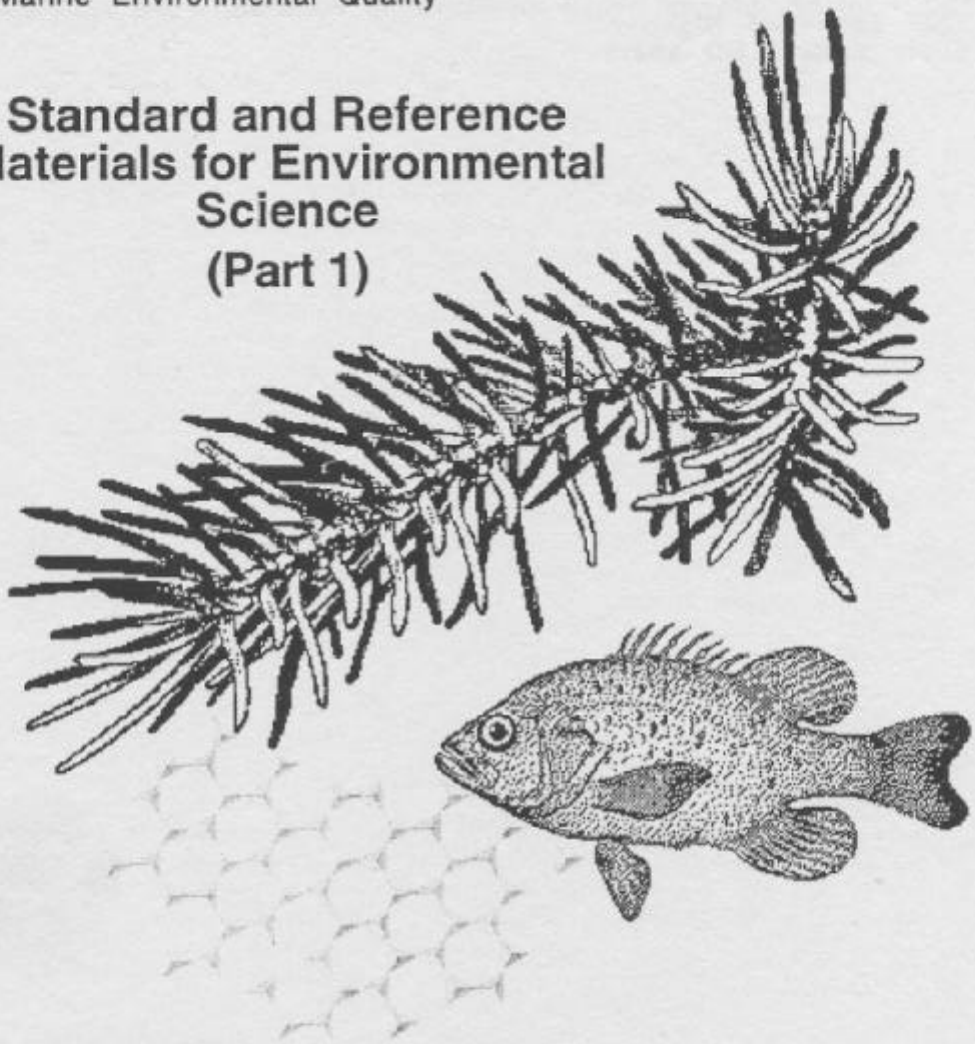
NOAA Technical Memorandum NOS ORCA 94 (Part 1)

National Status and Trends Program
for Marine Environmental Quality

Standard and Reference Materials for Environmental Science (Part 1)



Silver Spring, Maryland
November, 1995

US Department of Commerce

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Coastal Monitoring and Bioeffects Assessment Division
Office of Ocean Resources Conservation and Assessment
National Ocean Service

Coastal Monitoring and Bioeffects Assessment Division
Office of Ocean Resources Conservation and Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
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NOAA Technical Memorandum NOS ORCA 94

Standard and Reference Materials for Environmental Science

Silver Spring, Maryland
November, 1995

United States Department of Commerce	National Oceanic and Atmospheric Administration	National Ocean Service
Ronald H. Brown Secretary	D. James Baker Under Secretary	W. Stanley Wilson Assistant Administrator

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ACRONYMS

AAFC	Agriculture and Agri-Food (Canada)
ANRT	Association Nationale de la Recherche Technique (France)
ASSO	Association of Russian Reference Materials Producers (Russia)
BAS	Bureau of Analysed Samples Ltd. (UK)
BCR	Community Bureau of Reference (Belgium)
CAL-NRI	Central Analytical Laboratory, Nuclear Research Institute (Czech Republic)
CANMET	Canada Centre for Mineral and Energy Technology (Canada)
CAS	Chemical Abstracts Service
CRM	Certified reference material
CRPG	Centre de Recherches Pétrographiques et Géochimiques (France)
CSK	Cooperative Study of the Kuroshio and Adjacent Regions Program
GEMSI	Group of Experts on Methods, Standards and Intercalibration
GESREM	Group of Experts on Standards and References Materials
GIPME	Global Investigation of Pollution in the Marine Environment
GIT-IWG	International Working Group "Analytical Standards of Minerals, Ores, and Rocks" (France)
GSJ	Geological Survey of Japan (Japan)
IAEA	International Atomic Energy Agency
IAPSO	International Association for Physical Sciences of the Ocean
ICES	International Council for the Exploration of the Sea
ICHTJ	Instytut Chemii i Techniki Jadrowej (Poland)
IGEM	Institute of Geology of Ore Deposits, Petrology, Mineralogy and Geochemistry, Russian Academy of Sciences (Russia)
IGI	Institute of Geochemistry, Russian Academy of Sciences (Russia)
IOC	Intergovernmental Oceanographic Commission
IOS	Institute of Oceanographic Sciences (UK)
IPT	Instituto de Pesquisas Tecnológicas (Brazil)
IRMM	Institute for Reference Materials and Measurements (Belgium)
LGC	Laboratory of the Government Chemist (UK)
MACSP	Marine Analytical Chemistry Standards Program (Canada)
NIES	National Institute for Environmental Studies (Japan)
NIST	National Institute of Standards and Technology (USA)
NMi	Nederlands Meetinstituut (The Netherlands)
NOAA	National Oceanic and Atmospheric Administration (USA)
NRC	National Research Council of Canada (Canada)
NRCCRM	National Research Center for Certified Reference Materials (China)
NWRI	National Water Research Institute (Canada)
OSI	Ocean Scientific International Ltd. (UK)
RIAP	Research Institute of Applied Physics, Irkutsk State University (Russia)
RM	Reference or research material
SABS	South Africa Bureau of Standards (South Africa)
SRM	Standard reference material
UNEP	United Nations Environment Programme
UNS	Institute of Mineral Raw Materials (Czech Republic)
USGS	United States Geological Survey (USA)
VNIIMSO	All-Union Research Institute of Metrology of Certified Reference Materials (Russia)

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Standard and Reference Materials for Environmental Science

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Office of Ocean Resources Conservation and Assessment
National Ocean Service

ABSTRACT

This is the fourth edition of the catalog of reference materials suited for use in environmental science, originally compiled in 1986 for NOAA, IOC, and UNEP. The catalog lists more than 1200 reference materials from 28 producers and contains information about their proper use, sources, availability, and analyte concentrations. Indices are included for elements, isotopes, and organic compounds, as are cross references to CAS registry numbers, alternate names, and chemical structures of selected organic compounds. This catalog is being published independently by both NOAA and IOC/UNEP and is available from NOAA/NOS/ORCA in electronic form.

1. INTRODUCTION

The Thirteenth Session of the Assembly of the Intergovernmental Oceanographic Commission (IOC), which met 12-28 March 1985, recognized that the availability and adequacy of standards and certified reference materials are key components in the conduct of intercalibration exercises, regional contaminant assessments, and marine chemistry research in general. The Assembly instructed the Working Committee for the Global Investigation of Pollution in the Marine Environment (GIPME), through the IOC/UNEP [IOC/United Nations Environment Programme Group of Experts on Methods, Standards, and Intercalibration (GEMSI)] to conduct an in-depth study on the matter.

At the Sixth Session of GEMSI, in November 1985, an Ad Hoc Group on the Coordination of International Activities on the Preparation and Distribution of Reference Materials for Marine Chemistry was constituted. The first meeting of the Ad Hoc Group took place in Geneva at the UNEP - Oceans and Coastal Areas Programme Activity Centre, 3-4 June 1985. It was decided at that time to convene a meeting with representatives from a number of national and international agencies and institutions involved in the production of reference materials. This meeting took place in Washington, D.C., 28-30 October 1985. One of the recommendations arising from this meeting was the preparation and maintenance of a publication that assembles and updates all information available on reference materials for use in marine chemistry and marine pollution research and monitoring (IOC, 1985). In response to this recommendation, the Office of Ocean Resources Conservation and Assessment of the National Oceanic and Atmospheric Administration (NOAA) undertook the project. This was accepted by IOC and UNEP, the co-sponsors of GEMSI. The Ad Hoc Group that met in Washington, D.C., subsequently was established as the IOC/UNEP Group of Experts on Standards and References Materials (GESREM). At its first formal meeting (Paris, July 1987), GESREM noted the great value of the catalog and recommended that NOAA periodically update it.

This document is the fourth edition of the compendium of information originally published in 1986 on various types of reference materials. In answer to user needs, materials of terrestrial origin have been included resulting in a compilation of standard and reference materials for use in environmental science, not just marine studies. The instrument performance materials are of special interest since they span a variety of analytical techniques

from scanning electron microscopy to spectrophotometry. Coal and ore reference materials are not included. This catalog is being published independently by both NOAA and IOC/UNEP and is available from NOAA/NOS/ORCA in electronic form.

2. REFERENCE MATERIALS SOURCES, TYPES, AND USE

2.1. Sources

Agriculture and Agri-Food Canada
Centre for Land and Biological Resources Research
Ottawa, Ontario K1A 0C6
CANADA
Telephone: 613 759 1880, Fax: 613 759 1924

Agriculture and Agri-Food Canada (AAFC) has prepared 12 reference materials in cooperation with some 161 analysts in 73 laboratories worldwide. The culmination of this endeavor was a Technology Licensing Agreement between AAFC and National Institute of Standards and Technology (NIST) allowing NIST to market worldwide this series of Reference Materials over a five year period. The conception, research, development, coordinatior of the interlaboratory analytical campaign and completion of the commercialization of the 12 technologies was by Dr. Milan Ihnat of the Centre for Land and Biological Resources Research.

Bureau of Analysed Samples Ltd.
Newham Hall, Newby
Middlesbrough, Cleveland TS8 9EA
ENGLAND
Telephone: 0642 300500, Fax: 0642 315209

The materials provided by Bureau of Analysed Samples Ltd. (BAS) are prepared under the auspices of an Honorary Advisory Committee and a body of 250 cooperating analysts representing government departments, manufacturers and users. The British Chemical Standard Certified Reference Materials (BCS-CRMs) are analyzed by eight analysts, and a certificate showing the mean values obtained by each analyst and a summary of the methods used is made available with each material. BAS also provides EURONORM certified reference materials which are analyzed by 20 European laboratories and approved by the European Committee for Iron and Steel Standardization.

Association of Russian Reference Materials Producers
4 Krasnoasmeyskaya Str.
Yekaterinburg 620219
RUSSIA
Distributed by:
Breitländer Gmbh
Postfach 8046
D-59035 Hamm, Germany
Telephone: 0 23 81 40 40 00, Fax: 0 23 81 40 31 89

Various Russian organizations such as the All-Union Research Institute of Metrology of Certified Reference Materials (VNIIMSO), the Research Institute of Applied Physics (RIAP) (Irkutsk State University), and the Institute of Geochemistry (IGI) and the Institute of Geology of Ore Deposits, Petrology, Mineralogy and Geochemistry (IGEM) of the Russian Federation Academy of Sciences produce reference materials of a variety of matrices. These producers do no foreign trade and the reference materials are commercialized under the umbrella of the

Association of Russian Reference Materials Producers (ASSO). The sole distributor of the ASSO materials is Breitländer. The materials are stocked Germany and Breitländer provides translations of certificates into English. Contact Breitländer for a complete listing of these and other reference materials.

Canada Centre for Mineral and Energy Technology
555 Booth Street
Ottawa K1A 0G1
CANADA
Telephone: 613 995 4738, Fax: 613 943 0573

The Canada Centre for Mineral and Energy Technology (CANMET) Certified Reference Materials Project (CCRMP) identifies, prepares, and certifies compositional reference materials to ensure reliability and quality of chemical measurements carried out by Canadian minerals and metallurgical industries. CCRMP Certified Reference Materials (CRMs) have certified concentrations established from measurements carried out by 10 or more independent laboratories using a variety of methods. Values are certified only if definite standards of consensus between the results of the contributing laboratories are met. The Certification Report provided with each CRM contains information on analytical methods, measurement results, the procedures used to establish the recommended values, estimates of uncertainty, and statistical information by which a user may judge if the results of a method under testing are in accord with consensus results. CANMET CCRMP makes available more than 60 CRMs representative of mineralogical and metallurgical matrices.

Central Analytical Laboratory
Nuclear Research Institute Řež plc
250 68 Řež
CZECH REPUBLIC
Telephone: 42 2 66 41 21 71, 6857 526, Fax: 42 2 6857 567

The Central Analytical Laboratory of the Nuclear Research Institute (CAL-NRI) produces within its nuclear and environmental analytical activities some certified reference materials (CRMs) of environmental matrices such as yeast and mushrooms, with certified contents of some radionuclides and toxic and/or essential elements. Intercomparison runs by an international network of experienced analytical laboratories, typically 30 to 40 labortories, using different analytical methods analyze the candidate CRMs and produce the needed data. The Certification Reports are approved by the Czech State official body, the Czech Institute of Metrology.

Community Bureau of Reference
Commission of the European Communities
Directorate General for Science
Research and Development
200 rue de la Loi
B-1049 Brussels
BELGIUM
Telephone: 33 2 235 31 15, Fax: 32 2 235 80 72

An objective of the Community Bureau of Reference (BCR), a department of the Commission of the European Communities, is the general improvement of the quality of measurements and of the consistency of the results of these measurements throughout the Community (Community Bureau of Reference, 1985). The certified values of BCR reference materials are based on the results of measurements by expert laboratories of the member countries using different methods. The certified value is the mean of all the acceptable results. BCR also produces

various types of reference materials, including ores, fertilizers, and soils. The series of polynuclear aromatic hydrocarbons, sewage sludges, and particle size reference materials are described in this catalog. Responsibility of sales of the BCR CRMs was transferred to the European Commission Institute for Reference Materials and Measurements (IRMM) in Geel, Belgium.*

Geological Survey of Japan
Geochemistry Section
Higashi 1-1-3, Tsubuka, Ibaraki 305
JAPAN
Telephone: 0298-54-3533, Fax: 0298-54-3533

The Geological Survey of Japan (GSJ) has produced a variey of geocehmical reference samples since 1967 for the analyses of major, minor, and trace elements, isotopic compositionsm and isotopic ages. These samples are composed of powdered igneous and sedimentary rocks, and sediments. Certified values are not available for the GSJ reference samples. Recommended values are based on the data of collaborative studies and have been reported in several papers.

Geostandards
CNRS/CRPG
BP 20 54501
Vandoeuvre - Nancy Cedex
FRANCE
Telephone: 33 83 59 42 00, Fax: 33 83 51 17 98
E-mail: geostand@crpg.cnrs-nancy.fr

In 1977, the International Working Group on "Analytical Standards of Minerals, Ores, and Rocks" (GIT-IWG) was formed and the journal Geostandards Newsletter launched to promote the preparation, study and use of geological reference materials. IWG-GIT has produced nine geological reference materials and has cooperated with the Centre de Recherches Pétrographiques et Géochimiques (CRPG) and the Association Nationale de la Recherche Technique (ANRT) of France in the production of 14 others. These geostandards are available to members in the Working Group. Membership in the Working Group is US$125. Please contact Dr. K. Govindaraju at Geostandards for further information. In 1994, working values for over 380 international geostandards were published as a special issue of Geostandards Newsletter. Another special issue, dated July 1995, is devoted specifically to the French standards and is entitled "1995 working values with confidence limits for twenty-six CRPG, ANRT and GIT-IWG geostandards." An electronic database of geostandard data, GeoStan, is available from Geostandards (Govindaraju, 1993).

International Atomic Energy Agency
Analytical Quality Control Service
Laboratory Seibersdorf
P.O. Box 100
A-1400 Vienna
AUSTRIA
Telephone: 43 1 2360, Fax: 43 1 234564

The International Atomic Energy Agency (IAEA) has established the Analytical Quality Control Service Program to enable laboratories engaged in the analysis of nuclear materials,

* Dr. J. Pauwels, Institute for Reference Materials and Measurements, Retieseweg, B-2440, Geel, Belgium. Tel: 32 014 571 211. Fax: 32 014 590 406.

radionuclides, and trace elements to check the quality of their work and maintain high standards of analytical performance. Elemental, organic, and radioisotope concentrations are available for IAEA reference materials. Values are based on data acquired during intercalibration exercises by various laboratories. These exercises are accessible to all laboratories and are free of charge.

Institute of Mineral Raw Materials
Kutná Hora
CZECH REPUBLIC
Distributed by:
Breitländer Gmbh
Postfach 8046
D-59035 Hamm, Germany
Telephone: 0 23 81 40 40 00, Fax: 0 23 81 40 31 89

No information is available from the Institute of Mineral Raw Materials (UNS) at Kutná Hora in the Czech Republic. The UNS materials are available through Breitländer.

Instituto de Pesquisas Tecnológicas
Agrupamento de Materials de Referência
Cidade Universitária Armando de Salles Oliveira
05508 São Paulo - SP
BRAZIL
Telephone: 011 268 2211 x 544/545, Fax: 011 869 3353

The Instituto de Pesquisas Tecnológicas (IPT) is a non-profit corporation established in 1899 and owned by the São Paulo State Government. IPT areas of expertise include engineering, ship and ocean research, applied geology, and chemistry. The Agrupamento de Materials de Referência (Reference Materials Group) makes available many certified reference materials, including ores, steels, refractories and minerals analyzed for major and trace elements. Of these, the clay and limestone reference materials are included in this catalog. All analyses are performed by IPT scientists.

Instytut Chemii i Techniki Jadrowej
Department of Analytical Chemistry
03-195 Warsawa
POLAND
Telephone: 48 22 11 27 37, Fax: 48 22 11 15 32
E-mail: RAJDYB at PLEARN.PL.EDU

In 1988, the Department of Analytical Chemistry of the Instytut Chemii i Techniki Jadrowej (ICHTJ) (Institute of Nuclear Chemistry and Technology) began the development of reference materials primarily for trace element analysis. The Instytut, led by Dr. R. Dybczyhski, has prepared three materials using an approach similar to that used by IAEA (Dybczyhski, 1980; Dybczyhski *et al.*, 1991; Dybczyhski *et al.*, 1993).

Laboratory of the Government Chemist
Office of Reference Materials
Queen's Road
Teddington, Middlesex TW 11 OLY
UNITED KINGDOM
Telephone: 44 181 943 7565, Fax: 44 181 943 7554
E-mail: orm@lgc.co.uk

The Office of Reference Materials of the Laboratory of the Government Chemist (LGC) markets a variety of reference materials produced by LGC and other producers, and operates REMAS (Reference Materials Advisory Service). LGC makes available pesticide samples of certified purity for use in the analysis of technical grade pesticides and formulations, and residue analysis. In recent years, work at LGC on the production of CRMs has expanded to cover calibration standards and matrix reference materials including development of pure pesticides, metal decanoates certified for metal content, environmental radiochemical materials, and others. REMAS is an LGC service providing information on specifications, applications, and availability of LGC reference materials as well as those produced in Europe and America. As part of this service, LGC makes use of the COMAR reference materials database developed by the Laboratoire National d'Essais in Paris. COMAR contains information on more than 7,000 reference materials.

National Institute for Environmental Studies
Yatabe-machi
Tsukuba, Ibaraki, 305
JAPAN
Telephone: 81 0298 51 6111, Fax: 81 0298 51 4732

The National Institute for Environmental Studies (NIES) of Japan has produced a variety of reference materials certified for elemental composition over the past several years (Okamoto and Fuwa, 1985). Certification of reference materials is based on collaborative studies performed by 20-30 qualified participating laboratories. The resulting analytical data are subjected to statistical treatment, and certified values are provided for elements determined by at least three independent analytical techniques. NIES currently has under preparation NIES 12 (marine sediment), NIES 14 (brown alga), and NIES 15 (scallop). Please contact Dr. Jun Toshinaga for further information on availability of these CRMs.

National Institute of Standards and Technology
Office of Standard Reference Materials
Gaithersburg, MD 20899
USA
Telephone: 301 975 6776, Fax: 301 948 3730
E-mail: srminfo@enh.nist.gov

NIST has distributed reference materials for the last 80 years and now provides 50 broad categories of materials ranging from engineering mechanics to cement. The reference materials produced by NIST have certified values determined by at least two independent analytical methods or by one definitive method. NIST also offers a variety of calibration services for such devices as thermometers.

National Research Center for Certified Reference Materials
No. 7, District 11
Heping Street, Chaoyangqu
Beijing 100013
CHINA
Telephone: 421 3149, Fax: 86 1 422 8404

The production of CRMs by the National Research Center for Certified Reference Materials (NRC-CRM) is under the supervision of the State Bureau of Technical Supervision of China. The CRMs are prepared by professional research institutes or factories. [At the time of completion

of this compilation, information about some CRMs produced by NRC-CRM had not been received. These materials can also be ontained through Breitländer Gmbh (address listed previously).]

National Research Council of Canada
Marine Analytical Chemistry Standards Program
Division of Chemistry
Montreal Road
Ottawa, Ontario K1A OR9
CANADA
Telephone: 613 993 2359, Fax: 613 993 2451
E-mail: crm.iert@nrc.ca

National Research Council of Canada
Marine Analytical Chemistry Standards Program
Atlantic Research Laboratory
1411 Oxford Street
Halifax, Nova Scotia B3H 3Z1
CANADA
Telephone: 902 426 8280, Fax: 902 426 9413

An important aspect of the National Research Council of Canada's (NRC) Marine Analytical Chemistry Standards Program (MACSP) is the development, production, and distribution of reference materials to support the analysis of marine materials. NRC certified reference materials (CRMs), like the NIST SRMs, have certified values determined by at least two independent analytical methods. All analyses are performed by NRC scientists.

National Water Research Institute
Canada Centre for Inland Waters
867 Lakeshore Road, P. O. Box 5050
Burlington, Ontario L7R 4A6
CANADA
Telephone: 905 336 4869, Fax: 905 336 4989
E-mail: yvonne.stokker@cciw.ca

One of the functions of the National Water Research Institute (NWRI) is to develop and improve analytical chemistry methods and to design and conduct quality assurance programs. As part of the QA program, NWRI has developed and prepared a series of reference materials (RMs) for water analyses, and CRMs for sediment analyses. They include lake sediment CRMs for PAHs, chlorobenzenes, PCBs and Se. These RMs and CRMs were developed to serve various Canadian national, as well as international, laboratory performance assessments.

Nederlands Meetinstituut
PO Box 654
2600 AR Delft
THE NETHERLANDS
Telephone: 31 15 69 15 00, Fax: 31 15 61 29 71

As a national metrology institute, Nederlands Meetinstituut (NMi) makes it possible to perform traceable measurements in the chemical field. The gaseous reference materials provided by NMi are used as standards in the calibration of analytical instruments or for evaluation and validation of methods of analysis. The use of these standards, which are directly traceable to national standards, provides a guarantee of quality. Practical applications include measurements carried out during production processes, energy accountancy, air pollution testing, and odor nuisance assessment. Among other activities, NMi specializes in the

preparation of reference materials of granular substances. The original bulk materials (soil, sediment, coal, waste- and building materials) are processed in such a way that a large number of representative samples can be made for laboratory analysis. In order to investigate one or more characteristics of these materials, the samples taken may be subjected to an interlaboratory study. The results of this "round robin" exercise are then used to assign consensus values for the relevant parameters and possibly for the certification of such a material.

Ocean Scientific International Ltd.
South Down House, Station Road
Petersfield, Hampshire, GU32 3ET
UNITED KINGDOM
Telephone: 01730 265015, Fax: 01730 265011
E-mail: osil@soc.soton.ac.uk

The International Association for Physical Sciences of the Ocean (IAPSO) has authorized the Ocean Scientific International Ltd. (OSI) to assume responsibility for the production of the Standard Seawater Service formerly provided by the Institute of Oceanographic Sciences (IOS) at Wormley. Ocean Scientific International Ltd. is on the site of IOS and continues to employ former IOS Standard Seawater Service staff. The calibrated standards produced by this organization are used worldwide for calibration of salinity determination instrumentation. The production of standard seawater operated from Copenhagen until 1975 when this service was assumed by the ISO at the request of IAPSO. In addition to the salinity determination standards, OSI produces low nutrient seawater for the preparation of standards.

Sagami Chemical Research Center
Nishi-Ohnuma 4-4-1
Sagamihara-shi 229
JAPAN

The Sagami Chemical Research Center of Japan prepared standard solutions of nutrient elements in both saline and fresh water and potassium iodate solutions for dissolved oxygen analysis for use in the Cooperative Study of the Kuroshio and Adjacent Regions Program (CSK) and other international oceanographic programs. These reference materials are available through Wako Chemicals worldwide.◊ A range of nutrient concentrations is available.

South Africa Bureau of Standards
Private Bag X191
Pretoria, Transvaal 0001
Republic of South Africa
Telephone: 012 428 7911, Fax: 012 344 1568

The South African certified reference materials are produced and issued under the guidance and control of the South African Committee for Certified Reference Materials. This committee was appointed in 1974 by the Council of the South African Bureau of Standards, which is the statutory standards organization in South Africa. The South African Bureau of Standards (SABS) is internationally recognized and is also a member of ISO/REMCO, a committee of the International Organization for Standardization, Geneva, dealing with reference materials. The committee concentrates on the preparation of certified reference materials specific to

◊ Wako Chemicals USA, 1600 Bellwood Rd., Richmond, VA 23237, USA; Wako Chemicals GmbH, Nissanstr. 2, 4040 Neuss 1, Germany; Wako Pure Chemical Industries Ltd., 1-2, Doshomachi 3-Chome, Chuo-Ku, Osaka, Japan.

minerals, ores, and intermediate and final products that are produced by and exported from South Africa and for which no equivalent internationally recognized certified reference materials are available. A complete and comprehensive report, which is obtainable on request, is issued for each certified reference material describing the method of preparation, packaging, analysis, and statistical evaluation of observed analytical results. These reports are available from the Council for Mineral Technology, Private Bag X3015, Randburg, 2125, Republic of South Africa.

US Geological Survey
Branch of Geochemistry
Box 25046, Federal Ctr., MS 973
Denver, CO 80225
USA
Telephone: 303 236 2454

The US Geological Survey (USGS) has prepared a series of reference materials of geologic origin for inorganic analyses. These materials are composed of powdered rocks collected from various locations in the USA. Detailed mineralogical descriptions are available for these materials. No certified values are available for the USGS standard rocks as in the case of NIST or NRC materials. "Accepted values" for these rocks are based on the results of various analysts and have been compiled in several publications.

2.2. Types

The reference materials are listed in this catalog by type: ashes (including air particulate materials), gases, instrument performance materials (including calibration standards and single element/compound solutions), oils, physical properties (including color and size reference materials), rocks, sediments, sludges, soils, tissues, and waters (natural and simulated). All of the materials described in the catalog are listed in the index. Many other RMs, including a wide variety of alloys, ores, and minerals, are available from the producers described in this catalog. These may be useful to the marine scientist in specialized studies. Please contact the producing organizations for complete listings.

Source, description and preparation, analytes and values, cost, references, and comments are given for each reference material. Elements are listed in order of atomic number. Organic compounds are listed in alphabetical order. Confidence intervals listed are generally at the 95% significance level and are obtained from the producers' literature. The distribution by type, analyte, and producer of the reference materials described in this catalog are listed in Tables 1, 2, and 3. Registry numbers and alternate names of elements and organic compounds in the catalog are listed in Appendix I and II, and selected structures are shown in Appendix III. Indices are available to facilitate search matrix and analyte combinations.

Reference material users should use the analyte values listed by the producing organizations. These organizations can, at times, change accepted values or issue new ones as appropriate. The values listed in this catalog are to be used only as a reference.

2.3. Use

Until recently, only a few reference materials of marine origin existed, and their use by the marine science community was limited. The use of reference materials is part of good quality assurance practices that include evaluation of instrument performance independent of the methodology used. An excellent discussion of various aspects of quality assurance and of the use of reference materials can be found in Taylor (1985).

Table 1. Distribution of reference materials by matrix and analyte

Source	Analytes					
	Elements	Isotopes	Inorganics	Organics	Others	Total
Ashes	18	-	-	3	-	21
Gases	-	-	117	52	-	169
Inst. perf.	187	50	15	208	39	499
Oils	2	-	-	8	-	10
Physical prop.	-	-	-	-	44	44
Rocks	202	-	-	-	-	202
Sediments	58	11	-	20	-	89
Sludges	3	-	-	2	-	5
Soils	47	5	-	1	-	53
Tissues	69	13	-	19	-	101
Waters	28	1	5	-	7	41
Total	614	80	137	313	90	1234

NOTE: Several RMs are counted twice as more than one type of analyte is reported for each.

When using reference materials, it is important to follow certain guidelines:

- The matrix of the reference material should be as similar as possible to that of the samples. If such reference materials are not available, the user should be aware of possible matrix effects.
- Reference materials should not be used as primary standards. Rather, they should be analyzed as part of the sample set.
- The results of analyses should not be corrected based on recovery results from reference materials. Rather, the results of both samples and reference materials should be reported as part of the data set along with any corrections based on percent recoveries. Such reference material results are invaluable when comparing data sets generated using different analytical methods as they provide a common reference point.
- Sample homogeneity as described by the reference material producer should be taken into account in determining minimum sample size of the reference material.
- Reference materials should be used on a regular basis so changes in the analytical procedure over time can be noted and documented.
- There is a lack of reference materials with low and high concentrations of any given analyte in a matrix. Methodology, therefore, can only be tested at one concentration level, and possible problems at low or high concentrations cannot be documented.

Table 2. Distribution of reference materials by source and matrix

Source	Matrix										
	Ashes	Gases	Instr. perf.	Oils	Phys. prop.	Rocks	Sedi-ments	Sludges	Soils	Tissues	Waters
AAFC	-	-	3	-	-	-	-	-	-	6	-
ANRT	-	-	1	-	-	7	-	-	-	-	-
BAS	-	-	-	-	-	8	-	-	-	-	-
BCR	3	-	92	2	17	-	4	5	4	29	8
CAL-NRI	-	-	-	-	-	-	-	-	-	4	-
CANMET	1	-	-	-	-	14	8	-	7	4	-
CRPG	-	-	-	-	-	5	-	-	-	-	-
GIT-IWG	-	-	-	-	-	9	-	-	-	-	-
GSJ	-	-	-	-	-	22	4	-	-	-	-
IAEA	-	-	1	-	-	-	15	-	6	23	1
ICHTJ	1	-	-	-	-	-	-	-	-	1	-
IGEM	-	-	-	-	-	24	-	-	-	-	-
IGI	-	-	-	-	-	8	-	-	-	-	-
IPT	-	-	-	-	-	10	-	-	-	-	-
LGC	-	-	120	-	8	-	-	-	-	3	-
NIES	1	-	-	-	-	-	1	-	-	2	-
NIST	8	95	213	8	19	15	7	-	5	11	1
NMi	4	34	-	-	-	-	-	-	-	-	-
NRC	-	-	5	-	-	-	11	-	-	7	4
NRCCRM	2	40	63	-	-	21	20	-	18	11	-
NWRI	-	-	-	-	-	-	15	-	-	-	18
OSI	-	-	-	-	-	-	-	-	-	-	5
RIAP	-	-	-	-	-	22	-	-	-	-	-
SABS	-	-	-	-	-	16	3	-	1	-	-
SAGAMI	-	-	1	-	-	-	-	-	-	-	4
UNS	-	-	-	-	-	6	-	-	-	-	-
USGS	-	-	-	-	-	15	1	-	-	-	-
VNIIMSO	-	-	-	-	-	12	-	-	1	-	-
Total	20	169	499	10	44	214	89	5	42	101	41

NOTE: Several RMs are counted twice as more than one type of analyte is reported for each.

Table 3. Distribution of reference materials by source and analyte

Source	Analytes					
	Elements	Isotopes	Inorganics	Organics	Others	Total
AAFC	9	-	-	-	-	9
ANRT	8	-	-	-	-	8
BAS	8	-	-	-	-	8
BCR	49	-	-	96	19	164
CAL-NRI	4	-	-	-	-	4
CANMET	32	2	-	-	-	34
CRPG	5	-	-	-	-	5
GIT-IWG	9	-	-	-	-	9
GSJ	26	-	-	-	-	26
IAEA	17	23	-	6	-	46
ICHTJ	2	-	-	-	-	2
IGEM	24	-	-	-	-	24
IGI	8	-	-	-	-	8
IPT	10	-	-	-	-	10
LGC	31	-	-	89	11	131
NIES	4	-	-	-	-	4
NIST	128	54	87	58	55	382
NMI	4	-	22	12	-	38
NRC	11	-	-	16	-	27
NRCCRM	124	1	23	27	-	175
NWRI	24	-	-	9	-	33
OSI	-	-	-	-	5	5
RIAP	22	-	-	-	-	22
SABS	20	-	-	-	-	20
SAGAMI	-	-	5	-	-	5
UNS	6	-	-	-	-	6
USGS	16	-	-	-	-	16
VNIIMSO	13	-	-	-	-	13
Total	614	80	137	313	90	1234

NOTE: Several RMs are counted twice as more than one type of analyte is reported for each.

- The concentrations of analytes in a reference material are not necessarily representative of the concentrations of those analytes as they existed at the time of collection. Rather, the analyte levels in the reference materials are representative of the final concentrations after any changes in the original concentrations due to sample processing (e.g., contamination during handling).

- The elemental concentrations listed for the USGS rock standards are based on the analyses of various laboratories over a period of years. The quality of the data varies and the user of such "best" or "consensus" values should be aware of the methodology used in their determination, and, most importantly, the number of individual analytical results used.

3. SOURCES OF NON-CERTIFIED REFERENCE MATERIALS

The US National Cancer Institute maintains a repository of reference-grade radio-labelled and unlabeled compounds for cancer research. The repository is operated under contract by the Midwest Research Institute[◊] and the Chemsyn Science Laboratories.[Δ] The repository includes more than 800 chemicals including benzo[a]pyrenes, benz[a]anthracenes, benzofluoran-thenes, benzo[e]pyrenes, chrysenes, heterocyclic PAHs, nitrosamines and other nitroso compounds, aromatic amines, aromatic amine metabolites, aflatoxins, dioxins, pesticides, herbicides, fungicides, pharmaceuticals, chlorinated hydrocarbons, dyes, organometallics, selected inorganic compounds and others. Due to chemical decomposition and radioactive decay, the chemicals are periodically purified or resynthesized. Therefore, the purity of the chemicals may change by the time of shipment. These are not CRMs or SRMs. Unlabeled compounds may be ordered from the Midwest Research Institute, and radiolabeled ones from Chemsyn Science Laboratories.

4. LITERATURE ON QUALITY ASSURANCE AND REFERENCE MATERIALS

4.1. NIST[Δ]

The NIST Special Publication 829 describes the use of NIST standard reference materials for decisions on performance of analytical chemical methods and laboratories (Becker *et al.*, 1992). The general principles of SRM use are described in NBS Special Publication 260-100 (Taylor, 1985).

4.2. ISO/REMCO[◊]

REMCO is the International Organization for Standardization (ISO) Council Committee on reference materials. The aim of this organization is to carry out and encourage a broad international effort for harmonization and promotion of CRMs and their applications. REMCO has published five guides related to CRMs and quality assurance: ISO Guide 6 (ISO, 1978) discusses information necessary to describe reference materials in standards; ISO Guide 30 (ISO, 1981) lists terms and definitions used in connection with reference materials; ISO Guide 31 (ISO, 1981) recommends content of certificates of reference materials; ISO Guide 33 (ISO, 1989)

◊ NCI Chemical Carcinogen Radio Repository, c/o Midwest Research Institute, 425 Volker Blvd., Kansas City, MO 64110, USA.

Δ NCI Chemical Carconigen Radio Repository, c/o Chemsyn Science Laboratories, 13605 W. 96 Terr., Lenexa, KS 66219, USA.

Δ National Institute of Standards and Technology, Gaithersburg, MD 20899, USA.

◊ ISO Central Secretariat, Case Postale 56, CH-1211 Genève 20, Switzerland.

discusses the use of CRMs; and ISO Guide 35 (ISO, 1989) discusses the certification process including general and statistical principles. Other ISO/REMCO publications of interest are ISO/REMCO 240 on linear calibration using reference materials (ISO, 1992), the proceedings of the symposium on Harmonization of Quality Assurance Systems in Chemical Analysis (ISO/REMCO, 1991), worldwide production of reference materials (ISO/REMCO, 1994), list of producers of reference materials (ISO/REMCO 330), and others.

4.3. UNEP*

UNEP makes available a variety of publications on various aspects of quality assurance in environmental analyses (UNEP/IOC/IAEA, in prep., a and b) including reference methods descriptions (UNEP/IOC/IAEA, 1988; UNEP/IOC/FAO/IMO/IAEA, in prep.), chemical contaminant monitoring guidelines (UNEP/IOC/IAEA/FAO, 1989; UNEP/FAO/IOC/ IAEA, 1990), sampling protocols (UNEP/FAO/IAEA, 1984; UNEP/FAO/IOC/IAEA, 1984), and data analyses and interpretation (UNEP/IOC/IAEA, 1990; UNEP/IOC/FAO/IMO/IAEA, in prep.). These publications are available in English, French, or Spanish.

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* UNEP Regional Seas, Programme Activity Centre for Oceans and Coastal Areas, PO Box 30552, Nairobi, Kenya.

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International Organization for Standardization (1989) Uses of certified reference materials. ISO/REMCO Guide 33. ISO Central Secretariat, 1 rue de Varembé, Case Postale 56, Ch-1211, Genève, Switzerland. 12 pp.

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