

52452



# WHO

REGIONAL OFFICE FOR EUROPE

---

EUR/ICP/CEH 041(1)  
ORIGINAL: ENGLISH  
UNEDITED

*Long-term Programme for Pollution Monitoring  
and Research in the Mediterranean Sea  
(MED POL Phase II)*

## **GUIDELINES FOR MONITORING LAND- BASED SOURCES OF MARINE POLLUTION**



UNEP

Issued in cooperation with the  
United Nations Environment Programme

SCHERFIGSVEJ 8  
DK-2100 COPENHAGEN Ø  
DENMARK

---

TEL: (45) 39 17 17 17  
TELEFAX: (45) 39 17 18 18  
TELEX: 15348

1994

EUR/HFA TARGET 20

## TARGET 20 WATER QUALITY

*By the year 2000, all people should have access to adequate supplies of safe drinking-water, and the pollution of groundwater sources, rivers, lakes and seas should no longer pose a threat to health.*

### ABSTRACT

The overall objectives of the Long-term Programme of Pollution Monitoring and Research in the Mediterranean Sea (MED POL Phase II), which constitutes the environmental assessment component of the Mediterranean Action Plan, adopted by the governments of the region in 1975, includes the assessment, on a continuing basis, of the state of pollution of the Mediterranean Sea, the identification of the sources, pathways and effects of pollutants entering into it, and the establishment of temporal trends in pollution levels.

### *Keywords*

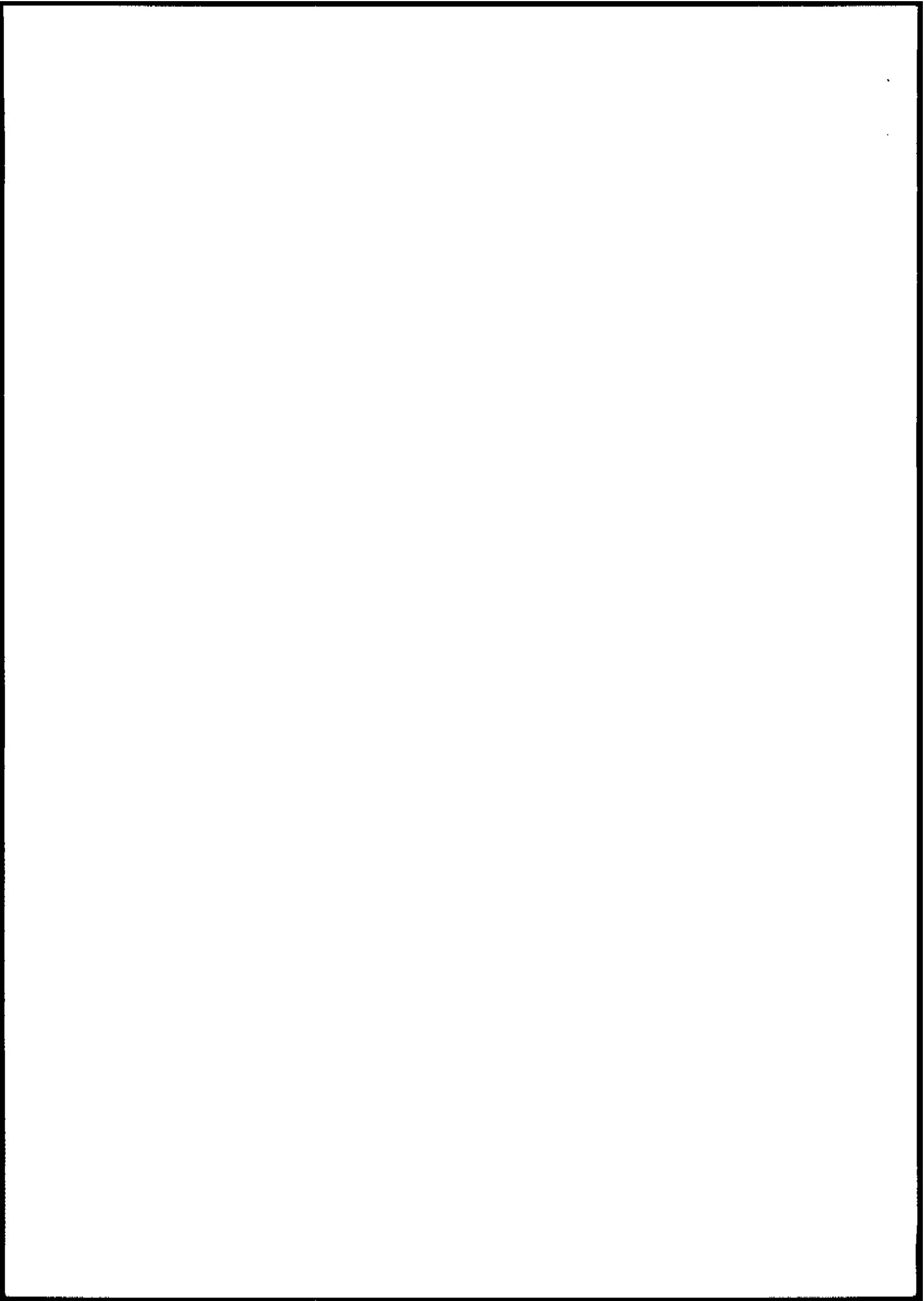
ENVIRONMENTAL MONITORING  
WATER POLLUTION – prevent/control  
SEAWATER  
MED

---

All rights in this document are reserved by the WHO Regional Office for Europe. The document may nevertheless be freely reviewed, abstracted, reproduced or translated into any other language, but not for sale or for use in conjunction with commercial purposes. Any views expressed by named authors are solely the responsibility of those authors. The Regional Office would appreciate receiving three copies of any translation.

## TABLE OF CONTENTS

	<i>Page</i>
1. INTRODUCTION.....	1
2. SCOPE AND FIELD OF APPLICATION.....	1
3. DEFINITIONS .....	2
4. SCOPE OF ACTIVITY.....	3
5. AREA AND PROBLEM IDENTIFICATION.....	5
5.1 Sources of information .....	5
5.2 Landward information.....	6
5.3 Seaward information .....	6
5.4 Maps .....	7
5.5 Preparation of preliminary report.....	7
6. SAMPLING.....	7
6.1 Matrices and locations.....	8
6.2 Sampling methodology.....	14
6.3 Sampling frequency.....	18
7. MONITORING PARAMETERS.....	21
8. METHODOLOGY FOR ANALYSIS OF SAMPLES AND FLOW MEASUREMENTS ..	21
8.1 Analysis of the samples.....	22
8.2 Flow measurement.....	22
9. REFERENCES.....	23



## 1. INTRODUCTION

The overall objectives of the Long-term Programme of Pollution Monitoring and Research in the Mediterranean Sea (MED POL Phase II), which constitutes the environmental assessment component of the Mediterranean Action Plan, adopted by the governments of the region in 1975, includes the assessment, on a continuing basis, of the state of pollution of the Mediterranean Sea, the identification of the sources, pathways and effects of pollutants entering into it, and the establishment of temporal trends in pollution levels.

The monitoring component of MED POL includes sources of pollution to provide information on the type and amount of pollutants reaching the marine environment from coastal sources. The purpose of this monitoring is to establish the pollution load reaching the Mediterranean Sea and to contribute to the knowledge of biogeochemical cycles of pollutants relevant to this sea. Pollutants to be monitored include relevant substances from those listed in Annexes I and II to the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources, adopted by Governments of the region in May 1980, and in force since June 1983.

In order to assist laboratories participating in the monitoring component of MED POL, and to ensure the necessary degree of intercomparison of data, a set of reference methods and guidelines has been developed by the Regional Sea Programme of UNEP in cooperation with the relevant specialized agencies of the United Nations system, as well as other organizations. A number of these have been prepared by the World Health organization. In these reference methods and guidelines, the style used by the International organization for Standardization (ISO) is followed as closely as possible.

Actual preparation of methods and guidelines falling within the responsibility of WHO is entrusted to competent experts in the relevant disciplines with experience of the relevant characteristics of the Mediterranean marine environment. Following its preparation in draft form, each method is reviewed by international experts in the field either on an individual basis or (normally) during consultation meetings. On issue in substantive form, methods and guidelines are distributed to Mediterranean laboratories and are periodically updated and/or revised on the basis of experience.

The first draft of these guidelines was prepared for WHO by Professor Kriton Curi of the Environmental Pollution Research Group, Faculty of Engineering, Bogazici University, Istanbul, Turkey. The draft was comprehensively reviewed during an ad hoc consultation meeting jointly convened by WHO and UNEP in Istanbul from 27 to 29 September 1990. This first substantive issue of the guidelines contains various amendments made since that time.

## 2. SCOPE AND FIELD OF APPLICATION

The guidelines described are designed for use in the formulation and implementation of programmes for monitoring the types and amounts of pollutants reaching the coastal marine environment from land-based sources. They should be used in connection with appropriate methodology for the determination of relevant chemical and microbiological parameters, and with appropriate statistical methods to enable accurate interpretation of results and assessment of the pollution load reaching the sea on a yearly basis.

Monitoring programmes based on these guidelines would be useful in coastal water management practices, particularly in the case of municipal and/or industrial effluents having to

conform with legally-defined limits with respect to the concentration level of any specific pollutant.

The guidelines would also be useful for the assessment and evaluation of overall coastal water pollution prevention and control programmes, when performed in combination with complementary monitoring of marine water quality in specific areas such as recreational beaches, shellfish grounds, aquaculture farms and nature reserves. Furthermore, parameters monitored on the basis of these guidelines should provide scientific information for a sound environmental impact assessment of developmental or industrial projects close to the coastal areas of the Mediterranean Sea.

Though developed for the Mediterranean region and primarily designed for application under the conditions prevailing in this region, these guidelines may be broadly applied to regions with other environmental conditions.

### 3. DEFINITIONS

Land-based pollution sources can be classified into two main types: point sources and diffuse (non-point) sources.

#### Point sources

Point sources are those from which pollutants are continuously or discontinuously discharged into a receiving water body from a single point. Examples of this type of source are:

- (a) **Sewer outfalls, including outfalls of municipal or industrial sewage, stormwater outfalls and combined outfalls:** They may either discharge into the immediate coastal area from points above or below sea level, or enter the marine environment away from the coastline via a submarine pipeline.
- (b) **Rivers:** polluted rivers discharging in coastal areas may be important carriers of pollutants originating from points located inland, far away from the sea.
- (c) **Coastal lagoons:** These may be also important sources of pollution, particularly if they act as final recipients of wastes.
- (d) **Solid waste and sludge disposal and dumping sites:** Solid wastes and sludge disposed of directly into the sea, whether from specific points on land or from barges or ships can be considered as a point source of pollution.
- (e) **Accidents and leakages:** Discharges of pollutants into the sea as a result of incidental or continuous leakage, or arising out of terrestrial accidents, such as an explosion in a coastal refinery, are also included in the category of point sources.

#### Diffuse (non-point) sources

Sources from which pollutants do not flow into the receiving water from a single point but are spread along the coast, are considered diffuse sources. They can be classified as:

- (a) **Run-off:** stormwater which flows in an uncontrolled way into the sea, or leachate reaching the sea from dumping sites in the vicinity of the coastline are the main examples of diffused sources.

- (b) **Small outfalls:** untreated sanitary outfalls that are present in large numbers along the coast behave as diffused sources.
- (c) **Airborne pollution:** There is evidence that considerable quantities of lead and possibly other trace metals, DDT, PCBs, low molecular weight petroleum hydrocarbons and other organic substances are transported to the open ocean by the atmosphere, either as particles or in the gas phase (Duce, *et al.* 1976; SCEP, 1979; FAO, 1971). The sources thus contributing to airborne pollution are also diffused sources

#### 4. SCOPE OF ACTIVITY

The aims of a programme of monitoring land-based sources of marine pollution should be:

- (a) Completion of baseline studies necessary to survey the types and amounts of pollutants discharged or dumped into the coastal marine environment in any given area;
- (b) Compilation, and regular updating, of an inventory of land-based sources of marine pollution, including data of the probable fate of the pollutants;
- (c) Effluent quality control where criteria or standards already exist, and assessment of control measures being implemented;
- (d) Compilation of data on the basis of which decisions on the promulgation and implementation of control measures can be taken where such measures do not already exist.
- (e) Formation of a database to be used for the environmental impact assessment of any future coastal development.

Proper planning of a monitoring programme enables the collection of all the necessary information at the lowest possible cost and, at the same time, results in the programme becoming easily readjustable in the light of experience acquired, to enable improvements consonant with both local requirements and developments in technology.

A well planned monitoring programme should specify clearly:

- (a) The purpose of the monitoring programme;
- (b) The parameters to be determined;
- (c) The methodology to be followed;
- (d) The methodology of quality control and assurance.

During the planning of an effective monitoring programme, the outline given in Figure 1 (modified from Mancy Allen, 1978) could be followed. The main flow-chart is provided at the left side of this figure, while the right side contains information regarding the considerations to be made for a proper decision. As can be seen in the outline, several factors are affecting decisions related to the planning of a monitoring programme, among which financial restrictions may be the most important. A realistic decision related to monitoring should be always financially feasible, and the monitoring programme prepared accordingly.



The determination of parameters to be measured is very important in planning any monitoring programme. Generally speaking, these parameters will depend on the types of sources present and the pollutants they discharge. Priority parameters agreed on by Mediterranean States for pollution source monitoring in the region within the framework of the Long-term Programme of Pollution Monitoring and Research in the Mediterranean Sea (MED POL Phase II) are listed in Chapter 7. These parameters were essentially designed for a coordinated regional programme, and the final choice in any particular area would depend mainly on local circumstances. However, consideration should be given to both required and obtainable precision because these factors may affect the significance, performance, and cost of the monitoring programme.

Once the monitoring programme is planned, it should be kept in mind that this programme is not, by its very nature, permanent as to detail. On the contrary, it should be readjusted continuously, or periodically, in the light of experience gained during its implementation.

After evaluation of the results, the following action should be taken:

- (a) If results indicate that standards are exceeded or the environment is endangered, remedial action should be taken;
- (b) According to results obtained, it may be decided to:
  - (i) continue the monitoring programme without any changes;
  - (ii) change the aim of monitoring programmes;
  - (iii) modify the applied programme.

To adequately meet the very different national requirements in terms of monitoring and the equally different levels of field and laboratory training, it is worth distinguishing between two different approaches:

- (a) **Basic monitoring:** this would involve sampling and analysis of a few priority parameters. Limited resource allocation and only the basic elements of quality assessment and control would be provided under this approach.
- (b) **Extended monitoring:** this would involve sampling and analysis of several parameters. It would be more resource-demanding and would often involve an element of research, e.g. on the dispersion and fate of pollutants in the marine environment after discharge. Ultimately a series of extended monitoring programmes may lead to new achievements in terms of pollution control, which may then cause redefinition of the scope of activities, new choice of monitoring parameters, etc.

## 5. AREA AND PROBLEM IDENTIFICATION

### 5.1 Sources of information

For proper planning of any monitoring system, it is essential for all available information to be collected, and a preliminary survey on the area in question should be conducted. Sources for available information related to pollution from land-based sources may be one or more among the following:

- (a) Hydrographic and/or oceanographic offices;

- (b) Higher educational institutions conducting research in related fields, maritime and naval academies;
- (c) National and local authorities (municipalities, etc.) dealing with the particular problem;
- (d) Chambers of Commerce, Industry or individual industries;
- (e) Non-governmental organizations dealing with environmental problems;
- (f) Inhabitants of the areas in question, especially fishermen and aquaculturalists.

A preliminary survey or area assessment is also advisable. This preliminary survey should include both the landward and seaward descriptions of the area (WHO/UNEP, 1977; UNEP/WHO, 1987), and data obtained should be recorded.

## 5.2 Landward information

From the **landward side**, the following should be examined:

**5.2.1 Land use:** Determination and identification of the categories of land use within the watershed area, including beaches as industrial, residential, agricultural and forestry giving information on the amount and type of fertilizers, pesticides, etc. used; recreational (including beaches), harbour facilities on land, etc.,

### 5.2.2 Sources

The following possible sources should be examined:

- (i) **Surface runoff:** Determination of location and flow rate of rivers, streams and other sources of runoff;
- (ii) **Wastewater discharges and outfalls:** Identify outfall sites and estimate individual and total daily flow, indicating type of outfall and problems to be encountered during sampling. Indicate points on a map and supplement by a fact sheet;
- (iii) **Wastewater Treatment Plants:** Location, capacity and degree of treatment,
- (iv) **Dumps:** Dumping sites on land for solid waste sewage or sludge disposal in the vicinity of the coast should be indicated on a map, giving information about volume of deposit per year;
- (v) **Coastline:** Type of coastline (sand, gravel, rock, cliff, shallow or deep water, marshlands, wetlands, coastal lagoons) should be indicated;
- (vi) **Soil characteristics:** Soil characteristics in the watershed area.

## 5.3 Seaward information

The **seaward** description should include, where appropriate, the following information:

### 5.3.1 Activities

- (i) **Shellfish areas:** Site and type of shellfish should be indicated on a map, and information about catch (tonnage per year) should be given;
- (ii) **Fishing grounds:** Site, type of fish and, if possible, information about catch, tonnage, etc. should be indicated;
- (iii) **Protected areas:** Information about fish in marine parks and other similar protected areas;
- (iv) **Dumping sites:** Determination of locations, material and amount dumped;
- (v) **Marine biota:** General information about marine fauna and flora, wildlife and nature reserves should be provided.

### 5.3.2 Oceanographic and meteorological data

Any relevant data on winds, currents, tides, etc. should be obtained

### 5.4 Maps

Collection of all adequate maps and nautical charts is essential. If they are not available, or if the existing ones are not satisfactorily detailed, maps of the area to be monitored should be prepared. Each map should be clearly identified by location, coordinates, scale (preferably graphed then giving numerical values) and orientation.

### 5.5 Preparation of preliminary report

A brief and concise report stating clearly the aims of the monitoring programme, and including information collected during the preliminary survey, summary of previous studies and related maps, should be prepared. This report should form the basis for finalization of the monitoring programme.

## 6. SAMPLING

Sampling techniques should be determined with great care as, even with the most sensitive analytical techniques, it is not possible to obtain more accurate and dependable results than the collected sample can provide.

It is not possible to provide specific sampling instructions which would be suitable and applicable under all conditions. Because of this, only general principles are outlined in the following sections.

The most important principle in sampling is to enable the performance of analysis on samples which are "representative" of the water being samples. In other words, the sample and its source should have the same composition. Furthermore, the sample should be able to provide a true presentation of the variations in the characteristics of the source with time. Sampling should be performed in a systematic way in order to minimize discrepancies.

Selection of the sampling point location as well as the frequency of sampling for the determination and monitoring of land-based marine pollution sources depends mainly on the

sensitivity required as well as the resources allocated to the monitoring programme. There is a basic difference between the selection of sampling methodology for application by all Mediterranean countries on a common joint basis, and the selection of a methodology in order to comply with national or even local requirements.

## 6.1 Matrices and locations

In national monitoring programmes aimed at the determination of land-based pollution, details will have to be determined in the light of the situation existing in each particular locality. These will necessarily differ according to land-use and related activities, as well as water use, in the area in question.

In a regional monitoring programme aiming at the determination of land-based marine pollution originating from all Mediterranean countries, mandatory monitoring would be restricted to major sources of pollution while at the same time allowing for additional components to enable the satisfaction of national and local requirements.

In keeping with these general principles, the matrices to be monitored and the location of sampling points should be as explained below.

### 6.1.1 Point sources

When samples are to be collected from a point source, the homogeneity of the system should first be checked and, if possible, sampling points should be located at points where homogeneous distribution of the parameters to be measured is observed. This is not always possible, especially if undissolved materials with densities different from that of the water are involved or when chemical and/or biological reactions vary in extent in different parts of the system.

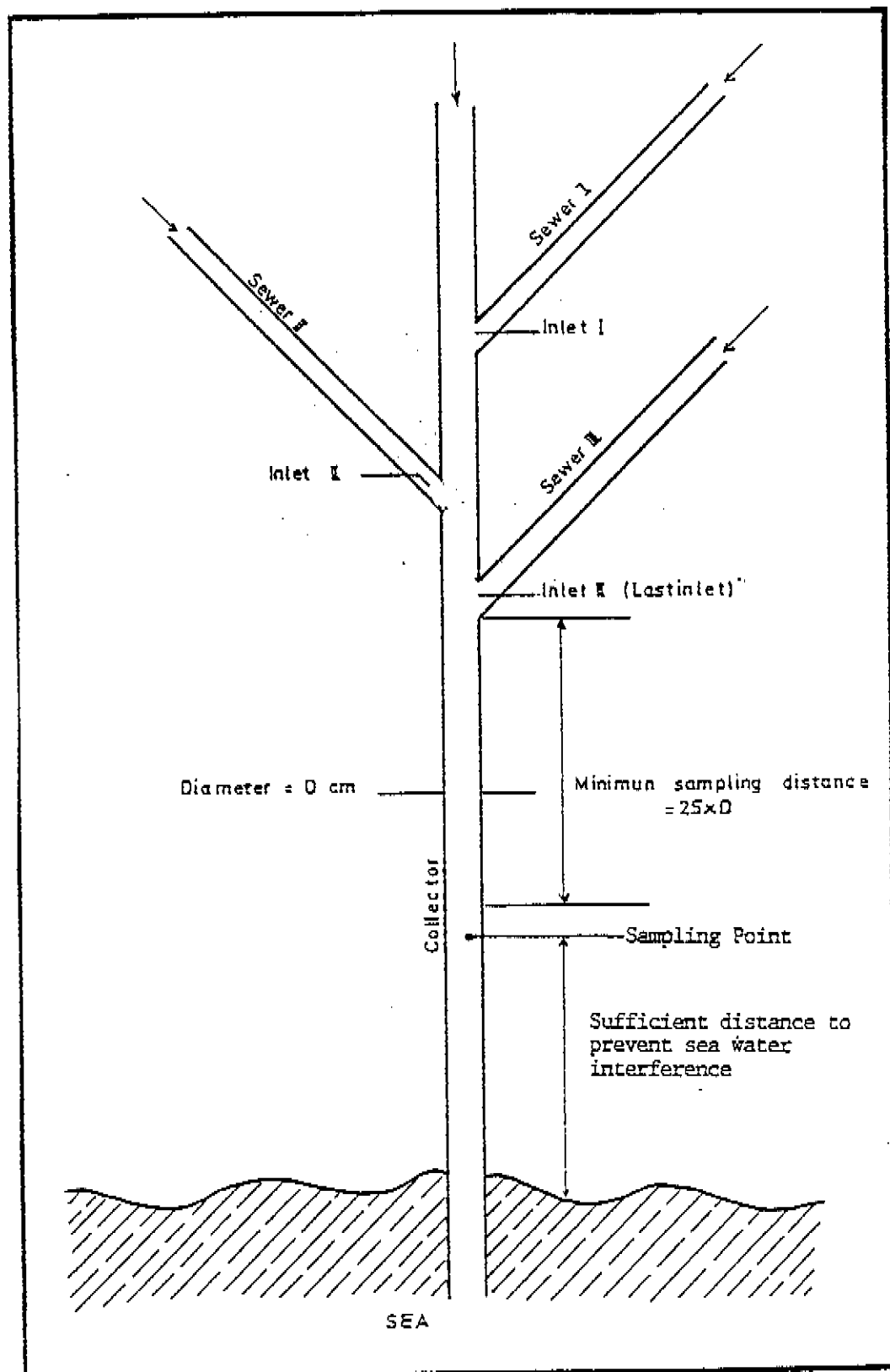
When the system is of a heterogeneous nature, the number and location of samples to be collected should be adjusted accordingly to enable results to be representative. Variations in the homogeneous character of a system with time should be checked because seasonal variations etc. are possible. Sampling locations near the boundaries of water systems, such as the banks of rivers or the walls of pipes and channels, should be avoided unless these locations are of special interest. The following principles should be adhered to in relation to the different types of point sources:

- (a) **Outfalls:** To collect a representative sample from an outfall, the sampling point should be located in such a way that it is not affected either by the coastal receiving waters or from any particular wastewater inlet. To achieve this, the sampling point should be located away from the last inlet so that complete mixing can have taken place. The minimum distance recommended between the sampling point and the last inlet into the main outfall should be 25 times the diameter of the outfall (Figure 2). At the same time, sampling point should be performed at a point in the main outfall pipe located inland from the coastline, in order to prevent interference by the receiving waters.

The order of preference of sampling points is as follows:

- (i) If the outlet of the outfall is above sea level, located in such a way that seawater cannot enter into it, but still making sampling possible, this point should be preferred as a sampling point;

Figure 2. Location of a sampling point



- (ii) If (i) above is not possible, a manhole satisfying the general requirements mentioned above should be chosen;
- (iii) If a manhole satisfying the requirement mentioned in (ii) above is not available, then a special sampling point should be constructed or special precautions should be taken. One method recommended when sewers terminate a little below sea level, is to clog the sewer by an inflatable pillow with a pipe located in its centre. This pipe is elevated above sea level and, after enough time is permitted to elapse in order to discharge any seawater remaining in the pipe, samples are collected (Figure 3). When selecting a sampling point, it should be kept in mind that such selected point should be easily accessible under all possible weather conditions.

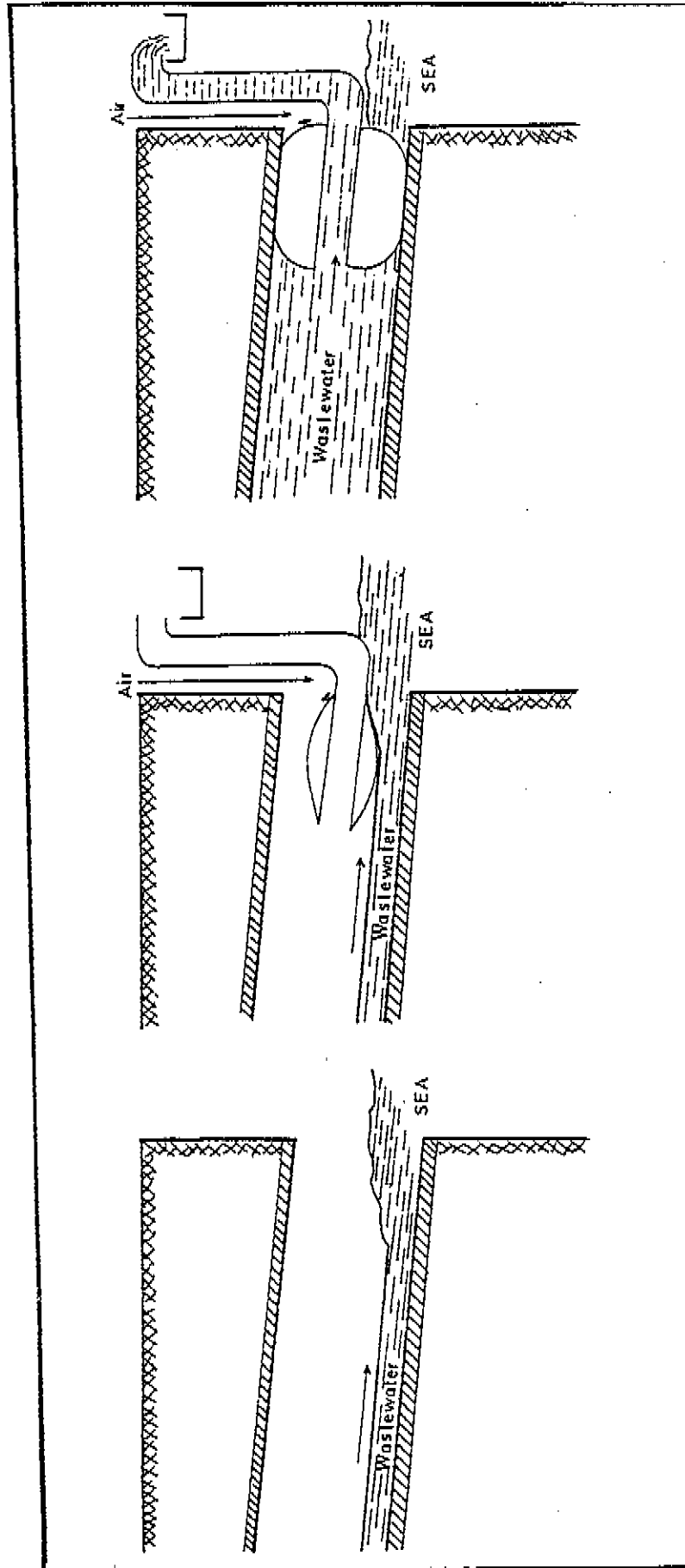
Whenever a flow measuring device is required to be located within the sewer, care should be taken to avoid variations in the characteristics of the sample, which can affect its validity. For example, the use of a weir may cause re-oxygenation, thus changing the characteristics of the sampled liquid. In such cases, flow measuring devices should be located at a point downstream from the sampling point at a distance sufficient to prevent any effect on the sample, but still giving dependable flow measurements. In cases when the flow measuring device is portable and easily located and/or removed, then flow measurements should be realized after the samples are collected.

It is suggested that samples be collected systematically from:

- (i) Treated or untreated municipal sewers, provided that their average flow is above 5000 m<sup>3</sup>/day;
  - (ii) Sewer outlets of treated or untreated industrial wastewaters or cooling waters if the average flow is above 500 m<sup>3</sup>/day or from any other outlet, if preliminary studies indicate that there is an indication that it is a significant contributor of any pollutant which is among the parameters measured in the monitoring programme;
  - (iii) Major storm outfalls;
  - (iv) Combined systems, including any two or all of the above.
- (b) **Rivers and streams:** Monitoring stations on rivers should be established, provided that they satisfy one of the conditions given below:
- (i) Their average flow is above 100 m<sup>3</sup>/sec;
  - (ii) Their watershed is larger than 100 km<sup>2</sup>;
  - (iii) They are expected to be heavily polluted.

The location of the monitoring station on a river should be chosen outside the limits affected by tides and waves, at a point downstream from the last effluent discharge at a distance sufficient to obtain a homogeneous distribution. If there is any possibility of non-homogeneous distribution of quality at the chosen location, experimental tests of the nature and magnitude of any heterogeneity should be made. If the results indicate that the river is of homogeneous character, one position for sampling will be enough otherwise, either the location of the sampling point should be changed for one of a homogeneous character, or samples should be taken from several additional locations in addition to the original one selected, so that the overall characteristics can be represented. For main rivers, even if homogeneous, it is advisable for more than one sample to be taken from different depths on the same cross section, forming a sampling

Figure 3. Use of inflatable pillow for collecting samples from sewers terminating below sea level



point grid if necessary. In such a case, the effect of variation of flow rate at the different points should be taken into consideration when preparing composite samples or estimating the overall input of any specific pollutant to the receiving water. When a limited number of samples need to be taken for determination of existent pollutants, if equipment is available, it is recommended to take an "integrated" sample from top to bottom in midstream, or from side to side at mid-depth, in such a way that the sample is integrated according to flow. If only a grab or catch sample can be collected, this is best taken in mid-stream at mid-depth (APHA, 1990). On the other hand, velocity measurements, which are essential in order to determine the flow and, consequently, the total amount of pollutant discharged into the receiving water, sampling should be performed at a point located at 0.6 of the total depth measured from the bottom or, to increase accuracy, at points located 0.2 and 0.8 of the total depth (Linsley and Franzini, 1969) and taking the average of these (Figure 4). Special attention is necessary when dealing with rivers which have a flooding tendency or a seasonally-varying stratification.

Bridges located over the river are an easily accessible and convenient sampling point. However, before a decision is taken regarding their use, it should be verified that samples collected from there are valid and representative. Sampling from areas where stagnation may occur and from areas located near the inside bank of a curve in the stream which may not be representative of the main channel should be avoided.

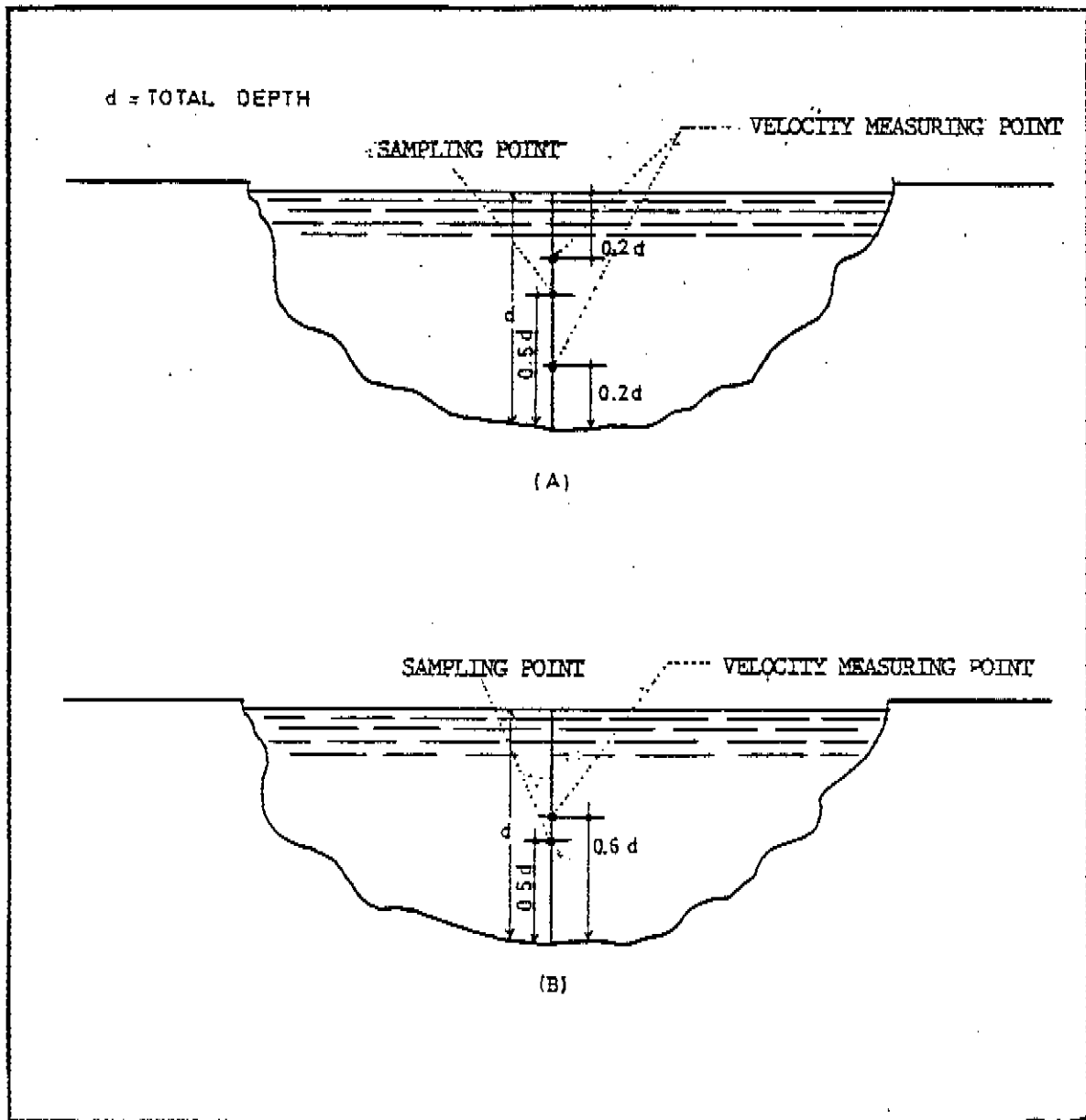
- (c) **Solid waste and sludge disposal:** Although it is not recommended practice, solid wastes and sludge can, in some countries, be dumped into a receiving water either legally (with an authorization) or illegally, directly from the coast or from barges used for such purpose.

In the case of authorized dumping, the amount of waste should be determined either by weighing the load in a specially allocated scale or, if this is not available, by estimating the amount by volume. All municipalities or other institutions dumping their solid wastes and sludge in this way should be obliged to provide information in an appropriate format regarding the amount and composition of the material dumped. Random sampling is normally performed on the basis of taking one sample for every 500 tons of municipal solid wastes and one sample for every 10 tons of industrial solid wastes, taking into consideration the waste's origin and classification. Samples should be collected from different parts of the solid waste load carefully trying to be as representative as possible. In cases when it is proven that the declaration of a certain industry is not correct, all loads coming from that particular industry should be examined.

The sampling of solid wastes and sludges from unauthorized dumping into receiving water is very difficult, if not impossible. The only possible way for controlling unauthorized dumping and estimating the possible amount, is source control. To achieve this, all sources of hazardous wastes should be obliged to fill in a declaration form giving information about the amount, properties and place of disposal of hazardous wastes. The correctness of the information given in the declaration should be investigated by random inspection.

- (d) **Major accidents:** Major accidents undoubtedly contribute to the pollution of the sea. If detailed information about the characteristics of the material flowing into the sea as a result of an accident is available, estimation of the volume of the material in question reaching the sea is enough for determining the amount of pollutant. If the analysis of the leaking material is not available, samples should be collected from the accident site and affected areas.

Figure 4. Velocity measuring location in a river



### 6.1.2 Diffuse sources

Sampling from diffuse sources is a very complicated process for which a generally acceptable procedure is not available. In such cases, the following approaches are suggested:

- (i) Collection of a representative sample and estimation of the overall effect;
- (ii) Determination of the concentrations of selected pollutants in various parts of the receiving marine environment in combination with salinity or other tracers, extrapolating to zero salinity and flow estimations;
- (iii) Utilization of information obtained from similar situations in which accurate load calculations are available;

- (iv) In the case of urban waste, calculation of the population equivalent on the basis of previous experience.

As can be seen from the four possible methods outlined above, only the first two require an actual sampling, while the other two are based purely on estimates. The collection of a representative sample in order to make an overall estimate can be easily achieved if the diffuse source is in the form of small outfalls. In this case, one of them should be chosen arbitrarily, and the results obtained extended to all the others. In the case of a "runoff", it is recommended that a channel at least 50m long perpendicular to the direction of the runoff be constructed, and samples collected from the outlet of this channel. It is considered that a 50m-length collection channel would be sufficient in most cases.

Selection of the location of sampling points in the receiving marine environment in order to apply approach (ii) above, depends entirely on local conditions. However, the following general principles can still be applied:

- (a) A grid of sampling points should be formed covering all the immediately-affected marine environment;
- (b) The depth from which the sample is to be collected should be decided according to local conditions. However, it is recommended that, at points where the depth exceeds 10 m, at least three samples (one below the surface, one at mid depth, and one at 1m above the bottom) should be collected (Wright *et al*, 1976; WHO/UNEP, 1977).

## 6.2 Sampling methodology

### 6.2.1 Type of sample

According to the character of the effluent being sampled, grab, composite or integrated samples can be used.

- (i) A **Grab sample** is a sample collected at a particular time and place. Consequently such a sample represents only the composition at the particular moment of sampling, at that particular point from where the sample is collected.

Another sample taken earlier or later may show different characteristics. A grab sample may be preferred to a composite sample when:

- (a) The water to be sampled does not flow on a continuous basis, such as occurs when contaminated process tanks are periodically dumped. A grab sample from such a discharge is sufficient to obtain the waste characteristics of a batch dump;
- (b) The waste characteristics do not vary with time;
- (c) It is necessary to study the variations in the characteristics of the sampled water with time;
- (d) The parameters intended to be measured are subject to significant and unavoidable changes, or contamination occurs with time, such as trace metals and organics.

- (ii) A **composite sample** is a mixture of grab samples collected at time intervals and mixed in proportion to their rate of flow. This type of sampling is useful for determining the mean values of the characteristics of the wastes but cannot provide information about extreme values.
- (iii) An **integrated sample** is a mixture of grab samples collected at the same time from different points. The mixing is done in proportion to the relative flow. This type of sampling is required in a river or stream, the composition of which varies across its width and depth (Curi, 1980).

### 6.2.2 Selection of type of samples

The type of sample to be collected depends on the purpose of the monitoring programme, as well as on the type of pollution source. It is recommended that in programmes aiming at the determination of the amount of pollutants carried to the sea from land-based sources, the following types of samples should be collected:

- (i) Grab samples are recommended for examination of the effect of batch discharges, solid waste and sludge dumping, major accidents, etc. or under other conditions when the discharge of a pollutant takes place within a short time;
- (ii) Grab samples taken at certain intervals are also recommended when it is desired to investigate the daily variations of the characteristics of a river or outfall;
- (iii) Composite samples are recommended for collection from sewers or rivers when the only parameter aimed at determining is the overall amount of pollutants. The time over which samples should be mixed depends on the variability of the wastestream.

### 6.2.3 Sampling equipment

Detailed information about sampling equipment is provided in several textbooks, as well as in publications of the US Environmental Protection Agency and in *Standard methods for the examination of water and wastewater* (APHA, 1990).

### 6.2.4 Sample tags and log sheets

A tag or label should be attached to each sample container, having as a minimum the following information:

- Station number or name
- Location
- Date
- Time
- Type of sample
- Weather conditions
- Analyses required
- other relevant information
- Name of sample collector

If a sample is taken from a river, the sampling depth should also be determined. The tags should be filled out legibly in waterproof ink. The same information should also be recorded in a bound notebook which would also be used to record field measurements and





#### 6.2.4 Type of sample container and use of preservatives

In order to avoid changes or deterioration in the characteristics of the collected sample, special attention should be given to:

- (a) Type of the container (glass or polyethylene)
- (b) Preservative used
- (c) Time elapsing between the collection of the sample and the performance of the analysis
- (d) Conditions for storing

Appendix I summarizes the conditions which should be adhered to in relation to the above-mentioned points.

#### 6.3 Sampling frequency

The frequency of sampling should be selected in such a way as to adequately represent true quality and variation but, at the same time, should not exceed the minimum essential requirements, in order to avoid unnecessary effort and cost.

The best solution to the question of frequency is the use of continuously and automatically measuring instruments. This, however, is not always possible due to the unavailability of adequate instrumentation and the high cost involved.

The decision on the frequency of sampling can be taken only after available data are examined and an evaluation of the variation of characteristics is conducted.

When systematical data are not available, the following sampling programme should be followed, at least for major sources:

- (a) Hourly sampling during one 24-hour period in each quarter (season) to assess daily cyclic effects.
- (b) Daily sampling during 7 consecutive days in each season, to determine any weekly cyclic effects;
- (c) Weekly samples to delineate seasonal effects and to determine how less frequent sampling would have affected the results;

After a one-year trial period on the basis of the above programme, an evaluation should be performed to enable a decision on the suitable sampling frequency providing the required confidence limit of the means.

If the parameters to be determined show systematic trends or cyclic variations the, in addition to the number of samples, the time of sampling should be considered. Both should be chosen in such a way as to reflect the actual situation. Whatever the results of the above-mentioned analysis, the frequency of sampling should not be less than once per month. For practical reasons, whenever applicable, the sampling frequency may be adjusted to fit other monitoring programmes, such as the monitoring of the quality of coastal recreational and shellfish-growing areas.

APPENDIX I

Recommendation for sampling and preservation of samples

Measurement	Holding Time	Preservative	Temp (°C)	Volume Req. (ml)	Container	Other details
Acidity	24 hrs	-	4 °C	100	Polyethylene, Borosilicate glass	1. Avoid sample agitation 2. Avoid prolonged exposure to air 3. Fill sample bottles completely and cap them tightly
Alkalinity	24 hrs	-	4 °C	200	Polyethylene, Borosilicate glass	Same as above
BOD	24 hrs (if is preferred not to exceed 6 hrs)	-	4 °C	1000	Polyethylene or glass	
COD	As soon as possible	H <sub>2</sub> SO <sub>4</sub> to pH<2	-	50	Polyethylene or glass	
Chlorine	Immediately	-	-	500	Polyethylene or glass	Avoid excessive light and agitation
<b>Dissolved oxygen:</b>						
Probe	No holding	Det. on site	-	300	Glass only	
Winkler	4-8 hrs	Fix on site	-	300	Glass only	
MBAS	24 hrs	-	4 °C	250	Polyethylene or glass	
Oil and grease	24 hrs	H <sub>2</sub> SO <sub>4</sub> or HC <sub>1</sub> to pH<2	4 °C	1000	Glass	
Organic carbon	24 hrs	H <sub>2</sub> SO <sub>4</sub> or HC <sub>1</sub> to pH<2	4 °C	25	Polyethylene or glass	
pH	Immediately	-	-	-	Polyethylene, Borosilicate glass	
Phenolics	24 hrs	H <sub>3</sub> PO <sub>4</sub> to pH<4	4 °C	500	Glass	

APPENDIX I (Continued)

Measurement	Holding Time	Preservative	Temp (°C)	Volume Req. (ml)	Container	Other details
Phenols	4 hrs or preserve for 24 hrs after adding preservatives	H <sub>3</sub> PO <sub>4</sub> to pH<4 1.0 gr CuSO <sub>4</sub> . 5H <sub>2</sub> O/1			Glass	If H <sub>2</sub> S or SO <sub>2</sub> is known to be present, briefly aerate or stir the sample
Phosphate	Filter immediately	40 mg/l HgCl <sub>2</sub> /1 of sample	- 10 °C	-	Glass rinsed with 1+HN03	Do not use detergent containing phosphate for glassware cleaning
<b>Phosphorus :</b>						
Orthophosphate, dissolved	24 hours	Filter on site	4 °C	50	Polyethylene or glass	
Hydrolyzable	24 hrs	H <sub>2</sub> SO <sub>4</sub> to pH<2	4 °C	50	Polyethylene or glass	
Total	24 hrs	H <sub>2</sub> SO <sub>4</sub> to pH<2	4 °C	50	Polyethylene or glass	
Total dissolved	24 hrs	Filter on site H <sub>2</sub> SO <sub>4</sub> to pH<2	4 °C	50	Polyethylene or glass	
Silica	7 days	-	4 °C	50	Polyethylene or glass	
Sulphate	7 days	-	4 °C	50	Polyethylene or glass	
Sulphide	24 hrs	2 ml zinc acetate	-	500	Polyethylene or glass	
Sulphite	No holding	Det. on site	-	50	Polyethylene or glass	
Total organic carbon	As soon as possible	Hcl to pH=2	0 4 °C (when HCl is not used as preserver)	Glass (dark)	Minimize exposure to light	

## 7. MONITORING PARAMETERS

During the course of the Long-term Programme of Pollution Monitoring and Research in the Mediterranean (MED POL Phase II), National Coordinators agreed on the following parameters for inclusion in the pollution-source component of national monitoring programmes in the region:

### Category I parameters: (obligatory)

- Flow rate
- pH (to be determined at the discharge point)
- Temperature (to be determined at the discharge point)
- Total mercury Total cadmium
- Total suspended solids
- Total phosphorus
- Total nitrogen
- Faecal coliforms
- BOD (COD)
- High molecular weight halogenated hydrocarbons

### Category II parameters: (as necessary)

- Petroleum hydrocarbons
- Detergents
- Phenols
- Total Chromium
- Selected radionuclides
- Other pollutants known to be discharged in significant quantities

It should be stressed that the above parameters only apply to that part of national monitoring programme which is being performed as a contribution to the overall regional programme. Local requirements will require adjustments depending on the situation prevailing in each particular area monitored.

In the case of municipal effluents, the minimum parameters should be determined on the basis of a comprehensive evaluation of the general situation. In this case, when results obtained through a baseline survey indicate that certain parameters are not encountered at all, they may be omitted. A similar evaluation should be performed for mixed effluents of municipal and industrial wastes, taking into account (beyond the others) the number and types of industries discharging into the common system. From the public health viewpoint, pathogens or an appropriate indicator microorganism (faecal coliform or equivalent) may be included in the list of components to be determined. Parasites should be monitored, particularly in municipal effluents from heavily-populated areas with a well-documented history of endemic parasitic diseases.

## 8. METHODOLOGY FOR ANALYSIS OF SAMPLES AND FLOW MEASUREMENTS

Qualitative and quantitative analysis of the collected samples, and determination of the flow rate are the two main subjects which will be discussed in this section.

## 8.1 Analysis of the samples

### Techniques:

Determination of the different parameters existing in the samples should be performed according to standard techniques.

### Intercalibration and quality control:

The accuracy of the tests performed should be checked in order to ensure that the results are correct and the method used compatible. Because of this, all laboratories should participate in appropriate intercalibration exercises.

## 8.2 Flow measurement

Assessment of the pollution load in coastal waters requires adequate estimates of pollution concentration and flow of effluents. of great importance are variations in flow and concentration over periods of time. For rivers, the monthly variation is often of significance, whereas for sewers daily variations must be considered.

Flow estimation techniques may vary greatly depending on type of flow and effluent, and the degree of accuracy required may also be crucial.

River flow estimates may be made according to one of the following principles:

- (1) Use of existing hydrological data established by other specialized groups.
- (2) Establishment of representative cross-section flow-rate profiles in amounts that take adequate account of seasonal flow variations. Plotting speed data (m/s) against area ( $m^2$ ) will determine the flow directly by simple graphical integration.

Ultimately, this approach implies only an average speed of flow (m/s) and multiplication by the cross-section of the river ( $m^2$ ). A crude estimate of speed may be established by drogoue or float drift time over a known distance.

- (3) Tracer methodologies using dilution of known amounts (or flows) of an artificially added tracer. Local aims and circumstances are important in choosing a feasible and efficient strategy. A number of references are available for different tracer applications.

It should be recognized that river flow measurement is a comprehensive and resource-demanding exercise that should normally be carried out by people with training in hydrology and hydraulics.

Sewage flow estimates are made differently, depending on type of flow. For pressure lines, two principal methods are recommended.

- (1) Use of existing calibration curves (e.g. delivery test documents) for already installed pumps and thus utilizing the power consumption of the pumps involved to estimate flow.
- (2) Use of tracer methodologies, the particular choice depending on local aims and means.

For open channels or free flow surface sewers, the method would be as follows:

- (1) Use of existing weirs or flumes; very often this procedure is a questionable one because of poor maintenance of the level meters involved, or because of clogging and other disturbances, particularly where raw sewage is involved.
- (2) Estimates of speed of flow, for example, by a float whose travel time over a known distance (e.g. between two manholes) is determined. Speed of flow may also be gauged by wet cross-section.
- (3) Use of tracer methodologies.

## 9. REFERENCES

- APHA (1990). *Standard methods for the examination of water and wastewater*, 17th edition American Public Health Association, Washington~
- CURI, K. and ECKENFELDER, W.W. Jr. (1980). *Theory and practice of biological wastewater treatment*. Sighoff and Noordhoff, Maryland.
- DUCE, R.A. *et al.* (1976). Transport Paths. In Goldberg E.D. (ed.) *Strategies for Marine Pollution Monitoring*. John Wiley and Sons, Inc., New York.
- EPA (1973). *Handbook of Monitoring Industrial Wastewater*. U.S. Environmental Protection Agency, Technology Transfer Series, Tennessee.
- EPA (1978). *Microbiological Manual*. U.S. Environmental Protection Agency, Ohio.
- FAO (1971). *Report of Seminar on Methods of Detection Measurements and Monitoring of pollutants in the Marine Environment*. FAO Fisheries Report No.99, Supplements, FAO, Rome.
- LINSLEY, R. K. (1964). *Water Resources Engineering*. McGraw-Hill Book Company Inc., New York.
- MANCY, K.H. and ALLEN, H.E. (1978). Design of Measurement Systems and Environmental Sampling, Sample Preservation and in-situ Measurements, Course 1. *Modern Environmental Analysis Methods*. Middle East Technical University, Ankara.
- PRICE, D.H.A. (1975). The Development of a Harmonized Monitoring Programme for Rivers in the United Kingdom. *Progress in Water Technology*, 7(2): 35-46.
- SCEP.(1970). *Man's Impact on the Global Environment*. MIT Press, Cambridge, Massachusetts.
- UNEP/WHO (1987). *Guidelines for Monitoring the Quality of Coastal Recreational and Shellfish Areas*. Reference Methods for Marine Pollution Studies No. 1, Rev.1. United Nations Environment Programme. Nairobi.
- USEPA (1973). *Handbook of monitoring industrial wastewater*. Technology Transfer Series, US Environmental Protection Agency, Tennessee.

USEPA (1978). *Microbiological Manual*. US Environmental Protection Agency, Cincinnati, Ohio.

WHO/UNEP (1977). *Guidelines for Health-related Monitoring of Coastal Water Quality*. Document ICP/RCE 206(4), World Health Organization, Regional Office for Europe, Copenhagen.

WILSON, A.L. (1978). Design of Sampling Programmes in Environmental Sampling, Sample Preservation and in-situ Measurements Course. *Modern Environmental Analysis Methods*. Middle East Technical University, Ankara.