AAS		2	(0.2-26.7)	Birmingham, " " "
					Blood serum		
ASIA							
Japan		25	NAA		3.5 ± 2.0	(1.3-8.0)	Urban, Nakahara et al 1979
Thaiwan		17	NAA		15.4		Urban, plasma, Heydorn 1970
EUROPE							
Denmark		16	NAA		2.4 ± 0.6		Roskilde, plasma, Heydorn 1970, Heydorn 1980
Italy		13	NAA		1.7	(0.9-3)	Urban, Giovenetti 1967
Norway		281	NAA		6.6 ± 17	(0.2-120)	Urban, Blekastad et al 1983

TABLE 11. ARSENIC IN WHOLE BLOOD AND BLOOD SERUM

Table 12. Regional values for the concentration of Arsenic in milk (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		6	NAA	1.8	3.o ± 3.6		Ibadan, urban elite, urban poor and rural mothers, Byrne 1984, Parr 1984
Zaire		2o	NAA	o.26	o.25 ± o.21	(o.13-o.82)	Lwiro, urban elite, urban poor and rural mothers, Byrne 1984, Parr 1984
ASIA							
India		24	NAA		o.7o ± o.3o	(o.2-1.4o)	Bombay, Dang et al 1983
Japan							
Philippines		14	NAA	19	24.o ± 23	(1-95.5)	Manila, urban elite, urban poor and rural mothers Byrne 1984, Parr 1984
EUROPE							
Greece		5	NAA		3.2	(1.6-6.o)	Athens, Grimanis et al 1978
Hungary		11	NAA	o.24	o.34 ± o.38	(o.11-1.5)	Budapest, urban elite, urban poor and rural mothers Byrne 1984, Parr 1984
Sweden		8	NAA	o.55	1.2o ± 1.8o	(o.4o-5.5o)	Uppsala, urban only, Byrne 1984, Parr 1984
Yugoslavia		29	NAA		2.o ± 1.2		Ljubljana, Kosta et al 1983, Byrne & Kosta 1983
NORTH AMERICA							
CENTRAL AND SOUTH AMERICA							
Chile		12	NAA		1.3o ± 1.2o	(o.o5-3.9o)	Santiago, Toro 1983
Guatemala		26	NAA	o.32	o.42 ± o.5o	(o.1o-2.5o)	Guatemala city, urban elite, urban poor and rural mothers, Byrne 1984, Parr 1984

Table 13. Reference values for the concentration of Arsenic in liver (µg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
India		19	NAA		14.5 ± 7.o		Bombay, Dang et al 1983
Japan		4	SAS		53	(33-7o)	Urban, Sumino et al 1975
		13	AAS		47 ± 25	(24-12o)	Urban, Kitamura et al 1978
EUROPE							
Belgium		5	NAA		8	(2-11)	Ghent area, Lievens et al 1977
Denmark		7	NAA		11 ± 7		Copenhagen area, Larsen et al 1972
Norway		8	NAA		16 ± 4	(2-37)	Jonsen and Steinnes 1983
Sweden		5	NAA		6 ± 2		North of Sweden, Brune 1978
U.K.		6	MS		5 ± 3		Hamilton 1979, Hamilton et al 1972/73
		27	NAA		1o	(1.5-72)	Glasgow area, Lenihan 1967
NORTH AMERICA							
U.S.A.		34	NAA		12 ± 16	(<1-97)	Baltimore, Mineapolis & Baltimore, Zeisler 1984
AUSTRALIA AND NEW ZEALAND							
New Zealand		11	AES		52 ± 1o	(2o-3o)	Urban, Johnson 1976

Table 14. Regional values for the concentration of Arsenic in hair (µg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Hong Kong		11	NAA		300	(40-1500)	Urban, Chuang et al 1978
India		17	NAA		470 ± 600	(64-2140)	Urban, Dang & Somasundaram 1983
Japan		234	NAA		85		From all over Japan, Ohmori et al 1981
		228	NAA		100 ± 80		Urban, Tekauchi et al 1982
	F	53	NAA		310 ± 320		Tokyo city, Imahori et al 1979
	M	61	NAA		310 ± 290		" " " " "
Pakistan	F+M	105	NAA		260 ± 280	(40-1420)	Islamabad area, Qureshi et al 1982
MIDDLE EAST							
Iraq	F+M	229	NAA		270 ± 300	(< 150-16000)	Urban, Bagdad, Al-Shahristani 1978
EUROPE							
Austria	F+M	197	NAA		130[a]	(<100-4000)	Vienna, Lanzel et al 1980
Czechoslovakia		29	NAA		250 ± 160	(80-640)	Near Prague, Kucera 1983
		53	NAA		140 ± 90	(30-440)	" " Obrusnik 1979, 1983
Denmark		6	NAA		150 ± 260	(<700-6700)	Roskilde, Damsgaard 1982
U.K.		26	NAA		460	(30-740)	Glasgow area, Dale 1983
		82	NAA		130[a]	(40-530)	" " " 1974

a) geometric mean

Table 14.(contd) Regional values for the concentration of Arsenic in hair (/ug/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
Canada	M+F	76	PAA		68o	(45o-17oo)	Rural population, Chatt et al 1977
	M+F	45	PAA		75o	(4oo-21oo)	Urban " " " "
SOUTH AND CENTRAL AMERICA							
Chile		39	NAA		14o ± 14o	(2o-64o)	Industrial area, Toro 1983
AUSTRALIA AND NEW ZEALAND							

TABLE 14. ARSENIC IN HAIR (Contd.)

Table 15. Regional values for the concentration of Arsenic in urine (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
MIDDLE EAST							
EUROPE							
Belgium	M	12	AAS		1o ± 6	3 - 21	Brussels, Buchet et al 198o
Denmark		3			3o	2o - 45	Roskilde, Heydorn & Damsgaard 1982
NORTH AMERICA							
AUSTRALIA & NEW ZEALAND							

Table 16. Regional values for the concentration of Cadmium in whole blood (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
China	M+F	161	AAS	0.7o	0.8o ± 0.54		Peking, non-smokers, Friberg and Vahter 1983
	M+F	7o	AAS	1.8o	2.oo ± 0.92		" smokers, " " "
India	F	1oo	AAS	0.8o	0.9o ± 0.44		Ahmedabad, non-smokers, " " "
	M	76	AAS	0.9o	1.oo ± 0.41		" " " " "
	M+F	176	AAS	0.9o	0.9o ± 0.43		" " " " "
	M+F	17	AAS	1.1o	1.oo ± 0.35		" smokers " " "
	M+F	53	AAS	0.9o	0.9o ± 0.4o		Bangalore, non-smokers " " "
	M+F	13	AAS	1.1o	1.oo ± 0.4o		" smokers " " "
	M+F	81	AAS	0.8o	0.8o ± 0.3o		Calcutta, non-smokers " " "
	M+F	16	AAS	0.7o	0.7o ± 0.3o		" , smokers " " "
Japan	F	46	AAS		1.2o ± 1.oo	(0.5o-5.o)	Urban, Satoh et al 1978
	M	45	AAS		1.4o ± 0.7o	(0.4o-3.6)	" " " "
	F	163	AAS	0.27	0.32 ± 0.01[a]	(0.o8-1.o8)	Hokkaido region, Saito et al 1979
	M	145	AAS	0.32	0.36 ± 0.01[a]	(0.o6-0.94)	" " " " "
	M+F	94	AAS	1.1o	1.2o ± 0.61		Tokyo, non-smokers, Vahter and Friberg 1983
	M+F	79	AAS	1.5o	1.6o ± 0.8o		Tokyo, smokers, " " " "
MIDDLE EAST							
Israel	M+F	143	AAS	0.5o	0.5o ± 0.4o		Tel-Aviv, non-smokers, Friberg and Vahter 1983
	M+F	54	AAS	1.3o	1.7o ± 1.5o		" smokers, " " " "
EUROPE							
Belgium	F	1o9	AAS		2.oo ± 1.2o	(0.2o-6.1o)	Brussels, smokers, Buchet et al 1978
	F	331	AAS		1.2o ± 1.2o	(0.1o-9.7o)	" non-smokers, " " "
	F	7o	AAS		1.2o ± 0.9o	(0.2o-4.5o)	Urban, Roels et al 1971
	M	47	AAS		1.7o ± 1.4o	(0.2o-6.oo)	" " " 1982
	M+F	89	AAS	1.oo	1.1o ± 0.5o		Brussels, non-smokers, Friberg and Vahter 1983
	M+F	44	AAS	2.oo	2.5o ± 1.7o		" smokers, " " " "

a) standard error

TABLE 16. CADMIUM IN WHOLE BLOOD

Table 16 (contd.) Regional values for the concentration of Cadmium in whole blood (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
EUROPE (continued)							
Germany (FR)	M+F	353	AAS		1.93	(0.3o-6.5o)	Urban, smokers, Stoeppler and Brandt 1979
	M+F	6o2	AAS		1.o2	(0.2o-3.oo)	" non-smokers, " " " "
	M+F	284	AAS	1.1, 1.2	1.3, 1.5		Bavarian area, Valentin 1983, see Schaller et al
Holland	F	84	AAS		o.4		Urban, non-smokers, Zielhuis et al 1977
	F	138	AAS		o.62 , o.7o		" smokers, " " "
Italy		18	AAS		1.57 ± o.74	(o.5o-3.5o)	Urban, smokers, Stoeppler 1983
		42	AAS		o.59 ± o.25	(o.2o-1.4o)	" non-smokers, " "
Sweden		45	AAS		2.1o	(o.o5-7.6o)	Urban, smokers, Ulander and Axelson 1974
		44	AAS		o.5o	(o.o3-1.2o)	" non-smokers, " " " "
	M+F	76	AAS	o.2o	o.3o ± o.3o		Stockholm, non-smokers, Friberg & Vahter 1983
	M+F	84	AAS	1.6o	1.8o ± 1.1o		" smokers, " " "
Yugoslavia	F	84	AAS		o.5o ± o.4o	(o.1o-2.oo)	Zagreb, Kostial 1983
	M	3o	AAS		o.6o ± o.4o	(o.1o-1-5o)	" " "
	M+F	114	AAS	o.5o	o.6o ± o.35		" , non-smokers, Friberg & Vahter 1983
	M+F	72	AAS	3.2o	3.9o ± 2.9o		" smokers, " " "
NORTH AMERICA							
Canada	M+F	61	NAA/AAS		2.3o ± 3.1o	(o.2o-9.6o)	Halifax, Ward et al 1979
U.S.A.		36	AAS		1.25	(o.5o-3.2o)	Urban, smokers, Kowal et al 2979 (1976 study)
		113	AAS		o.83	(o.2o-3.1o)	" non-smokers, " " " "
		31	AAS		1.54	(o.4o-3.3o)	" smokers, Kowal et al 1979 (1974 study)
		115	AAS		o.95	(o.2o-3.3o)	" non-smokers " " " "
		2o	NAA		7.oo ± 3.1o		Urban, Georgia, Andrews et al 198o
		4o	NAA		1.1o ± o.75		Rural, Georgia, " " " "
	M+F	88	AAS	o.6o	o.6o ± o.3o		Baltimore, non-smokers, Friberg and Vahter 1983
	M+F	6o	AAS	1.oo	1.3o ± 1.1o		" " " " " "
CENTRAL AND SOUTH AMERICA							
Mexico	M+F	47	AAS	o.3o	o.6o ± o.6o		Mexico city, non-smokers, Friberg and Vahter 1983
	M+F	25	AAS	3.7o	3.6o ± 2.9o		" " smokers, " " " "
Peru	M+F	1o3	AAS	o.8o	o.8o ± o.4o		Lima, non-smokers, Friberg and Vahter 1983
	M+F	29	AAS	1.5o	2.oo ± 1.5o		" smokers, " " " "
AUSTRALIA & NEW ZEALAND							
New Zealand		17	AAS		o.9 ± o.3		Dunedin, non-smokers, Mckenzie 1983

TABLE 16. CADMIUM IN WHOLE BLOOD (Contd.)

Table 17. Regional values for the concentration of Cadmium in milk (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		6	NAA	3.4	4.6 ± 5.o	(2.7-9.7)	Ibadan, Parr 1984
Zaire		6	NAA	o.85		(o.o-4.1)	Lwiro, Parr 1984
ASIA							
Philippines		11	NAA	2.7	2.7 ± 2.o	(o.o-6.7)	Manila, Parr 1984
EUROPE							
Hungary		6	NAA		o.66 ± 1.o	(o.o-4.o)	Budapest, Parr 1984
Sweden		13	NAA		o.74 ± 1.3	(o.o-4.o)	Uppsala, Parr 1984
NORTH AMERICA							
U.S.A.		25	AAS		<2		Urban, Casey 1976
CENTRAL AND SOUTH AMERICA							
Guatemala		13			1.7o ± o.51	(o.6o-4.o)	Guatemala, Parr 1984
AUSTRALIA AND NEW ZEALAND							
New Zealand		25	AAS		<1		Dunedin, Casey 1977

Table 18. Regional values for the concentration of Cadmium in liver (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		64	AAS		3.7o - 7.9o[a]	(range of GM)	Shinjuku-ku area, subjects aged 2o-7o years, Tsuchiya and Iwao 1978
	F	41	AAS		3.1o - 5.2o	(range of mean	Tokyo, Kjellström 1979
	M	74	AAS		4.oo - 6.oo	values)	" " "
		15	AAS		2.93 ± 2.12	(o.43-8.4o)	Urban group, Kitamura et al 1978
		1o			o.8o		" " Tanaka 1983
		9	NAA		3.42 ± 2.54		" " Terai et al 1979
EUROPE							
Belgium		5	NAA		2.48	(o.77-6.8o)	Ghent area, Lievens et al 1977
		2o	AAS		1.73 ± 1.32	(o.3o-5.oo)	Brussels, Lauwerys et al 1983
		13	AAS		2.44 ± 1.31	(o.3o-5.5o)	Liege, " " "
Finland		86	AAS		o.77[a]	(o.o1-4.46)	Helsinki, Vuori et al 1979
Germany (FR)		2o7	AAS		1.15		Munich area, Drasch 1983
Norway		8	NAA		1.34 ± o.84	(o.3o-2.9o)	Urban, Jonsen and Steinnes 1983
		76	AAS		2.31	(o.3o-6.94)	" Syversen et al 1976
Sweden		15	NAA		1.5o ± 1.9o		Stockholm, older subjects, Plantin 1978
		5	NAA		o.3o ± o.o6		North of Sweden, Brune et al 1978
	F	116	AAS		o.73 - 2.21	(range of mean	Stockholm, Kjellstörm 1979
	M	138	AAS		o.69 - 2.1o	values)	" " "
U.K.		2o	AAS		2.o3	(1.2o-3.7o)	Aldermaston, Curry and Knott 197o
		11	MS		2.oo ± o.4o		Urban, Hamilton et al 1972/73

a) geometric mean

Table 18. (contd.) Regional values for the concentration of Cadmium in liver (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
Canada	M+F	44	AES-ICP	1.8		(o.4o-6.7o)	Ottawa, Subramanian and Meranger 1982
U.S.A.	M+F	36	NAA/AAS		1.6o ± 1.1o	(o.2o-4.96)	Baltimore, Mineapolis & Seattle, Zeisler et al 1984
	M+F	47	AAS		1.o2	(o.o9-2.43)	Urban, nonsmokers, Kowal et al 1979
	M+F	115	AAS		1.31	(o.13-3.7o)	" smokers " " "
		162	AAS		1.23	(o.o9-3.68)	Dallas, Kjellström 1979
		13o	AAS		1.1 to 1.4	(range of mean	" " " 2o-6o years old subjects
		17	AAS		o.4o	values)	Cincinnatic area, black subjects, Gross 1976
		77	AAS		1.o1		" " white " " "
		2o	NAA		2.9o ± 1.6o		Brooklyn, in-vivo method, Ellis et al 1979
		8	NAA		2.3o ± 1.6o		" " non-smokers, " "
		12	NAA		4.1o ± 1.6o		" " smokers, " "
AUSTRALIA AND NEW ZEALAND							
Australia		89	AAS		2.1	(o.1o-7.4o)	Perth area, includes children, Spickett & Lanzer 1979
New Zealand		53	AAS		2.44 ± 2.26	(o.o1 -11.2)	Dunedin partly, Casey et al 1+83, Johnson 1979

Table 19. Regional values for the concentration of Cadmium in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Kenya	M+F	195	POL		2.43 ± o.55	(o.93-5.5o)	All over Kenya, Wandiga and Jumba 1983
	M+F	265	AAS		2.22 ± o.59	(o.3o-7.8o)	" " " " " " "
Nigeria		25	NAA	2.2o		(o.2o-14.6)	Ibadan, Olatunbosun et al 1976
ASIA							
India	M+F	34	NAA		1.38 ± 1.o4	(o.34-5.o)	All over India, students, Arunachalam et al 1978
Japan		75	NAA		1.62 ± 2.oo	(o.3o-16.1o)	All over Japan, Tekauchi et al 1982
	F	96	AAS		o.38 ± o.28		Tokyo, Matsuzawa et al 1977
	M	96	AAS		o.54 ± o.41		" " " "
		76	NAA		1.1o[b]		Urban, Ohmori et al 1981
MIDDLE EAST							
Egypt	M+F	65	NAA		o.1 to 1.o	(range of mean values)	From various areas of Egypt, Kasperek et al 1982
Iran		9	PIXE		1.1 ± o.1[a]		Teheran, Aframian et al 198o
Iraq	M+F	135	NAA		1.4 ± 2.1	(<o.6-8.2)	Bagdad area, Al-Shahrastani et al 1978
Europe							
Austria	M+F	198	NAA	o.79		(o.o8-4.4)	Vienna, Lanzel 198o
Bulgaria		22	NAA		o.o1		Varsta city, Damyanova 1983
Czechoslovakia		29	NAA		o.94 ± o.55	(<o.5-2.7)	Prague, Kucera 1983

a) standard error, b) geometric mean

Table 19. (contd) Regional values for the concentration of Cadmium in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD (Range)	Remarks and Reference
EUROPE (continued)						
Finland		2o	AAS		o.35 ± o.27	Urban, Vuori et al 1975
France	M	44o	AAS		1.33 ± o.95	Urban, smokers, Orssand et al 1983
	M		AAS		o.37 ± o.24	" non-smokers, " " " "
NORTH AMERICA						
Canada	M+F	76	PAA	1.2	o.25-2.7o	Rural. Chatt et al 1977
	M+F	45	PAA	2.o	o.32-3.4o	Urban, " " "
U.S.A,		228	AAS		1.1o	Chicago area in 1974, Kowal et al 1979
		189	AAS		o.83	" " in 1976, " " "
		14	AAS		1.23	Cincinnati area, black, Gross 1976
		62	AAS		1.32	" " white, " "

TABLE 19. CADMIUM IN HAIR (Contd.)

Table 2o. Regional values for the conecentrations of Cadmium in urine (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	M+F	1o9	AAS		4.7 ± 4.4		Akita, Ishikawa & Nagasaki area, Iwao et al 1981
	M+F	374	AAS		o.64		Urban, Fukabori & Nakaaki 1974, o.96 /ug/24 hours
MIDDLE EAST							
EUROPE							
Belgium	M	47	AAS		o.84 ± o.48	o.23 - 2.2	Brussels, Roels et al 1982, /ug/g creatinine
	F	7o	AAS		o.96 ± o.77		" , " " " , " " , /ug/day
Germany FR		15	AAS		o.7o	o.3o - 1.8	Urban, Stoeppler & Brandt 1979
NORTH AMERICA							
U.S.A.	M+F	223	AAS	o.61[a]	o.77	o.o6 - 5.1	Chicago area, smokers+nonsmokers, Kowal et al 1974
	M+F	189	AAS	o.48	o.64	o.o2 - 2.1	" , values from 1976, " " "
	M	86	AAS	o.5o	o.59	o.11 - 2.1	Dallas area, " " " " " "
	M	51	AAS	o.4o	o.45	o.14 - 1.o	" , nonsmokers only, " " "
	M	14	AAS	o.65	o.83	o.11 - 2.1	" , smokers only, " " "
SOUTH & CENTRAL AMERICA							
Venezuela		1o	SAS		2.o4 ± o.o2	o.5o - 3.4	Merida, Burguera et al 1982
AUSTRALIA & NEW ZEALAND							

a) Geometric mean, applicable to all values of Kowal et al 1974 under this group

Table 21. Regional values for the concentration of Chromium in blood & serum (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
					Whole blood		
Japan		15	AAS		45 ± 18	16 - 8o	Sumino et al 1975
Egypt		8	NAA		28	9 - 4o	Maxia et al 1972
Germany FR		36	AAS	2.8		o.2 - 24	Erlangen area, Zober et al 1984, µg/kg
U.K.		1o2	MS		3o ± 4		Urban, Hamilton 1979, Hamilton et al 1972
Canada		61	AAS/NAA		2o	1o - 35	Halifax, Ward et al 1979
					Blood serum		
Japan		18	NAA		2.1 ± 1.1	3 - 4.4	Urban, Nakahara et al 1979
Israel		52	AAS		1.6 ± o.13[a]		Jerusalem, 2o-59 years old, Abraham et al 1981
		29	AAS		1.9 ± o.2[a]		" 6o-9o " " " " "
Belgium		2o	NAA		o.16 ± o.83	o.o4 - o.95	Ghent, Versieck et al 1978
Finland		6	AAS		o.12 ± o.o5[a]	o.1o - o.2o	Helsinki, Kumpulainen et al 1983
Germany FR		5	AAS		o.19 ± o.o4		Düsseldorf, Iyengar & Schütze 1984
		5	NAA		o.18 ± o.o4		" " " "
U.S.A.		8	AAS		o.14		Philadelphia, Keyne et al 1978

[a] Standard error

TABLE 21. CHROMIUM IN WHOLE BLOOD AND BLOOD SERUM

Table 22. Regional values for the concentration of Chromium in milk (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		4	AAS	4.4	5.1 ± 2.1	(3.4-8.2)	Ibadan, Parr 1984
Zaire		11	AAS	1.1	1.5 ± 1.2	(1.3-3.o)	Lwiro, Parr 1984
ASIA							
Philippines		8	AAS	3.6	3.5 ± 1.6		Manila, Parr 1984
EUROPE							
Finland		2o	AAS		o.4o ± o.15	(o.2-o.53)	Helsinki, Kumpulainen et al 1983
Hungary		11	AAS	o.8	1.o3 ± o.62		Budapest, Parr 1984
Sweden		6	AAS	1.5	1.87 ± 1.3o		Uppsala, Parr 1984
NORTH AMERICA							
CENTRAL & SOUTH AMERICA							
Guatemala		8	AAS	1.2	1.3o ± o.6o		Guatemala city, Parr 1984

Table 23. Regional values for the concentration of Chromium in liver (µg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		15	AAS		72 ± 23	(4-11o)	Urban, Yukawa et al 198o
		29	AAS		66 ± 53	(15-23o)	Urban, Sumino et al 1975
		1o	AAS		28		Urban, Tanaka 1983
		9	NAA		12 ± 4		Urban, Terai et al 1979
EUROPE							
Belgium		5	NAA		18	(7-33o)	Ghent area, Lievens 1977
Sweden		15	NAA		41 ± 5o		Stockholm, Plantin 1978
U.K.		11	MS		8 ± 6		Urban, Hamilton 1979, Hamilton et al 1972/73
NORTH AMERICA							
U.S.A.		3	NAA		11o ± 12o	(<1o-239)	Baltimore, Mineapolis and Seattle, Zeisler et al 1984
		2o	AAS	32			Pima Indians, Eatough 1977

Table 24. Regional values for the conecentration of Chromium in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Bangladesh	M+F	4o	PIXE		2.45 ± 1.43	(o.6-5.8)	Dacca, Khan et al 198o
Hong Kong		11	NAA	o.23		(o.12-o.85)	Chinese subjects, Chuang 1978
India	M+F	239	NAA		o.46 ± o.39	(o.1o-2.63)	All over India, Arunachalam 1978
Japan		34	NAA		o.58[a]		Urban population, Ohmori et al 1981
	F	65	NAA		o.36 ± o.47	(o.o7-3.48)	Urban, Imahori et al 1978
	M	64	NAA		o.32 ± o.22	(o.o8-1.22)	Urban, " " "
		121	NAA		o.82 ± 1.66	(o.15-15.6)	All over Japan, Tekauchi et al 1982
Pakistan	M+F	1o5	NAA		1.42 ± 1.3o	(o.2o-6.3o)	Islamabad area, Qureshi et al 1982
Thailand		25	AES		o.16 ± o.o4[b]		Bangkok, Hambidge et al 1974
MIDDLE EAST							
Egypt	M+F	65	NAA		o.1-1.o (range of mean values)		From different parts of Egypt, Kasperek et al 1982
Iraq	M+F	259	NAA		4.1 ± 4.5	(<o.5-24)	Bagdad area, Al-Shahristani et al 1978
Turkey		11	AAS		o.56 ± o.24	(o.28-1.o)	Istanbul, Saner et al 1983

a) geometric mean, b) standard error

Table 24.(contd) Regional values for the concentration of Chromium in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
EUROPE							
Bulgaria		22	NAA		0.34 ± 0.10		Vrasta city, Damyanova 1983, Donev et al 1978
Czechoslovakia		29	NAA		0.41 ± 0.20	(0.02-1.2)	Near Prague, Kucera 1983
Finland		10	AAS		0.06 ± 0.04	(0.02-0.15)	Helsinki, Kumpulainen 1982
France		73	AAS		0.46 ± 0.27		Urban, Cote et al 1983, Cote & Shapcott 1981
Italy		49	NAA	0.50		(0.5-65.3)	Rome, Clemente et al 1978
		8	AAS		0.35 ± 0.22		Urban, Cote et al 1983, Cote & Shapcott 1981
Spain		10	AAS		0.35 ± 0.23		Urban, " " "
NORTH AMERICA							
Canada		86	AAS		0.64 ± 0.39		Sherbrook, Cote et al 1983, Cote & Shapcott 1981
U.S.A.		50	AAS	0.15	0.18 ± 0.11		Atlanta, Sheard et al 1980
		20	AAS	0.52			Pima Indians, Eatough 1977
		18	AES		0.09 ± 0.01		Denver, Hambidge et al 1974
CENTRAL AND SOUTH AMERICA							
Chile		28	NAA		1.40 ± 1.86	(0.01-7.4)	Santiago, Toro et al 1983

Table 25. Regional values for the concentration of Chromium in urine (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	F	98	AAS		0.34 ± 0.31(SE)[a]		Several locations in Japan, Nomiyama et al 1980
	M	91	AAS		0.48 ± 0.41(SE)		" " " " " " "
	F+M	189	AAS		0.41 ± 0.37(SE)		" " " " " " "
MIDDLE EAST							
Turkey	F+M	12	AAS		0.31 ± 0.15	0.1 - 0.6	Istanbul, Saner et al 1983
EUROPE							
Belgium		3	NAA			0.3 - 1.2	Ghent area, Cornelis et al 1975, µg/24hours
Finland		9	AAS		0.24 ± 0.10	0.1 - 0.4	Helsinki, Kumpulainen et al 1981
Germany (FR)	F	60	AAS		1.80 ± 1.10		Erlangen-Nürnberg, Schaller et al 1973
NORTH AMERICA							
AUSTRALIA AND NEW ZEALAND							
New Zealand	F+M	27	AAS		1.06 ± 0.29	0.5 - 1.6	Dunedin area, Guthrie and Huger 1982

[a] Standard error

Table 26. Regional values for the concentration of Cobalt in whole blood, serum & RBC

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
					Whole blood (/ug/L)		
Canada	M+F	61	AAS/NAA		4o, 42	(8 - 86)	Halifax, Ward et al 1979
					Blood serum (/ug/L)		
Belgium		2o	NAA		o.11 ± o.o6	(o.o4 - o.27)	Ghent, Versieck et al 1978, 1981
Germany FR		5	NAA		o.12	(o.o8 - o.22)	Düsseldorf, Iyengar & Schütze 1984
Italy		12	NAA		o.46	(o.2 - 1.3)	Pisa, Giovanetti et al 1967
Australia		31	NAA		o.3o ± o.2o	(o.1 - o.9)	Geelong, blood plasma, Cuming 1983
					Erythrocytes (/ug/kg)		
Belgium	M+F	46	NAA		16.4 ± 5.4	(9 - 4o.4)	Ghent area, Versieck et al 1979, 1981
Italy		4	NAA		46.o ± 6	(37 - 6o)	Pisa, Giovanetti et al 1967

Table 27. Regional values for the concentration of Cobalt in milk (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		18	NAA	o.64	o.7o ± o.32	(o.26-1.4o)	Ibadan, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Zaire		69	NAA	o.36	o.5o ± 1.4o	(o.1o-1.9o)	Lwiro, urban elite, urban poor and rural mothers Iyengar 1984, Parr 1984
ASIA							
India		6	NAA		o.5o ± o.1o	(o.4o-o.6o)	Bombay, Dang et al 1983
Philippines		65	NAA	1.4o	1.6o ± o.95	(o.5o-4.7o)	Manila, urban elite, urban poor and rural mothers Iyengar 1984, Parr 1984
EUROPE							
Greece		5	NAA		2.o	(1.3o-3.o)	Athens, Grimanis et al 1978
Hungary		71	NAA	o.15	o.23 ± o.44	(o.o2-3.7)	Budapest, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Italy		13o	NAA		3.oo ± o.6o	(o.1-36.4)	Rome, Clemente et al 1983
Sweden		32	NAA	o.27	o.3o ± o.16	(o.1o-o.75)	Uppsala, Iyengar 1984, Parr 1984
NORTH AMERICA							
CENTRAL AND SOUTH AMERICA							
Chile		11	NAA		1.2o ± o.64	(o.3o-2.3o)	Santiago, Toro 1983
Guatemala		8o	NAA	o.24	o.42 ± o.48	(o.o7-2.5o)	Guatemala city, urban elite, urban poor and rural mothers
AUSTRALIA AND NEW ZEALAND							
Australia		4o	NAA		o.2o ± o.4o	(o.2)	Geelong, Cumming et al 1983

Table 28. Regional values for the concentration of Cobalt in liver (ug/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		9	NAA		6.o ± 4.o		Urban, Terai et al 1981
		1o	AAS		28		" Tanaka 1983
EUROPE							
Belgium		5	NAA		31	(22-37)	Ghent area, Lievens et al 1977
Sweden		5	NAA		13o.o ± 4.o		North of Sweden, Brune et al 1978
		12	NAA		16.3 ± 9.o		Stockholm, Plantin 1978
NORTH AMERICA							
U.S.A.		36	NAA		42 .o ± 1o.o	(13.5-6o.5)	Baltimore, Mineapolis and Seattle, Zeisler et al 1984
AUSTRALIA AND NEW ZEALAND							
New Zealand		11	AAS		151.o ± 41.o	(128-256)	Urban, Johnson 1976

a) standard error

TABLE 28- COBALT IN LIVER

Table 29. Regional values for the concentration of Cobalt in hair (/ug/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Hong Kong		11	NAA		<1oo	(<6o-19oo)	Chinese subjects, Chuang 1978
India	F+M	257	NAA		7o ± 1oo	(1o-12oo)	All over India, Arunachalam et al 1978
Japan		375	NAA		42[a]		Urban, Ohmori et al 1981
	M	95	NAA		12o ± 23o	(11-114o)	Tokyo, Imahori et al 1979
	F	75	NAA		83 ± 85	(13-47o)	" " " "
		313	NAA		84 ± 22o	(o-22oo)	All over Japan, Tekauchi et al 1982
Pakistan	M+F	1o5	NAA		33o ± 4oo	(4o-7oo)	Islamabad area, Qureshi et al 1982
MIDDLE EAST							
Egypt	F+M	65	NAA		(14o-2oo)	range of mean values	From several parts of Egypt, Kasperek et al 1982
Iraq		176	NAA		28o ± 28o	(<1oo-12oo)	Bagdad area, Al-Shahristani et al 1978
EUROPE							
Czechoslovakia		29	NAA		31 ± 13		Near Prague, Kucera 1983
		52	NAA		6o ± 11o	(7-78o)	" " Obrusnik 1979, 1983
Germany		26	NAA		5oo ± 2oo		Urban, Kasperek et al 1971
Italy		49	NAA		13o ± 18o	(< 2o-11oo)	Rome, Clemente et al 1978
NORTH AMERICA							
Canada		76	NAA	o.41		(o.12-1.8o)	Rural population, Chatt et al 1977
		45	NAA	o.48		(o.15-2.6o)	Urban " " " "

a) geometric mean

Table 3o. Regional values for the concentrations of Cobalt in urine (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	M+F	9	NAA		1.35		Ishii et al 1978
MIDDLE EAST							
EUROPE							
Belgium		3	NAA			o.5 - 2.7	Ghent, Cornelis et al 1975, /ug/24 hours
Italy	M+f	47	NAA		1.2 ± 1.o	< o.1 - 16	Rome, Cigna Rossi et al 1978, Clemente et al 1978
NORTH AMERICA							
AUSTRALIA & NEW ZEALAND							

Table 31. Regional values for the concentration of Copper in whole blood (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Bangladesh	M+F	1oo	PIXE		o.98 ± o.4o	(o.4-2.76)	Dacca, Khan et al 198o
India	F	23	NAA		o.93 ± o.22	(o.55-1.7)	Bombay, Dang & Somasundaram 1983
Japan	M	45	AAS		o.82 ± o.14	(o.5-1.13)	Urban, Satoh et al 1978
	M+F	346	AAS		o.9o ± o.19		Urban, Usagimoto et al 198o
	F	46	AAS		o.86 ± o.1o	(o.7-1.14)	Urban, Satoh et al 1978
	M+F	3o8	AAS		o.96 ± o.o1[a]	(o.6-1.35)	Hokkaido region, Saito et al 1979
MIDDLE EAST							
Iran	M+F	29	PIXE		1.3o ± o.6o	(1.o-2.2o)	Teheran, Aframian 1983
EUROPE							
Denmark	M		AAS		o.83 ± o.26	(o.71-2.55)	Odensee area, Clausen and Rastogi 1977
Finland	M+F	48	AAS		o.93 ± o.13	(o.72-1.32)	Jyväskylä area, Tummavuori & Pirinen 1983
Sweden	M+F	1o	NAA		1.oo	(o.5o-2.5o)	Studsvik, Brune et al 1962
	M+F	7o	NAA		o.99 ± o.22		Stockholm area, Plantin and Strandberg 1967
U.K.	M+F	268	XRF		1.2o ± o.o2[a]		National average, Hamilton et al 1972, 1979
NORTH AMERICA							
Canada	M+F	61	NAA		1.11, 1.22	(o.78-1.6o)	Halifax, range of means, Ward et al 1979
U.S.A.	M+F	85	ASV		1.oo ± o.45	(o.31-2.81)	Ann Arbor, Hecker et al 1974
	F	187	AAS		o.8o		Samples from 8 states, Creason et al 1976
	M	6o9	AAS		o.9o, o.95		Chicago, urban & country men, Creason 1976
CENTRAL AMERICA							
Venezuela	M+F	9o	ASV		o.99 ± o.34	(o.43-2.6o)	Yanamano area, Hecker et al 1976
AUSTRALIA & NEW ZEALAND							
Australia	M+F	39	AAS		o.965 ± o.155		Tasmania, Lutana and Cygnot areas, Lewis et al 1977

a) standard error

Table 32. Regional values for the concentration of Copper in blood serum (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria	M+F	44	AAS	1.1o	1.1o ± o.2o	(o.72-1.5o)	Ibadan, Olatunbosum et al 1973
	M+F	18	AAS		1.12		Zaria, elite group, Kapu et al 1977
	M+F	127	AAS		1.2o		" non-elite group, Kapu et al 1977
ASIA							
India	M	31	NAA		1.1o ± o.3o	(o.7o-1.7o)	Bombay, Dang & Somasundaram 1983
	F	23	NAA		1.1o ± o.2o	(o.7o-1.5o)	Bombay, " " "
	F	67	AAS		1.3 ± o.o3[a]		Hyderabad, Rajalakshmi et al 198o
Japan	F	49	AAS		o.82 ± o.1o	(plasma)	Hiroshima, Hatano et al 1982
	F	24	AAS		1.3o ± o.24	(o.93-1.84)	Urban, Ishihara 1983
	M+F	25	NAA		1.o1 ± o.38	(o.5o- 1.98)	Tokyo, Nakahara et al 1979
MIDDLE EAST							
Israel	F	48	AAS		1.3o ± o.22	(o.88-1.62)	Haifa, Lightman et al 1983
Turkey	F	31	AAS		1.38 ± o.31	(o.8o-2.oo)	Urban, various groups, Yüregir and Donma 1983
	M	35	AAS		1.o3 ± o.15	(o.8o-1.5o)	" " " " " "
	M	19	AAS		1.42 ± o.o6[a]	(o.87-1.96)	" " " " " "
	F	13	AAS		1.46 ± o.o8[a]	(o.88-2.o4)	" " " " " "
	F	61	AAS		1.39 ± o.o6[a]	(o.52-2.26)	" " " " " "
	M+F	11	AAS		o.95 ± o.12	(o.68-1.17)	Istanbul, upper middle class subjects, Saner 1983
EUROPE							
Belgium	M+F	46	NAA		1.o7 ± o.24		Ghent area, Versieck et al 1974, 1977, 1978
Germany	F	137	AAS		1.o9	(o.65-1.86)	Berlin, Heineman 1974
Greece	F	16	XRF		1.2o ± o.15	(o.88-1.57)	Athens, Gregoriades et al 1982
	M	19	XRF		1.o6 ± o.14	(o.77-1.35)	" " " "
Ireland	F	69	AAS		1.o2 ± o.24	(o.6o-1.2o)	Belfast, McMaster and Erwin 1983
	M	19	AAS		o.99 ± o.32	(o.55-2.1o)	" " " "
Poland	F	31	NAA		1.15 ± o.3o		Lower Silasian region, Masaik et al 1981
	M	2o	NAA		1.o3 ± o.15		" " " " " "
U.K.	M+F	132	AAS		1.3o ± o.21		Glasgow area, Fell et al 1971

a) standard error

Table 32. (contd) Regional values for the concentration of Copper in blood serum (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
Canada	F	34	AAS		1.34 ± o.31		Guelph, vegetarians, Anderson et al 1981
U.S.A.	F	4o	AAS			(o.85-1.55)	Cleveland, Shamberger 1983
	M	4o	AAS			(o.7o-1.4o)	" " "
	M+F	37	AAS		1.o6 ± o.3o		Omaha, Blotcky et al 1979
	M+F	128	NAA		o.87 ± o.15		San Diego, Campero et al 1967
	F	2o	AAS		1.o7		Denver, Hambidge et al 1974
AUSTRALIA & NEW ZEALAND							
Australia	F	41	NAA		1.1o ± o.5o	(o.97-1.64)	Geelong, Cumming et al 1983
	M+F	25	AAS		1.2o ± o.36	(o.8o-1.8o)	Adelide, Baghurst et al 1981
	M+F	35o	AAS		1.4o in most cases		N.W. Australian aboriginal settlements with hypo-zincaemia, Cheek et al 1981
New Zealand	F	52	AAS		o.91 ± o.15	(o.68-1.53)	Dunedin, McKenzie et al 1979
	M	91	AAS		o.8o ± o.14	(o.41-1.18)	" " " "
	M	32	AAS		1.65 ± o.28		Tokelau islanders, staple food coconut, Mckenzie et al 1979
	F	34	AAS		1.75 ± o.28		" " " " " "

Table 33. Regional values for the concentration of Copper in erythrocytes (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	F	49	AAS		0.70 ± 0.07		Hiroshima, Hatano et al 1982
		24	AAS		0.81 ± 0.29	(0.30-1.31)	Urban, Ishihara 1983
Europe							
Belgium	M+F	46	NAA		0.72 ± 0.04	(0.58-1.05)	Ghent area, Versieck et al 1974, 1977, 1978
NORTH AMERICA							
U.S.A.	M+F	15	NAA		0.80 ± 0.04[a]		San Diego, Campero et al 1967

a) standard error

Table 34. Regional values for the concentration of Copper in milk (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		18	NAA	278	28o ± 77	(1o3-44o)	Ibadan, urban elite, urban poor and rural mothers, Iyengar 1984 , Parr 1984
Zaire		68	NAA	2o1	228 ± 12	(57-72o)	Lwiro, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
ASIA							
India		24	NAA		3oo ± 1oo	(2oo-6oo)	Bombay, Dang et al 1982 ?
		67	AAS		29o ± 1o[a]		Hyderabad, Rajalakshmi et al 198o
Japan		45	AAS		29o ± 9o		Kumanoto area, Higashi et al 1982
Philippines		61	NAA		31o ± 93	(141-485)	Manila, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
U.S.S.R.		23	NAA		197 ± 15		Moscow, Reschetkina 1969
MIDDLE EAST							
Turkey		13	AAS		751 ± 4o7	(38o-164o)	Istanbul, 3 months pp, Saner 1983
		1o	AAS		572 ± 251	(35o-1o2o)	" " " "
EUROPE							
Finland		229	AAS		6oo ± 27o	(3o-75o)	Helsinki, Vuori and Kuitunen 1979
Germany (FR)		2o	AAS		3o7 ± 55		Dortmund, Stolley et al 1981
Greece		15	NAA		46o	(4oo-5oo)	Athens, Grimanis et al 1978
Hungary		71	NAA	2o3	21o ± 65	(77-387)	Budapest, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Italy		55	AAS		29o ± 4o[a]		Urban, Nassi et al 1974
Sweden		31	NAA	186	197 ± 93	(8o-41o)	Uppsala, Urban population, Iyengar 1984, Parr 1984
Yugoslavia		7	NAA		24o ± 15o	(3o-45o)	Ljubljana, Byrne and Kosta 1982, 1983

a) standard error

Table 34.(contd) Regional values for the concentration of Copper in milk (ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
U.S.A.		22	AAS		24o ± 8o		Urban population, Murthy and Rhea 1971
		5o	AAS		245 ± 77		Urban, random samples, Picciano and Guthrie 1976
		28	AAS		43o		Urban, 1-3 months pp, Vaughan et al 1977
		39	AAS		33o		" 4-6 " " " "
		23	AAS		31o		" 7-9 " " " "
		13	AAS		24o		" 1o-12 " " " "
		28	AAS		28o		" 13-18 " " " "
		3o	AAS		27o		" over 19 " " " "
CENTRAL AMERICA							
Chile		12	NAA		34o ± 4o	(28o-4oo)	Santiego, Toro 1983
Guatemala		84	NAA	263	275 ± 79	(115-476)	Guatemala city, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
AUSTRALIA & NEW ZEALAND							
Australia		41	AAS		39o ± 16o		Geelong, Cumming et al 1983
New Zealand		25	AAS		4oo		Dunedin, Casey 1977

TABLE 34. COPPER IN MILK (Contd.)

Table 35. Regional values for the concentration of Copper in Liver (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
India	M+F	16	NAA		6.2 ± 2.4	(2.6-11.1)	Bombay, Dang et al 1978
Japan	M+F	64	AAS	5.5-9.3[a]	(range of GM values)		Shinjuku-ku area, 2o-7o years subjects, Tsuchiya and Iwao 1978
		15	AAS		9.7 ± 7.2	(2-25)	Urban, Kitamura et al 1978
	M+F	3o	SAS		9.9 ± 5.5	(2-23)	Hiroshima area, Sumino 1975
		1o	AAS		9.5		Urban, Tanaka 1983
EUROPE							
Belgium		5	NAA		5.7	(3.7-7.3)	Ghent area, Lievens et al 1977
Bulgaria		3o	NAA		3.2 ± 1.4		Vratsa city, Damyanova 1983
Finland	M+F	86	AAS		6.7 ± 2.54	(2-15.7)	Helsinki, Vuori et al 1978
Norway		31	AAS		6.o ± 2.2	(3-2o)	Urban, Norheim and Aaseth 198o
Sweden		15	NAA		6.4 ± 2.5		Stockholm, Plantin 1978
U.K.		9	XRF		7.8 ± 1.4		Urban, Hamilton 1979, Hamilton et al 1972
	M+F	24	NAA	6.6			Glasgow area, Lenihan 1967
NORTH AMERICA							
Canada	M+F	44	ICP-AES	5.3		(2-14.8)	Ottawa, Subramanian and Meranger 1982
U.S. A.	M+F	36	NAA		6.2 ± 2.o	(3.5-1o.6)	Baltimore, Mineapolis & Seatle area, Zeisler et al 1983, 1984
		2o	AAS		5.1 ± o.54		Omaha, Blotckey et al 1979
AUSTRALIA & NEW ZEALAND							
New Zealand	M+F	64	AAS		7.5 ± 6.3	(2-49)	Dunedin, Casey et al 1983, McKenzie et al 1974

a) geometric mean

Table 36. Regional values for the concentration of Copper in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Botswana	F	11	AAS		11 ± 3	(9-19)	Bushmen population, Baumslag & Petering 1976
Kenya	M+F	71	NAA		18 ± 6	(6-4o)	Machakos district, Othman and Spyrou 198o
Nigeria		25	NAA		1o	(3-3o)	Urban, Olatunbosun et al 1976
S. Africa	F	37	NAA		1o ± 4.5		Bantu women, Baumslag and Petering 1976
Zambia	F	95	AAS		22 ± 18		Lusaka, Briggs et al 1972
	M	97	AAS		16 ± 9		" " " "
ASIA							
Bangladesh	M+F	1o2	PIXE		6.8 ± 1.6	(4-14)	Decca, Khan et al 198o
India	M+F	246	NAA	16.3	16.2 ± 6.2	(7-6o)	All over India, Arunachalam et al 1978
Japan	F	35	NAA		18 ± 9.3		Urban, Sakura 198o
	M	68	NAA		17 ± 11		" " "
		79	NAA	12[a]			" Omahori et al 1981
	M	96	AAS		16.6 ± 9.2		" Matzuzawa et al 1977
	F	97	AAS		23.1 ± 19		" " " "
Pakistan	M+F	1o5	NAA		9.6 ± 4.8		Islamabad, Qureshi et al 1982
MIDDLE EAST							
Iran		9	PIXE		2o.1 ± 4.8		Tehran, Aframian et al 198o
Turkey		11	AAS		1o.7 ± 3.3	(6.5-17)	Istanbul, Saner 1983
EUROPE							
Bulgaria		22	NAA		14.2 ± 1.5		Vrasta city, Dāmyanova 1983
Czecholslovakia		29	NAA		15.4 ± 8.2		Near Prague, Kucera 1983
		52	NAA		14.8	(7-14o)	" " Obrusnik 1979, 198o
Finland		2o	AAS		23.3 ± 18.5		Helsinki, Vuori et al 1975

a) geometric mean

Table 36 (contd) Regional values for the concentrations of Copper in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
EUROPE (Continued)							
Germany (DR)	M+F	61	NAA		12.2 ± 4.1	(8-28)	Dresden, Wiesener et al 1978
Ireland	F	41	AAS		17 ± 8	(7.5-38)	Belfast, McMaster and Erwin 1983
	M	8	AAS		24.5 ± 19.3	(8.7-63)	" " " "
Poland	M+F	6o	NAA		22	(3-11o)	Warsaw, Dybczenski 1975, 1976, 1983
U.K.		29	NAA	21[a]		(8-55)	Glasgow, Dale 1983
NORTH AMERICA							
Canada	F	34	NAA	15		(11-2o)	Guelph, Anderson et al 1981, vegetarians
	F	3o	NAA	16		(13-23)	" " " non-vegetarians
	M+F	42	NAA	29		(4-245)	Halifax, Holzbecher and Ryan 1982
U.S.A.	F	5o	AAS		18 ± 11		Cicinnati, Baumslag and Petering 1976
		18	SAS		14 ± 2.5		Denver, Hambidge et al 1974
CENTRAL AMERICA							
Chile		35	NAA		18 ± 8.7	(4.3-5o)	Santiego, Toro 1983
AUSTRALIA & NEW ZEALAND							
Australia	F	59	AAS		39 ± 22	(7.3-85)	Brisbane, Reilly 1981
	M	24	AAS		26 ± 13	(9.9-53)	" " "
New Zealand	M+F	9o	AAS		26.2 ± 15	(8.7-86)	Dunedin, Mckenzie 1979
	M	32	AAS		1o.5 ± 1.8		Tokelau islanders, Mckenzie et al 1974, 1979 and Casey et al 1983
	F	34	AAS		1o.4 ± 2.7		" " " Coconut as staple food for both groups

a) geometric mean

Table 37. Regional values for the concentration of Copper in urine (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	M+F	1o4	AAS		12 ± 7.1		Akita, Ishikawa & Nagasaki area, Iwao et al 1981
MIDDLE EAST							
Turkey	M	24	AAS		33 ± 11	14 - 52	Özgunen et al 1977
	F	1o	AAS		38 ± 13	2o - 56	" " "
	M+F	12	AAS		59 ± 23	36 - 1o3	Istanbul, Saner et al 1983
EUROPE							
Belgium		3	NAA			12 - 34	Ghent area, Cornelis et al 1975, /ug/24 hours
NORTH AMERICA							
U.S.A.		4o	AAS		<4o		Cleveland, Ohio, Shamberger 1983, /ug/24 hours
AUSTRALIA & NEW ZEALAND							
New Zealand	M+F	96	AAS		8o ± 81	<2 - 63o	Dunedin, McKenzie et al 1973, /ug/24 hours

Table 38. Regional values for the concentration of Fluorine in milk (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		46	ISE	17	16.8 ± 3.8	1o.1 - 21.4	Ibadan, urban elite, urban poor and rural mothers, Parr 1984,
Zaire		68	ISE	7.5	7.7 ± 5.6		Lwiro, urban elite, urban poor and rural mothers, Parr 1984,
ASIA							
Philippines		32	ISE	118	113 ± 5o	19 - 214	Manilla, urban elite, urban poor and rural mothers, Parr 1984
MIDDLE EAST							
EUROPE							
Finland		24	ISE		1o ± 1	2 - 2o	Esala et al 1982
		15	ISE	7		4 - 14	" " " , drinking H_2O F content = o.2ppb
		9	ISE		11	5 - 51	" " " , " " " " " 1.7ppb
Hungary		52	ISE	14.5	15.3 ± 6.2		Budapest, urban elite, urban poor and rural mothers, Parr 1984
Sweden		1o	ISE	17	16.8 ± 3.8	1o.1 - 21.4	Uppsala, Parr 1984
NORTH AMERICA							
CENTRAL & SOUTH AMERICA							
Guatemala		23	ISE	9.1	13.5 ± 14.6		Guatemala city, urban poor, urban elite and rural mothers, Parr 1984
AUSTRALIA & NEW ZEALAND							

Table 39. Regional values for the concentration of Iodine in blood, serum & urine (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
					Whole blood		
U.K.	M+F	1o3	MS		4o ± 3		From all parts of U.K., Hamilton et al 1972
					Blood serum		
Belgium		9	NAA		58 ± 16	3o - 8o	
France		2o	NAA		6o ± 4o		Paris, Stulzaft 1983
U.S.A.		231	NAA		73 ± 7	48 - 1oo	Columbia, Missouri, Rumsey et al 198o
					Urine		
Belgium		3	NAA			96 - 921	Ghent, µg/24 hours, Cornelis et al 1975

TABLE 39. IODINE IN WHOLE BLOOD, BLOOD SERUM AND URINE

Table 4o. Regional values for the concentration of Iodine in milk (ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		7	NAA	62	61 ± 37		Ibadan, Parr 1984, Byrne 1984
Zaire		18	NAA	15	14o ± 373		Lwiro, " " " " "
ASIA							
Philippines		11	NAA	57	58 ± 34	15 - 131	Manila, Parr 1984, Byrne 1984
EUROPE							
Hungary		31	NAA	64	68 ± 43	17 -192	Budapest, Parr 1984, Byrne 1984
Sweden		16	NAA	56	68 ± 46	17 - 172	Uppsala, Parr 1984, Byrne 1984
Yugoslavia		7	NAA		85 ± 79	21 - 264	Ljubljana, Byrne & Kosta 1978, 1983
		31	NAA		41 ± 23		" " " " "
NORTH AMERICA							
CENTRAL AND SOUTH AMERICA							
Guatemala		23	NAA	6o	168 ± 476		Guatemala city, Parr 1984, Byrne 1984
AUSTRALIA AND NEW ZEALAND							

Table 41. Regional values for the concentration of Iodine in hair and liver (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
					Hair		
AFRICA							
Kenya	F	31	NAA		o.63 ± 1.9		Machakos district, Othman & Spyrou 1978
	M	4o	NAA		o.6o ± 1.7		" " " " "
Nigeria		25	NAA		4.2	1 - 228	Urban, Olatunbosun et al 1976
ASIA							
Hongkong		11	NAA	o.5		o.18 - 8.3	Chinese subjects, Chuang 1978
India	M+F	149	NAA		3.4 ± 4.3	2.3 - 36	All over India, students, Arunachalam et al 1978
Japan	M+F	271	NAA		o.76 ± 2.1	o.1 - 33	All over Japan, Tekauchi et al 1982
	F	66	NAA		o.27 ± o.27		Urban, Nakahara & Terai 1983
	M	35	NAA		o.57 ± o.81		" " " "
	F	9o	NAA		o.44 ± o.5o	o.o5 - 2.4	Urban, Imahori et al 1979
	M	93	NAA		o.43 ± o.45	o.o5 - 2.3	" , " " "
EUROPE							
Germany GD	M	76	NAA		1.o4	o.2 - 4.6	Dresden, Wiesener et al 1978
	F	24	NAA		o.6o	o.1 - 4.7	" , " " "
					Liver		
U.K.		11	MS		o.2o ± o.o6		Urban, Hamilton et al 1972

Table 42. Regional values for the concentration of Iron in whole blood (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Bangladesh	M+F	1oo	PIXE		339 ± 23	(28o-41o)	Dacca, Khan et al 198o ,, Lodhi & Khan 1979
India	F	23	NAA		421 ± 79	(252-519)	Bombay, Dang and Somasundaram 1983
Japan	M	45	AAS		5o4 ± 32	(416-562)	Urban, Satoh et al 1978
	F	46	AAS		445 ± 39	(333-5o6)	" " " "
	M	135	AAS		521 ± 49		Different cities in Japan, Usagimoto et al 198o
	F	211	AAS		436 ± 53		" " " " " "
USSR	M+F	1128	AES		315		Urban, Nozdryukina 1977
MIDDLE EAST							
Iran	M+F	29	PIXE		3o9 ± 118	(194-457)	Teheran, Aframian 1983
EUROPE							
Belgium							
Bulgaria	M+F	22	NAA		5o7 ± 32		Vrasta city, Damyanova 1983
Finland	M+F	47	AAS		46o ± 7o	(335-596)	Jyväskylä, Tummavuori and Pirinen 1983
Italy	M+F	47	NAA		425 ± 166	(18o-71o)	Rome, Clemente et al 1978, Cigna Rossi et al 1978
Sweden	F	12	NAA		445 ± 76		Stockholm, Plantin and Mauering 198o
U.K.	M+F	168	XRF		491 ± 24		National average, Hamilton et al 1972/73
NORTH AMERICA							
U.S.A.	F	187	AAS		486, 5o8		Different states of USA, Creason et al 1976

Table 43. Regional values for the concentration of Iron in blood serum (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Botswana	F	2o	AAS		1.o5 ± o.42		Bushmen population, Baumslag and Petering 1976
S. Africa	M+F	78	SAS		1.22 ± o.37		Indians from Natal area, Brain 1982
	M+F	78	SAS		1.o9 ± o.35		Black population, Natal area, Brain 1982
	M+F	78	SAS		1.21 ± o.34		White population, " " " "
ASIA							
Thailand	F	1o1	SAS		1.o6 ± o.6o		Si Sa Ket region, villagers, Suwanik et al 1981
	M	37	SAS		1.25 ± o.63		" " " " " " "
	F	144	SAS		1.o8 ± o.22		Bangkok, " "
	M	45	SAS		1.o7 ± o.28		" " "
U.S.S.R.		5o			1.o6 ± o.o4[a]	(o.5-1.5)	Moscow, Brusovanik 1981
MIDDLE EAST							
Turkey	M+F	1oo	AAS		o.97		Selected subjects, Yüregir and Donma 1983
	M+F	15o	SAS		1.oo		Urban, " " "
	M+F	11	AAS		1.45 ± o.25	(1.1-2.o)	Istanbul, Saner 1983
EUROPE							
Austria	F	591	SAS		o.83 ± o.33		Urban, 4o year old subjects, Müller et al 1982
	M	552	SAS		o.9o ± o.31		" " " " "
	F	553	SAS		o.75 ± o.24		" 6o " " " "
	M	4oo	SAS		o.87 ± o.33		" " " " " "
Belgium	F	17	SAS		o.99 ± o.29	(o.4-1.6)	Brussels area, Roels et al 1982
	M	17	SAS		1.4o ± o.35	(1.o-2.o)	" " " "
Germany	F	136	AAS	o.85		(o.65-1.1)	Berlin, Heineman 1974
Greece	M+F	35	PIXE		1.4o ± o.29	(o.8o-2.o)	Athens, Paradellis 1983

a) standard error

Table 43. (contd) Regional values for the concentration of Iron in blood serum (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
Canada	F	4o	AAS		1.o7 ± o.31		Vegetarians, Guelph area, Anderson et al 1981
U.S.A.	M	2o3	AAS	o.95			Chicago, military recruits, Creason 1976
	M	4o6	AAS	o.9o			Illinois country area, " " "
		5o	AAS			(o.35-1.7)	Ohio, Shamberger 1983
AUSTRALIA AND NEW ZEALAND							
Australia	F	33	NAA		1.5o ± o.39	(o.87-1.9)	Geelong area, Cumming et al 1983

Table 44. Regional values for the concentration of Iron in milk (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		18	NAA	523	477 ± 2o	(273-177o)	Ibadan, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Zaire		69	NAA	556	71o ± 43o	(142-2ooo)	Lwiro, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
ASIA							
India		6	NAA		6oo ± 1oo	(4oo-7oo)	Bombay, Dang et al 1983
Philippines		65	NAA	721	77o ± 36o	(128-187o)	Manila, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
MIDDLE EAST							
Turkey		23	AAS		78o, 14oo		Istanbul, range of mean values, Saner 1983
EUROPE							
Finland		229	AAS		56o ± 3oo	(11o-14oo)	Urban area, Siimes et al 1979
Germany		19	AAS		26o ± 73		Dortmund, Stolley et al 1981
Hungary		71	NAA	365	415 ± 222	(173-191o)	Budapest, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Italy		13o	NAA		15oo ± 4oo	(1oo-2oooo)	Rome area, Clemente et al 1983
Sweden		32	NAA	445	477 ± 2oo	(2o5-1o49)	Uppsala, Iyengar 1984, Parr 1984
Spain		46	SAS		392 ± 196		Malaga, Celada et al 1982

Table 44. (contd) Regional values for the concentration of Iron in milk (/ug/g)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
U.S.A.	5o		AAS		2o2 ± 17o		Urban subjects, daily samples, Picciano & Guthrie 1976
	5o		AAS		232 ± 19o		" " weekly " " " "
	28		AAS		49o		" " , 1-3 months pp, Vaughan et al 1977
	39		AAS		425		" " , 3-9 " " "
	28		AAS		38o		" " , 1o-18 " " "
	3o		AAS		42o		" " , 19 " " "
CENTRAL AMERICA							
Chile	11		NAA		171o ± 73o	(5oo-28oo)	Santiego, Toro 1983
Guatemala	84		NAA	346	361 ± 189	(1oo-11oo)	Guatemala city, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
AUSTRALIA AND NEW ZEALAND							
Australia	4o		NAA			(3oo-5oo)	Geelong, Cumming et al 1983
New Zealand	25		AAS		72o		Dunedin, Casey et al 1977

Table 45. Regional values for the concentration of Iron in liver (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		8	NAA		12o ± 83		Urban, Yukawa et al 198o
		1o	AAS		25o		Urban, Tanaka 1983
EUROPE							
Belgium		5	NAA		195	(2o-458)	Ghent area, Lievens et al 1977
Bulgaria		3o	NAA		3o2 ± 137		Vrasta city, Damyanova 1983
Italy		4	NAA		297 ± 143	(83-714)	Rome area, Ingrao 1983
Sweden		12	NAA		166 ± 55		Stockholm, Plantin 1978
U.K.		9	XRF		2o7 ± 39		Urban, Hamilton et al 1972/73
NORTH AMERICA							
Canada		44	AAS	3o7		(37-1o69)	Ottawa, Subramanian and Meranger 1982
	M	45	AAS		237 ± 1o5 to 262 ± 154		Urban, up to 55 years of age, Shah 1976
	M	17	AAS		132 ± 48 to 144 ± 98		" over 56 years of age, " "
	F	19	AAS		46 ± 14 to 88 ± 5o		" up to 55 years of age, " "
	F	4	AAS		116 ± 78		" over 55 years of age, " "
U.S.A.	M+F	36	NAA		23o ± 12o	(43-51o)	Baltimore, Mineapolis & Seatle, Zeisler et al 1984
CENTRAL AMERICA							
Cuba	M	71	SAS		2o1 ± 71 to 245 ± 113		Havana, Gautier du Defaix et al 198o, 21-6o years old
	F	23	SAS		115 ± 51.4		" , 2o-46 years old, " " "
	F	6	SAS		189 ± 92		" , over 46 years old " " "

Table 46. Regional values for the concentration of Iron in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Botswana	M	8	AAS		9o5 ± 8o3	(224-237o)	Bushman population, Baumslag and Petering 1976
	F	12	AAS		296 ± 196	(83.68o)	Bushman population, Baumslag and Petering 1976
Kenya	M+F	165	AAS		177	(19-424)	All provinces of Kenya, Wandiga and Jumba 1983
S. Africa	F	37	AAS		135 ± 68		Bantu women, Ba-mslag and Petering 1976
Zambia	F	59	AAS		34 ± 21		Lusaka, Briggs 1972
	M	74	AAS		31 ± 17		" " "
ASIA							
Bangladesh	M+F	1o2	PIXE		3o ± 17.3	(6.3-1o7)	Dacca, Khan et al 198o
India	M+F	252	NAA	59	6o ± 38	(8.4-334)	All over India, Arunachalam et al 1978
Japan	F	79	NAA		47 ± 38	(9-2o8)	Tokyo, Imahori et al 1978
	M	59	NAA		34 ± 28	(8-155)	" " " "
	M+F	112	NAA		35 ± 33	(12-3oo)	All over Japan, Tekeuchi et al 1982
Pakistan	M+F	1o5	NAA		51 ± 33	(11-156)	Islamabad area, Qureshi et al 1982
Thailand		25	AES		19 ± 3		Bangkok, Hambidge et al 1974
Vietnam		2o	PIXE		13 ± 2		Vietnamese students sampled in Poland, Hung et al 1982
MIDDLE EAST							
Egypt	M+F	65	NAA		4o-1oo, range of mean values		Different groups from all over Egypt, Kasperek et al 1982
Iran		9	PIXE		3-5	" "	Teheran, Aframian et al 198o
Iraq		23o	NAA		122 ± 115	(<5o-5oo)	Bagdad, Al-Shahristani et al 1978
Turkey		11	AAS		21 ± 7	(14-34)	Istanbul, Saner 1983

Table 46. (contd) Regional values for the concentration of Iron in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
EUROPE							
Germany		26	NAA		3o ± 1o		Urban, Kasperek et al 1971
Italy		49	NAA			(1o-24oo)	Rome, Clemente et al 1978
Poland		2o	PIXE		27 ± 4		Urban, Hung et al 1982
NORTH AMERICA							
Canada	M+F	76	PAA	31		(1o-85)	Rural population, Chatt et al 1977
	M+F	45	PAA	41		(8-1oo)	Urban population, " " "
U.S.A.	F	5o	AAS		3o ± 29		Cincinatti area, Baumslag and Petering 1976
CENTRAL AMERICA							
Chile	M+F	38	NAA		41 ± 19	(21-1o4)	Santiego, Toro 1983
AUSTRALIA & NEW ZEALAND							
Australia	F	59	AAS		22 ± 11	(6-6o)	Brisbane, Reilly 1981
	M	24	AAS		16 ± 13	(1o-52)	" " "

Table 47. Regional values for the concentration of Iron in urine (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		9	NAA		1.2 ± o.44	o.5 - 1.5	Ishii et al 1978
MIDDLE EAST							
EUROPE							
Italy	M+F	47	NAA		145 ± 45o	1oo - 25oo	Rome, Cigna Rossi et al 1978, Clemente et al 1978
NORTH AMERICA							
U.S.A.	M	12	SAS		6oo	5o - 9oo	Greensboro, NC, Ganapathy et al 1981
AUSTRALIA AND NEW ZEALAND							
New Zealand		11	AAS		112 ± 22	7o - 16o	Dunedin, Robinson et al 1973

Table 48. Regional values for the concentration of Lead in whole blood (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
China	F	118	AAS	55	59 ± 19		Peking, teachers, Vahter 1982, Friberg & Vahter 1983
	M	43	AAS	65	71 ± 21		" " " " "
India	F	1oo	AAS	129	147 ± 23		Ahmadabad, teachers, " " "
	M	7o	AAS	137	155 ± 71		" " " " "
	F	44	AAS	171	198 ± 1o1		Bangalore, teachers, " " "
	M	9	AAS	215	238 ± 91		" " " " "
	F	5o	AAS	145	1o8 ± 35		Calcutta, teachers, " " "
	M	31	AAS	173	132 ± 128		" " " " "
Japan	F	46	AAS		56 ± 5o	(14-136)	Urban, Satoh et al 1978
	M	45	AAS		8o ± 36	(2o-16o)	" " "
	F	163	AAS	6o	66 ± 3[a]	(23-282)	Hokkaido region, Saito et al 1979
	M	145	AAS	7o	73 ± 3[a]	(27-346)	" " " "
	F	77	AAS	51	55 ± 18		Tokyo, teachers, Vahter 1982, Friberg & Vahter 1983
	M	17	AAS	64	67 ± 2o		" " " " "
Nepal	F	3o	AAS		29[b]		Up to 5ooo m altitude, Piomelli et al 198o
	M	3o	AAS		38[b]		" " " " "
Thailand	F	2o	AAS		1o8.5		Bangkok, Htun and Ramachandran 1977
	M	2oo	AAS		124		" " "
MIDDLE EAST							
Israel	F	51	AAS	98	7o ± 28		Tel Aviv, teachers, Vahter 1982, Friberg & Vahter 1983
	M	92	AAS	123	93 ± 26		" " " " "

a) standard error b) geometric mean

Table 48. (contd) Regional values for the concentration of Lead in whole blood (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
EUROPE							
EEC countries	M+F	176o9	AAS	13o	3 % of the results 3oo,		9 EEC countries, average, Berlin 1981, 1983
Belgium	F	39	AAS	111	123 ± 3o		Brussels, teachers, Vahter 1982, Friberg & Vahter 1983
	M	5o	AAS	162	165 ± 39		" " " " "
	F	333	AAS		1oo ± 4o	(3o-181)	" ,smokers, Buchet et al 1978
	F	1o9	AAS		1o5 ± 32	(5o-21o)	" ,non-smokers, " " "
	F	41	AAS		1o6	(51-216)	Drinking water Pb = 12 ppm, Hubermont et al 1978
	F	29	AAS		138	(53-263)	" " Pb = 298 ppm, " " "
	F	7o	AAS		159	(7o-265)	Aged 7o to 92 years, Roels et al 1981
	M	47	AAS		152 ± 42	(69-268)	Aged 21-59 years, Roels et al 1982
	F	47	AAS	16o			Brussels, Berlin 1981, 1983
	M	75	AAS	19o			" " " "
Denmark	F	121	AAS		9o ± 3o	(o-26o)	Urban, wide coverage, Nygaard et al 1973. 1977
	M	47	AAS		15o ± 42	(69-268)	" " " " " "
	F	91	AAS	8o			4o years old non-smoking subjects, Grandjean 1981
	F	8o	AAS	9o			" " smoking " " "
	F	36	AAS	89			Copenhagen, Berlin 1981, 1983
	M	35	AAS	118			" " " "
	F	548	AAS	9o			Suburb of Copenhagen, Olsen et al
	M	5o4	AAS	13o			" " "
France	M	44o	AAS		195 ± 6o		Paris, smokers, Orssund et al 1983
	M		AAS		164 ± 46		" non-smokers, " "
	F	917	AAS	9o-12o	(range of median values)		8 cities in France, Berlin 1981, 1983
	M	782	AAS	13o-17o	" " "		" " " " "
Germany	M+F	8oo			13o	(4o-4oo)	Mixed population, Stoeppler 1983
	F	165	AAS	99		(8o-115)	Hamburg and Hannover, Berlin 1981, 1983
	M	169	AAS	116		(1oo-125)	" " " " " "
	F	85	AAS	93			Nordenham area, Aurand et al 1978
	M	85	AAS	127			" " " " "
Greenland	F	89	AAS	128			Angmagssalik area, Hansen et al 1983
	M	61	AAS	148			" " " " "
Holland	M	57	AAS		138 ± 39		Amsterdam, 19-21 years, Wibobo et al 1977
	F	47	AAS		13o ± 32		" " " " " "

Table 48. (contd) Regional values for the concentration of Lead in whole blood (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
EUROPE (continued)							
Holland	F	1o1	AAS		1o1[b]		Urban nonsmoking subjects, Zielhuis et al 1977
	F	76	AAS		118[b]		" smokers, 1o cigarettes a day," " "
	F	5o	AAS		1oo		Amsterdam, Berlin 1981, 1983
	M	5o	AAS		15o		" " " "
Ireland	F	25	AAS	125			Dublin, Berlin 1981, 1983
	M	25	AAS	16o			" " " "
Italy	F	7o1	AAS	14o	11o-15o	(range of medians)	From 5 big cities in Italy, Berlin 1981, 1983
	M	613	AAS	2oo	18o-21o,	" "	" " " " " " " "
	M	379	AAS		198 ± 53	8o - 4oo	Rome, Pallotti et al 1983
	M	25	AAS		2o3 ± 59		Wine drinkers, Stoeppler 1983
	M	11	AAS		136 ± 38		Non-drinkers, " "
	F	422	AAS		15o ± 39	6o - 34o	Rome, Pallotti et al 1983
Luxumbourg	F	52	AAS	115			Berlin 1981, 1983
	M	59	AAS	15o			" " "
Sweden	F	45	AAS	58	64 ± 25		Stockholm, random sampling, Friberg & Vahter 1983
	M	31	AAS	77	83 ± 38		" " " " " "
	F	5o	AAS		85 ± 26		South of Sweden, Hoeger-Aronsen et al 1971
	M	5o	AAS		123 ± 43		" " " " " "
	M	66	AAS		81 ± 27		Vuxuna area, non-smokers, Andersson 1981
	M		AAS		93 ± 25		" " smokers, " "
	F	9o	AAS		56 ± 21		" " non-smokers, " "
	F		AAS		64 ± 23		" " smokers, " "
U.K.	F	452	AAS	12o	1oo-15o	(range of medians)	Several cities in the U.K., Berlin 1981, 1983
	M	431	AAS	16o	14o-19o	" " "	" " " " " " " "
	F	19	AAS		14o	(1o-33o)	North west England, Barry and Mossmann 197o
	M	3o	AAS		22o	(1o-79o)	" " " " " "
	M	1558	AAS		127[a]		Non-smokers, Sharper et al 1982
	M	3612	AAS		141-157[b]	(range)	Smokers, " " "
	M	436	AAS		127[b]		Non-drinkers, " " "
	M	5182	AAS		129-165[b]	(range)	Drinkers " " "
	M	423	AAS		122[b]		Non-drinkers & non-smokers "
	M	229	AAS		176[b]		Smokers + drinkers, "
Yugoslavia	F	84	AAS	76	9o ± 2o	(31-225)	Zagreb, teachers, Kostial 1983, Friberg & Vahter 1983
	M	3o	AAS	125	14o ± 5o	(46-26o)	" " " " " " " "

b) geometric mean

TABLE 48. LEAD IN WHOLE BLOOD (Contd.)

Table 48. (contd) Regional values for the concentration of Lead in whole blood (/ug/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
Canada	M+F	1231	POL		19o	(8o-4oo)	Adults and children, Roberts et al 1974
	M+F	61	AAS		18o-194	(82-32o)	Halifax, Ward et al 1979
		254	POL	127			Urban, Neri et al 1978, Schmitt et al 1979
U.S.A.	F	1368	AAS		128 ± 51		From 32 locations in the USA, Mahaffey et al 1979
	M	1278	AAS		177 ± 65		" " " " " " " " " "
	F	64	AAS	65	65 ± 2o		Baltimore, teachers, Vahter 1982, Friberg & Vahter 1983
	M	24	AAS	89	87 ± 26		" " " " " " "
	M	56	AAS	172[b]	193 ± 11		Los Angeles, residents near high way, Johnson et al 1975
	F	7o	AAS	128[b]	142 ± 11		" " " " " " " " "
	M	5o	AAS	1o8[b]	118 ± 6		Lancaster, residents in desert area, " " "
	F	69	AAS	88[b]	96 ± 4		" " " " "
CENTRAL AND SOUTH AMERICA							
Mexico	F	33	AAS	198	2o1 ± 6o		Mexico city, trachers, Friberg and Vahter 1983
	M	21	AAS	255	269 ± 77		" " " " " " "
Peru	F	91	AAS	92	94 ± 21		Lima, teachers, Vahter 1982, Friberg and Vahter 1983
	M	12	AAS	1o7	115 ± 31		" " " " " " " "
Venezuela		9o	POL		8 ± 6	(o-39)	Yanomamö, southern Venezuela, non-industrial area, Hecker et al 1974
AUSTRALIA AND NEW ZEALAND							

b) geometric mean

Table 49. Regional values for the concentration of Lead in milk samples (ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		14	AES-ICP	5	6.5 ± 5.o	(o-2o.3)	Ibadan, urban elite, urban poor and rural mothers, Kirkbright 1984, Parr 1984
Zaire		69	AES-ICP	5	6.5 ± 7.o	(o-41.o)	Lwiro, urban elite, urban poor and rural mothers, Kirkbright 1984, Parr 1984
ASIA							
Philippines		63	AES-ICP	17	24.o ± 26.o	(4.7-141)	Manila, urban elite, urban poor and rural mothers, Kirkbright 1984, Parr 1984
EUROPE							
Hungary		72	AES-ICP	15	18.o ± 13.7	(o-219)	Budapest, urban elite, urban poor and rural mothers, Kirkbright 1984, Parr 1984
Spain		12	SAS		3o		Bucharest, control population, town with known Lead pollution from the environment = 42o, Ghelberg et al 1972
Sweden		32	AES-ICP	17	18.2 ± 5.7	(9.6-37)	Uppasala, urban subjects, Kirkbright 1984, Parr 1984
NORTH AMERICA							
U.S.A.		22	AAS		12 ± 4.o		Cincinnati, Murthy and Rhea 1971
		25	AAS		2o		" " " " "
		29	AAS		26 ± 11	(6-58)	7 cities in the U.S.A., Dillon et al 1974
CENTRAL AND SOUTH AMERICA							
Guatemala		74	AES-ICP	3	3.6 ± 3.2	(o-15.4)	Guatemala city, urban elite, urban poor and rural mothers, kirkbright 1984, Parr 1984
AUSTRALIA AND NEW ZEALAND							
New Zealand		25	AAS		<1o		Dunedin, Casey 1977

Table 5o. Regional values for the concentration of Lead in liver (/ug /kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		64	AAS		34o-59o[a]	(range of GM)	Shinjuku-ku, 2o-7o year old subjects, Tsuchiya and Iwao 1978
		15	AAS		41o ± 21o	(14o-95o)	Urban, Kitamura et al 1978
		3o	SAS		46o ± 24o	(1oo-1ooo)	Urban, Sumino et al 1975
		1o	AAS		5oo		Urban, Tanaka 1983
EUROPE							
Sweden		5	AAS		37o ± 12o		North of Sweden, Brune et al 1978
U.K.		11	MS		23oo ± 6oo		Urban, Hamilton et al 1972/1973
NORTH AMERICA							
U.S.A.		36	MS (IDMS)		55o ± 34o	(12o-166o)	Baltimore, Mineapolis and Seattle, Zeisler et al 1984
AUSTRALIA AND NEW ZEALAND							
New Zealand		11	AAS		1o6o ± 575	(46o-25oo)	Urban, Johnson et al 1976

a) geometric mean

Table 51. Regional values for the concentration of Lead in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Kenya	M+F	195	POL		42.o ± 7.8		From all parts of Kenya, Wandiga and Jumba 1983
	M+F	265	AAS		52.o ± 12.5		" " " " " " " " "
Nigeria		25	AAS	13		(3-246)	Ibadan,Olatunbosun et al 1976
ASIA							
Bangladesh	M+F	96	PIXE		4.2 ± 2.4	(1-11.2)	Dacca, Khan et al 1981
India	M	2oo	AAS		5.1 ± 4.3		Rural, Rajastan province, Barker et al 1976
	M	2oo	AAS		9.4 ± 8.o		Urban, " " " " "
Japan	F	99	AAS		9.2 ± 9.6		Urban, Matsuzawa et al 1977
	M	98	AAS		8.o ± 7.5		" " " "
MIDDLE EAST							
Iran		11	PIXE		2.3 - 3.8	(range of mean values)	Teheran, Aframian et al 198o
EUROPE							
NORTH AMERICA							
Canada	M+F	76	PAA	1o		(o.5-25)	Rural, Chatt et al 1977
	M+F	45	PAA	17		(o.5-35)	Urban, " " "
U.S.A.	M+F	115	AAS		27[a]	(45 ± 4.3)	Los Angeles area, Johnson et al 1975
	M+F	1o9	AAS		12[a]	(19 ± 3.1)	Lancaster desert area, " " "

a) geometric mean

Table 51. (contd) Regional vlaues for the concentration of Lead in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
CENTRAL AND SOURTH AMERICA							
Panama	F	242	AAS	11.4			Both adults and children, Klevay 197o, 1973
	M	184	AAS	18			" " " " " " "
AUSTRALIA AND NEW ZEALAND							
Australia	M	39	AAS		1o.3 ± 8.7	(o-34.1)	Brisbane, Reilly 1981
	F	59	AAS		8.1 ± 7.o	(o.2-37.2)	" " "

Table 52. Regional values for the concentrations of Lead in urine (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	M+F	98	AAS		1o ± 6.5		Akita, Ishikawa & Nagasaki area, Iwao et al 1981
	M+F	368	AAS		6.3		Urban, Fukabori & Nukaaki 1974, 1o µg/24 hours
	M+F	61	AAS		13 ± 12		Urban, Koizumi et al 1978
MIDDLE EAST							
EUROPE							
Belgium	M	47	AAS		11.3 ± 7.2	4 - 45	Brussels, Roels et al 1982, µg/g creatinine
NORTH AMERICA							
AUSTRALIA & NEW ZEALAND							

Table 53. Regional values for the concentration of Manganese in whole blood (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
China					8.0 ± 2.0		Urban samples, Wang 1982
India		8	NAA		18.7 ± 8.0	(8.4-25.1)	Bombay, Dang and Somasundaram 1983
Japan	M	145	AAS	16.1	17.0 ± 0.5[a]		Hokkaido region, Saito et al 1979
	F	163	AAS	17.5	18.5 ± 0.4[a]		" " " "
EUROPE							
Belgium		20	AAS		12.2 ± 4.0		Brussels, Buchet et al 1976
Norway		32	AAS		10.0 ± 4.0		From all parts of Norway, Tsalev et al 1977
Sweden		10	NAA		15	(5-20)	Stockholm, Brune et al 1962
NORTH AMERICA							
Canada	M+F	61	NAA/AAS		20-28 (range of mean values)		Halifax, Ward et al 1979
U.S.A.		14	NAA		8.4 ± 3.0		Brookhaven, Cotzias et al 1966

a) standard error

Table 54. Regional values for the concentration of Manganese in blood serum (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
EUROPE							
Belgium	M+F	46	NAA		o.57 ± o.13	(o.4o-1.o4)	Ghent area, Versieck et al 1973, 1974
Denmark		11	NAA		o.54 ± o.5o	(o.23-o.8o)	Roskilde, Heydorn and Norgaard 1973
Germany FR	M+F	8	NAA		o.6o	(o.31-o.94)	Juelich, Iyengar 1984
U.K.		6	AAS		o.63	(o.44-o.96)	Glasgow, Hall and Fell 198o
		28	NAA		1.76 ± o.45		Manchester area, Molokhia & Portnoy 1973
NORTH AMERICA							
U.S.A.		2o	AAS		1.o ± o.2	(o.74-1.25)	Chicago, D'Amico and Klawans 1976
		12	NAA		o.64	(o.4o-o.9o)	Los Angeles, Fernandez et al 1963
	M+F	128	NAA		1.4o ± o.5o		San Diego, Campero et al 1967
		14	NAA		o.59 ± o.2o		Brookhaven, Cotzias et al 1966

MANGANESE IN ERYTHROCYTES (mg/kg)

EUROPE						
Belgium	M+F	46	NAA		16.4 ± 5.4[a]	Ghent area, Versieck et al 1973, 1974
NORTH AMERICA						
U.S.A.	M+F	15	NAA		16.o ± 1.o	San Diego, Campero et al 1967

a) packed cells, /ug/L

TABLE 54. MANGANESE IN BLOOD SERUM

Table 55. Regional values for the concentration of Manganese in milk (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		18	NAA	15.8	19.3 ± 11.2	(4.1-43.3)	Ibadan, urban elite, urban poor and rural mothers Iyengar 1984, Parr 1984
Zaire		68	NAA	11.2	18.3 ± 2o.o		Lwiro, " " " " " "
ASIA							
India		24	NAA		8.o ± 4.o	(3-15)	Bombay, Dang et al 1983
Philippines		63	NAA	39.5	42.o ± 24.5	(6-153)	Manila, urban elite, urban poor and rural mothers Iyengar 1984, Parr 1984
EUROPE							
Finland		229	AAS		6.o ± 7.8	(2-18)	Helsinki, Vuori 1979
Germany (FR)		17	AAS		11.8 ± 2.2		Dortmund, Stolley et al 1981
Hungary		71	NAA	4.o	5.5 ± 4.1	(1.1-18)	Budapest, urban elite, urban poor and rural mothers Iyengar 1984, Parr 1984
Sweden		31	NAA	3.2	5.o ± 5.3	(1.5-26)	Uppsala, Iyengar 1984, Parr 1984
Yugoslavia		6	NAA		3.2 ± 2.1	(1-6.4)	Ljubljana, Byrne and Kosta 1978, 1982, 1983
NORTH AMERICA							
U.S.A.		28	AAS		2o		urban, 1-3 months pp, Vaughan et al 1977
		39,23	AAS		24, 25		" 4-9 " " "
		13	AAS		18		" 1 year " " "
		28	AAS		14		" > 1 year " " "
CENTRAL AND SOUTH AMERICA							
Guatemala		84	NAA	3.8	6.o ± 8.7	(1.4-7o)	Guatemala city, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
AUSTRALIA AND NEW ZEALAND							
Australia		39	NAA		5.o ± 3.o	(1-12)	Geelong area, Cumming et al 1983, 1984

Table 56. Regional values for the concentration of Manganese in liver (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
India		8	NAA		2.1 ± 1.1	(2.6-11.1)	Bombay, Dang et al 1978
Japan		15	AAS		1.7 ± o.44	(1.2-2.9)	Urban, Kitamura et al 1978
		3o	AAS		1.2 ± o.36	(o.5-2.1)	Urban, Sumino et al 1975
		1o	AAS		1.2		Urban, Tanaka 1983
		9	NAA		1.1 ± o.6o		Urban, Terai et al 1979
EUROPE							
Belgium		5	NAA		1.34	(1-2)	Ghent, Lievens et al 1977
Denmark		7	NAA		1.1 ± o.2		Copenhagen, Larsen et al 1972
Sweden		5	NAA		o.54 ± o.17		North of Sweden, Brune et al 1978
		15	NAA		1.32 ± o.45		Stockholm, Plantin 1978
U.K.		9	MS		o.5o ± o.o8		Urban, Hamilton et al 1972/73
NORTH AMERICA							
Canada	M+F	44	AES-ICP	1.3		(o.4-3.2)	Ottawa, Subramanian 1983
U.S.A.	M+F	36	NAA,AAS		1.2o ± o.4o	(o.6-2.o3)	Baltimore, Mineapolis & Seattle, Zeisler et al 1984
AUSTRALIA AND NEW ZEALAND							
New Zealand	M+F	111	AAS		1.15 ± o.44	(o.37-2.38)	Dunedin, Casey et al 1983

Table 57. Regional values for the concentration of Manganese in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Kenya	F	31	NAA		15.0 ± 2.6		Machakos district, Othman and Spyrou 1978
	M	40	NAA		11.5 ± 2.7		" " " " "
Nigeria	M+F	25	NAA		4.4	(0.3-255)	Ibadan, Olatunbosun et al 1976
ASIA							
Bangladesh	M+F	92	PIXE		2.3 ± 1.35	(0.5-6.1)	Dacca, Khan et al 1980
Hong Kong		11	NAA		0.9	(0.4-28)	Chinese subjects, Chaung 1978
India		14	NAA		3.4 ± 2.1		Bombay, Somasundaram et al 1981
	M+F	243	NAA		3.4 ± 3.4	(0.1-22)	All over India, students, Arunachalam et al 1978
Japan	F	94	NAA		1.5 ± 2.5	(0.13-20)	Urban, Tokyo, Imahori et al 1978
	M	90	NAA		1.3 ± 2.5	(0.12-22)	" " " " "
	M+F	375	NAA	0.5[a]			Tokyo area, Ohmori et al 1981
	M+F	336	NAA		1.1 ± 3.8	(0.1-50)	Urban, Tekauchi et al 1982
Pakistan	M+F	105	NAA		4.3 ± 3.6	(0.5-16)	Islamabad, Qureshi et al 1982
Thailand		25	AES		3.8 ± 0.75[b]		Bangkok, Hambidge et al 1974
MIDDLE EAST							
Egypt	M+F	65	NAA		2 to 3.8	(range of mean values)	Various parts of Egypt, Kasperek et al 1982
Iran	M+F	9	PIXE		0.7 to 2	(range of mean values, groups of subsamples)	Teheran area, Aframian et al 1980
Turkey		11	AAS		0.6 ± 0.4	(0.3-1.3)	Istanbul, Saner 1983

a) geometric mean b) standard error

Table 57. (contd) Regional values for the concentration of Manganese in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
EUROPE							
Finland		2o	AAS		1.56 ± 1.2		Helsinki, Vuori et al 2975
Germany (DR)		45o	NAA	1.2[a]			Dresden, Wiesener et al 1978
Poland		6o	NAA	o.83	o.1o-43		Warsaw, Dybczynski et al 1983
NORTH AMERICA							
Canada		42	NAA	o.6		(<o.1-3.7)	Halifax area, Ryan et al 1978
	F	34	NAA		o.4o	(o.25-o.87)	Guelph area, Vegetarians, Gibson et al 1983
	F	3o	NAA	o.26	o.26	(o.14-o.41)	" " nonvegetarians, " " "
U.S.A.		18	AES		o.2o ± o.o6[b]		Denver area, Hambidge et al 1974

a) geometric mean, b) standard error

TABLE 57. MANGANESE IN HAIR (Contd.)

Table 58. Regional values for the concentrations of Manganese in urine (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	F	48	AAS	0.54[a]		0.08-2.4	Urban area, Watanabe et al 1978
	M	78	AAS	0.53[a]		0.11-2.7	" " " " "
MIDDLE EAST							
EUROPE							
Belgium	M+F	20	AAS		0.65 ± 0.53	< 0.1 - 1.8	Brussels, Buchet et al 1978
		3	NAA			0.1 - 0.7	Ghent, Cornelis et al 1975, µg/24 hours
NORTH AMERICA							
AUSTRALIA & NEW ZEALAND							
New Zealand	M+F	12	AAS		9.8 ± 4.8	3 - 19	Dunedin, McLeod & Robinson 1972, µg/24 hours

a) Geometric mean

Table 59. Regional values for the concentration of Mercury in whole blood (µg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	F	2o	AAS		2o ± 16		Urban, Usagimoto et al 198o
	M	135	AAS		4o ± 4o		" " " "
		19			59 ± 26		" Sumino et al 1975
EUROPE							
Belgium	M	47	AAS		2.3 ± 1.2	(o.5o-5.9)	Brussels, Roels et al 1982
Denmark	M+F	264	AAS		2.o	(o-17)	Wide national coverage, Bach 198o
Germany FR	M+F	2o2	AAS	o.6		(o.1-7.2)	Bavarian area, Valentin 1983, see Schaller et al
Italy	M+F	47	NAA		18 ± 21	(<5-76)	Rome, detected in 11 subjects, Clemente et al 1978, Cigna Rossi et al 1978
Sweden		7	NAA			(6-12)	Stockholm, Lundgren et al 1967
	-	-	-			(5-1o)	Average Swedish value, quoted Skerfving 1974
Yugoslavia	M+F	54	NAA		5.1 ± 5.o		Urban, Byrne and Kosta 1983
NORTH AMERICA							
U.S.A.	F	187	AAS	4	1o		8 states in U.S.A., Creason et al 1976
		1oo	AAS		9.5 ± 2.5	(5-2o.5)	Michigan, Hecker et al 1974
	F	1oo	AAS		1.o1 ± o.12	(o - 8)	Pitkin et al 1976
		17	AAS		2o		Alaska, coastal Eskimos, Galster 1976
		11	AAS		13		" interior " " "
		12	AAS		6		Urban " " "
		1o	AAS		7.6 ± 1.o[a]		Alaska, Magos and Clarkson 1972
CENTRAL AND SOUTH AMERICA							
Venezuela		9o	AAS		14.3 ± 11.9	(3-57)	Yanamano area, Hecker et al 1974
		24	AAS		6.o ± 1.5		Indians, " " "

a) standard error

TABLE 59. MERCURY IN WHOLE BLOOD

Table 6o. Regional values for the concentration of Mercury in serum and erythrocytes

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
					serum (/ug/L)		
EUROPE							
France		1o	NAA		3.1 ± o.2		Urban, Stulzaft 1983
Norway		281	NAA		< 1.3	(<o.2-6.5)	Urban, Blekastad et al 1983
Sweden		7	NAA		3-6		Urban, Lundgren et al 1967
NORTH AMERICA							
U.S.A.	F	17	AAS		5.8 ± o.71		Alaska, coastal females, plasma, Galster 1976
	F	11	AAS		5.o ± o.8		" interior " "
	F	1o	AAS		2.6 ± o.3		Urban Eskimos, " "
		1o	AAS		2.2 ± o.9[a]		Alaska, plasma, Magos and Clarkson 1972
					Erythrocytes (/ug/kg)		
U.S.A.	F	17	AAS		33.5 ± 5.1		Alaska, coastal females, Galster 1976
	F	11	AAS		22.6 ± 3.o		" interior, " "
	F	1o	AAS		9.o ± o.9		Urban Eskimos, " "
		1o	AAS		16.6 ± 2.2[a]		Alaska, Magos and Clarkson 1972

a) standard error

Table 61. Regional values for the concentration of Mercury in milk (µg /L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		18	NAA	2.2	5.2 ± 1o.8	(o.9-48)	Ibadan, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Zaire		69	NAA	2.7	13 ± 3.5	(o.6-257)	Lwiro, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
ASIA							
India		12	NAA		o.2 ± o.1	(o.1-o.3)	Bombay, Dang et al 1983
Philippines		65	NAA	1.7	2.7 ± 2.3	(o-12)	Manila, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
EUROPE							
Hungary		71	NAA	o.4	1.8 ± 1.6	(o-1o.9)	Budapest, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Italy		13o	NAA			(<o.5-17.5)	Rome, Clemente et al 1983
Sweden		32	NAA	3.3	3.4 ± 1.6	(1.o3-7.7)	Uppsala, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Yugoslavia		6	NAA		1.o ± o.9	(o.25-2.5)	Urban, Byrne and Kosta 1983
NORTH AMERICA							
U.S.A.		32	AAS		o.93 ± o.23		Urban, Pitkin et al 1976
		5	AAS		3.2 ± o.8o		Alaska, interior, Galster 1976
		5	AAS		3.3 ± o.5		" urban " "
		11	AAS		7.6 ± 2.7		" coastal, " "
CENTRAL AND SOUTH AMERICA							
Guatemala		84	NAA	1.5	1.9 ± 1.7	(o-13.8)	Guatemala city, urban and rural mothers, Iyengar 1984, Parr 1984

Table 62. Regional values for the concentration of Mercury in liver (ug/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		15	NAA		23o ± 13o	(53-42o)	Urban, Kitamura et al 1978
		3o	AAS		47o ± 26o	(16o-13oo)	Urban, Sumino et al 1975
		1o	SAS		49o ± 31o	(5o-39oo)	Ohta et al 1966
EUROPE							
Belgium		5	NAA		74	(51-1o3)	Ghent, Lievens et al 1977
Norway		8	NAA		12o ± 11o	(16-3oo)	Urban, Jonsen and Steinnes 1983
Sweden		5	NAA		1oo ± 2o		North of Sweden, Brune et al 1978
U.K.		22	NAA		428		Glasgow area, Lenihan 1967
Yugoslavia		14	NAA		33 ± 23	(4-76)	Urban, Byrne and Kosta 1983
NORTH AMERICA							
U.S.A.		35	NAA		86 ± 74	(26-47o)	Baltimore, Minèapolis & Seattle, Zeisler et al 1984
AUSTRALIA & NEW ZEALAND							
New Zealand		11	AES		16o ± 1oo	(22-37o)	Urban, Johnson et al 1976

Table 63. Regional values for the concentration of Mercury in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Kenya	M+F	27o	AAS		12.2 ± 1.8		From all parts of Kenya, Wandiga & Jumba 1983
	F	31	NAA		6.1 ± 1.5		Machakos district, Othman and Spyrou 1978
	M	4o	NAA		7.3 ± 1.9		" " " " " "
ASIA							
Hong Kong		11	NAA		2.8	(1.6-3.6)	Chuang 1978
Japan		15	AAS		3.1 ± 1.3	(1-58)	Urban, Kitamura et al 1978
	M+F	381	NAA		3.9[a]		Urban, Ohmori et al 1981
	F	7o	NAA		4.5 ± 2.7		Urban, Sakurai 198o
	M	37	NAA		6.8 ± 2.9		Urban, " "
	F	1o2	NAA		3.8 ± 2.o	(o.6-12)	Urban, Imahori et al 1979
	M	1oo	NAA		5.3 ± 3.3	(1-18.3)	Urban, " " "
Pakistan	M+F	1o5	NAA		1.8 ± 1.7	(o.2-8.8)	Islamabad area, Qureshi et al 1982
MIDDLE EAST							
Iraq	M+F	1oo	NAA			(o.4-4.o)	Bagdad area, Al-Shahristani et al 1973
	M+F	232	NAA		1.4 ± 2.1	(<o.1-12.8)	" " " " 1978
EUROPE							
Austria	M+F	2oo	NAA	o.66		(o.1-2.3)	Vienna, Lanzel 198o
Czechoslovakia		29	NAA		o.63 ± o.26	(o.1-1.23)	Urban, Kucera 1983
		52	NAA		o.73 ± o.37	(o.3-2.o)	" near Prague, Obrusnik 1979, 1983
Denmark		95	AAS		o.5o ± o.61	(o-3.1)	Wide coverage, Bach 198o
Italy		49	NAA	1.5o	3.4	(o.3-32)	Rome area, Clemente et al 1978
		12	NAA		1.8 ± o.3	(o.8-8.3)	Amiata area, Cigna R ssi et al 1976
U.K.		26	NAA			(o.14-2.11)	Glasgow area, Dale et al 1977, Dale 1983

[a] geometric mean

Table 63. (contd) Regional values for the concentration of Mercury in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
U.S.A.	F	12	AAS		4.3 ± o.62		Alaska, coastal area, Galster 1976
	F	6	AAS		3.6 ± o.74		" interior, " "
	F	4	AAS		4.1 ± o.8o		" urban area " "
CENTRAL AND SOUTH AMERICA							
Chile		4o	NAA		o.65 ± o.32	(o.o8-1.52)	Urban, mixed population (adults and children) Toro 1983
AUSTRALIA AND NEW ZEALAND							
Papua New Guinea		121	AAS		2.6 ± 2.2	(o.4-14.4)	Costal subjects, Kyle and Ghani 1983
		122	AAS		1.3 ± o.9	(o.2-5.2)	Non-coastal subjects, Kyle and Ghani 1983

Table 64. Regional values for the concentrations of Mercury in urine (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	M+F	355	SAS		7.35		Urban, 12 /ug/24 hours, Fukabori & Nakaaki 1974
MIDDLE EAST							
EUROPE							
Belgium		3	NAA			2.3 - 11.4	Ghent area, Cornelis et al 1975, /ug/24 hours
	M	47	AAS		1.3 ± 1.75	o.6 - 4.7	Brussels, Roels et al 1982, /ug/g creatinine
	F	7o	AAS		o.1 ± o.1o	o.oo4-o.6	" " " " " "
Denmark		6	NAA		2o	1o-3o	Roskilde, Heydorn & Damsgaard 1982, /ug/24 hours
Germany FR	M+F	2o2	AAS	o.7		o.1 - 26.4	Erlangen, Valentin 1983, see Ref. Schaller et al
Italy	M+F	47	NAA		6.4 ± 6.5	<2 - 22	Rome, Cigna Rossi et al 1978, Clemente et al 1978
		12	NAA		4.3 ± o.8		Amiata area, 4 /ug/24 hours, Cigna Rossi et al 1978
NORTH AMERICA							
U.S.A.		4o	AAS			o - 2o	Cleveland, Ohio, Shamberger 1983

Table 65. Regional values for the concentration of Molybdenum in blood and serum (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
Whole blood							
Sweden		5	NAA		3.3 ± 1.1[a]		Stockholm, Brune 1966
U.K.	M	8	AAS		o.8 ± o.3	o.5 - 1.4	Harwell, Morgan & Holmes 1972
	F	5	AAS		1.2 ± o.5	o.7 - 1.8	" " " "
Blood serum							
Belgium	M+F	3o	NAA		o.55 ± o.21	o.2 - 1.2	Ghent, Versieck et al 1978
Greece		35	XRF		3		Athens, Paradellis 1983

a) Standard error

TABLE 65. MOLYBDENUM IN WHOLE BLOOD AND BLOOD SERUM

Table 66. Regional values for the concentration of Molybdenum in milk (ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		6	NAA	2.8	3.8 ± 3.3		Ibadan, ~~Iyengar 1984~~, Parr 1984
Zaire		15	NAA	1.4	1.7 ± 1.9		Lwiro, ~~Iyengar 1984~~, Parr 1984
ASIA							
India		24	NAA		9.o ± 4.o		Bombay, Dang et al 1984
Philippines		11	NAA	21	19.5 ± 1o		Manila, ~~Iyengar 1984~~, Parr 1984
EUROPE							
Hungary		8	NAA	<1	1.1 ± 1.7		Budapest, ~~Iyengar 1984~~, Parr 1984
Sweden		1o	NAA	o.4	o.98 ± 1.8		Uppsala, ~~Iyengar 1984~~, Parr 1984
NORTH AMERICA							
CENTRAL AND SOUTH AMERICA							
Guatemala		14	NAA	21	2.7 ± 2.5		Guatemala city, ~~Iyengar 1984~~, Parr 1984

Table 67. Regional values for the concentration of Molybdenum in liver (/ug/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		15	AAS		5oo ± 13o	(3oo-7oo)	Urban, Kitamura et al 1978
		3o	AAS		57o ± 25o	(3oo-12oo)	Urban, Sumino et al 1975
EUROPE							
Belgium		5	NAA		36o	(14o-7oo)	Ghent area, Lievens 1977
Norway		31	AAS		8oo ± 5oo	(5oo-12oo)	Urban, Norheim et al 198o
Sweden		1o	NAA		71o ± 28o		Stockholm, Plantin 198o
		5	NAA		62o ± 8o		North of Sweden, Brune et al 1978
NORTH AMERICA							
U.S.A.		36	NAA		57o ± 25o	(21o-123o)	Baltimore, Mineapolis and Seattle, Zeisler et al 1984

Table 68. Regional values for the concentration of Molybdenum in hair (µg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
India		5	NAA		100 ± 70		Urban, Dang et al 1983
Japan	M	58	NAA		380 ± 310	(60-1840)	Urban, Imahori et al 1979
	F	76	NAA		490 ± 430	(30-2140)	Urban, " " "
MIDDLE EAST							
Egypt	M+F	65	NAA		50-160, range of mean values		From several parts of Egypt, Kasperek et al 1982
EUROPE							
NORTH AMERICA							

Table 69. Regional values for the concentration of Molybdenum in urine (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
MIDDLE EAST							
EUROPE							
Belgium		9	NAA		32.7 ± 22.3	11 - 88	Ghent, Cornelis et al 1981, /ug/24 hours
NORTH AMERICA							
AUSTRALIA & NEW ZEALAND							
New Zealand	M+F	12	AES		34 ± 21	11 - 58	Dunedin, Robinson et al 1973

Table 7o. Regional values for the concentration of Nickel in blood, serum & urine (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
					Whole blood		
Japan		15	AAS		24 ± 16	1o - 6o	Nakahara, personal communication 1983
		14	AAS		28 ± 15	2o - 76	
Denmark			AAS		17 ± 15	4 - 54	Odensee, Clausen 1977
Germany FR		36	AAS	4.5		o.2 - 115	Bavarian area, /ug/kg, Zober et al 1984
U.S.A.		17	AAS		4.8 ± 1.3	3 - 7	Hartford,Connecticut, Sunderman 197o
					Blood serum		
Greece		35	XRF		7.5 ± 3.6	1 - 15	Athens, Paradellis 1983
U.S.A.		8o	AAS		2.6 ± o.9	o.8 - 5.2	Hartford,Connecticut, Sunderman 197o
					Urine		
Germany FR	M+F	1o	AAS	2.7		o.1 - 25.6	Bavarian region, /ug/kg, Zober et al 1984
U.S.A.	M+F	52	AAS		2.2 ± 1.2	o.7 - 5.2	Farmington, Connecticut, Sunderman 197o, 1983
					2.6 ± 1.4	o.5 - 6.4	/ug/day, " " "

TABLE 70. NICKEL IN WHOLE BLOOD, BLOOD SERUM AND URINE

Table 71. Regional values for the concentration of Nickel in milk (ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		14	AAS	12.2	12.1 ± 7	2.4 - 22	Ibadan, Parr 1984, Kirkbright 1984
Zaire		59	AAS	5	1o.3 ± 11.7	o.o - 43.8	Lwiro, urban elite, urban poor and rural mothers, Parr 1984, Kirkbright 1984
ASIA							
Philippines		62	AAS	16	19.1 ± 12.5	3.6 - 87	Manila, urban elite, urban poor and rural mothers, Parr 1984, Kirkbright 1984
MIDDLE EAST							
EUROPE							
Finland		2o	AAS		1.5	1.2 - 3	Salmela, personal communication 1983
Germany GD		22	AAS		33 ± 16		Jena, 8 weeks pp, Anke 1983
		22	AAS		39 ± 26		Jena, 13 weeks pp, " "
Hungary		7o	AAS	14.4	16.6 ± 15.2	4.2 - 13o	Budapest, urban elite, urban poor and rural mothers, Parr 1984, Kirkbright 1984
Sweden		31	AAS	11	12.4 ± 5	6.3 - 24.5	Uppsala, Parr 1984, Kirkbright 1984
NORTH AMERICA							
CENTRAL & SOUTH AMERICA							
Guatemala		74	AAS	12.9	14 ± 1o.4		Guatemala city, urban elite, urban poor and rural mothers, Parr 1984, Kirkbright 1984
AUSTRALIA & NEW ZEALAND							
New zealand		25	AAS		2o		Dunedin, Casey et al 1977

Table 72. Regional values for the concentration of Nickel in liver (ug/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		15	AAS		4o ± 23	3o - 8o	Nakahara, Personal communication 1983
		27	AAS		78 ± 46	28 - 22o	
U.S.A.		18	AAS		37 ± 27	<1o - 1oo	Baltimore, Seattle & Mineapolis area, Zeisler 1984
		4	AAS		9		Hartford, Connecticut, Sunderman 197o, 1983

Table 73. Regional values for the concentration of Nickel in hair (ug/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Bangladesh	M+F	3o	PIXE		125o ± 75o	37o - 325o	Dacca, Khan et al 198o
MIDDLE EAST							
Iran		9	PIXE		63o ± 29o		Teheran, Aframian 1983
Iraq		12o	NAA		18 ± 17	6 - 78	Bagdad, Al-Shahrastani et al 1978
EUROPE							
Italy	M+F	47	NAA	5	44 ± 52	5 - 193	Rome, Clemente et al 1978
NORTH AMERICA							
Canada	M+F	76	NAA	2.1		1.6 - 17	Rural, Chatt et al 1977
	M+F	45	NAA	2.4		1.2 - 2o	Urban, Chatt et al 1977
U.S.A.	M+F	2o	AAS		22o ± 8o	13o - 51o	Hartford, Connecticut, Sunderman 197o, 1983
AUSTRALIA & NEW ZEALAND							

Table 74. Regional values for the concentration of Selenium in whole blood (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
China	M+F	173	FLU		21 ± 1[a]		Keshan region, unaffected subjects, Zhu 1981
	M+F	111	FLU		95 ± 9[a]		Other than Keshan region, " "
MIDDLE EAST							
Egypt		8	NAA		68	(54-79)	Urban region, Maxia et al 1972
EUROPE							
Belgium	M+F	162	AAS		123 ± 17	(82-178)	Urban 19-58 years old, Neve et al 1980 and
	M+F	31	AAS		130 ± 19	(95-173)	" 60-99 " " Verlinden 1981, 1983
Bulgaria	M+F	22	NAA		40 ± 20		Vrasta city, Damyanova 1983
Finland	M+F	45	AAS		58 ± 20		Yyväskylä area, Tummavuori and Pirinen 1983
	M+F	25	FLU		87 ± 17		Helsinki, Westermark 1979
Italy	M+F	47	NAA		90 ± 30		Rome, Cigna Rossi et al 1978, Clemente et al 1978
	M+F	13	NAA		77 ± 11	(34-166)	Amiata mountain area, Cigna Rossi et al 1978
U.K.	M+F	300	AAS		136 ± 20		Hampshire area, Lloyd et al 1982
	M+F	25	NAA		115 ± 17	(93-153)	Glasgow area, Dale 1983
	M+F	98	XRF		60 ± 5[a]		Several regions of U.K., Hamilton et al 1972/73
Yugoslavia	M+F	39	NAA		88 ± 27	(30-160)	Urban, north-west Yugoslavia, Byrne and Kosta 1983
NORTH AMERICA							
Canada	M+F	250	NAA		180 ± 40		Hamilton area, Dickson and Tomlinson 1967
U.S.A.	M+F	30	FLU		157	(103-191)	Cleveland, Ohio, Shamberger 1983
	M+F				120, 162, 234		Mean values for Illinois, California and Wyoming respectively, Shamberger et al 1979
	F	187	AAS	108	117		From 8 states in USA, Creason et al 1976
AUSTRALIA AND NEW ZEALAND							
New Zealand	M+F	104	FLU		59 ± 12		Dunedin, Rea et al 1979
	M+F	131	FLU		79 ± 16		Auckland, Kay and knight 1979

a) standard error

Table 75. Regional values for the concentration of Selenium in blood serum (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
EUROPE							
Belgium	M+F	36	NAA		13o ± 2o	(9o-18o)	Ghent area, Versieck et al 1977
Denmark		11	NAA		89 ± 4	(67-111)	Roskilde, Damsgaard et al 1973
Finland	M+F	34	FLU		99 - 1o8	(range of mean	Lapland to South West, Westermark 1979, 1983
	M+F	67	FLU		42 - 66	values)	South East, Central & East, " " "
	M+F	48	AAS		62 ± 7	(5o-1oo)	Helsinki area, Alfthan and Kumpulainen 1982 and Kumpulainen and Koivistoinen 1981
Germany	M+F	184	NAA		9o ± 16		Around Jülich, Kasperek et al 1972
	M+F	25	NAA		1o2 ± 9	(86-125)	Berlin, Behne and Jürgensen 1978
Holland	M+F	39	NAA		1o4 ± 17	(65-135)	North Holland, Das and Woittiez 1983
Italy		13	NAA		46 ± 4	(4o-7o)	Amiata mountain area, Cigna Rossi et al 1978
Norway	M+F	281	NAA		11o ± 16	(53-154)	Blekstad et al 1983
Sweden	M+F	31	NAA		78	(plasma)	Stockholm, 2o-69 years, Plantin et al 1981
U.K.	M+F	3oo	AAS		136 ± 2o		Hampshire area, Lloyd et al 1982
		45	NAA		75 ± 23	(43-135)	Glasgow area, Dale 1983
NORTH AMERICA							
Canada	M	15	FLU		143 ± 16		Montreal, Lelonde et al 1982
U.S.A.	M+F	37	NAA		12o ± 1o		Omaha, Sullivan et al 1979
		17	NAA		12o ± 1o		Louisville, Kentacky, McConnell et al 1975
	M+F	6o	NAA		8o-1o8	(range of mean values)	Georgia, Andrews et al 198o
AUSTRALIA AND NEW ZEALAND							
Australia	F	36	NAA		75 ± 16	(4o-1o3)	Geelong, Cumming 1983, Cumming et al 1983
New Zealand	M+F	97	FLU		48 ± 1o		Dunedin, Rea et al 1979

Table 76. Regional values for the concentration of Selenium in Erythrocytes (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
EUROPE							
Belgium	M+F	36	NAA		18o ± 3o[a]		Ghent area, Versieck et al 1977
Germany		17	NAA		14o ± 19		Berlin, Behne and Wolters 1979
Italy	M+F	12	NAA		1o5 ± 17	(4o-24o)	Amiata area, Cigna Rossi et al 1978
Sweden	M+F	29	NAA	97			Stockholm, Plantin et al 1981
NORTH AMERICA							
Canada	M+F	251	NAA		24o ± 6o		Hamilton area, Dickson and Tomlinson 1967
U.S.A.	M+F	6o	NAA		156 to 19o	(range of mean values)	Georgia, several areas, Andrews et al 198o
AUSTRALIA AND NEW ZEALAND							
New Zealand	M+F	97	FLU		74 ± 16		Dunedin area, Rea et al 1979

a) mg/L packed cells

Table 77. Regional values for the concentration of Selenium in milk (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		18	NAA	24	28.8 ± 8	(16.4-44)	Ibadan, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Zaire		69	NAA	19	2o.7 ± 9.2	(8 - 66)	Lwiro, " " " " " " Iyengar 1984, Parr 1984
ASIA							
India		6	NAA		19.o ± 3.3	(15 - 23)	Bombay, Dang and Somasundaram 1983
Philippines		65	NAA	33	34.o ± 9.2	17 - 57)	Manila, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
EUROPE							
Finland		2o	AAS		1o.o ± 2	(6 - 13)	Yokioinen, Kumpulaine 1983
Germany		44	NAA		21.o ± 8		Düsseldorf, Lombeck 1983
Greece		5	NAA		15	(11 - 22)	Athens, Grimanis 1978
		2o	FLU			(12 - 25)	" Hadjimarkos and Shearer 1973
Hungary		71	NAA	11	11.o ± 2.4	(6.4-2o.7)	Budapest, urban elite, urban poor and rural mothers Iyengar 1984, Parr 1984
Italy		13o(67)	NAA		13.o ± 1	(<1.o-5o)	Rome, Mean value calculated from 67 samples which contained Se above detection limit, Clemente et al 1983
Sweden		32	NAA	13	14.o ± 4.6	(3.7-25.o)	Uppsala, Iyengar 1984 , Parr 1984
U.K.		25	NAA		31.o ± 11		Glasgow, Dale 1983
NORTH AMERICA							
U.S.A.		15	FLU		13	(7 - 17)	Ohio, Shearer and Hadjimarkos 1975
		14	FLU		2o	(11 - 27)	Arizona, " "
		15	FLU		28	(17 - 6o)	South Dakota, " "
		15	FLU		21	(13 - 62)	Portland, Hadjimarkos and Shearer 1973
		15	FLU		2o	(15 - 24)	Iowa region, " " "
		241	FLU		18	(7 - 33)	17 States in USA, Shearer and Hadjimarkos 1975
		8	GC		16 ± 5	(8 - 34)	Urbana, Illinois, Smith et al 1982
		2o	AAS		14 ± 13.2		Urbana area, fore milk, Smith et al 1982
		2o	AAS		16 ± 3.1		" " , hind milk, " " "

Table 77. (contd) Regional values for the concentration of Selenium in milk (ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
CENTRAL AMERICA							
Chile		11	NAA		62 ± 55	(15 - 214)	Santiago, Toro 1983
Guatemala		84	NAA	19	19.8 ± 8.4	(3.4 - 46)	Guatemala city, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
AUSTRALIA AND NEW ZEALAND							
Australia		4o	NAA		12 ± 3	(5 - 18)	Geelong, Cumming 1983, Cumming et al 1983
New Zealand		3o	FLU		1o ± 3	(8 - 2o)	Urban, Miller and Sheppard 1972

Table 78. Regional values for the conecentration of Selenium in liver (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		9	NAA		o.57 ± o.1o		Urban, converted from dry basis, Terai et al 1979
		14	NAA		o.66 ± o.43	(o.23-1.77)	" " " " " Yukawa et al 198o
EUROPE							
Belgium		5	NAA		o.25	(o.21-o.31)	Gent area, Lievens et al 1977
Bulgaria		3o	NAA		o.o6		Vrasta city, Damyanova 1983, Donev et al 1978
Denmark		7	NAA		o.4o ± o.13		Copenhagen, Larsen et al 1978
Italy		4	NAA		o.25 ± o.o5	(o.12-o.33)	Rome, Ingrao 1983
Norway		31	NAA		o.4o ± o.o8	(o.5o-1.3o)	Urban, Norheim and Aaseth 198o, (from dry weight)
Sweden		5	NAA		o.29 ± o.o7		North of sweden, Brune et al 1978
		5	NAA		o.27 ± o.o9		Stockholm, Plantin et al 1978
U.K.		11	MS		o.3o ± o.1o		Urban, Hamilton et al 1972/73
		14	NAA		o.7o ± o.23	(o.43-1.1)	Glasgow, converted from dry weight basis, Dale 1983
Yugoslavia		13	NAA		o.3o ± o.1o	(o.2o-o.5o)	Urban, Byrne and Kosta 1983
NORTH AMERICA							
Canada		44	AAS	o.39		(o.2o-o.65)	Ottawa, Subramanian 1983
		1o	NAA		o.43 ± o.o8	(o.18-o.66)	Hamilton area, Dickson and Tomlinson 1967
U.S.A.		2o	NAA		o.62 ± o.o4		Omaha, Blotcky et al 1979
		7	NAA		o.51 ± o.o6		Louisville, McConnel et al 1975
		36	NAA/AAS		o.5o ± o.o8	(o.35-o.65)	Baltimore, Mineapolis & Seatle, Zeisler et al 1984
AUSTRALIA AND NEW ZEALAND							
New Zealand		41	FLU		o.19 ± o.o5	(o.1oo.27)	Dunedin, Casey et al 1978

Table 79. Regional values for the concentraton of Selenium in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
China	M+F	1745	FLU		o.359		Areas not including Keshan region, Zhu 1981
	M+F	1478	FLU		o.o74		Keshan area, Zhu 1981
	M+F	353	FLU		o.2o2		Shan Xi Province, Wang 1982
Hong Kong		11	NAA		o.58	(o.47-2.8)	Chinese in Hong Kong, Chuang 1978
India	M+F	229	NAA	1.23	1.3o ± o.84		All over India, students, Arunachalam et al 1978
Japan	M+F	375	NAA	o.7o[a]			Urban, Ohmori et al 1981
	F	1o2	NAA		3.4o ± 2.o	(1.o-9.6)	Urban, Imahori et al 1978
	M	1oo	NAA		3.7o ± 2.3	(1.o-14)	" " " "
Pakistan	M+F	1o5	NAA		1.o3 ± o.29	(o.42-1.91)	Islamabad, Qureshi et al 1982
MIDDLE EAST							
Egypt	M+F	65	NAA		o.45 - o.88	(range of mean values)	Different regions of Egypt, Kasperek et al 1982
Iraq	M+F	22o	NAA		1.4o to 1.6o	"	Urban and rural mixed, Al-sharistani et al 1978
EUROPE							
Czechoslovakia		29	NAA		o.46 ± o.19	(o.2o-o.9o)	Prague area, Kucera 1983
		46	NAA		o.45 ± o.16	(o.2o-1.oo)	Near Prague, Obrusnik 1979, 1983
Finland		14	AAS		o.3o ± o.o7	(o.17-o.45)	Jyväskylä area, Tumma vuori and Pirinen 1983
Germany (FR)	M+F	26	NAA		1.2o ± o.25		Jülich area, Kasperek et al 1971
Germany (DR)	F	26	NAA		o.3o ± o.o7	(o.1o-o.46)	Dresden, Wiesener et al 1978
	M	3o	NAA		o.36 ± o.o8	(o.1o-1.oo)	" " " "
Italy	M+F	12	NAA		o.33 ± o.o6	(o.22-o.51)	Amiata mountain region, Cigna Rossi et al 1978
	M+F	49(25)	NAA		1.4	(o.2-14.8)	Rome, detected in 25 samples, Clemente et al 1978
U.K.	M+F	46			2.24 ± o.84	(1.3-4.1)	Glasgow, Dale 1983

a) geometric mean

Table 79. (contd) Regional values for the concentration of Selenium in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
Canada	F	34	NAA		o.72	(o.61-o.78)	Guelph area, vegetarians, Gibson et al 1983
	F	3o	NAA		o.61	(o.51-o.7o)	" " , non-vegetarians, " " "
	M+F	61	NAA		o.47		Halifax area, Holzbecher and Ryan 1978
	M+F	42	NAA	o.44		(o.24-87.4)	Halifax area, Ryan et al 1978
U.S.A.	M+F	84	AAS		o.61 ± o.o4[b]		Greensboro, Thimaya and Ganapathy 1982
CENTRAL AND SOUTH AMERICA							
Chile	M+F	37	NAA		o.66 ± o.32	(o.1o-2.3o)	Santiago, Toro 1983

b) geometric mean

Table 8o. Regional values for the concentration of Selenium in urine (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan		9	NAA		16o ± 149	44 - 479	IShii et al 198o
MIDDLE EAST							
EUROPE							
Belgium		3	NAA			2o - 184	Ghent area, Cornelis et al 1975, /ug/24 hours
Denmark		6	NAA		45	3o - 6o	Roskilde area, Heydorn and Damsgaard 1983
Italy	M+F	47	NAA		2o ± 13	3 - 8o	Rome, Cigna Rossi et al 1978, Clemente et al 1978
		12	NAA		7 ± 1.3		Amiata area, Cigna Rossi et al 1978, 6.2 /ug/24 hours
U.K.	M+F	793	AAS		34 ± 24	o- 15o	Cardiff area, Glover 1967, 1956 to 1958 period
NORTH AMERICA							
Canada		1o	FLU		125 ± 76		Lolande et al 1982
U.S.A.	M	12	FLU		54	26 - 71	Greensboro, NC, Ganapathy et al 1981
AUSTRALIA & NEW ZEALAND							
New Zealand	M+F	56	FLU		13 ± 1.5	4 - 21	Dunedin, Stewart et al 1978, Thompson 1973

Table 81. Regional values for the concentration of Zinc in whole blood (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Bangladesh	M+F	99	PIXE		4.4 ± o.96	(3.o-6.3)	Decca, Khan et al 198o
India	F	23	NAA		4.9 ± 1.6	(2.7-9.2)	Bombay, Dang and Somasundaram 1983
Japan	M	45	NAA		6.2 ± o.7	(4.2-7.2)	Urban, Satoh et al 1978
	F	46	NAA		5.8 ± o.7	(4.3-8.o)	" " " "
	M	135	NAA		6.1 ± 1.o		Urban, Usagiømoto et al 198o
	F	211	NAA		5.o ± 1.3		" " " "
	M	138	AAS		8.5 ± o.1[a]	(6.2-11.4)	Hokkaido region, Saito et al 1979
	F	112	AAS		8.2 ± o.1[a]	(4.3-18.4)	" " " " "
MIDDLE EAST							
Iran	M+F	29	PIXE		6.4 ± 1.2	(4.9-7.5)	Teheran, Aframian 1983
EUROPE							
Bulgaria	M+F	22	NAA		6.6 ± o.41		Sofia, Damianova 1983
Finland	M+F	47	NAA		6.3 ± o.89	(4.2-8.7)	Urban, Tummavuori and Pirinen 1983
Sweden	M+F	1o	NAA		6	(4.o-8.o)	Studsvik, Brune et al 1962
	M+F	7o	NAA		6.7 ± o.93		Stockholm, Plantin and Strandberg 1967
	F	5o	AAS		5.9 ± o.66	(4.o-7.6)	Lund area, Abdulla et al 1982
	F	12	NAA		6.6 ± 1.12[a]		Stockholm, Plantin and Mauering 198o
U.K.	M+F	169	XRF		6.7 ± o.o5[a]		National survey, Hamilton et al 1979
NORTH AMERICA							
Canada	M+F	61	AAS/NAA		6.2 - 6.6	(2.o-1o.3)	Halifax, range of means, Ward et al 1979
U.S.A.	F	187	AAS	6.5[b]			From 8 states, Creason et al 1976
	M	2o5	AAS	7.3			Chicago, white population, military men, Creason 1976
	M	413	AAS	8.6			Country, Illinois area, " " " "

a) standard error b) geometric mean

Table 82. Regional values for the concentration of Zinc in blood serum (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria	M+F	37	AAS		1.09 ± 0.12	(0.80-1.30)	Ibadan, Olatunbosun et al 1976
	M+F	70	AAS		1.04 ± 0.12	(0.70-1.30)	Ibadan, Akindale et al 1976
	M+F	127	AAS		1.05		Zaria, non-elite population, Kapu et al 1977
Uganda	M+F	155	AAS		0.86 ± 0.17	(0.49-1.46)	Kampala, Bimenya et al 1980
ASIA							
India	M+F	54	NAA		1.10 ± 0.25	(0.70-1.70)	Bombay, Dang and Somasundaram 1983
	F	67	AAS		1.20 ± 0.04[a]		Hyderabad, Rajalakshmi et al 1980
Japan	F	24	AAS		0.71 ± 0.11	(0.53-1.10)	Urban, plasma, Ishihara 1983
	M+F	25	NAA		1.13 ± 0.28	(0.69-1.91)	Tokyo, Nakahara et al 1979
MIDDLE EAST							
Israel	M+F	48	AAS		0.93 ± 0.15	(0.77-1.18)	Haifa, Lightman et al 1983
Turkey	M+F	100	AAS		0.97 - 1.14	(range of means)	Specially chosen healthy adults from several parts of Turkey, Yüregir and Donma 1983, Arl et al 1977
	M+F	126	AAS		0.51 - 0.58 (range of means)	(0.27-0.85)	Population groups from different parts of Turkey, Yüregir and Donma 1983
EUROPE							
Belgium	M+F	46	NAA		0.94 ± 0.13	(0.69-1.21)	Ghent area, Versieck et al 1974, 1977, 1978
	M+F	70	AAS		0.91 ± 0.15	(0.54-1.31)	Brussels area, Roels et al 1981
France	M+F	46	AAS		0.84 ± 0.10[a]		Strasburg, Schechter et al 1977
Germany FR	M+F	25	NAA		0.88 ± 0.07	(0.54-1.10)	Berlin, Behne and Jürgenson 1978
	M+F	643	AAS		0.85 ± 0.15		Ulm area, Seeling et al 1982
Greece	M+F	35	XRF		1.00 ± 0.12	(0.69-1.30)	Athens, Paradellis 1983
Holland	M+F	40	NAA		0.93 ± 0.20	(0.65-1.52)	Petten area, Das and Woetticz 1983
Ireland	M+F	90	AAS		0.85 - 0.91	(range of means)	Belfast, McMaster and Erwin 1983
Norway	M+F	281	NAA		0.84 - 0.14	(0.50-1.40)	Oslo, Blekstad et al 1983
Sweden	F	50	AAS		0.85 ± 0.14	(0.70-1.10)	Lund area, Abdulla et al 1982
U.K.	M+F	132	AAS		1.11 ± 0.19		Glasgow area, Fell et al 1971

a) standard error

Table 82. (contd) Regional values for the concentration of Zinc in blood serum (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
Canada	F	47	AAS		o.99 ± o.24		Waterloo area, vegetarians, Anderson et al 1981
	M+F	114	AAS		o.7o ± o.32	(o.34-1.12)	Calgary area, Chooi et al 1976
U.S.A.	M+F	7o	AAS		1.13 ± o.13		Detroit area, Prasad 1982
	M	99	AAS		1.o2 ± o.17	(o.68-1.36)	Fredrick, military recruits, Pekarek et al 1972
	M	2o4	AAS		o.96 ± o.2o		Oklahama, Lindeman et al 1977
	M+F	37	AAS		o.97 ± o.13		Omaha, Sullivan et al 1977
	M+F	76	AAS		o.88 ± o.14		Dallas, Reinmold and Besch 1978
	M+F	8o	NAA		o.75 ± o.2o		San Diego, Campero et al 1967
	M+F	135	AAS		o.93 ± o.15		Florida, elderly black, Wagner et al 198o
	F	54	AAS		o.88		Oklahama, Lindeman et al 1982
CENTRAL AMERICA							
Guatemala		58	AAS		o.74 ±o.12		Guatemala city, fasting subjects, Solomons et al 1979
Panama	M	118	AAS		o.95		Panama, plasma, Kleevay 1972
	F	172	AAS		o.76		" " " "
AUSTRALIA & NEW ZEALAND							
Australia	M+F	25	AAS		o.86 ± o.14		Adelide, Baghurst et al 1981
	F	42	NAA		o.9	(o.5-2.4o)	Geelong, plasma, Cumming 1983
	M+F	35o	AAS		< o.71		N.W. Australian aboriginal settlements, hypozincaemia Cheek et al 1981
New Zealand	F	57	AAS		1.2o ± o.21	(o.57-1.88)	Dunedin, Mckenzie et al 1979
	M	91	AAS		o.84 ± o.11	(o.56-1.6o)	" " " "
	M+F	66	AAS		o.97 ± o.13		Tokelau islanders, coconut as staple food, McKenzie et al 1979

Table 83. Regional values for the concentration of Zinc in erythrocytes (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	F	24	AAS		13.2 ± 4.4	(5.7-22.7)	Urban, Ishihara 1983
EUROPE							
Belgium	M+F	46	NAA		11.1 ± 1.5[a]	(7.3-17.o)	Ghent area, Versieck et al 1974, 1977, 1978
Germany FR	M+F	17	NAA		1o.6 ± 1.7	(8.3-13.o)	Berlin,Behne & Wolters 1983
U.K.	M+F	31	AAS		13.o ± 2.3		Glasgow, Fell et al 1971
NORTH AMERICA							
U.S.A.	M+F	7o	AAS		11.5 ± 1.2		Detroit, Prasad 1982
	M+F	258	AAS		16		Oklahama, Lindeman et al 1982
	M+F	15	NAA		11.5 ± o.5		San Diego, Campero et al 1967
CENTRAL AMERICA							
Panama	M	145	AAS		9.7 ± 2.45		Panama, Kleevay 1972
	F	162	AAS		9.8 ± 2.46		" " "

a) mg/L

Table 84. Regional values for the concentration of Zinc in milk (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Nigeria		18	NAA	1.68	1.77 ± o.82	(o.74-3.5)	Ibadan, urban elite, urban poor & rural mothers, Iyengar 1984, Parr 1984
Zaire		69	NAA	1.9	2.oo ± o.75	(o.63-3.9)	Lwiro, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
ASIA							
India		24	NAA		1.8o ± o.6o	(1.2-3.2)	Bombay, Dang et al 1982
		67	AAS		1.7o ± o.12[a]		Hyderabad, Rajalakshmi et al 198o
Japan		45	AAS		1.14 ± o.67		Kumamoto area, Higashi et al 1982
Philippines		65	NAA	2.o	2.12 ± o.95		Manila, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
USSR		23	SAS		1.23	(o.56-2.o)	Moscow, Rechetkina 1969
MIDDLE EAST							
Turkey		13	AAS		o.84 ± o.78	(o.1-2.7)	Istanbul, Saner 1983
		1o	AAS		o.75 ± o.67	(o.1-1.9)	" " "
EUROPE							
Finland		229	AAS		4.oo ± o.44	(o.2-6.o)	Helsinki, Vuorie and Kuitunen 1979
Germany		67	NAA		1.68	(o.4-4.7)	Düsseldorf, Lombeck 1983
		22	AAS		1.7o ± o.38		Dortmund, Stolley et al 1981
Greece		15	NAA		1.5	(1.4-1.7)	Athens, Grimanis et al 1978
Hungary		71	NAA	1.2	1.o6 ± o.57	(o.28-2.7)	Budapest, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
Italy		13o	NAA		3.oo ± o.2o[a]	(o.4o-9.8)	Rome, Clemente et al 1983
Sweden		32	NAA	o.7	o.78 ± o.43	(o.26-2.o)	Uppsala, urban population, Iyengar 1984, Parr 1984
Yugoslavia		7	NAA		1.35 ± 1.oo	(o.3-2.8)	Ljubljana, Byrne and Kosta 1982, 1983

a) standard error

Table 84. (contd) Regional values for the concentration of Zinc in milk (mg/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
NORTH AMERICA							
USA		5o	AAS		1.59 ± o.84		Urban, daily samples, Picciano and Guthrie 1976
		5o	AAS		1.58 ± o.81		" weekly " " " " "
		5o	AAS		1.68 ± o.78		" random " " " " "
		22	AAS		1.34 ± o.94		" " " Murthy and Rhea 1971
		28	AAS		1.6o		" 1-3 months pp, Vaughan et al 1977
CENTRAL AMERICA							
Chile		11	NAA		7.2o ± 4.34		Santiago, Toro 1983
Guatemala		84	NAA	2.6	3.3o ± 2.4o		Guatemala city, urban elite, urban poor and rural mothers, Iyengar 1984, Parr 1984
AUSTRALIA & NEW ZEALAND							
Australia		38	NAA		1.6o ± o.54	(1.o-3.o)	Geelong, Cumming et al 1983
New Zealand		25	NAA		3.2		Dunedin, Casey 1977

Table 85. Regional values for the concentration of Zinc in liver (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
India	M+F	16	NAA		44.5 ± 13.1	(31.4-75)	Bombay, Dang et al 1978
Japan	M+F	15	AAS		48.0 ± 16.0	(21.0-72)	Urban, Kitamura et al 1978
	M+F	64	AAS	46-63[a]	(ranges of GM values)		Shinjuku-ku area, 20-70 years subjects, Tsuchiya and Iwao 1978
EUROPE							
Bulgaria	M+F	30	NAA		63.6 ± 26.5		Vratsa city, Damyanova, 1983
Belgium		5	NAA		56.3	(51-63)	Ghent area, Lievens et al 1977
Finland		20	AAS		56.3 ± 19		Vuori et al 1978
Italy		4	NAA		32.3 ± 4	(27-63)	Rome, Ingrao 1983
Norway		31	AAS		70.0 ± 28	(31-140)	Urban, Norheim and Aaseth 1980
Sweden		292	AAS		45.3 ± 14		Stockholm, Elinder et al 1977
		15	NAA		57.3 ± 19		Stockholm, Plantin 1978
U.K.		9	XRF		57.0 ± 7.3		Urban, Hamilton 1979, Hamilton et al 1972
		24	NAA		48		Glasgow area, Lenihan 1967
NORTH AMERICA							
Canada	M+F	44	ICP-AES	66		(29-188)	Ottawa, Subramanian 1983
U.S.A.		20	AAS		67 ± 6.0		Omaha, Blotcky et al 1979
	M+F	36	NAA/AAS		53 ± 13	(28-96)	Baltimore, Mineapolis & Seatle, Zeisler et al 1984
AUSTRALIA & NEW ZEALAND							
New Zealand		72	AAS		64 ± 36	(14-208)	Dunedin, Casey et al 1983, McKenzie et al 1974

a) geometric mean

Table 86. Regional values for the concentration of Zinc in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
Botswana	F	12	AAS		22o ± 57		Bushmen population, Baumschlag and Petering 1976
Kenya	F	31	NAA		145 ± 18	(13o-174	Machakos district, Agricultural area, Othman and Spyrou 198o
	M	4o	NAA		126 ± 39	(88-2o1)	" " " " " "
Nigeria		8	AAS		15o ± 67	(75-286)	Urban, Olatunbosun et al 1976
S. Africa	F	37	AAS		135 ± 68		Bantu women, Baumschlag and Petering 1976
Zambia	F	125	AAS		2o5 ± 93		Lusaka, Briggs et al 1972
	M	97	AAS		184 ± 16		" " " "
ASIA							
Bangladesh	M+F	1o2	PIXE		141 ± 34	(76-227)	Decca, Khan et al 198o
India	M+F	237	NAA	138	138 ± 44	(62-43o)	All over India, Arunachalam et al 1978
Japan	M+F	1o6	AAS		14o ± 7o		Different locations in Japan, Sakura 198o
	M	6o	NAA		163	(81-734	Urban, Imahori et al 1979
	F	6o	NAA		191	(63-915)	" " " "
	M+F	263	NAA	17o-2oo[a]	(range of GM values)		Omahori et al 1981
	F	91	AAS		153 ± 23		Urban, Matsuzawa et al 1977
	M	95	AAS		2o3 ± 66		" " " "
Pakistan	M+F	1o5	NAA		255 ± 76.5	(128-48o)	Islamabad, Qureshi et al 1982
MIDDLE EAST							
Egypt	M+F	65	NAA		15o ± 25	(12o-2oo)	All over the country, Kasperek et al 1982
Iran		11	PIXE		165 ± 2o		Teheran, Aframian et al 198o
	M+F	39	AAS		126		Villagers, Reinhold et al 1966
	M+F	36	AAS		22o		Urban controls, " " "
Iraq	M+F	242	NAA		18o ± 7o	(26-46o)	Mixed population of adults, Al-Shahristani et al 1978
Turkey		11	AAS		124 ± 38	(78-182)	Istanbul, Saner 1983

a) geometric mean

Table 86. (contd) Regional values for the concentration of Zinc in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
EUROPE							
Austria	M+F	2o1	NAA	142		(47-273)	Viennese population, Lanzel 198o
Bulgaria	M+F	22	NAA		25o ± 21		Vrasta city, Damyanova 1983
Czechoslovakia		29	NAA		138 ± 35	(72-241)	Prague, Kucera 1983
		53	NAA		185 ± 61	(93-5o3)	Rez/Prague, Obrusnik 1979, 198o
Finland		2o	AAS		199 ± 64		Helsinki, Vuori et al 1975
Germany (FR)		26	NAA		2oo ± 5o		Urban, Kasperek et al 1971
Germany (DR)		57	NAA		148 ± 42	(48-322)	Dresden, Wiesener et al 1978
Ireland		41	AAS		187 ± 3o	(128-3oo)	Belfast, McMaster and Erwin 1983
Italy		49	NAA	157		(2 - 824)	Rome, Clemente et al 1978
Poland		6o	NAA	32o		(71- 622)	Warsaw, Dybczenski 1975, 1976, 1983
U.K.		29	NAA	17o[a]		(92- 255)	Glasgow, Dale 1983
NORTH AMERICA							
Canada	F	52	NAA		187 ± 44		Guelph, vegetarians, Anderson et al 1981
	M+F	76	PAA	185		(4o- 45o)	Rural, Nova Scotia, Chatt et al 1977
	M+F	45	PAA	19o		(53- 57o)	Urban, " " " " "
	M+F	61	NAA	18o			Halifax, Holzbecher and Ryan 1982
U.S.A.	F	5o	AAS		136 ± 44		Cincinnati, Baumschlag and Petering 1976
		2o	AAS		19o ± 17		Detroit, Prasad 1982
		18	AES		176 ± 8[b]		Denver, Hambidge et al 1974
		88	AAS		18o ± 4[b]		" " " "
	M+F	44	AAS		174 ± 13		Lefayette, elderly subjects, Greger and Sciscoe 1977
	M+F	135	AAS		142 ± 77		Florida, black elderly subjects, Wagner et al 198o

[a] geometric mean, [b] standard error

Table 86. (contd) Regional values for the concentration of Zinc in hair (mg/kg)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
CENTRAL AMERICA							
Chile		4o	NAA		19o ± 61	(43-4o3)	Santiego, Toro 1983
Panama	M	64	AAS		142 ± 43		Panama, Kleevay 197o, 1973
	F	7o	AAS		167 ± 129		" " " "
AUSTRALIA & NEW ZEALAND							
Australia	M	56	AAS		172 ± 88	(77-296)	Brisbane, Reilly 1981
	F	7o	AAS		187 ± 86	(59-358)	" " "
New Zealand	M+F	11o	AAS		188 ± 24	(138-227)	Dunedin, McKenzie 1979
	M	32	AAS		25o ± 96		Tokelau islanders, McKenzie et al 1974, 1979
	F	34	AAS		155 ± 61		" " " " and Casey et al 1983

Table 87. Regional values for the concentration of Zinc in urine (/ug/L)

Region/Country	Sex	n	Meth.	Median	Mean ± SD	(Range)	Remarks and Reference
AFRICA							
ASIA							
Japan	M+F	1o3	AAS		361 ± 228		Akita, Ishikawa & Nagasaki area, Iwao et al 1981
MIDDLE EAST							
Turkey	M	21	AAS		524 ± 185	3oo - 6oo	Özgunen et al 1977
	F	1o	AAS		395 ± 1o6	25o - 85o	" " "
	M+F	12	AAS		599 ± 325	229 -1272	Istanbul, Saner et al 1983
EUROPE							
Belgium		3	NAA			85 - 75o	Ghent, Cornelis et al 1975, /ug/24 hozrs
Italy	M+F	47	NAA		43o ± 4oo	<1 - 3ooo	Rome. Cigna Rossi et al 1978, Clemente et al 1978
NORTH AMERICA							
U.S.A.		4o	AAS			15o - 13oo	Cleveland, Ohio, Shamberger 1983
AUSTRALIA & NEW ZEALAND							
New Zealand	M+F	11o			467 ± 249	1o7 - 221o	Dunedin, McKenzie et al 1979, /ug/24 hours

LITERATURE CITED

Aaseth J., Ferre A., Munthe E., Froland S.S. and Abrahamsen T.
In, "Penicillamine Research in Rheumatoid Diseases"
Munthe E. (ed), Fabritius, Oslo, 1977, pp. 8o-85

Abdulla M., Jagerstad M., Kolar K., Norden A. Schutz A. and Svenson S.
Essential and toxic elements in prepared meals- 24 hour dietary sampling employing the duplicate sampling technique
Trace Element Analytical Chemistry in Medicine and Biology, Brätter P. and Schramel P. (eds), 1982, pp. 75-86

Abraham A.S., Sonnenblick M. and Eini M.
Serum Cr and aging
Gerontology 27(1981)321-28

Aframian A., Shakiba H. and Houseiney A.
Trace element analysis of human hair by proton induced X-ray excitation (PIXE)
Nuclear Methods in Environmental and Energy Research, Vogt J.R. (ed), Conf. 8oo433, 198o, pp. 442-448

Aframian A., Teheran, Iran, Personal communication, 1983

Airey D.
Total Hg concentrations in human hair from 13 countries in relation to fish consumption and location
Sci. Total. Environ. 31(1983)157-18o

Akindele M.O., Adeniyi F.A. and Olatunbosun D.A.
Serum Zn in Schizophrenia in Nigerians
Afr. J. Psych. 3(1976)379-38o

Alfthan G. and Kumpulainen J.
Determination of Se by electrothermal atomic absorption spectrometry in small volumes of blood plasma and serum
Anal. Chim. Acta 14o(1982)221-227

Al-Shahrastani, Shihah K.M. and Jalil M.
Distribution and significance of trace element pollutants in hair of Iraqi population
IAEA Symposium, Nuclear Techniques in the Life Sciences, Vienna 1978, pp. 515-525

Al-Sharastani and Al-Haddard I.K.
Hg content of hair from normal and poisoned persons
J. Radioanal. Chem. 15(1973)59-7o

Anderson B.A., Gibson R.S. and Sabry J.H.
The Fe and Zn status of long-term vegetarian women
Amer. J. Clin. Nutr. 34(1981)1o42-1o48

Andersson K.
Studie av reference värden för bly i blod och urin hos vuxna
Läkart Tidningen 78(1981)3378-79

Andrews J.W., Haines C.G., Metts J.C. and Jevis J.M.
Se, Cd, and GSH-Px of blood of CVD and normal subjects for the cardiovascular belt of SE-USA
Trace Substances in Environmental Health XV, Hemphill D.D. (ed), 198o, pp. 38-42

Anke M.
Cu, Mo and Ni supply and status in animal and human beings
International Symp. Health Effects and Interactions of Essential and Toxic Elements, Lund, 1983

Arl E., Ozgünen T. and Ojkurt S.
Normal ve gebe kadinlarda serum cinko bakir duzeyleri
Biyokimya Dergisi Yil I, Sayi 3, Nisan Sahife 1977, pp. 69-73

Arunachalam J., Gangadharan S. and Yagnasubramanian S.
Elemental data on human hair sampled from Indian student population and their interpretation for studies in environmental exposure
IAEA Symp. Nuclear Techniques in the Life Sciences, Vienna, 1978, pp. 489-513

Aurand K., Englert N., Krause N., Sonneborn M., Thorn H.L. and Wagner H.M.
Untersuchungen zur Blei-Belastung der Bevölkerung in der Umgebung einer industriellen Emissionsquelle (Feldstudie Nordenham)
Blei und Umwelt 11, BGA Report 1/78, 1978

Aurand K. and Sonneborn M.
Lead content of human hair
International Symposium Environmental Health Aspects of Milk, Amsterdam, 1973, pp. 846-847

Bach E.
Voksnes belasning med bly
Danish Institut for Klinish Epidemiology, D.I.K.E. Copenhagen 198o

Barker D.H., Rancher A.C., Mittal B.M., Shanbhag S.V., Sharma V.N. and Sharma L.S.
Metal concentration in human hair from India (Pilani, Rajastan)
Trace Substances in Environmental Health, Hemphill D.D. (ed), 1976, pp. 71-81

Barry P.S.I. and Mossmann D.B.
Pb concentration in human tissues
Brit. J. Ind. Med. 27(197o)339-351

Baumslag N. and Petering H.G.
Trace metal studies in Bushman hair
Arch. Environ. Health 31(1976)254-257

Baghurst K., Buckley R.A.. and Dreosti I. E.
Trace element studies of transitional breast milk in relation to maternal blood status and pregnacy outcome
Proc. Nutr. Soc. Aust. 6(1981)154-16o

Behne D. and Wolters W.
Se content and glutathione peroxidase activity in the plasma and erythrocytes of non-pregnant and pregnant women
J. Clin. Chem. Clin. Biochem. 19(1979)133-35

Behne D. and W. Wolters, Berlin, Personal communication 1983

Behne D. and Jürgensen H.
Determination of trace elements in human blood serum and in the standard reference material "bovine liver" by instrumental neutron activation analysis
J. radioanal. Chem. 42(1978)447-453

Bennet B.J.
Exposure of man to environmental Se- an exposure commitment assessment
Sci. Total Environ. 31(1983)117-127

Bergmann H., Hall G. and Schaller K.H.
Blutblei Untersuchungen in Bayern in Rahmen einer EG-Studie
Bayerisches Ärzteblatt 5(198o)464-473

Berlin A.
Assessment of exposure to Pb of the general population in the European community through biological monitoring
Environ. Mon. Assess. 2(1981)225-231

Berlin A., Luxembourg, Personal communication 1983

Bimenya G.S., Lutalo-Bosa A.J. & Nzaro E.
Serum Zn reference values in healthy Ugandans
East Afr. Med. J. 57(198o)822-824

Blekastad V., Helgaland K., Jonsen J. and Steinnes E.
Oslo, Norway, Personal communication through Steinnes, E. 1983

Blotcky A.J., Jetton M.M. and Sullivan J.F.
Organ content of Se, Zn, Mg, Ca and Cu in alcoholic cirrhotic patients and controls
Trace Substances in Environmental Health XIII, Hemphill D.D. (ed), 1979,

Brain P., Red cells, serum Fe and total Fe binding capacity in 3 population groups in Natal
South Afr. Med. J. 61(1982)669-71

Briggs M.H., Briggs M. and Nakahara A.
Trace elements in human hair
Experientia 28(1972)4o6-4o7

Brune D., Nordberg G.F., Wester P.O. and Bievered B.
Accumulation of heavy metals in tissues of industrially exposed workers
IAEA Symp. Nuclear Activation Techniques in the Life Sciences, Vienna, 1978, pp. 643-655

Brune D., Frykberg B., Samsahl K. and Wester P.O.
Determination of elements in normal and leukemic human whole blood by NAA
Report AE-6o, Stockholm, Sweden, 1962

Brune S., Samsahl K. and Wester P.O.
A comparison between the amounts of As, Au, Br, Cu, Fe, Mo, Se and Zn in normal and uraemic human whole blood by means of NAA
Clin. Chim. Acta 13(1966)285-291

Brusovanik E.P.
Investigation of the serum Fe level in inhabitants of the North
Human Physiol. 7(1981)1o6-1o9

Buchet J.P., Lauwerys R. and Roels H.
Comparison of several methods for the determination of As compounds in water and in urine. Their application for the study of As metabolism and for the monitoring of workers exposed to As
Int. Arch. Occup. Environ. health 46(198o)11-29

Buchet J.P., Lauwerys R. and Roels M.
Determination of Mn in blood and urine by flameless atomic absorption spectrophotometry
Clin. Chim. Acta 73(1976)481-486

Buchet J.P., Roels H., Hubermont G. and Lauwery R.
Placental transfer of Pb, Hg, Cd and carbon monoxide in women. II Influence of some epidemiological factors on the frequence distributions of the biological indices in maternal and umbilical cord blood
Environ. Research 15(1978)494-5o3

Buchet J.P., Knepper E. and Lauwerys R.
Determination of V in urine by electrothermal AAS
Anal. Chim. Acta 136(1982)243-48

Burguera J.L., Burguera H. and Alarcon H., Merida, Venezuela,
Personal communication 1983

Byrne A.R. and Kosta L., Ljubljana, Yugoslavia,
Personal communication

Byrne A.R., Kosta L., Dermelj M. and Musek-Zuidavic M.
Aspects of some trace elements in milk
Trace Element Analytical Chemistry in Medicine and Biology,
Brätter P. and Schramel P. (eds), De Gryter, Berlin, 1982, pp. 29-35

Byrne A.R., Ljubljana, Yugoslavia, Personal communication 1984

Campero A., Graber F. M. and Lukens H. R.
NAA of biological materials
Proc. Int. Conf. on the Utilization of Research. Reactors, Mexico City,
CNM-R-2 Report, 1. (1967) pp.346-356

Casey C. E.
Concentrations of some trace elements in human and cow's milk
Proc. Univ. Otago. Med. School. 54 (1976) pp. 7-12

Casey C. E.
The content of some trace elements in infant milk foods and supplements
available in New Zealand.
NZ Med. J. 85 (1977) 275-278

Casey C. E. and Robinson M. F.
Cu, Mn, Zn, Ni, Cd, and Pb in human foetal tissues.
Br. J. Nutr. 39 (1978) 639-646

Casey C.E. Guthrie B. E. Friend G.M. Robinson M. F.
Se in human tissues from New Zealand. Personal communication.1983

Casey C. E., Guthrie B. E., and Mckenzie J . M.
Trace elements in tissues from New Zealanders. Personal communication,1983

Celada A., Busset R., Gutierrez J.and Herreros V.
No correlation between Fe concentration in breast milk and maternal Fe stores.
Helv. Med. Acta 37 (1982) 11-16

Chattopadyay A. and Jervis R. E.
Hair as an indicator of multielement exposure of population groups.
Trace Substances in Environ. Health VIII Hamphill D.D. (ed)(1974) pp.31-38

Chattopadyay A., Roberts T. M. and Jervis R. E.
Scalp hair as a monitor of community exposure to lead.
Arch. Environ. Health 32 (1977) 226-236

Cheek D. B., Spargo R. M. and Halt A. B.
Evidence for Zn deficiency in aboriginal settlements in North Western Australia.
Med. J. Aust. Suppl. 1 (981)4-5

Chooi M. K., Todd J. K. and Boyd M. D.
Influence of age and sex on plasma Zn levels in normal and diabetic individuals.
Nutr. Metale 20 (1976) 135-142

Cigna Rossi L. and Clemente G. F.
Hg and Se distribution in a defined area and in its population.
Arch. Environ. Health 31 (1976)160-165

Cigna Rossi L. Clemente G. F. and Santaroni.
Studies on the trace element distribution in the diets and population of Italy.
Personal Communication, 1983

Chuang L. S. and Emery J. F.
Hair as an indicator of environmental exposure in Hong Kong.
J. Radioanal. Chem. 45 (1978) 169-180

Clausen J and Rastogi S. C.
Heavy metal pollution among auto workers, 1. Lead
Brit. J. Ind. Med. 34 (1977) 208-15

Clansen J. and Rastogi S. C.
Heavy metal pollution among autoworkers. Cd, Co, Cu, Mn, and Ni.
Brit. J. Ind. Med. 34 (1977) 216-220

Clemente G. F., Cigna Rossi L. and Santaroni G. P.
Studies in the distribution and related health effects of the trace elements in Italy.
Trace Substances in Environmental Health. XII Hamphill D.D. (ed)(1978)pp.

Clemente G.F., Cigna Rossi L. and Santaroni G. P.
Trace element composition of hair in the Italian Population.
IAEA Symp. Nuclear Activation Techniques in the Life Sciences. Vienna,1978
pp. 527-543

Clemente G. F., Ingrao G. and Santaroni G. P.
The concentration of some trace elements in human milk from Italy.
Sci. Total Environ. 24 (1982) 255-265

Cornelis R. and Hoste J.
Neutron activation analysis of iodine in blood serum or other biological materials by substoichiometric precipitation of iodine as silver iodide.
J. Radioanal. Chem. 13 (1973) 419-426

Cornelis R., Specke A. and Hoste J.
Neutron Activation Analysis for bulk and trace elements in urine.
Anal. Chim. Acta, 78 (1978) 317-327

Cornelis R., Versieck J., Desmet A., Mees. and Vanballenberghe L.
Neutron activation analysis of the trace element molybdenum in urine of healthy persons.
Bull. Sec. Chim. Belg. 90 1981, 289-295

Cortes E., Santiago, Chili, Personal Communication, 1983.

Cortes E., Gras N., Munoz l., Ferradia A. and Luco H.
The effect of the environment in the trace element content of human milk
5th International Conference on Nuclear Methods in Environmental and Energy Research
Mayaguez, 1984, Abstract, p.2o9

Cote M. and Shappcott D.
Hair Cr concentrations and arteriosclerotic heart disease
Trace Elements in Man and Animals-4, Perth, 1981, pp. 521-25

Cote M., Shappcott D., Pruszynski V., Lemieux E., Suarez de Lezo J. and Delaye J.
Hair Cr concentration and coronary artery disease in Canada, France, Spain and Italy
International Symposium on Health Effects and Interactions of Essential and Toxic Elements, Lund, 1983 (in press)

Cotzias G.C., Miller S.T. and Edwards J.
NAA- the stability of Mn concentrations in human blood and serum
J. Lab. Clin. Med. 67(2966)836-49

Creason J.P., Svensgaard D., Bumgarner J., Pinkerton C. and Hinners T.
Maternal and fetal tissue levels of 16 trace elements in 8 selected continental U.S. communities
Trace Substances in Environmental Health, Hemphill D.D. (ed), 1976, pp. 53-62

Creason J.P., Hammer D.I., Colucci A.V., Priester L. and Davis J.
Blood trace metals in military recruits
Southrn Med. J. 69(1976)289-93

Cumming F.J., Fardy J.J. and Briggs M.H.
Trace elements in human milk
Obstet. Gynec. 61(1983)645-47

Cuming F.
PhD thesis, Deakin University, Geelong, Australia, 1984 and Personal Communication

Curry A.S. and Knott A.R.
National levels of Cd in human liver and kidney in England
Clin. Chim. Acta 3o(197o)115-18

D'Amico D.J. and Klawans H.L.
Direct microdetermination of Mn in normal serum and CSF by AAS
Anal. Chem. 48(1976)1469-72

Dale I.M., Lenihan J.M.A, and Smith H.
The environment as reflected in human tissue and hair; a comparison
Second International Conference on Nuclear Methods in Environmental Research, Vogt J.R. (ed), Columbia, Mo., 1974, pp.187-197

Dale I.M., Glasgow, U.K., Personal communication, 1983

Damsgaard E., Heydorn K., Larsen N.A. and Neilson B.
Simultaneous determination of As, Mn and Se in human serum by NAA
Reso Report 271, Rosekilde, 1983

Damsgaard E, Rosekilde, Denmark, Personal communication 1982

Damyanova A., Sofia, Bulgaria, Personal communication, 1983

Dang H.S., Jaiswal D.D., Wadhwani C.N. and Somasundaram S.
Studies on the role of Cu and Zn in liver disorders
IAEA Symposium on Nuclear Activation Techniques in the Life Sciences, Vienna, 1978, pp. 283-292

Dang H.S. and Somasundaram S., Bombya, India, Personal communication 1983

Dang H.S., Jaiswal D.D., Somasundaram S., Wadhwani C.N. and Dacosta H.
Distribution of As in human tissues and milk
Sci. Total Environ. 29(1983)171-175

Dang H.S., Jaiswal D.D., Somasundaram S., Deshpande A. and Dacosta H.
Concentrations of four essential trace elements in breast milk of mothers from two socio-economic groups: Preliminary observations
Sci. Total Environ. 35(1984)85-89

Dickson R.C. and Tomlinson R.H.
Se in blood and human tissues
Clin. Chim. Acta 16(1967)311-321

Dillon H.K., Wilson D.J. and Schaffner W.
Pb concentrations in human milk
Am. J. Dis. Child. 128(1974)491-92

Donev I., Radonov S., Stoev S., Marichkova L., Damyanova A. and Gotsed G.
Multielement analysis of some tissues for patients with endemic nephropathy
IAEA Symp. Nuclear Activation Techniques in the Life Sciences, Vienna, 1972, pp. 293-3o5

Donma O. and Yüregir G.
Problems encountered in serum Fe and Fe binding capacity measurement
Trace Element Analytical Chemistry in Medicine and Biology, Brätter P. and Schramel P. (eds), Walter de Gruyter & Co, Berlin, 198o, pp. 477-489

Dorea J.G., Horner M.R., and Campanate M.L.
A study of Zn and Cu in milk of Brazilian women
Trace Elements in Man and Animals-5, Aberdeen 1984, Abstract 1o2

Drabak I., Copenhagen, Denmark, Personal communication, 1982 (through Heydorn)

Drasch G.A.
An increase of Cd body burden for this century. An investigation of human tissues
Sci. Total Environ. 26(1983)111-119

Dybczynski R.
Forensic and environmental aspects of NAA of single human hairs
J. Radianal. Chem. 31(1976)267-289

Dybczynski R., Warsaw, Poland, Personal communication 1983

Eatough D.J., Hansen L.A., Starr S.E., Astin M.S., Larsen S.B., Izaitt R.M. and Christensen J.O.
Cr in autopsy tissues of diabetic and non-diabetic (pima) Indians
Trace Elements in Man and Animals-3, Munich-Weihenstephan, 1977 pp. 259-63

Elinder C.G., Piscator M. and Linnman L.
Cd and Zn relationships in kidney cortex, liver and pancreas
Environ. Res. 13(1977)432-44o

Elinder C.G., Kjellström T., Friberg L., Lind B. and Linnman L.
Cd in kidney cortex, liver and pancreas for swedish autopsies
Arch. Environ. Health 31(1978)292-3o2

Ellis K.J., Vartsky D., Zanzi E. and Cohn S.H.
Cd: In vivo measurements in smokers and non-smokers
Science 2o5(1979)323-24

Esala S., Vuori E. and Helle A.
Effect of maternal fluoride intake on breast milk fluorine content
Brit. J. Nutr. 48(1982)2o1-2o4

Fell G.S., Canning E., Hussain L. and Scott R.
Cu and Zn in huamn health and disease
Trace Substances in Environmental Health, Hemphill D.D. (ed), 1971, pp. 293-3o2

Fernandez A., Sobel A. and Jacobs J.L.
Sensitive method for the determination of submicrogramme quantities of Mn and its application to human serum
Anal. Chem. 35(1963)1721-24

Fischedick R., Hall G., Schaller K.H., Valentin H. and Wettle D.
Ergebnisse der biologischen Überwachung der Bevölkerung im Freistaat Bayern auf eine Gefärdung durch Blei
Arbeits. Sozial Med. 18(1983)39-43

Friberg L. and Vahter M.
Assessment of exposure to Pb and Cd through biological monitoring: Results of a UNEP/WHO global study
Environ. Res. 3o(1983)95-128

Fukabori S. and Nakaaki K.
On the urinary excretion of Cd, Pb, Hg and F
J. Sci. Lab. 5o(1974)249-69

Ganapathy S.N., Booker L.K., Craven R. and Edwards C.
Trace minerals, amino acids and plasma proteins in adult men fed wheat diets
J. Am. Dietet. Assoc. 78(1981)49o-95

Galster W.A.
Hg in Alaskan Eskimo mothers
Environ. Health Perspect. 15(1976)335-41

Gautier H. de Defaix, Puente R., Vidal B., Perez E. and Vidal H.
Liver storage of Fe in normal population of India
Am. J. Clin. Nutr. 33(198o)133-36

Ghelberg N.W., Ruckert J. and Straus H.
The Pb content of milk in an area with non-ferrous metallurgical industry
Igiena (Bucharest) 21(1972) 17-22

Gibbs C.W. and Bogdanovic E.
Trace elements in lung and hair
Advances in the assessment of health effects of environmental pollution-A Symposium, CEC, Luxembourg, 1974, pp. 2271-2283

Gibson R.S., Guelph, Canada, Personal communication, 1983

Gibson R.S., Anderson B.A. and Sabry J.H.
The Cu, Mn and Se status of post-menopausal vegetarians
J. Am. Dietet. Assoc.

Giovanetti S., Maggiore G. and Malvano R.
NAA of trace elements in plasma from normal subjects and from chronic uraemic patients
IAEA Symposium on Nuclear Activation Techniques in the Life Sciences, Amsterdam, 1967, pp. 511-516

Glover J.R.
Se in human urine. Tentative maximum allowable concentration for industrial and rural populations
Ann. Occup. Hyg. 1o(1967)3-14

Grandjean P.
Pb content of scalp hairs as an indicator of occupational Pb exposure
In, Toxicology and Occupational Medicine, Elsevier, Amsterdam 1979, pp. 311-18

Grandjean P., Olsen N.B. and Hollnagel H.
Influence of smoking and alcohol consumption on blood Pb levels
Int. Arch. Occup. Environ. Health 48(1981)391-97

Greger J.L. and Sciscoe B.S.
Zn nutriture of elderly participants in an urban feeding programme
J. Am. Dietet. Assoc. 7o(2977)37-41

Gregoriades G., Apostolides N., Romauos A. and Paradellis T.
Postoperative changes in serum Cu value
Surg.gynec. Obstet. 154(1982)217-221

Grimanis A.P., Grimanis M., Alexion D. and Papadatos C.
Determination of 7 trace elements in human milk, powdered cow's milk and infant foods by AA.
IAEA Symposium on Nuclear Activation Techniques in the Life Sciences, Vienna, 1978, pp. 241-53

Gross S.B., Yeager G.W. and Middendorf M.S.
Cd in liver, kidney and hair of humans- fetal through old age
J. Tox. Environ. Health 2(1976)153-167

Guthrie B.E. and Hughes P.M.
Urinary Cr excretion by New Zealanders, Personal communication 1983

Hadjimarkos D.M. and Shearer T.R.
Se in mature human milk
Am. J. Clin. Nutr. 26(2973)583-85

Hall D.J. and Fell G.S.
The determination of Mn in urine and serum
Trace Element Analytical Chemsitry in Medicine and Biology, Brätter P. and Schramel P. (eds), Walter de Gryter, Berlin, 198o, pp. 265-72

Hambidge M., Hambidge C., Jacobs M. and Baum J.D.
Low levels of Zn in hair, anorexia, poor growth and hypogeusia in children
Pediat. Res. 6(1972)868-74

Hamilton E.I., Minski M.J. and Cleary J.J.
The concentration and distribution of some stable elements in healthy human tissues from the U.K.
Sci. Total. Environ. 1(1972/73)341-61

Hamilton E.I.
The chemical elements and man
Charles C. Thomas Publishers, Springfield, 1979

Hansen J.C., Kromann N., Nulf H.C. and Alboge K.
Human exposure to heavy metals in east Greenland. II Lead
Sci. Total Environ. 26(1983)245-254

Hatano S., Nishi Y. and Usui T.
Cu levels in plasma and erythrocytes in healthy Japanese children and adults
Am. J. Clin. Nutr. 35(1982)12o-126

Hecker L.H., Allen H.E., Dinman B.D. and Neel J.V.
Heavy metal levels in acculturated and unacculturated populations
Arch. Environ. Health 29(1974)181-85

Heineman G.
Plasma Fe, serum Cu and serum Zn during therapy with ovulation inhibitors
Med. Klin. 69(1974)892-96

Heydorn, K.
Environmental variation of As levels in human blood determined by NAA
Clin. Chim. Acta 28(197o)349-357

Heydorn K. and Norgaard K.
Analysis of precision of activation analysis methods
Talanta 2o(1973)835-842

Heydorn K., Damsgaard E., Larsen N.A. and Nielsen B.
Sources of variability of trace element concentrations in human serum
IAEA conference on Nuclear Activation Techniques in the Life Sciences,
Vienna, 1978, pp. 129-142

Heydorn K.
Aspects of precision and accuracy in NAA
RISO-R-419, Roskilde, Denmark 198o

Higashi A., Ikeda T., Uchara I. and Matsuda
Zn and Cu contents in breast milk of Japanese women
Tohoky. J. Exp. Med. 137(1982)141-47

Hoeger-Arousen B., Abdulla M. and Fristedf L.
Effect of Pb on delta-ALA dehydrase activity in RBC
Arch. Environ. Health 23(1971)44o-445

Holt B., Spargo R.M., Iveson J.B., Faulkner G.S. and Cheek D.B.
Serum and plasma Zn, Cu, Fe concentrations in Aboriginal communities of
north western Australia
Am. J. Clin. Nutr. 33(198o)119-132

Holzbecher J. and Ryan D.E.
Some observations in the interpretation of hair analysis data
Clin. Biochem. 15(1982)8o-82

Howard H. Sky-Peck and Joseph B.J.
The use and misuse of human hair in trace metal analysis
In Chemical Toxicology and Clinical Chemistry of Metals, Brown S. and Savory J.
(eds), Academic Press, New York, 1984, 159-63

Htun M.N. and Ramachandran P.N.
An investigation of blood Pb content and atmosphereic Pb levels in Bangkok
Water Air Soil Poll. 7(1977)79-94

Hubermont G., Buchet J.P., Roels H. and Lauwerys R.
Placental transfer of Pb, Hg and Cd in women living in a rural area. Importance
of drinking water in lead exposure
Int. Arch. Occup. Environ. Health. 41(1978)117-129

Hung P.Q., Cholewa M., Kajfosz J. and Szymczyk S.
PIXE studies of ethnic differences of trace and other elements concnetraion
in hair.
Proc. Trace Element Analytical Chemistry in Medicine and Biology, Walter de
Gryter Co, Berlin, 1982, pp. 1oo9-1o17

Hussain M., Khaliquzzaman M., Abdulla M., Ahmed I. and Khan A.H.
Trace elements concentration in hair of the Bangladeshi population
Int. J. Rad. Iso. 31(198o)527

Ikeda N., Ichimura K., Usagimoto H., Tanaka K., Kasamo M., Mizouchi T., Sakaguchi S. and Banno T.
On the determination of trace element As in whole blood of the inhabitants in Nara prefecture
Zenkolku Kogai Kenkaishi 4(1979)43-47

Imahori A., Fukushima J., Shiobara S., Yanagida Y. and Tomura K.
Multielement NAA of human scalp hair: A local population survey in the Tokyo metropolitan area
J. Radianal. Chem. 52(1979)167-180

Ingrao G., Rome, Italy, Personal communication, 1983

Ishii T., Horiuchi K., Nakahara H. and Murakami Y. Japan,
Personal communication 1983,(through Nakahara)

Ishihara N., Sendai, Japan, Personal communication 1983

Iyengar G.V., Kollmer W.E. and Bowen H.J.M.
The Elemental Composition of Human Tissues and Body Fluids,
Verlag Chemie, Weinheim, 1978

Iyengar G.V., Presampling factors in the elemental composition of biological systems, Anal. Chem. 54(1982)554A-558A

Iyengar G.V. (Unpublished results), 1984

Iyengar G.V.

In Chemical Toxicology and Clinical Chemistry of Metals, Brown S. S. and Savory J. (eds), Academic Press, New York, 1983, pp. 153-158

Iyengar G.V. and Schütze R. (Unpublished results), 1984

Iyengar G.V.
Investigation of regional differences in the trace element composition of human foods and an evaluation of the tissue elemental composition
International Conference on Trace Elements in Man and Animals-5,
Aberdeen, 1984, (in press)

Iyengar G.V. and Kollmer W.E.
Some aspects of choice of specimen for biomedical trace element research studies in human subjects
5th International Conference on Nuclear Methods in Environmental and Energy Research, Vogt J.R. (ed), Mayaguez, 1984, (in press)

Iwao S., Sugita M. and Tsuchiya K.
Some metabolic interrelationships among Cd, Pb, Cu and Zn: Results from a field survey in Cd polluted areas of Japan, Part III
Keo. J. Med. 3o(1981)89-96

Jenkins D.W.,
Toxic trace metal in mammalian hair and nails
Report No. EPA-6oo/4-79-o49 (PB8o-1o3997)
NTIS, US Department of Commerce, Washington D.C.

Jensen A.S.
Chemical contaminants in human milk
Residue Rev. 89(1983)2-128

John W.
Relationship between trace element concentrations in human blood and atmospheric aerosol
Sci. Total Environ. 27(1983)21-32

Johnson D.E., Tillery J.B. and Prevost P.J.
Levels of Pt, K and Pb in populations of south California
Environ. Health Persp. 12(1975)27-33

Johnson C.A.
The determination of some toxic metals in human liver as a guide to normal levels in New Zealand. Part 1. Determination of Bi, Cd, Cr, Co, Cu, Pb, Mn, Ni, Ag, Tl and Zn
Anal. Chim. Acta 81(1976)69-74

Johnson C.A., Lewin J.F. and Fleming P.A.
The determination of some toxic metals in human liver as a guide to normal levels in New Zealand, Part 2. As, Hg and Se.
Anal. Chim. Acta 82(1976)79-82

Jonsen J. and Steinnes E., Trondenheim, Norway, Personal communication 1983

Kagey B.T., Bumgarner J.E. and Creason J.P.
As levels in maternal-fetal tissue sets
Trace Substances in Environmental Health, Hemphill D.D. (ed), 1977, pp. 252-56

Kapu M.A., Fleming A.F. and Egan B.U.
Plasma Zn in sickle-cell anaemia.
Lancet, April 24, 1976, pp 92o

Kapu M.M., Fleming A.F. and Edington G.M.
Trace element changes (Cu & Zn) in normal Nigerians, those with sickle cell disease and pulmonary tuberculosis
Trace Elements in Man and Animals-3, Munoch-Weihenstephan, 1977, pp.363-65

Kasperek K., Feinendegen L.E. and Siller V.
Aktivierungsanalyse von Spurenelementkonzentrationen im menschlichen Kopfhaar Einfluß von Geschlecht, Alter und Umwelt
Nuklearmedizin 9(1971)123-26

Kasperek K., Schicha H., Siller V., Feinendegen L.E. and Höck A.
Trace element concentrations in human serum: Diagnostic implications
IAEA Symp.on Nuclear Activation Techniques in the Life Sciences, Bled, 1972, pp. 517-26

Kay R.G. and Knight G.S.
Blood Se values in an adult Auckland population group
New Zealand Med. J. 9o(2979)11-13

Kayne F.J., Komar G., Laboda H. and Vanderlinde R.E.
AAS of Cr in serum and urine with a modified Perkin Elmer 6o3 AAS-Meter
Clin. Chem. 24(1978)2151-54

Khan A.H., Khaliquzzaman M., Zaman M.B., Husain M., Abdullah M. and Akhter S.
Trace element composition of blood in adult population in Bangladesh
J. Radioanal. Chem. 57(198o)157-67

Kirkbright G.F., Manchester, U.K., Personal communication 1984

Kitamura S., Sumino K., Hayakawa K. and Shibata T.
Contents of heavy metals in hair of the inhabitants in Nara Prefecture Japan. J. Hygeine 33(1978)1o1

Kjellstrom T.
Exposure and accumulation of Cd in populations from Japan, the U.S. and Sweden
Environ. Health Perspect.28(1979)169-197

Kleevay L.M.
Hair as a biopsy material. Assessment of Zn nutriture
Am. J. Clin. Nutr. 23(197o)284-89

Kleevay L.M.
Hair as a biopsy material
Arch. Environ. Health 26(1973)169-72

Kolbye A.C., Mahaffey K.R. and Fiorino J.A., Corneliussen D.C. and Jelinek C.F.
Food exposure to Lead
Environ. Health Persp. 7(1974)65-74

Kosta L., Byrne A.R. and Dermelj M.
Trace elements in some human milk samples by radio chemical NAA
Sci. Total Environ. 29(1983)261-68

Kostial K., Zagreb, Yugoslavia, Personal communication 1983

Kowal N.E., Johnson D.E., Kraemer D.F. and Pahven H.R.
Normal levels of Cd in diet, urine, blood and tissues of inhabitants of the United States
J. Tox. Environ. Health 5(1979)995-1o14

Kumpulainen J. and Vuori E.
Longitudinal study of Cr in human milk
Am. J. Clin. Nutr. 33(198o)2299-23o2

Kumpulainene J. and Koivistoinen P.
Interlaboratory comparison of Se levels in human serum
Kemia-Kemi 8(1981)372-73

Kumpulainen J., Koivistoinen P., Vuori E. and Lehto J.
Direct determination of Cr in biological fluids by Graphite Furnace AA
In, Euroanalysis-IV, Kirimaki M. and Ninistö L. (ed), Helsinki, 1981, Abstract 367

Kumpulainen J., Lehto J. and Koivistoinen
Determination of Cr in human milk, serum and urine by electrochemical atomic absorption spectrometry without preliminary ashing
Sci. Total Environ. 31(1983)71-8o

Kumpulainen J., Salmela S., Vuori E. and Lehto J.
Effects of various washing procedures on the Cr content of human scalp hair
Anal. Chim. Acta 138(1982)361-64

Kucera J,Prague, Czechoslovakia, personal communication, 1983

Kyle J.H. and Ghani N.
Hg concnetrations in canned and fresh fish and its accumulation in a population of Port Moresby residents
Sci. Total Environ. 26(1983)157-62

Lalonde L., Jean Y., Roberts K.D., Chapdelaine A. and Bleau G.
Fluorometry of Se in serum or urine
Clin. Chem. 28(1982)172-174

Lanzel E.
Aktiveirungsanalyse von Umweltmetallen in menschlichen Kopfhaar
J. Radioanal. Chem. 58(198o)347-57

Larsen N.A., Nielsen B., Pakkenberg H., Christoffersen P., Damsgaard E. and Heydorn K.
NAA of As, Mn and Se concentraions in organs of uraemic and normal persons
IAEA Symp. on Nuclear Activation Techniques in the Life Sciences, Bled, 1972, pp. 561-68

Lauwerys R., Buchet J.P., Roels H., Viau C., Bernard A., Bruaux P., Claeys-Thoreau F. and Rondia D.
Potential risk of Cd for the general population: Update of Liege study
Proc. 4th International Cd Conference, Munich, 1983 (in press)

Lenihan J.M.A. and Smith H.
Activation analysis and public health
IAEA Symp. on Nuclear Activation Techniques in the Life Sciences, Amsterdam, 1967, pp. 6o1-612

Lewis I.C., Bloom H. and Noller B.N.
Cu in whole blood of residents from Southern Tasmania
Search 8(1977)233-35

Lievens P., Versieck J., Cornelis R. and Hoste J.
The distribution of trace elements in normal human liver determined by semi-automated radiochemical neutron activation analysis
J. Radioanal. Chem. 37(1977)483-96

Lightman A., Hafia, Israel, Personal Communication, 1983

Lindeman R.D., Clark M.C. Colemore J.P.
Influence of age and sex on plasma and red cell Zn concentration
Gerontology 26(1971)358-63

Lindeman R.D., Bottomly R.C., Corrlisen R.L. and Jacobs L.D.
Influence of acute tissue injury on Zn metabolism in man
J. Lab. Clin. Med. 79(1972)452-6o

Lloyd B., Holt T. and Delves H.T.
Determination of Se in biological samples by hydride generation and AAS
Analyst 1o7(1982)927-33

Lodhi A.S. and Khan R.
Trace element analysis of whole blood and urine samples of diabetic patients
J. Radioanal. Chem. 49(1979)89-94

Lombeck I., Kasperek K. Bonnermann B., Feinendegen L.E. and Bremmer H.J.
The Se content of human milk, cow's milk and milk formula
Brit. J. Pediat. 229(1978)139-145

Lonnerdal B., Keen C.L. and Hurly L.S.
Fe, Cu, Zn and Mn in milk
Ann. Rev. Nutr. 1(1981)149-174

Lundgren K.D., Swensson A. and Ulfvarson U.
Studies in humans on the distribution of Hg in the blood and the excretion in urine after exposure to different Hg compounds
Scand. J. Clin. Lab . Invest. 2o(1967)164-66

Magos L. and Clarkson T.W.
AAS determination of total inorganic and organic Hg in blood
J. AOAC 55(1972)966-971

Mahaffey K.R., Annest J.L., Barbano H.E. and Murthy R.S.
Preliminary analysis of blood lead concentration fractions for children and adults: Hanes II. 1976-78
Trace Substances in Environmental Health, Hemphill D.D. (ed), 1979, 37-51

Murzan A.D.
An overview of the nutritional anemia problem in the Philippines
Phil. J. Nutr. 29(1976)14-24

Masaik M., Skowrton I., Owczartek H., Wodkiezicz L. and Stacherzak J.
Serum levels of certain trace elements (Cu, Au and Mn) in healthy subjects: Part 1
Acta Physiol. Pol. 32(1981)537-46

Matsuzawa K., Kubota M. and Asakawa K.
Contents of heavy metals in hair of the inhabitants in Nagaro Prefecture
Report No. 148, 1977, pp. 1-1o (personal communication through Nakahara)

Maxia V., Meloni S., Rollier M.A., Brandone A., Patwardhan V.N., Waslien C.I. and Shamiel S.
Se and Cr assay in Egyptian foods and in blood of Egyptian children by AA
IAEA Symp. on Nuclear Activation in the Life Sciences, Bled, 1972- pp. 527-55o

McConnell K.P., Broghamer W.L. Jr., Blotcky A.J. and Hurt O.J.
Se levels in human blood and tissues in health and in disease
J. Nutr. 1o5(1975)1o26-31

McKenzie J.M.
The nutritional status of New Zealand People with respect to Zn, Cu and Cd
PhD thesis, University of Otago, 1973

McKenzie J.M.
Tissue concentration of Cd, Zn and Cu from autopsy samples
New Zealand Med. J. 79(1974)1o16-19

Mckenzie J.M., Guthrie B.E. and Prior I.A.M.
Zn and Cu status of Polynesian residents in the Tokelau Islands
Am. J. Clin. Nutr. 31(1978)422-28

McKenzie J.M.
Content of Zn in serum, urine, hair and toe nails of New Zealand adults
Am. J. Clin. Nutr. 32(1979)57o-79

McKenzie J.M. Dunedin, New Zealand, Personal communication 1983

Mclead B.E. and Robinson M.F.
Metabolic balance of Mn in young women
Brit. J. Nutr. 27(1972)221-227

McMaster D., Belfast, Ireland, Personal communication 1983

McNeely M.D.
Chemical monitoring of exposure to heavy metals
Can. Med. Assoc. J. 118(1978)478-79

Mehkeri K.A., Romanowski M. and Sonallbone B.
Use of a filter-disc micro sampling atomic absorption method for blood Pb level
Am. Ind. Hyg. Assoc. J. (1976)541-45

Millar K.R. and Sheppard A.D.
α-Tocopherol and Se levels in human and cow's milk
New Zealand J. Sci. 15(1972)3-15

Molokhia M.M. and Portnoy B.
NAA of trace elements in skin VI. Mn in psoriasis vitiligo and other dermatoses
Brit. J. Derm. 88(1973)273-78

Moore M.R.
Lead in drinking water areas- health hazards
Sci. Total Environ. 7(1977)1o9-115

Morgan A. and Holmes A.
Determination of Mo in blood and biological materials by NAA
Radiochem. Radioanal. Letters 9(1972)329-333

Muller M.M., Kuzmits R., Lorant P. Frass M. and Trambik E.
Laborbefunde im Rahmen der "Wiener-Gesundheits Studie"
Wiener Med. Wochschr. 132(1982)35-42

Murthy G.K. and Rhea S.
Cd, Cu, Fe Pb, Mn and Zn in evaporated milk, infant products and human milk
J. Dairy Sci. 54(1971)1oo1

Nakahara H., Nagame Y., Yoshizawa Y. Oda H., Gotoh S. and Murakami Y.
Trace element analysis of human blood serum by NAA
J. Radianal. Chem. 54(1979)183-19o

Nakahara H., Kudo H., Muramatsu H., Masago K. and Murakami Y.
Activation analysis of trace elements in the human blood serum
Trace Element Analytical Chemistry in Biology and Medicine, Brätter P. and Schramel P. (eds), Walter de Gryter Co, Berlin, 198o, pp. 365-38o

Nassi G., Poggini G., Nassi P.A., and Galvan P.A,
Zn in different protein fractions of human milk
Bull. S c. It. Biol. Sper. 5o(1974)9o7-915

Neri L.C., Johansen H.L., Schmitt N., Pagan R.T. and Hewitt D.
Blood Pb levels in 2 British Columbia communities
Trace Substances in Environmental Health, Hemphill D.D. (ed), 1978, pp. 4o3-41o

Neve J. and Molle J.
Critical study of some wet digestion methods for decomposition of biological materials for determination of total Se and Se (VI)
Microchim Acta 1(198o)259-269

Nomiyama H., Yotoriama H. and Nomiyama K.
Normal Cr levels in urine and blood of Japanese subjects determined by direct FAAS, and valancy of Cr in urine after exposure to Cr (VI)
Am. Ind. Hyg. Assoc. 41(198o)98-1o2

Nird P.J., Kadaba M.P.& Sorenson J.R.J.
Hg in human hair
Arch. Environ. Health 27(1973)4o-44

Nordberg G., Umea, Sweden, Personal communication, 1983

Norheim G. and Aaseth J.
Essential trace elements in human liver in Norway- Cu, Zn, Mo and Se
J. Oslo City Hosp. 3o(198o)1o5-112

Nozdryukina L.R.
Use of trace elements for diagnostic of heart and liver diseases
Trace Elements in Man and Animals, Munich-Weihenstephan, 1977, pp. 336-39

Nygaard S.P., Bonde G.J. and Hansen J.C.
Standard values of Pb and Cd in human blood
Nordisk Hygienisk Tidskrift, Stockholm 54(1973)153-62

Nygaard S.P., Ottosen J., and Hansen J.C.
Whole blood Pb concentration in relation to age and environment
Dan. Med. Bull. 24(1977)49-51

Obrusni I. and Bencko V.
INAA study of trace elements in hair of three selected population groups in Chechoslovakia
Radiochem. Radioanal. Lett. 38(1979)189-196

Obrusnik I., Rez, Czechoslovakia, Personal Communication 1983

Ohmori S., Tsui H., Kusaka Y., Takeuchi T., Hayashi T., Takada J., Koyama M., Kozuku H. Shinogi M., Aoki A. Takayama K. and Tomiyama T.
Radioactivation analysis of hair: A means of biological monitoring of the environment
J. Radioanal. Chem. 63(1981)269-282

Ohta N., Terai M. and Koshinaga J.
Hg contents in human tissues
Nippon Kagaku Zasshi 87(1966)45-47

Olatunbosun D.A., Adeniyi F.A. and Adadevoh B.K.
The effect of oral conraceptions on serum Cu levels in Nigerian women
J. Obstet. Gynec. Brit. Commonwealth 8o(1973)937-939

Olatunbosun D.A., Isaac S., Sodeye W.A., Adeniyi F.A. and Adadevoh B.K.
Serum Cu in sickle cell anemia
Lancet 1(1975)285

Olatunbosun D.A.- Bolodeoku J.O., Cola T.O. and Adadevoh B.K.
Relationship of serum Cu and Zn to human hypertension in Nigerians
Bull. WHO 53(1976)134-35

Olatunbosun D.A., Morris S., Lichte F., Koirtyohann S.R. and Vogt J.R.
Trace element content of hair from Nigerians with sickle-cell anemia
Trace Substances in Environ. Health, Hemphill D.D. (ed), 1976, pp. 383-388

Olatunbosun D.A., Koirtyohann S.R. and Vogt J.R.
Zn in hair of sickle cell anemia patients
Clin. Chem. 23(1977)767

Olery U.G.
Epidemiological implications of environmental Cd
Am. Ind. Hyg. Assoc. J. 36(1975)229-233

Olehy D.A., Schmitt R.A. and Bethard W.F.
NAA of Mg, Ca, Sr, Ba, Mn, Co, Cu, Zn, Na and K in human erythrocytes and plasma
J. Nucl. Med. 7(1966)917-927

Olsen N.B., Hollnagel H. and Grandjean P.
Indicators of Pb exposure in an adult Danish suburban population
Dan. Med. Bull. 28(1981)168-176

Orssoud G., Moreau T., Juguet B., Warnet J.M., Claude J.R., Ferty B. and Lellouch J.
Effect of smoking on Cd and Pb blood levels
Abstracts, XXIV Congress of the European Society of Toxicology, Rome, 1983, pp.144

Othman I. and Spyrou N.M.
The abundance of some elements in hair and nail from the Machakos district of Kenya
Sci. Total Environ. 16(198o)267-78

Özgünen F.T., Özgünen T., Kaya R., Özkurt S.& Kandemir E.
Erken gebelikdöneminde idrarla eser element atilimi
Biokymya Dergisi, Yil 1, Sayi 3, Nisan 1977, Sahife 74-81
(Turkish Journal)

Pallotti G., Consolino A. Benlivenga B. and Iacoponi V.
Pb levels in whole blood of an adult population group from Rome
Sci. Total Environ. 31(1983)81-87

Panday V.K.,Parameshwaran M. Raut S.J., Soman S.D. and Dacosta H.
Nutritional studies and the serum levels of Mg, Ca, Zn and Cu
Sci. Total Environ. 27(1983)261-264

Pankhurst C.A. and Pate B.D.
Trace elements in hair
Reviews in Analytical Chemistry, Freund Publishing Co, Tel Aviv, Volume 4, 1979, pp. 112-235

Paradellis T., Athens, Greece, Personal communication, 1983

Parr R.M., Vienna, Austria, Personal communication 1984

Pekarek R.S., Beisel W.R., Bartellono P.J. and Bostian K.A.
Determination of serum Zn concentrations in normal adult subjects by AAS
Am. J. Clin. Path. 57(1972)5o6-51o

Pekarek R.S., Hauer E.C., Wannemacher R.W. and Beisel W.R.
The direct determination of serum Cr by an AAS with a heated graphite atomizer
Anal. Biochem. 59(1974)283-92

Picciano M.F. and Guthrie M.A.
Cu, Fe and Zn contents of mature human milk
Am. J. Clin. Nutr. 29(1976)242-47

Piomelli S., Corash G., Corash M.B., Seaman C., Mushak P., Glover B. and Padgett R.
Blood Pb concnetrations in a remote Himalayan population
Science 21o(198o)1135-37

Pitkin R.M., Bahns J.A., Filer L.J. amd Reynolds W.A.
Hg in human maternal and cord blood
Proc. Soc. Exp. Biol. Med. 151(1976)565-567

Plantin L.O.
Trace elements in cardiovascular diseases: Contribution to a joint WHO/IAEA project
IAEA Symp. on Nuclear Activation Techniques in the Life Sciences, Vienna, 1978, pp. 321-32

Plantin L.O. and Mauerling S.
The concentration of trace elements in blood of healthy new borns
Proc. Trace Element Analytical Chemistry in Medicine and Biology
Walter de Gryter Co., Brätter P. and Schramel P. (eds), Berlin, 198o,
pp. 243-54

Plantin L.O. and Strandberg P.O.
Whole blood concentrations of Cu and Zn in rheumatoid arthritis studied by AA
Acta Rheum Scand. 11(1965)3o-34

Prasad A.S.
Clinical and biochemical spectrum of Zn deficiency in human subjects
In, Clinical, Biochemical and Nutritional aspects of trace elements,
Prasad A.S. (ed), Alan Riss., 1982, p.3-62

Prasad A.S., Detroit, U.S.A., Personal communication 1983

Quereshi L.H., Chaudhary M.S. and Ahmad S.
Trace element concnetration in head hair of the inhabitants of Rawalpindi-
Islamabad area
J. Radioanal. Chem. 68(1982)2o9-218

Räisänen M., Hyvönen-Dabek and Dabek J.T.
External proton beam for X-ray emission analysis of human blood plasma
Int. J. Appl. Rad. Isot. 32(1981)165-17o

Rajalakshmi K. and Srikantaiah S.G.
Cu, Zn and Mg content of breast milk of Indian women
Am. J. Clin. Nutr. 23(198o)264-69

Rea H.M., Thomson C.D., Campbell D.R. and Robinson M.F.
Relation between erythrocyte Se concentration and GSH-Px activities of New
Zealand residents and visitors to New Zealand
Brit. J. Nutr. 42(1979)2o1-2o8

Reilly C. and Harrison F.
Zn, Cu, Fe and Pb in scalp hair of students and non student adults in Oxford
J. Human Nutr. 33(1979)248-52

Reilly C.
A comparison of levels of Zn in scalp hair of residents of Oxford, UK and
Brisbane, Queensland
Proc. Nutr. Soc. Aust. 6(1981)141-43

Reinhold J.C., Kroury G.A., Ghalambor M.A. and Bennet J.C.
Zn and Cu in hair of Iranian villagers
Am. J. Clin. Nutr. 18(1966)294-3oo

Reinhold E.W. and Besch D.J.
Detection and elimination of contaminations interfering with the determination
of Zn in Plasma
Clin. Chem. 24(1978)675-8o

Rechetkina L.P.
Zn content of baby food and its alimentary allowances for young children
Vopr. Pitan. Moscow 28(1969)62-66

Rechetkina L.P.
Cu contents in products for infant feeding and the alimentary retention of Cu
in infants of varying ages
Vopr. Oktv. Materin Det. 14(1969)86-88

Robinson M.F., McKenzie J.M., Thomson C.D. and van Rij A.L.
Metabolic balance of Zn, Cu, Cd, Fe, Mo and Se in young women
Brit. J. Nutr. 3o(1973)195-2o5

Roberts T.N., Hutchinson T.C., Paciga J., Chattopadhyay H., Jervis R.E.
Van Horn J. and Parkinson D.K.
Pb contamination around secondary smelters: Estimation of dispersal and accumu-
lation by humans
Science 186(1974)112o-23

Roels H., Buchet J.P.,Lauwerys R., Bruaux P., Claeys-Thoreau F., Lafontaine A.S., Van Overshcelde J. and Verduyn G.
Pb and Cd absoprtion among children near a non-ferrous smelter metal plant: A follow-up study of a test case
Environ. Res. 15(1978)29o-3o8

Roels H.A., Balis-Jacques M.N., Buchet J.P. and Lauwerys R.
The influece of sex and chelation therapy on erythrocyte protoporphyrin and urinary aminolevulinic acid in Pb exposed workers
J. Occup. Med. 21(1979)527-39

Roels H.A., Buchet J.P., Lauerys R., Bruaux P., Claeys-Thoreau F., Lafontaine A.S. and Verduyn G.
Exposure to Pb by the oral and the pulmonary routes of children living in the vicinity of a primary Pb smelter
Environ. Res. 22(198o)81-94

Roels H.A., Lauwery R., Buchet J.P. and Bernard A.
Environmental exposure to Cd and renal function of aged women in 3 areas of Belgium
Environ. Res. 24(1981)117-13o

Roels H., Lauwerys R., Buchet J.P., Bernard R., Barthels A., Oversteyns M and Gaussin J.
Comparison of renal function and psychomotor performance in workers exposed to elemental Hg
Int. Arch. Occup. Environ. health 5o(1982)77-93

Rumsey N.K., Andersen H.D. and Morris J.S.
Analysis of I in biofluids from CAPD patients in an experimental I maintenance program.
Trace Substances in Environmental Health, Hemphill D.D. (ed), 198o, pp. 34o-352

Ryan D.E., Holzbecher J. and Stuart D.C.
Trace elements in scalp hair of persons with multiple sclerosis and of normal individuals
Clin. Chem. 24(1978)1996-2ooo

Saito K., Sasaki T., Sato Y. and Yasuda H.
Distribution of trace metals in snow fall and human blood in the northern region of Japan
Trace Substances in Environmental Health, Hemphill D.D. (ed), 1979, pp. 68-76

Sakura S.
A study on the determination of the elements in hair by non-destructive activation analysis and its significance
J. Iwate. Med. Assoc. 32(198o)869-884

Salmela S., Vuori E. and Kilpö J.O.
The effect of washing procedures on trace element content of human hair
Anal. Chim. Acta 125(1981)131-37

Säner G., Istanbul, Turkey, Personal communication, 1983

Satoh Y. and Yazawa A.
Contents of heavy metals in the blood of inhabitants in Yokohoma city in Japan
Yokohamaa Eiken Nenpo 17(1978)63-66

Schaller K.H., Breiniger M., Schiele R. and Schierling P.
Der Hg-Spiegel für Blut und Urin bei Normalpersonen
Erlangen, Germany, Personal communication, 1983 (through Valentin)

Schaller K.H., Schneider L,, Hall G. and Valentin H.
Untersuchungen zum Cd-Gehalt im Vollblut bei Bewöhnern verschiedener Regionen des Freistaattes Bayern
Erlangen, Germany, Personal communication 1983 (through Valentin)

Schaller K.H., Essing H.G., Valentin H. and Schäcke G.
The quantitative determination of Cr in urine by FAAS
Atom. Absorp. Newslett. 12(1973)147-15o

Schechter P.J., Giroux F. and Sjoertsmer A.
Zn distribution in human serum with data on alternations in pregnancy and hepatic cirrohsis
Trace Elements in Man and Animals-3, Munich-Weihenstephan, 1977, pp.343-345

Schmitt N., Phillon J.J., Larsen A.J., Harnadek M. and Lynch A.J.
Surface soil as a potential source of Pb exposure for young children
Can. Med. Assoc. J. 121(1979)1474-1478

Seeling W., Feist H., Grünert A., Heinrich H. and Luckner L.
Untersuchungen über den Einfluß von Blutabnahmetechnik und Probenvorbereitung bei der Bestimmung von Zn in serum und plasma sowie über die Häufigkeitsverteilung der plasma.Zn-Konzentration bei männlicher und weiblicher Blutspendern
Magnesium Bulletin 4(1982)18-27

Servant J. and Delapart M.
Blood Pb and Pb-21o organs in residents of Toulouse
Health Phys. 41(1981)483-87

Shah B.
Liver storage Fe in Canadians
Am. J. Clin. Nutr. 29(1976)66-69

Shamberger R.J., Willis C.E. and McCormack L.J.
Se and heart disease - III. Blood Se and mortality in 19 states
Trace Substances in Environmental Health, Hemphill D.D. (ed), 1979, pp. 59-63

Shamberger R.J., Cleveland, Ohio, USA, Personal communication, 1983

Sharper A.G., Pocock S.J., Walker M., Wade C.J., Clayton B. and Delves H.J.
Effect of alcohol and smoking on blood Pb in middle aged British men
Brit. Med. J. 284(1982)299-3o2

Sheard E.A., Johnson M.W. and Carter R.J.
The determinaion of Cr in hair and other biological materials
In, Hair Trace Elements and Human Illness, Brown A.C. and Crounse R.G. (eds), Praeger Scientific Publishers, N.Y. 198o

Shearer T.R. and Hadjimarkos M.
Geographic distribution of Se in human milk
Arch. Environ. Health 3o(1975)23o-35

Siimes M.A., Vuori E. and Kuitunen P.
Breast milk Fe- a declining concentration during the course of lactation
Acta Paediatr. Scand 68(2979)29-31

Sillanpää M.
Micronutrients and the nutrient status of soils: A global study
FAO soils Bulletin, No. 48, Rome 1982

Sinn W.
Relationship between Pb concentration in the air and blood Pb levels of people living and working in the centre of a city (Frankfurt blood Pb study)
Part I. Int. Arch. Occup. Environ. Health 47(198o)93-118
Part II. Int. Arch. Occup. Environ. Health 48(1981)1-23

Skerfving S.
Methyl Hg exposure, Hg levels in blood and hair and health status in Swed consuming contaminated fish. Toxicology 2(1974)3-23

Smeyers-Verbeke J., Massart D.L., Versieck J. and Speecke A.
The determination of Cu and Zn in biological materials. A comparison of absorption with spectrophotometry and NAA
Clin. Chim. Acta 44(1973)243-48

Smith A.M., Picciano M.F. and Mitner J.A.
Se intakes and status of human milk and formula fed infants
Am. J. Clin. Nutr. 35(1982)521-26

Solomons N.W., Jacob R.A., Pineda O. and Viten F.E.
Studies on the bioavailability of Zn in man. Effects of the Guatemalan rural diet and of the Fe-fortifying agent NaFe-EDTA
Am. J. Clin. Nutr. 1o9(1979) 1519-28

Somasundaram S., Dacosta H., Iyer R.K., Desai H.B., Dang H.S., Jaiswal D.D. and Wadhwani C.N.
Study of trace elements in human nutrition with special reference to newborns and infants
Progress Report 1982, IAEA Vienna, 1983

Spickett J.T. and Lanzer J.
Cd concnetration in human kidney and liver tissues for Western Australia
Bull. Environ. Contam. Toxicol. 23(1979)827-3o

Steward R.D.H., Griffiths N.M., Thomson C.D. and Robinson M.F.
Quantitative Se metabolism in normal New Zealand women
Brit. J. Nutr. 4o(1978)45-54

Stolley H., Galgan V. and Droese W.
Nutrient content in human milk
Protein, lactose, minerals, trace elements and thiamin
Monatschr. Kinderheil Kd. 129(1981)293-97

Stoeppler M, Juelich, FRG, Personal communication 1983

Stoeppler M. and Brandt K.
Rapid determination of Cd in whole blood and urine with electrothermal AAS
Int. Conf. Management and Control of Heavy Metals in the Environment, CEP consultants, Edinburgh, 1979, pp. 183-186

Strain W.H., Steadman L.T., Lankan C.A., Berliner W.P. and Pories W.J.
Analysis of Zn levels in hair for the diagnosis of Zn deficiency in man
J. Lab. Clin. Med. 68(1966)244-49

Stulzaft O., Paris, France, Personal communication, 1983

Subramanian K.S. and Meranger J.C.
Simultaneous determination of 2o elements in some human kidney and liver autopsy samples by ICP-AES
Sci. Total Environ. 24(1982)147-157

Subranian K.C. and Meranger J.C. & also, Subramanian K.L., pers. comm. 1983
Rapid hydride evolution electrothermal atomization AAS method for determining As and Se in human kidney and liver
Analyst 1o7(1982)157-62

Sullivan J.F., Blotcky A.J., Jetton M.M., Hahn H.K.J. and Burch R.E.
Serum levels of Se, Ca, Cu, Mg, Mn and Zn in various human diseases
J. Nutr. 1o9(1979)1432-37

Sumino K., Hayakewa K., Shibata T. and Kitamura S.
Heavy metals in normal Japanese tissues. Amounts of 15 heavy metals in 3o subjects
Arch. Environ. Health 3o(1975)487-494

Sunderman F.W., Nomoto S. amd Nechay M.
Ni metabolism in myocardial infarction. Measurement of Ni in human tissues
Trace Substances in Environmental Health, Hemphill D.D. (ed), 197o, pp. 352-56

Sunderman F.W. Jr.,
Nickel, In Disorders of Mineral Metabolism, Academic Press, Volume 1, 1981, pp. 2o1-232

Sunderman F.W. Jr., Farmington, USA, Personal communication, 1983

Suwanik R., Punyaprateep B., Pleehachinda R., Tuntawiroun M., Pattamachak S. and Punyasat K.
Fe status of the populations in Bangkok and of Village in NE-Thailand
J. Med. Assoc. Thai. 64(1981)283-87

Syversen T.L.M., Stray T.K., Syversen G.B. and Otslad J.
Cd and Zn in human liver and kidney
Scand. J. Clin. Lab. Invest. 36(1976)251-56

Tanaka G. Ibaraki, Japan, Personal communication, 1983

Tekauchi T.
Variation of elemental concentration in hair of the Japanese in terms of age, sex and hair treatment
J. Radianal. Chem. 7o(1982)29-55

Thimaya S. and Ganapathy S.N.
Se in human hair in relation to age, diet, pathological condition and serum levels
Sci. Total Environ. 23(1982)41-49

Thomson C.D.
The metabolism and nutritional importance of Se
PhD thesis, University of Otago, New Zealand, 1973

Thurauf J.R.E., Schaller K.H., Valentin H. and Weltle D.
Zur gegenwärtigen Belastung der Bevölkerung mit Kadmium
Fortschr. Med. 33(1981)1312-17

Terai M., Akabane A., Matsumoto M. and Hashimoto K.
An application of neutron activation analysis to biological materials III, Natural abundances of small and micro amounts of elements and their interactions in human tissues
Bul. Chem. Soc. Japan. 52(1979)143-52

Tsalev D.C., Langmyhr F.J. and Grundersen N.
Direct AAS determination of Mn in whole blood of unexposed individuals and exposed workers in a Norwegian Mn alloy plant
Bull. Environ. Contam. Toxicol. 17(1977)66o-667

Tsuchiya K. and Iwao S.
Interrelationships among Zn, Cu, Pb and Cd in food, feces and organs of humans
Environ. Health Persp. 25(197o)119-24

Tummavuori J. and Pirinen A.
Jyvaskyla, Finland, Personal communication, 1983 (through Lakoma 1983)

Ueno S. and Ishizaki M.
Concentrations of V in human urine and hair
Jap. J. Ind. Health 22(198o)378-379

Ulander A. and Axelsen O.
Measurement of blood Cd levels
Lancet, April 13, 1974, pp. 682-83

Usagimoto H., Ichimura K., Ikeda N., Kasano N., Nakaoka K., Sakaguchi S. Ueda E. and Banno T.
Contents and correlation of heavy metals in blood and hair of inhabitants of Nara Prefecture
Japan. J. Public Health 27(198o)6o5-61o

Vahter M.
Assessment of human exposure to Pb and Cd through biological monitoring
National Swedish Institute of Environmental Medicine Report, Stockholm, 1982

Valentin, H. & Schaller K.-H., Erlangen-Nürnberg, Germany FR
Personal communication 1983

Vaughan L.A., Weber C.W. and Kemberling S.R.
Relationship between the trace mineral content of lactating women's milk, serum and dietary intake
Trace Elements in Man and Animals-3, Munic-Weihenstephan, 1977, pp. 452-455

Verlinden M.
PhD thesis, University of Antwerp, Belgium, 1981

Verlinden M., Van Sprundel M., Van der Anwera and Eylenbosch W.J.
The Se status of Belgian population groups I. Adults
Biol. Trace Element Res. 5(1983)91-1o2

Versieck J., Speecke A., Hoste J. and Barbier F.
Determination of Mn, Cu and Zn in serum and packed blood cells by NAA
Z. Klin. Chem. Klin. Biochem. 11(1973)193-196

Versieck J., Barbier F., Speecke A. and Hoste J.
Mn, Cu, and Zn concentrations in serum and packed blood cells during acute hepatitis, chronic hepatitis and posthepatitic cirhosis
Clin. Chem. 2o(1974)1141-1145

Versieck J., Hoste J., Barbier F., Michels H. and De Rudder J.
Simultaneous determination of Fe, Zn, Se, Rb and Cs in serum and packed blood cells by NAA
Clin. Chem. 23(1977)13o1-o7

Versieck J., Hoste J., Barbier F., Stewart H., De Rudder J. and Michels H.
Determination of Cr and Cü in human serum by NAA
Clin. Chem. 24(1978)3o3-3o8

Versieck J., Hoste J., Barbier F., Vanballenberghe L., De Rudder J. and Cornelis R.
Determination of Mo in human serum by NAA
Clin. Chim. Acta 87(1978)135-14o

Versieck J., Vanballenberghe L., Barbier F., Cornelis R. and Waelput I.
Serum Mo in diseases of the liver and biliary system
J. Lab. Clin. Med. 97(1981)535-544

Versieck J. and Cornelis R.
Normal levles of trace elements in human blood plasma or serum
Anal. Chim. Acta 116(198o)217-254

Vuori E., Huunan-Seppälä A. and Kilpiö J.O.
The concentrations of Cu, Fe, Mn , Zn and Cd in human hair as a possible indicator of their tissue concentrations
In, International Symposium on Recent Advances in the Assessment of the Health Effects of Environmental Pollution, Paris, 1974, pp. 2263-227o

Vuori E., Huunan-Seppälä A. and Kilpiö J.O.
Biologically active metals in human tissues I
Scand. J. Work Environ. Health 4(1978)167-75

Vuori E., Huunan-Seppälä A., Kilpiö J.O. and Salmela S.
Biologically active metals in human tissues II
Scand J. Work Environ. Health. 5(1979)16-22

Vuori E. and Kuitunen P.
The concentration of Cu and Zn in human milk: A longitudinal study
Acta Paediat. Scand. 68(1979)33-37

Vuori E.
A longitudinal study of Mn in human milk
Acta Paediatr. Scand. 68(1979)571-73

Vuori E., Vetter M., Kuitunen P. and Salmela S., Helsinki, Finland,
Cd in Finnish breast milk: A longitudinal study, Personal communication, 1983

Wagner P.A., Krista M.L., Baily L.B., Gristakis G.J., Jerningen J.A., Avarigo P.E., Appledorf H., Davis C.G. and Dinntug J.S.
Zn status of elderly black Americans from urban low income house-holds
Am. J. Clin. Nutr. 33(198o)1771-77

Wandiga S.O. and Jumba I.O., Nairobi, Kenya, Personal communication 1983

Wang H.C.
Trace element analytical chemistry in the People's Republic of China
In, Trace Element Analytical Chemistry in Medicine and Biology,
Brätter P. and Schramel P. (eds), De Gryter, Berlin, 1982, pp. 555-69

Ward N.I., Stephan R. and Ryan D.E.
Comparison of 3 analytical methods for the determination of trace elements in whole blood
Anal. Chim. Acta 11o(1979)9-19

Watanabe T., Tokunaga R., Iwahana T., Tati M. and Ikeda M.
Determination of urinary Mn by the direct chelation extraction method and flame AAS
Brit. J. Ind. Med. 35(1978)73-77

Watanabe T., Hujita H., Koizumi A., Kumai M. and Ikeda M.
(Title missing)
Japan. J. Hyg. 37(1982)265

Westermarck T.
Studies on Se status in the Finnish Republic
Thesis, University of Helsinki, Helsinki, 1979

Wibowo A.A.E., Castilho P.D., Herber R.F.M. and Zielhuis R.L.
Blood Pb and serum Fe levels in non-occupationally exposed males and females
Int. Arch. Occup. Environ. Health. 39(1977)113-2o

Wiesener W., Goerner W. and Neese S.
Changes in trace element concentration in hair and other organs in relation to disease and metal burden
IAEA Symp. Nuclear Activation Techniques in the Life Sciences, Vienna 1978
pp. 3o7-32o

Yukawa M., Suzuki Y.M., Amano K. and Terai M.
Distribution of trace elements in the human body determined by the NAA
Arch. Environ. Health 35(198o)36-44

Yüregir G. and Donma O. Adana, Turkey, Personal communication, 1983

Zeisler R., Harrison S.H., and Wise S.A.
Trace elements in human liver using quality control in the complete analytical process
Biol. Trace Ele. Res. 6(1984)31-49

Zhu
Keshan Disease, Proc. Trace Elements in Man And Animals-4, Perth, 1981, pp.514-17

Zielhuis R.L., Stuik E.J., Herber R.P.M., Salle H.J.A., Verbrek M.M., Posma F.D. and Jager J.H.
Smoking habits and levels of Pb and Cd in blood in urban women
Int. Arch. Occup. Environ. Health 39(1977)53-58

Zober A., Kick K., Schaller K.H., Schellmann B. and Valentin H.
Normal values of Cr and Ni in human lung, kidney, blood and urine samples
Zbl. Bakt. Hyg. 179(1984)8o-95