



**DRAFT-NOT TO BE CITED
PROJET-NE PAS DIVULGUER**

*Determination of mercury in estuarine
waters and suspended sediment by cold
vapour atomic absorption spectrophotometry*

Reference Methods For Marine Pollution Studies No. 19

Prepared in co-operation with



IAEA



IOC

Note: This document has been prepared jointly by the International Oceanographic Commission (IOC) of Unesco, the International Atomic Energy Agency (IAEA) and the United Nations Environment Programme (UNEP) under projects .

For bibliographic purposes this document may be cited as:

UNEP/IOC/IAEA: The determination of mercury in estuarine waters and suspended sediments by cold vapour atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 19 (draft), UNEP 1985.



REGIONAL SEAS

UNITED NATIONS ENVIRONMENT PROGRAMME

25 March 1985

**DRAFT-NOT TO BE CITED
PROJET-NE PAS DIVULGUER**

*Determination of mercury in estuarine
waters and suspended sediment by cold
vapour atomic absorption spectrophotometry*

Reference Methods For Marine Pollution Studies No. 19

Prepared in co-operation with



IAEA



IOC

PREFACE

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans. The Regional Seas Programme at present includes ten regions and has over 120 coastal States participating in it. (1), (2)

One of the basic components of the action plans sponsored by UNEP in the framework of the Regional Seas Programme is the assessment of the state of the marine environment and of its resources, and of the sources and trends of the pollution, and the impact of pollution on human health, marine ecosystems and amenities. In order to assist those participating in this activity and to ensure that the data obtained through this assessment can be compared on a world-wide basis and thus contribute to the Global Environment Monitoring System (GEMS) of UNEP, a set of Reference Methods and Guidelines for marine pollution studies are being developed and are recommended to be adopted by Governments participating in the Regional Seas Programme.

The methods and guidelines are prepared in co-operation with the relevant specialized bodies of the United Nations system as well as other organizations and are tested by a number of experts competent in the field relevant to the methods described.

In the description of the methods and guidelines the style used by the International Organization for Standardization (ISO) is followed as closely as possible.

The methods and guidelines, as published in UNEP's series of Reference Methods for Marine Pollution Studies, are not considered as final. They are planned to be periodically revised taking into account the development of our understanding of the problems, of analytical instrumentation and the actual need of the users. In order to facilitate these revisions the users are invited to convey their comments and suggestions to:

International Laboratory of Marine Radioactivity
International Atomic Energy Agency
c/o Musee Oceanographique
MC98000 MONACO

which is responsible for the technical co-ordination of the development, testing and intercalibration of Reference Methods.

-
- (1) UNEP: Achievements and planned development of the UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies. UNEP Regional Seas Reports and Studies No. 1 UNEP, 1982.
 - (2) P. HULM: A Strategy for the Seas. The Regional Seas Programme: Past and Future UNEP, 1983.

This draft issue of the Reference Method for Marine Pollution Studies No. 19 was prepared in co-operation with the International Oceanographic Commission (IOC) of Unesco and the International Atomic Energy Agency (IAEA). It includes comments received from the joint IOC/UNEP Group of Experts on Methods, Standards and Intercalibration (GEMSI) of GIPME and from a number of scientists who reviewed and tested the method. The assistance of all those who contributed to the preparation of the draft issue of this reference method is gratefully acknowledged.

CONTENTS

	<u>Page</u>
1. Scope and field of application	1
2. References	1
3. Principles	1
4. Reagents	1
5. Apparatus	3
6. Cleaning procedure	4
7. Sampling and pretreatment	5
8. Analysis	6
9. Expression of results	8
10. Estimation of precision, accuracy and quality control	8
11. Analytical Report	10

1. SCOPE AND FIELD OF APPLICATION

This Reference Method is applicable for the analysis of different forms of mercury in water and suspended sediments. Inorganic dissolved mercury, total dissolved and particulate mercury are measured after mineralization by cold vapour atomic absorption spectrophotometry.

The method described below has a detection limit of about 0.2 ng of mercury. The instrument used for the analysis is a Laboratory Data Control Mercury Monitor or a Coleman Analyzer, having a 30 cm optical cell and stable light source and detector.

2. REFERENCES

- AGEMIAN, H. and DA SILVA, J.A. (1979) Automatic method for the determination of total mercury in fresh and saline waters and sediments. *Analyt. Chimica Acta*, 104, 285-291.
- BLOOM, S.N. and CRECELIUS, E.A. (1983) Determination of mercury in sea water at sub-nanogram per litre levels. *Marine Chemistry*, 14, 49-59.
- FELDMAN, C. (1974) Preservation of dilute mercury solutions. *Analytical Chemistry*, 46, 99-102.
- RANDLESOME, J.E. and ASTON, S.R. (1980) A rapid method for the determination of mercury in sediments, suspended solids and soils. *Environmental Technology Letters*, 1, 3-8.

3. PRINCIPLES

After preparation of the sample, ionic mercury is reduced to the elemental state at room temperature and flushed from solution by gas flow in an open system. The mercury is then determined by a physical method based on the absorption of radiation of 253.7 nm by mercury vapour.

4. REAGENTS

All reagents, including the deionised double distilled water must be as low in mercury concentration as possible. All reagents must be checked for mercury contamination by analyzing blanks.

4.1 Deionised Double Distilled Water (DDDW). Water is deionised with a mixed-bed resin and double distilled.

4.2 Sulphuric acid ($d_{20^{\circ}\text{C}} = 1.84 \text{ gml}^{-1}$), Aristar or similar grade.

4.3 Nitric acid ($d_{20^{\circ}\text{C}} = 1.40 \text{ gml}^{-1}$), Aristar or similar grade.

4.4 Hydrochloric acid ($d_{20^{\circ}\text{C}} = 1.15 \text{ gml}^{-1}$), Aristar or similar grade.

4.5 Potassium permanganate (Analar or similar), solution of 6 g^{-1} in DDDW (4.1).

4.6 Hydroxylamine hydrochloride (Analar or similar) 3% solution of DDDW (4.1).

4.7 Stannous chloride, 15% solution of $\text{SnCl}_2, 2\text{H}_2\text{O}$: prepare this solution daily for the analysis; transfer 37.5 g $\text{SnCl}_2, 2\text{H}_2\text{O}$ (B.D.H. low in mercury or similar) into a 250 ml flask. Dissolve in approximately 15 ml sulphuric acid (4.3). Bring to volume with DDDW (4.1) and mix.

4.8 An entrainment gas: nitrogen or argon supply at 120 ml min^{-1} and cleared of mercury by passing through a dreschel bottle containing 100 ml of KMnO_4 solution (4.5).

4.9 Potassium dichromate (Analar or similar grade).

4.10 Concentrated hydrofluoric acid (40% w/v).

4.11 Mercury standard solutions.

4.11.1 Stock mercury solution. Transfer 1.354 g (weighed to nearest 0.001 g) of mercuric chloride (HgCl_2) into 1 litre volumetric flask, add 50 ml of nitric acid (4.3) and add 10 g of potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) (4.9). Make up to volume with DDDW (4.1). This solution contains 1 g Hg l^{-1} , and may be diluted with DDDW to a 1 mg Hg l^{-1} stock solution which is stable for several months if stored in a glass bottle

4.11.2 Mercury standard solutions. Prepare daily a series of working standard solutions by appropriate dilution of solution 4.11.1 with DDDW (4.1) containing 10 ml or sulphuric acid (4.2) per litre.

NOTE: The concentration of the mercury standard solutions (4.9.2) depends on the mercury levels anticipated in the samples to be analysed. These levels should lie approximately in the middle of the range of concentration of the standard solutions.

4.12 Working matrices: Prepare working matrices (water and suspended sediment) by homogenising sufficiently large samples of the same types of materials. Test the homogeneity of the working matrix by analyzing 5 subsamples for their mercury content(s). If the coefficient of variation of the five analyses is less than 10% the working matrix is ready for use. Otherwise homogenize the working matrix until the above coefficient of variation is obtained or prepare a new working matrix.

5. APPARATUS

5.1 Sampling equipment.

5.1.1 For surface samples: Pyrex bottle. For the deep samples: sampling bottle with a minimum amount of metallic parts such as P.V.C., Niskin or GOFLO bottles attached to non-metallic wire.

5.2 Filtration equipment

5.2.1 A filtration set: glass filtration system, a vacuum pump.

5.2.2 0.4 μm filters (Nuclepore or similar).

5.3 Plastic tweezers to hold filters.

5.4 Disposable plastic Petri-dishes.

5.5 Usual laboratory equipment such as assorted volumetric flasks, pipettes and micropipettes, etc..

5.6 Analytical balance with a precision of ± 0.01 mg.

5.7 Balance with a precision of ± 0.1 g to weight reagents.

5.8 Pyrex flask for chemical digestion of suspended matter.

5.9 Centrifuge.

5.10 Bubbling flask. Tall form having a volume adapted for the analytical portion. In this flask, mercury-free gas is bubbled into the solution to liberate gaseous mercury. For this, the bubbling tube is terminated with a fritted end (100 - 200 μm porosity).

5.11 Gold collector for amalgamation of gaseous elemental mercury: gold thread cut up into small pieces; quartz tube for gold thread.

5.12 Ni-Cr heating wire with variable transformer to heat trap flask.

5.13 Atomic absorption spectrophotometer equipped with a U.V. source lamp, and an optical cell with quartz window transparent to U.V..

NOTE: Because of their long cell path length and their high sensitivity, a Laboratory Data Control Mercury Monitor or a Coleman Analyser are recommended.

5.14 An X-Y recorder with multirange variable millivoltage control.

5.15 A device for the absorption or elimination of mercury vapour at the outlet of the measuring cell (e.g. fume hood of the laboratory).

5.16 Silicone rubber tubing to connect the different portions of apparatus assembly (see figure 1: Assembly of the various constituents).

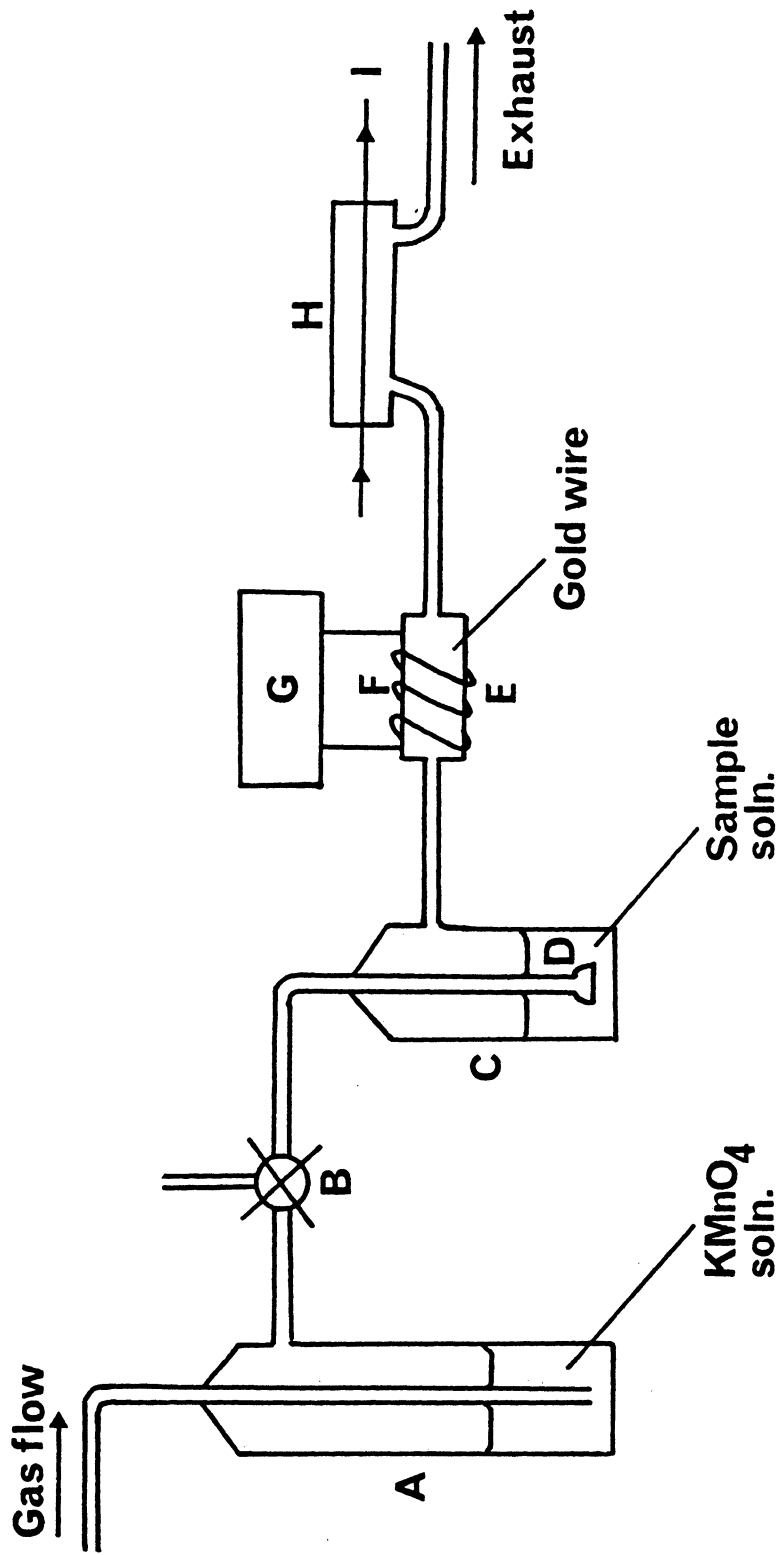


FIGURE 1: DIAGRAMMATIC REPRESENTATION OF MERCURY ANALYSIS SET-UP
(A - Dreschel bottle for $KMnO_4$; B - two way valve; C - Dreschel bottle for $SuCl_2$; D - sintered bubbler; E - Gold trap; F - heating coil; G - variable transformer; H - quartz window cell; I - beam to photocell of AAS)

5.17 500 Watt U.V. lamp.

5.18 Clean cupboard for drying samples.

6. CLEANING PROCEDURE

Glassware used for the analytical method must be thoroughly cleaned by the following procedure:

- Fill the glassware with concentrated nitric acid (4.3). Heat to 40°C for 4 hours.
- Rinse with an HNO₃/HF mixture (10:1) (4.3, 4.10).
- Rinse several times with DDDW (4.1).

7. SAMPLING AND PRETREATMENT

7.1 Sampling

If possible, use a small non-metallic boat. For the surface water; if it is possible sample by hand directly into a pyrex bottle. Otherwise, sample as below. For the deep water: sample with precleaned P.V.C. Niskin or GOFLO bottles (5.1). Transfer the water sample immediately into a pyrex flask (5.1). A pyrex flask is used for the storage because mercury in water samples stored in plastic bottles may diffuse through bottle walls.

NOTE: The P.V.C. Niskin or GOFLO bottle is washed with HNO₃ (4.3) diluted 1:5 and rinsed several times with DDDW (4.1).

7.2 Cleaning of filters

Filters are soaked in cold 50% HCl (4.4) for 2 days. The acid is changed and the filters are left in a fresh solution of the same acid. The filters are then rinsed several times with DDDW (4.1). The filters are kept in 1% HCl (4.4) for longer storage. Several days before use, the filters are rinsed with DDDW (4.1).

7.3 To determine dissolved mercury, the water sample is filtered as soon as possible through 0.4 µm filter (Nucleopore or similar) (5.2.2). After filtration, the water samples are acidified with 2 ml of sulphuric acid (4.2) or nitric acid (4.3) per 100 ml sample.

7.4 For the determination of total dissolved mercury (organic + inorganic mercury compounds) photo-oxidize the water sample for 8 hours

with a 500 watt U.V. lamp (5.17). An alternative solution to oxidize organic mercury can be provided by a slow oxidation with HNO_3 (4.3) at $\text{pH} = 1$ during 2 months. This procedure is especially relevant for seawater and estuarine waters with low organic matter content.

NOTE: For the determination of inorganic mercury, analyse the acidified filtered water sample prior to photo-oxidation.

7.5 Mercury in suspended matter

Weigh the filter with a precision of ± 0.01 mg; the water sample is filtered as in 7.3; the particulate sample retained on the filter is treated as follows:

- Rinse the filter with about 50 ml of DDDW to remove salt.
- Transfer the filter with its particulate load into a plastic Petri dish (5.4) and store at room temperature. In the laboratory it is dried at 40°C for 8 hours in a drying cupboard (5.18). The drying temperature must not be higher than 40°C to avoid gaseous mercury losses.
- After cooling to ambient temperature, the filter with its suspended matter is weighed with a precision of ± 0.01 mg.

8. ANALYSIS

8.1 Dissolved mercury determination

8.1.1 At the time of use prepare from standard solutions of mercury (4.11) at least five calibration solutions covering the range of concentrations to be determined. Treat each of these solutions as soon as possible, after their preparation, exactly in the same way as the sample taken for the analysis (see 8.1.2).

8.1.2 Determination

Preparation step: Put 100 ml of water sample into a bubbling flask. Add 5 ml SnCl_2 solution (4.7) to reduce ionic mercury to elemental form:



Aeration step: Adjust the controls of the apparatus, particularly the entrainment gas flow (4.8), to obtain a flow rate of 120 ml min^{-1} . Wait for the stabilization of gas flow. Divert the gas flow towards the bubbling flask filled with the water sample. The solution is bubbled for 10 minutes to strip the mercury. The gas is then passed through a gold collector (5.11) for amalgamation of the liberated gaseous mercury. After 10 minutes, the aeration is stopped. The gold collector is heated with a heating coil (5.12) to a red colour to liberate gaseous elemental

mercury, and the gas flow is resumed. The entrainment of gaseous elemental mercury into the measuring cell produces, on the recorder (5.14), a peak which rapidly reaches its maximum. After the measurement purge the aeration flask for several minutes to eliminate residual gaseous mercury.

NOTE: During the determination if the peaks are not the same form as those obtained during calibration, it is necessary to use the peak areas in preference to the heights.

Blank test: Follow the procedure in (8.1.2) replacing the analytical sample with DDDW (4.1) using the same quantities of reagents.

8.2 Particulate mercury determination in suspended matter

8.2.1 Digestion

Transfer the loaded filter after weighing to a pyrex flask. Add a few ml of DDDW (4.1), 10 ml concentrated sulfuric acid (4.2), 5 ml concentrated nitric acid (4.3) and 10 ml KMnO_4 . Place the flask in a water bath at ambient temperature and digest for 12 hours. After digestion, add 10 ml hydroxylamine hydrochloride solution (4.6). Mix until the solution is clean and the precipitated MnO_2 is dissolved. To eliminate the remaining particulate matter, centrifuge this solution for 10 minutes at 3000 rpm. Transfer the supernate to a 100 ml volumetric flask and bring to volume with DDDW (4.1).

8.2.2 Prepare at the time of measurement at least 5 calibration solutions from the standard solutions of mercury (4.9.2) covering the range of concentration to be determined. Transfer appropriate aliquots into a 100 ml flask. Add 1 ml nitric acid (4.3) and bring to volume with DDDW (4.1) and mix thoroughly. Conduct the analysis in the same way as the sample (see 8.2.3).

8.2.3 Determination

Preparation step: Transfer the sample of 100 ml or an aliquot diluted to 100 ml (containing not more than $1 \mu\text{g}^{-1}$ of mercury) into the bubbling flask. Add 4 ml 10% SnCl_2 solution (4.7).

Aeration step: After adjustment of the controls of the apparatus and when the gas flow is stabilized, aerate the bubbling flask. A peak will appear on the recorder which will rapidly reach its maximum. When the absorbance decreases, purge the gas circuit of the apparatus by deviating the gas flow into another flask filled with DDDW (4.1).

8.2.4 Blank tests

Reagent blank: Follow the same procedure used in 8.2.3 but replace the sample with DDDW (4.1) using the same amounts of reagents as for the actual sample (8.2.3).

NOTE: Contrary to the determination of dissolved mercury (8.1), if the concentration of mercury in the sample is greater than 100 ng^{-1} , do not use the gold collector to concentrate mercury vapour to avoid contamination and recorder saturation.

Filter blank: After rinsing and weighing the filter place it in a flask and follow the instructions given in 8.2.1, 8.2.2 and 8.2.3. This will determine the concentration of mercury in the Nuclepore (or similar) filter. It is assumed that the average blank of all filters is that which is determined in this step.

9. EXPRESSION OF RESULTS

From the peak height or area corresponding to the mercury measurement, determine by reference to the calibration curve and taking into account the blank tests (reagents blank for dissolved mercury, reagents and filter blanks for particulate mercury), the concentration of mercury in the test solutions.

Calculate from this value the mercury concentration taking into account the volume and/or the quantity of matter weighed. Express the dissolved mercury concentration in ng l^{-1} of water and the particulate mercury concentration in μg^{-1} g of suspended matter.

- mercury concentration in the water sample: C_w (ng Hg^{-1})

$$C_w = (\text{ng Hg}^{-1}) - (\text{ng Hg}^{-1})$$

aliquot reagent
of the sample blank

- mercury concentration in the suspended matter: $C_{S.M.}$ ($\mu\text{g Hg/g}$)

$$A = (\text{ng Hg}^{-1}) - (\text{ng Hg}^{-1}) - (\text{ng Hg}^{-1})$$

aliquot reagent filter
of the sample blank blank

A = mercury concentration in the digestion solution of the suspended matter sample in ng Hg l^{-1} .

$$C_{S.M.} = \frac{A \times V}{P}$$

V = Volume of the aliquot in litres

P = Dry weight of suspended matter in mg.

10. ESTIMATION OF PRECISION, ACCURACY AND QUALITY CONTROL

10.1 Precision

Estimate the precision of the entire analytical procedure (8) by

analyzing five samples of the working matrices (4.7). Calculate the standard deviation (S) and the coefficient of variation (CV) where $CV=S.100/\text{mean value}$. If the CV is greater than 10% check the whole procedure for possible errors and/or contamination. The precision of the method is normally better than $\pm 10\%$ at the 95% confidence level.

10.2 Accuracy

Using this Reference Method, analyze a certified standard, with a matrix similar to the material under study, together with your own working matrix chosen from among your samples (4.7). Calculate the mean and the standard deviation for the certified standard and the working matrix. If the value given for the certified standard is within the interval of your mean \pm standard deviation, your method has the required accuracy and the working matrix can be used as a standard for checking the accuracy of your procedure. If not, check the whole procedure for errors.

NOTE: In addition, by participating in intercalibration exercises involving several analytical laboratories, the accuracy of the method as used by the analyst can be checked and compared with the accuracy obtained by other participants in the exercise.

10.3 Quality Control

Analyse periodically, at least once a week or whenever the routine has been interrupted for more than a week, the working matrix, in order to guarantee the precision and accuracy of your results. If, on any occasion, the calibration curve is found to be altered by more than 10% from the previous one, check your routine for errors.

11. ANALYTICAL REPORT

Fill in the Analytical report (table 1) giving full details in every column.

Table 1: Analytical Report on Mercury in Estuarine
Waters and Suspended Sediments

1. Sample code: _____

2. Determination of dry weight of suspended sediment: _____
 - 2.1 Duration of drying: _____ hours
 - 2.2 Date of drying: _____ day; _____ month; _____ year
 - 2.3 Weight of filter: _____ mg
 - 2.4 Weight of filter and suspended sediment _____ mg
 - 2.5 Weight of suspended sediment: _____ mg

3. Digestion of suspended sediment
 - 3.1 Duration of digestion: _____ hours
 - 3.2 Temperature used for digestion: _____ °C
 - 3.3 Date of mineralization: _____ day; _____ month; _____ year
 - 3.4 Anomalies observed which may influence results:

4. Standardization (calibration)
 - 4.1 Date: _____ day; _____ month; _____ year

4.2 Result:

solution sample	1	2	3	4	5	6	7	8
-----------------	---	---	---	---	---	---	---	---

(blanks)

concentration

(ngl⁻¹ Hg)

units of recorded signal

5. Analytical result and estimation of precision for water subsamples.

5.1 Date: _____ day; _____ month; _____ year

5.2 Result:

subsample	1	2	3	4	5
-----------	---	---	---	---	---

volume of subsample

units of recorded signal

ngl⁻¹ Hg

mean concentration _____ ngl⁻¹; Stand. deviation _____

coeff. of variation _____ %

6. Estimation of accuracy

6.1 Date: _____ day; _____ month; _____ year

6.2 Type of certified standard used: _____

6.3 Declared ngl⁻¹ of certified standard: _____

6.4 Results:

sample 1 2 3 4 5

units of recorded signal

ngl⁻¹ Hg

7. Anomalies observed during analysis and other remarks relevant to the interpretation of results for analysis of water sample:

8. Analytical result and estimation of precision for suspended sediment subsamples

8.1 Date: _____ day; _____ month; _____ year

8.2 Result:

subsample 1 2 3 4 5

mass of subsample (mg)

units of recorded signal

ngl⁻¹ Hg in suspended sediment

mean concentration _____ ngl^{-1} ; Stand. deviation _____

coeff. of variation _____ %

9. Estimation of accuracy

9.1 Date: _____ day; _____ month; _____ year

9.2 Type of certified standard used: _____

9.3 Declared ngl^{-1} of certified standard: _____

9.4 Results:

sample	1	2	3	4	5
_____					(blanks)

(ngg^{-1} Hg)

units of recorded signal

10. Anomalies observed during analysis and other remarks relevant to the interpretation of results relevant to the interpretation of results for analysis of suspended sediment:

8. Intercalibration exercise (give details): _____

12. Full address of the institution which carried out the analysis:

13. Name(s) and signature(s) of the person(s) who carried out the analysis:

Date: _____

LIST OF REFERENCE METHODS FOR MARINE POLLUTION STUDIES

LISTE DES METHODES DE REFERENCE POUR LES ETUDES DE POLLUTION MARINE

- UNEP/WHO : Guidelines for monitoring the quality of coastal recreational and shellfish-growing waters. (Draft) Reference Methods for Marine Pollution Studies No. 1, UNEP 1984.
- UNEP/WHO : Determination of total coliforms in sea-water by the membrane filtration culture method. Reference Methods for Marine Pollution Studies No. 2 Rev. 1, UNEP 1983.
- PNUE/OMS : Détermination des coliformes totaux dans l'eau de mer par la méthode de culture sur membranes filtrantes. Méthodes de Références pour les Etudes de Pollution Marine No 2, Rév. 1, PNUE 1983.
- UNEP/WHO : Determination of faecal coliforms in sea-water by the membrane filtration culture method. Reference Methods for Marine Pollution Studies No. 3 Rev. 1, UNEP 1983.
- PNUE/OMS : Détermination des coliformes fécaux dans l'eau de mer par la méthode de culture sur membranes filtrantes. Méthodes de Références pour les Etudes de Pollution Marine No 3, Rév. 1, PNUE 1983.
- UNEP/WHO : Determination of faecal streptococci in sea-water by the membrane filtration culture method. Reference Methods for Marine Pollution Studies No. 4 Rev. 1, UNEP 1983.
- PNUE/OMS : Détermination des streptocoques fécaux dans l'eau de mer par la méthode de culture sur membranes filtrantes. Méthodes de Références pour les Etudes de Pollution Marine No 4, Rév. 1, PNUE 1983.
- UNEP/WHO : Determination of faecal coliforms in bivalves by multiple test tube method. Reference Methods for Marine Pollution Studies No. 5 Rev. 1, UNEP 1983.
- PNUE/OMS : Détermination des coliformes fécaux dans les bivalves par le test des tubes multiples. Méthodes de Références pour les Etudes de Pollution Marine No 5, Rév. 1, PNUE 1983.
- UNEP/FAO/IAEA : Guidelines for monitoring chemical contaminants in marine organisms. Reference Methods for Marine Pollution Studies No. 6, UNEP. (in preparation)
- UNEP/FAO/IOC/IAEA : Sampling of selected marine organisms and sample preparation for trace metal analysis. Reference Methods for Marine Pollution Studies No. 7 Rev. 2, UNEP 1984.
- UNEP/FAO/IOC/IAEA : Determination of total mercury in selected marine organisms by cold vapour atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 8 Rev. 1, UNEP 1984.
- UNEP/FAO/IAEA : Determination of total arsenic in selected marine organisms by hydride generation atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 9, UNEP 1985.
- UNEP/FAO/IAEA : Determination of total selenium in selected marine organisms by hydride generation atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 10, UNEP 1984.
- UNEP/FAO/IOC/IAEA : Determination of total cadmium, zinc, lead and copper in selected marine organisms by flameless atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 11 Rev. 1, UNEP 1984.
- UNEP/FAO/IAEA : Sampling of selected marine organisms and sample preparation for the analysis of chlorinated hydrocarbons. Reference Methods for Marine Pollution Studies No. 12 Rev. 1, UNEP 1984.
- UNEP/FAO/IAEA : Determination of methylmercury in selected marine organisms by gas chromatography. Reference Methods for Marine Pollution Studies No. 13, UNEP 1984.
- UNEP/FAO/IOC/IAEA : Determination of DDTs and PCBs in selected marine organisms by packed column gas chromatography. Reference Methods for Marine Pollution Studies No. 14 Rev. 1, UNEP 1985.

- UNEP/IOC/IAEA : Monitoring of tar on marine beaches. Reference Methods for Marine Pollution Studies No. 15, UNEP 1985.
- UNEP/IAEA : Determination of DDTs, PCBs, PCCs and other hydrocarbons in sea-water by gas chromatography. (Draft) Reference Methods for Marine Pollution Studies No. 16, UNEP 1982.
- UNEP/IAEA : Determination of DDTs, PCBs and other hydrocarbons in marine sediments by gas-liquid chromatography. (Draft) Reference Methods for Marine Pollution Studies No. 17, UNEP 1982.
- UNEP/IOC : Determination of total dissolved cadmium in sea-water by differential pulse anodic stripping voltammetry. (Draft) Reference Methods for Marine Pollution Studies No. 18, UNEP 1983.
- UNEP/IOC/IAEA : Determination of mercury in estuarine waters and suspended sediment by cold vapour atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 19, UNEP 1985.
- UNEP/IOC/IAEA : Monitoring of petroleum hydrocarbons in sediments. Reference Methods for Marine Pollution Studies No. 20, UNEP. (in preparation)
- UNEP/WHO/IAEA : Determination of total coliforms in sea-water by multiple test tube (MPN) method. Reference Methods for Marine Pollution Studies No. 21, UNEP 1985.
- UNEP/WHO/IAEA : Determination of faecal coliforms in sea-water by multiple test tube (MPN) method. Reference Methods for Marine Pollution Studies No. 22, UNEP 1985.
- UNEP/WHO/IAEA : Determination of faecal streptococci in sea-water by multiple test tube (MPN) method. Reference Methods for Marine Pollution Studies No. 23, UNEP 1985.
- UNEP/WHO/IAEA : Sampling of aerosols and wet precipitation for analysis of chemical pollutants. Reference Methods for Marine Pollution Studies No. 24, UNEP 1985.
- SPC/UNEP : Coral reef monitoring handbook. Reference Methods for Marine Pollution Studies No. 25, UNEP 1984.
- UNEP/IAEA : Determination of total mercury in marine sediments and suspended solids by cold vapour atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 26, UNEP 1985.
- UNEP/IAEA : Determination of total cadmium in marine sediments by flameless atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 27, UNEP 1985.
- UNEP : Sampling and identification of common Mediterranean Scyphomedusae and evaluation of their occurrence. (in preparation)
- UNEP/IOC/IAEA : Monitoring of petroleum hydrocarbons in sea-water. (in preparation)
- UNEP/IAEA : Guidelines for monitoring of estuarine waters and suspended matter. (in preparation)
- UNEP/WHO/IAEA : Determination of faecal coliforms in estuarine waters, suspended matter and sediments. (in preparation)
- UNEP/WHO/IAEA : Determination of phosphorus in suspended matter and sediments. (in preparation)
- UNEP/WHO/IAEA : Determination of nitrogen in suspended matter and sediments. (in preparation)
- UNEP/WHO/IAEA : Determination of BOD₅ and COD in estuarine waters. (in preparation)
- UNEP/FAO/IAEA : Acute toxicity tests. (in preparation)
- UNEP/IOC/IAEA : Determination of total cadmium in estuarine waters and suspended matter. (in preparation)
- UNEP/FAO/IAEA : Biological non-acute toxicity tests. (in preparation)
- UNEP/IOC/IAEA : Determination of basic oceanographic and meteorological conditions. (in preparation)

- UNEP/IOC/IAEA : Determination of standard physical and chemical parameters. (in preparation)
- UNEP/WHO/IAEA : Statistical methods for the evaluation of results from monitoring the quality of coastal recreational and shellfish-growing waters. (in preparation)
- UNEP/FAO/IOC/IAEA : Determination of DDTs and PCBs in selected marine organisms by capillary column gas chromatography. (in preparation)
- UNEP/IAEA : Determination of selected trace metals in aerosol and in wet precipitation. (in preparation)
- UNEP/IAEA : Determination of halogenated hydrocarbons in aerosol and in wet precipitation. (in preparation)
- UNEP/WMO/IAEA : Sampling of dry deposition. (in preparation)
- UNEP/WHO/IAEA : Determination of staphylococcus aureus in sea-water and sewage by the membrane filtration culture method. (in preparation)
- UNEP/WHO/IAEA : Determination of pseudomonas aeruginosa in sea-water and sewage by the membrane filtration culture method. (in preparation)
- UNEP/WHO/IAEA : Isolation/Enumeration of salmonella from sea-water and sewage. (in preparation)
- UNEP/WHO/IAEA : Determination of methylmercury, total mercury and selenium in human hair. (in preparation)
- UNEP/WHO/IAEA : Guidelines for monitoring and epidemiological studies on health effects of methylmercury. (in preparation)



Issued and printed by:



Programme Activity Centre for Oceans and Coastal Areas
United Nations Environment Programme

Additional copies of this and other publications issued by
the Programme Activity Centre for Oceans and Coastal Areas
can be obtained from:

Programme Activity Centre for Oceans and Coastal Areas
United Nations Environment Programme
Palais des Nations
GENEVA
Switzerland

