



Caspian Environment Programme  
Phase 2

# A Water Quality Monitoring System for the Caspian Sea

December 2001

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## Summary

This report suggests how a water quality monitoring system for the Caspian Sea – Caspian Environment Programme, the Caspian Monitoring Programme (CMP), should be designed. Suggestions are given as to (1) how responsibilities should be shared, (2) which monitoring strategies to use, (3) how the data quality should be ensured and (4) how and which data should be shared and stored in the database.

The report contains rather detailed suggestions on how the CMP should be constructed, and gives a background on the actual design process for monitoring programmes. Utilising the suggested monitoring activities, the CMP will be able to disseminate information to the relevant authorities on:

- The development of the environmental situation in the Caspian Sea
- The main causes for the existing problems
- Trends in pollution and pollution effects
- The situation at the most polluted sites
- The effects of measures being taken to reduce pollution
- Compliance with allowable discharges

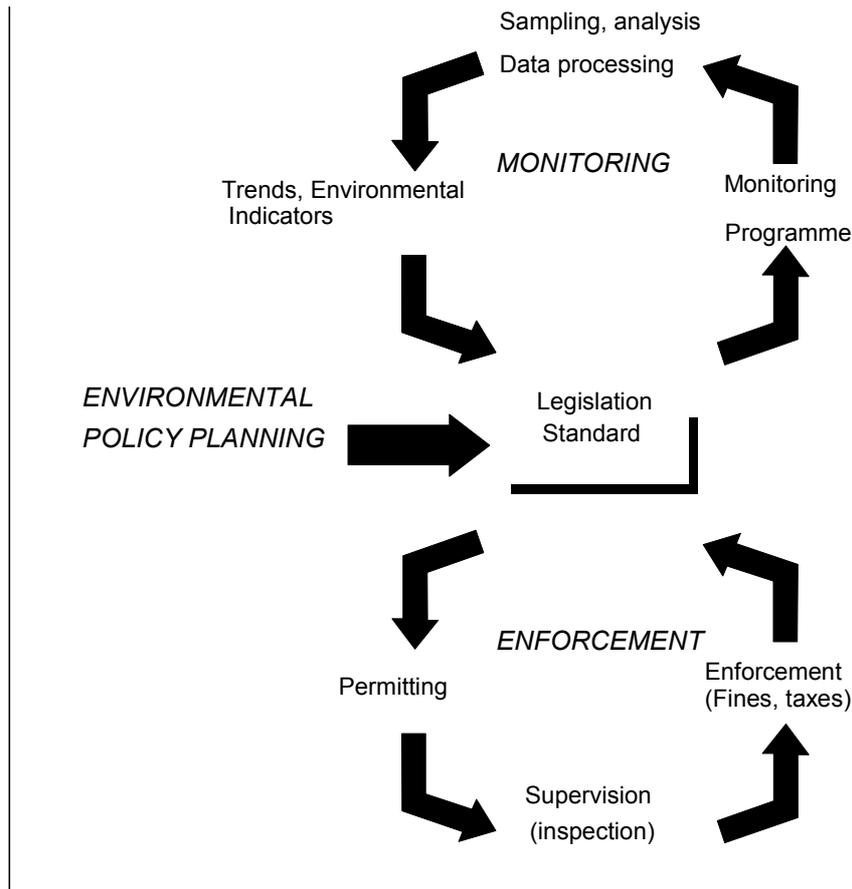
The suggestion builds very much on co-operation between the littoral countries, and it should be emphasised that the success of the monitoring will depend much upon this co-operation.

It is important to point out, though, that before the monitoring activities can begin, the capacity of the laboratories involved must be improved, to ensure that the data produced is of the required quality. Data that does not meet quality requirements is of little use for evaluation of the state of the environment, and will only cause confusion if published. The necessary upgrading of the laboratories involved has been suggested in a separate report (Building a Reference Laboratory Structure for the Caspian Environment Programme).

# Chapter 1. The Role of Monitoring

As the terms monitoring, control, supervision, inspection and enforcement are used in many different ways within the environmental sector, this introduction provides a general framework for this component of the project. A monitoring and enforcement system is outlined in figure 1.

**Figure 1 Outline of the Enforcement/monitoring System**



The enforcement of the system ensures that the laws, standards and norms set for the environment are complied with by the users of the environment (industry, agriculture, private persons, etc.). The government may promote public awareness and expectations, industry self-regulation and economic incentives for the public and for industry. However, measures to enforce general compliance with their laws are necessary; a systematic and effective regulation system must be adhered to. The government jeopardises its own credibility and the validity of the laws if enforcement is not implemented.

The enforcement cycle includes:

- Legislation and development of standards, norms, guidelines, etc.
- Permitting/licensing of the use of the environment (e.g. fishing and waste water permits).

- Supervision (inspection and control). The inspection carried out for discharge permits involves, by nature, source monitoring (emission monitoring/ pollution load monitoring).
- Enforcement. These are often charges, taxes, fines or fees. Other means are negotiation, legal action and compliance promotion.

The elements of the enforcement cycle are interdependent. A continuous evaluation of the elements must be fed back to the policy makers as shown in figure 1 (Environmental Policy Planning).

There is a trend towards using “integrated enforcement” for industries/companies where the permit becomes a “license to operate”. The permits in integrated enforcement contain several or all sectors: water extraction/use, wastewater discharge, air pollution emission, solid waste handling permits, noise permits etc. There are several benefits in this approach. Pollution loads will not be moved between sectors in an uncontrolled way. The permit holder has only one permit to consider, reducing the number of visits from inspectors and the necessary paper work. Overall, integrated enforcement will promote the use of cleaner technology.

The “polluter pays” principle and the related “user pays” principle state that the polluter or user of natural resources should pay for the cost of maintaining the resources or repairing the damage, usually through a fee or levy paid to the government. These fees offer financial incentives to polluters and users of natural resources to reduce pollution and make more efficient use of the resources. The fees can also provide required revenues to water management authorities for maintenance and investment.

The monitoring part of the system in figure 1 is the tool of society / the government to verify whether laws, standards etc. have the planned effects. This monitoring will often be ambient monitoring like monitoring of the quality of air, surface water, groundwater etc. The monitoring may also be transport control, e.g. monitoring of pollution loads to the Caspian Sea.

The monitoring cycle includes:

- Legislation and development of standards, norms, guidelines, etc.
- Monitoring programme. Definition of a monitoring programme that will supply the data and information necessary to verify if the intentions of the laws are met.
- Implementation of the monitoring programme. Sampling, analysis and processing the results obtained.
- Assessment of the results. Environmental indicators, time series, analysis and evaluation of trends and reasons for these.

The elements of the monitoring cycle are also interdependent. A continuous evaluation of the elements must be fed back to the policy makers as shown in figure 1.

## Chapter 2. Water Quality Monitoring Strategies.

Several different approaches towards the monitoring of water quality can be employed. The choice of strategy depends entirely on the goals set up for the monitoring programme, which in turn depends on the decision support information needed by the relevant authorities. An overview of various monitoring strategies, their goals and general implications for the character of the monitoring activities is given in Table 1.

**Table 1: Typical Objectives and Characteristics of Monitoring Activities.**

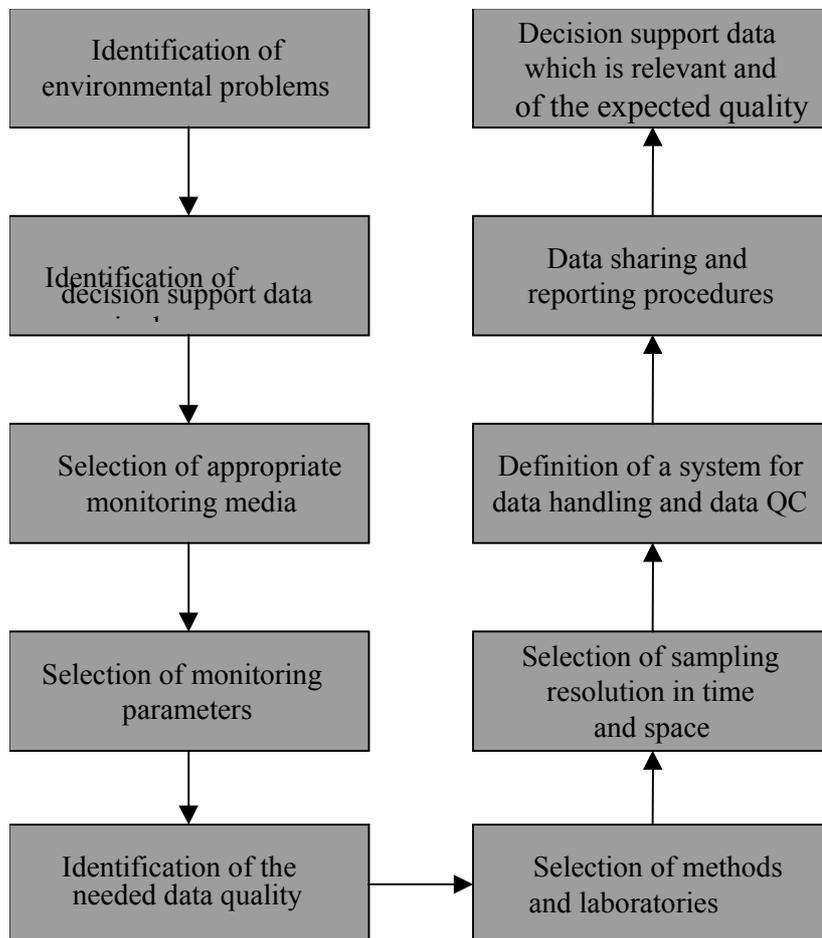
Type of monitoring	Focus	Station density and location	Sampling frequency	Number of variables	Duration
Multipurpose monitoring	Space and time distribution of water quality in general	Medium	Medium (12 per year)	Medium	Medium (> 5 years)
Background monitoring	Level of natural water quality	Low	Low (< 6 per year)	Low to high	Variable
Trend monitoring	Long-term evolution of concentrations and loads	Low: major uses and boundaries	High (> 18 per year)	Low for single objective High for multi objectives	Long (> 10 years)
Compliance monitoring	Industrial pollution output	At the industrial outlet	High	Specific for each industry	Continuous
Input monitoring	Pollution input from point sources	River mouths, industrial sites	High enough to resolve seasonal variations	High	Long
Impact surveys	Effects of pollution sources on WQ	Limited to the pollution sources	Medium	Specific (according to source)	Variable
Operational surveillance	WQ for specific uses	Low: at specific sites	Medium	Specific	Variable
Modelling survey	Collection of data for water quality model	Specific	High	Low	Short: calibration and verification
Early warning	Protect critical water use locations such as drinking water intake	Very limited	Continuous	Very limited	Unlimited

The table has been used as reference when outlining the different types of future monitoring activities within the CMP. It should be noted from the table that, depending on the type of information needed, the different monitoring strategies will result in widely different sampling frequencies, station densities and number of variables measured.

## Chapter 3. The Design Process for Water Quality Monitoring Programmes

The first, and most important, step when designing a monitoring programme must be to define the purpose of the monitoring activities. Only by making very clear what kind of problems are encountered in the environment to be monitored, and what kind of information is needed as support for political decisions, will it be possible to design a monitoring programme which is fit for the purpose. By defining the goals of the monitoring, it will be possible to understand more exactly what is needed in terms of sampling frequency, parameter choice, laboratory capacity, reporting requirements, and other critical issues in the gathering of useful information. The process for the design of a monitoring programme is described as a step-by-step overview in Figure 2.

**Figure 2. The Step-by-Step Approach Towards Monitoring Programme Design**



In reality, historical reasons and practical or economic restraints tend to govern the design of many monitoring programmes, which will produce data and information less fit for the purpose. Few ideal monitoring programmes exist, but by following this step-by-step approach in the design process, it will be possible to avoid wasting time and money on producing data which has no value for the decision-makers. The next chapter will be devoted to discussing the different steps in the process, and to see how it can be used in a practical way in the

design of a suitable monitoring programme for the Caspian Sea – the CMP. Many suggestions and conclusions in this report draw upon the data gathered and reported during earlier and current phases of the CCPC work.

The processes for building a laboratory structure capable of producing data of known and expected quality is described elsewhere, and will only be touched upon very briefly in this report (Building a Reference Laboratory Structure for the Caspian Environment Programme, CCPC, November 2001). That report also contains discussions on the choice of monitoring parameters that have been used as a background for this report.

## Chapter 4. A Step-wise Approach

### 4.1. Identification of Environmental Problems

The main problems concerning the water quality of the Caspian Sea have been identified as being:

- The effects of eutrophication
- High levels of oil related pollution
- Anthropogenic organic and inorganic pollutants in water, sediment and biota

This has been outlined and discussed in detail in the specific CCPC country reports, where more exact information on pollution sources and problems can be found.

### 4.2. Identification of Decision Support Data Required

*To study eutrophication, its sources and effects, the following is needed:*

- Long term trend data for nutrient concentrations in the open sea
- Data on the annual cycle for nutrient fluctuations in the open sea
- Data on nutrient input from rivers and other point sources, and the availability of nutrients in sediments
- Mapping of dissolved oxygen conditions in the bottom water and sediments of the coastal areas
- Biological effects monitoring to identify ecological disturbances

*To study the effects of pollution from oil related activities, the following data is needed:*

- Trend data from the open sea
- Hot spot data to identify and monitor inputs and very contaminated sites
- Biological effects and toxicity studies, to identify ecological disturbances

*To study contamination by man-made pollutants, the following is needed:*

- Data on the concentrations of organic pollutants and heavy metals, both at contaminated sites and at remote areas.
- Monitoring of inputs from point sources and non-point sources (e.g. atmospheric input)
- Long-term trend monitoring of these pollutants at selected sites
- Toxicity tests at contaminated sites

In addition, the use of water quality objectives may require other measurements to be carried out, if the monitoring activities are to provide enough information to judge if the objectives have been met.

### 4.3. Selection of Appropriate Monitoring Media

Generally, three principal media can be used for monitoring an aquatic system: water, particulate matter/sediments and living organisms. Each medium has its own set of characteristics for monitoring purposes, such as

- applicability to water bodies,
- specificity to given pollutants,
- possibility of quantification such as flux determination,
- sensitivity to pollution, and
- time-integration of the information received (ranging from instantaneous for water samples to integrate for biotic samples).

Water is by far the most common monitoring medium used to date (including in the current CEP activities). The main reason for this is that water samples are comparatively easy and cheap to sample and to analyse (given the necessary equipment and analytical reagents are available) with standardised methods, and easy to compare to water quality objectives, which are usually defined as concentrations in water samples. However, for many substances such as hydrophobic organic micro-pollutants and certain heavy metals, water is not the most appropriate medium to monitor because the water-solubility of these substances is very low and hence they concentrate in particulate matter and biota. In water containing suspended solids at concentration ranges of 10-100 mg/l (a range found in rivers or near coasts), the suspended fraction typically accounts for more than 50% for many pesticides. For metals such as Pb, Cr, Fe, Zn, Al and Hg the fraction carried by particulate matter can be more than 99%. Another obstacle is that it is very easy to contaminate water samples with metals by using inadequate sampling equipment or sample handling procedures. Also, the analytical detection limit for some of the substances is of the same order as the water quality requirements for various uses, and it will thus be virtually impossible to carry out the measurements other than at highly specialised laboratories with specifically designed facilities (clean rooms etc.).

For these reasons many of the 'Not Detectable' or very low values of these substances reported in monitoring data in various programmes may not be a representation of the true presence or absence of the substances, but rather a reflection of an inappropriate medium being monitored. Unfiltered samples are analysed, but the sensitivity of monitoring would be highly increased by analysing particulate matter or biological material.

So far, in the Caspian Sea area there has been little experience of monitoring other than water phase monitoring, but it is recommended to introduce monitoring of particulate matter, sediments and biota (including bioassays/toxicity tests) on a more regular basis. Some laboratories are monitoring sediments and biota to some degree already, but there is certainly no overall CEP strategy behind these activities.

The suggested monitoring media are thus:

Pristine river water - for background monitoring of certain parameters, thus giving a picture of the natural backgrounds of certain fresh water input components.

Water (wastewater, sewage water, river water) - for eutrophication studies (input of nutrients, dissolved oxygen, organic matter etc.), for input of toxic oil components and for toxicity and microbiological tests at contaminated sites. Specific input studies might have to be introduced at industrial sites, depending on the nature of the expected local contamination sources.

Water (near coastal and open sea) - for eutrophication studies (nutrients, dissolved oxygen, organic matter etc.) and for overall trends in toxic oil components.\_

Particulate matter (river water) – for input of trace elements (metals) and organic contaminants (pesticides, PCBs, DDT etc.).

Sediments – for eutrophication studies (nutrient content, dissolved oxygen) and for trace elements (metals), organic contaminants (pesticides, PCBs, DDT etc.) and toxicity tests (bioassays).

Biota – for trace elements (heavy metals) and organic contaminants (pesticides, PCBs, DDT etc.).

As pointed out in the laboratory report, there is a need for a pilot project to determine more exactly the extent and design of the monitoring of organic and inorganic contaminants in sediment and biota before the final decision on the monitoring programme is taken.

#### **4.4. Selection of Monitoring Parameters**

A list of appropriate monitoring parameters in the selected media is given in Annex A. The contents of the list are complemented by the list of priority pollutants given in a separate report (Development of a priority list of chemical pollutants, CCPC), which is why the list is less detailed for organic and inorganic pollutants.

The choice of parameters is a direct result of the identification of the above information , and of the above discussion on appropriate monitoring media.

#### **4.5. Identification of the Required Data Quality**

Before choosing analytical methods and laboratories for the monitoring work, it has to be made clear what data quality will be necessary for the programme. The necessary data quality depends on the following aspects:

- In trend monitoring, how small concentration trends do we want to be able to detect, and over what time interval? Analytical methods have to be much more precise in order to detect a 5% per year trend in 3 years than if you want to see a

25% per year trend in 5 years, given that you work with the same sampling frequency and station density.

- How often can we sample? Lower sampling frequency demands better analytical precision.
- How many samples do we take? Naturally, taking many samples can compensate for an analytical method where the precision is not as good as expected.

This gives rise to several interesting questions that have to be considered:

- What are the laboratories capable of, in terms of analytical quality?
- How much will sampling and sample handling affect the data quality?
- Which methods will give the expected quality? Often a better method is much more expensive or demands the purchase of new equipment.
- Can we compensate for poor data quality by increasing the sampling frequency or using a denser sampling station net? Or is it cheaper to buy new instruments and not have to take so many samples?

Experience shows the following:

- Laboratories that are equipped with the correct equipment, good facilities and trained staff, will be able to reach a similar and expected analytical data quality. We can thus estimate the expected data quality simply by looking at the laboratory resources.
- Reaching a better-than-expected data quality takes a long time, and is often a very costly process. It may thus be wiser to increase the sampling frequency if the data is not good enough.
- Errors in the sampling and sample handling, as well as natural variations in the sea, contribute to the unreliability of much of the total data for most parameters. It is thus very important to design a proper sampling strategy, and to use quality assured and quality controlled sampling and sample handling techniques, in order to reach the required data quality. This is often the best way of improving data quality.

The approximate feasible data quality for the parameters in this monitoring programme is given in Annex B. Please note that this is the expected data quality after the laboratories have been equipped in accordance with the suggestions given in the laboratory report, and after the reference laboratory structure has become functional. A similar scheme should be used by the Reference Laboratory for general QA/QC of the CEP as a performance requirement for the laboratories taking part in the CEP monitoring. Such a table can then be used as a quality requirement for laboratories in the CEP, thus providing the background for regular laboratory evaluations.

For reasons given above, this will be the data quality expected for the monitoring programme, and it will thus be used as background for setting up an appropriate sampling

strategy. It is not expected that time and resources will be spent on improving the laboratory performance far beyond this expected quality level, as that will be a difficult, expensive and complicated task.

#### **4.6. Selection of Methods and Laboratories**

The Reference Laboratory report lists equipment that should be purchased by laboratories involved in the monitoring programme. Some laboratories should mainly be equipped with so called test kit methods, while others, notably those performing open sea monitoring, need more advanced equipment. The laboratories using the test kits will, for those analyses, use the methods recommended by the manufacturer. For all other methods, and for all other laboratories, international standard methods have to be employed. These methods, which are either ISO (International Standardisation Organization) or EN (European Norm) standards, take advantage of the most recent and widely accepted methods for sampling and analysis. There is also a range of such standards for statistical calculations, the Quality work and other important steps. The suggested analytical methods are listed in the Reference Laboratory report.

The use of these international standards will also give the data produced in the Caspian monitoring a better international reputation. It will undoubtedly lead to a better comparability between this data and data produced in other monitoring programmes of similar nature (for example the monitoring of the Black Sea, the Baltic Sea and the Mediterranean).

The candidate laboratories for use in the monitoring have been scrutinised in some detail in the laboratory report, and based upon that investigation a suggestion has been made as to which responsibilities each laboratory should shoulder. The first draft of that suggestion has been circulated to the national focal points in the countries involved, and has been amended in the light of new information as a result of this.

#### **4.7. Selection of Sampling Resolution in Time and Space**

The selection of different sampling strategies has already been discussed in Chapter 1, and the choices made here are based on that discussion. In choosing sampling frequency we also have to assume that the laboratories will be capable of reaching the permissible performance as outlined in paragraph 3.5, and we have to take into account which goals were set for the monitoring in paragraph 3.2. We will, of course, also have to take into account the hydrographic conditions of the Caspian Sea, as turnover times, circulation patterns and known annual cycles will govern the needed resolution.

The suggested resolutions are:

Type of monitoring	Water	Where?	Frequency	Comments
Background river	X	At major rivers, as far upstream as possible	2 times/year	
Input	X	At all spots identified as problems in the national reports	24 times/year	
Open sea	X	One sampling station per basin	18 times/year	For annual cycles and long term trends
Near coastal/open sea	X	Dense network, mainly covering the shelves	Summer and winter	To map oxygen and nutrient conditions
Sediments		Both close to contaminated sites and background in the open sea	Every 3-5 years	To monitor long term trends of contaminants
Sediments		At contaminated sites	Once every year	For toxicity tests only
Biota		Both close to contaminated sites and background in the open sea	Once every year	To monitor long term trends of contaminants

The suggestion is outlined in much more detail, including suggested sampling stations and responsibilities, in Annex C.

#### 4.8. A System for Data Handling and Data Quality Control

It is extremely important that the data produced is handled in a quality assured way, in order to ensure that:

- No data leaves the laboratories without being quality controlled
- All data produced can be found when needed
- Data from different data producers is merged into one data set
- The data is stored in a safe way

Therefore the following is suggested:

- All data produced in the water quality monitoring must be reported to the database at CCPC in Baku.

- CCPC is responsible for maintaining a suitable database, capable of storing all produced data together with metadata, analytical quality data and quality flags (see Annex D)
- CCPC is responsible for storing all data in a quality controlled way, and is also responsible for the data being available to all relevant authorities and other data users.
- The data reported has to be quality controlled and quality flagged by the data producer before it is submitted (see Annex D)
- Data from the water phase should be reported annually, on an agreed format, directly by the institution producing the data (i.e. not on a national basis) to CCPC. The deadline for reporting last year's data should be 15 March the following year.
- Data from the sediment and biota monitoring campaigns (those measurements which are not carried out annually) is reported as soon as the samples have been analysed and the data has been quality controlled.
- The system used by ICES for data reporting should be used as a model when developing a common data reporting format and data reporting routines for the CMP.

#### **4.9. Data Sharing and Reporting Procedures**

In order to make the information handling as efficient and practical as possible, the involved parties have to agree on the following:

- All data is submitted at the agreed intervals to the CEP database at the CCPC
- The data is reported electronically, in a standardised and agreed format facilitating the rapid and safe inclusion of the data into the database.
- All parties have access to all data in the database.
- An annual report on the conditions of the Caspian Sea is produced, and should be published no later than 30 June the next year.
- The contents of the annual report will be a formal and standardised report, showing trends and developments, supplemented by articles on subjects of special interest. The suggested contents of the annual report are given in Annex E.
- CCPC in Baku takes the leading role in producing the annual report, supported by all data providers.

#### **4.10. Decision Support Data Relevant and of the Required Quality**

Once all the outlined steps of the procedure for designing a monitoring system have been carefully reviewed and agreed upon, the data and the reports produced should be able to satisfy the needs of the authorities. It has to be kept in mind, though, that there must be a

system for feed-back to ensure that the data quality will be reviewed, a) on a regular basis, and b) as a result of e.g. changes in legislation. It should also be noted that it will be of increasing interest to check over time that the monitoring programme fulfils the requirements set out by directive 2000/60/EC of the European Parliament, the Water Framework Directive. This directive, together with underlying documents, will form the development of water quality monitoring in Europe during the next decades.

## **Chapter 5. Monitoring of Wastewater Discharged from Municipal Treatment Plants**

An appropriate monitoring programme for wastewater discharged from municipal WWTP's will vary according to the purpose of the monitoring activity. In the following, the programme is seen as a means of controlling effluent standards, and for collection of data to assess of the effect of the pollution load on the ecological system.

First of all it is recommended that considerable effort be put into the improvement of flow measurement and sampling procedures. At present, data on flows at wastewater treatment plants (WWTP's) are based on rough estimates from visual inspection of flow velocities or from pump characteristics, and sampling appears to be based on grab sampling only. This practice results in highly unreliable data on flow and loads of pollutants. It is recommended that continuous flow measurement is implemented on all treatment plants. Furthermore it is recommended that time proportional sampling is introduced at smaller treatment plants (less than 100,000 PE) and flow proportional measurement is applied at larger plants.

In general, the list of parameters for analysis should be based on the list of parameters of the effluent standards. The effluent standards should reflect the treatment level applied, i.e. the list of parameters would be extended in case of a more advanced treatment process in comparison to a less advanced process.

The sampling and analysis frequency should reflect both possible requirements with respect to legislation and to the size of the treatment plant in question, i.e. the larger the plant, the higher the sampling frequency.

Finally, the list of parameters and the frequency of analysis should take into account the resources available in the country.

On this basis the following sampling and analysis programme is suggested as a first step to improve the possibilities of enforcing effluent standards and to obtain appropriate data for assessments of pollution loads to the receiving waters (Table 5.1 and Table 5.2).

**Table 5.1 Suggested Sampling and Analysis Programme for Wastewater Effluent at Municipal Treatment Plants.**

Parameter	M <sup>1</sup>	MB/MBN/ MBNP <sup>1</sup>
Flow	X	X
COD	X	X
BOD	X	X
SS	X	X
TN	X	X
NH <sub>4</sub> -N		X
NO <sub>3</sub> -N		X
TP	X	X

<sup>1</sup> Wastewater Treatment Methods: M = Mechanical, B = Biological, N = Nitrogen removal and P = Phosphorus removal.

**Table 5.2 Suggested Frequency of Sampling and Analysis in Relation to WWTP size**

WWTP size (p.e.)	Sampling and analysis frequency	Sampling method
< 10,000	4	Time proportional
10,000 – 100,000	12	Time proportional
> 100,000	24	Flow proportional

In case of effluent standards that relate to the percentage of reduction by the treatment process, the sampling and analysis programme should include the influent wastewater as well. Samples of influent wastewater should be taken after screening but upstream any internal recirculated streams.

### 5.1. EU Standards (BOD, N and P-removal)

The EU standards for discharge of municipal wastewater to sensitive recipients is shown as an example in table 5.3. These standards are used in the EU for discharges above 10,000 p.e. It requires mechanical and biological treatment with N and P removal.

**Table 5.3 EU effluent Standards for Discharge of Municipal Wastewater to Sensitive Recipients**

<b>Parameter</b>	<b>10,000- 100,000 p.e.</b>	<b>More than 100,000 p.e.</b>
BOD <sub>5</sub> (mg/l)	25	25
Total-N (mg/l)	15	10
Total-P (mg/l)	2.0	1.5

## Chapter 6. Monitoring of Industrial Wastewater

The existing programme of monitoring industries includes only discrete sampling and often without flow measurements. It is suggested that the future monitoring will be based on statistical control of compliance with emission limit values as described below. The parameters to be monitored are given in Annex A.

It is suggested that emission limits shall be established on a concentration or a toxicity that must not be exceeded. The monitoring may be conducted by either the industry itself or by some external controlling body or laboratory. However, the concentrations of chemicals as well as the composition and toxicity of the wastewater will almost never be constant but will vary over time as a result of variations in the production processes and the function of any treatment systems. It is therefore impossible to document compliance with emission limits without taking and analysing a very large number of wastewater samples. To avoid that, statistical methods should be employed both for the emission limit stated in the permit and for the compliance monitoring.

Two types of statistical control methods are applicable:

1. Transport Control is used when the total amount emitted, and not the momentary value measured in the discharged wastewater, is critical for the environmental risk. This may pertain to emission limits established with the aim of protecting against chronic and acute ecotoxic effects for specific chemicals (ELVs calculated as the total daily amount or the daily amount divided by the average water flow of the discharge). However, it could also pertain to emission limits for nutrients, BOD or COD, or the total volume of wastewater. In these cases, daily average values should be stated in the permit and the monitoring should be designed to check compliance with this requirement.
  - When emissions are monitored against emission limits for chronic ecotoxicity, BOD, nutrient etc., it applied to the average amount of the discharge within the control period and not for a specific critical fraction. If the variation in the daily discharge is small, then the average value will be close to the 50-percentile. However, the difference between the average value and the 50-percentile grows with increasing variation and the control becomes a control with a critical fraction above 50%.
  - When emissions are monitored against limits for acute ecotoxicity the permit should state a percentage of between 5-20% of the period when the emission limit may be exceeded. This percentage of time is also called the critical fraction. It could, for example, be permissible to exceed ELVs for acute effects for 10% of the time. In addition, a requirement of an absolute maximum could be stated, that must never be exceeded.
2. Condition Control is used when a momentary value as measured in the effluent of an industry or an STP is critical to the environmental risk. This could be for ecotoxicity of the whole discharge (ETLs expressed in concentrations) or for specific requirements regarding temperature or pH. The emission limit should be established with a value,

which must not be exceeded in more than a certain percentage of the control period (e.g. 20%). This could be combined with the stipulation of an absolute maximum, which must never be exceeded in any of the samples measured.

When the emission limit and the critical fraction have been established in the permit, the compliance can be documented by calculating the Control Value C. It is a requirement that the samples are 24-hour flow-proportional samples and that the data set comprises at least 6 samples and measurements. Daily pollutant discharges are often found to be log-normally distributed (DS 2399). When this is the case C is estimated by the equation below:

$$\ln C = \alpha + k_n \cdot \beta$$

$\alpha$  is the average of the natural logarithm to the measured values or amount and  $\beta$  is the corresponding standard deviation.  $k_n$  is an adjustment factor, which is calculated by the equations given in the box below. These equations pertain to a situation where the emission limit is given as either a daily amount or a daily amount divided with the average flow (Transport Control) or a value (Condition Control).

The emission complies with the demands in the permit if the Control Value C is lower than or equal to the emission limit value. The permit is violated if C is greater than the emission limit. The statistical control procedure presented here ensures that a discharge will always obtain the same likelihood of acceptance (95%) regardless of the number of samples ( $\geq 6$ ).

**Box.** The equations below are used for statistical compliance control (DS 2399):

$$k_n = \frac{t_0}{\sqrt{N}}$$

$$t_0 = \frac{\sqrt{E} - B}{2 \cdot A}$$

$$A = \frac{1.6449^2}{2 \cdot (N - 1)} - \left(1 - \frac{1}{4 \cdot (N - 1)}\right)^2$$

$$B = -2 \cdot \delta \cdot \left(1 - \frac{1}{4 \cdot (N - 1)}\right)$$

$$D = 1.6449^2 - \delta^2$$

$$E = B^2 - 4 \cdot A \cdot D$$

$$\delta = -\sqrt{N} \cdot \frac{\beta}{2} \text{ (for Transport Control of e.g. chronic ecotoxicity, BOD, nutrients)}$$

$$\delta = -\sqrt{N} \cdot U_{1-p} \text{ (for Transport Control of acute ecotoxicity and Condition Control)}$$

N is the number of samples and measurements.

$U_{1-p}$  is the percentile in the normal distribution, and p is the critical fraction (e.g. if p = 20% then  $U_{1-0.20}$  is 0.8416).

The permit should include the emission limits, a description of the methods that must be used for control of compliance, including number and frequency of samples, sampling station, sampling method, period of sampling (control period), method for chemical analysis or ecotoxicity test, statistical method, and critical fraction.

The control period will often be one year, but a shorter period, e.g. 3 months, may also be chosen. The control period must be chosen on the basis of the specific condition and variability of the discharge under scrutiny. All measured values or amounts for the emission within the control period are used in calculation of the C-value. When performing the Transport Control, the daily flow -weighted amount of an emission is calculated using:

$$Y_i = \frac{C_i \cdot V_i}{V_m},$$

$C_i$  is the concentration day  $i$  (e.g. mg/L)

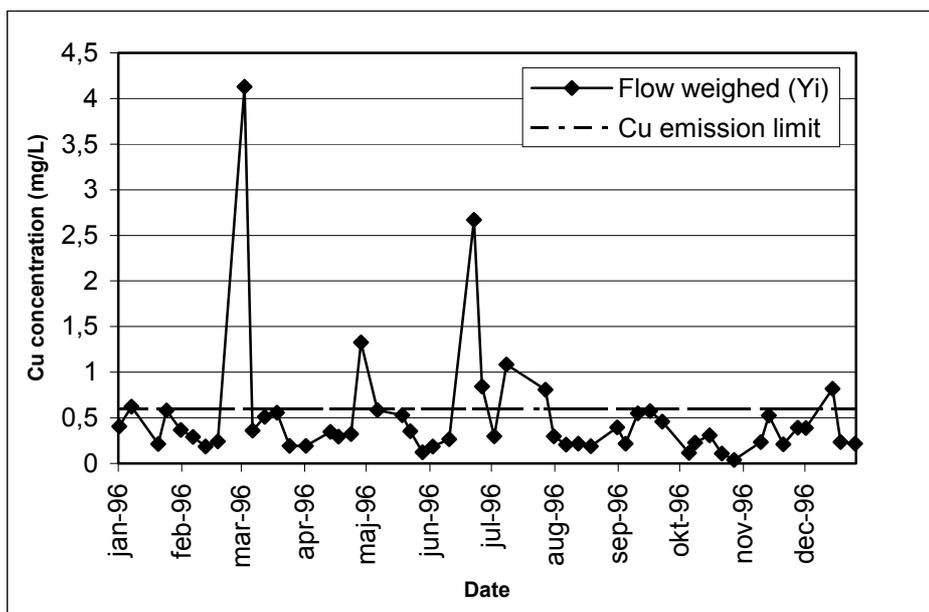
$V_i$  is the flow rate day  $i$  (L/day)

$V_m$  is the average flow rate in the control period (L/day)

### Example: Industrial Discharge

An industry discharges copper (Cu) into a bay. The permitting authority has set an ELV based on the average dilution of the discharge in the bay at the impact zone boundary, the WQS of Cu and the background concentration in the receiving water. The ELV for protection against chronic effects was set to 0.6 mg/L of Cu at the sampling point. Additionally, an absolute maximum was set to 6 mg/L. A 24- hour sample was taken once a week during the year 1996. The flow rate was measured at the sampling point and the concentration of Cu analysed in each sample. The calculated daily flow weighted amount of copper in the effluent samples is seen in Figure 6.1.

**Figure 6.1 Daily flow weighted amount of copper discharged from an industry**



The data in Figure 6.1 shows that the flow weighed concentration never exceeded the maximum at 6 mg/L. Application of Transport Control on the data gave:

$$k_n = 0.158$$

$$C = 0.40$$

The Control Value C was found to be less than the emission limit at 0.6 mg/L. Consequently it was concluded that the permit was not violated.

## **Chapter 7. Institutional Arrangements for the Caspian Monitoring Programme (CMP)**

### **7.1. Before Monitoring Starts**

As pointed out clearly in the Reference Laboratory Report, most of the laboratories that will be involved in the monitoring suffer from a lack of quality assurance and quality control procedures (QA/QC), equipment and knowledge in the most modern analytical techniques. It will thus be absolutely necessary to start the process of upgrading the laboratories and training the staff before the actual monitoring programme is finalised. The laboratory upgrading is almost certainly too expensive to be dealt with as one single project, and thus has to be divided into several smaller steps where donors can be found, for example:

- i) education in QA/QC and start-up of reference laboratory activities
- ii) upgrading of the equipment at the reference laboratories
- iii) one laboratory upgrading project per country
- iv) implementation of reference laboratory activities at all levels

It would be a waste of time and resources to start up any new monitoring activities before at least the first two steps above have been finalised. Otherwise the result will be useless or, at best, vaguely useful data.

### **7.2. Institutional Arrangements**

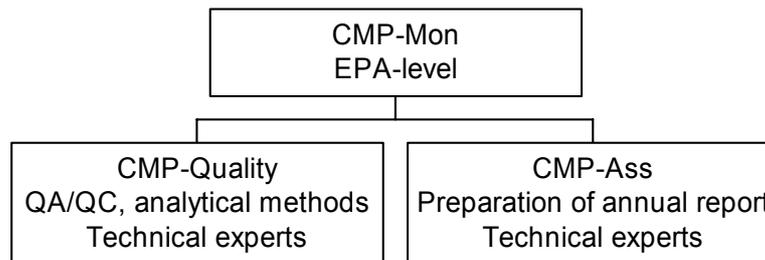
The set up and maintenance of a monitoring programme of this size and ambition will naturally require both time and resources from the countries involved. Most of all it will require an openness and a willingness to co-operate, both within and between the countries. The openness is necessary because the programme cannot exist as suggested if the involved parties are not willing to share all data and all facts about the data, and if they are not willing to discuss problems or obstacles, such as lack of funding or poor data quality. Co-operation is needed because all involved countries have to take responsibility for their own share of the monitoring, and the programme will suffer if any party does not fulfil its obligations in connection with this.

The starting point for all involved countries will be to study the suggested monitoring programme, and the responsibilities they have been given. From this they will have to conclude how many resources will be needed to carry out their tasks and to which extent they can be carried out with the existing economic and technical resources available. There will also have to be domestic discussions on possible sources for the lacking resources covering such things as ship time or missing sampling equipment and similar.

The countries then have to form a group dedicated to working with monitoring issues, the CMP-Mon (under the CEP framework) and discuss the common goals and the results they want to see from the monitoring programme. The CMP-Mon must contain representatives from the respective organisations nationally responsible for the monitoring (e.g. the SCE:s or

EPA:s) and its members will be directly appointed by the ministries responsible. Normally, a meeting frequency of two times per year should be enough for this group.

Under the CMP-Mon work will involve two different groups of technical experts. CMP-Quality will consist of representatives of the Reference Laboratories, and will give advice and instruct on data quality issues, such as the choice of the correct analytical methods, the use of reference materials and similar. The CMP-Ass (Assessment) group will be responsible for the annual assessment of the state of the Caspian Sea, and for the preparation of the annual report. The two sub-groups will report their activities directly to CMP-Mon.



The exact monitoring responsibilities of each country have to be discussed by the CMP-Mon, using this report as starting material, and the countries should agree on the suggested structure, or try to formulate something similar which they all can agree upon. When the structure is agreed upon, the discussions can continue at a more detailed level. Two conclusions have to be drawn as soon as possible:

- i) How much of the suggested monitoring programme can be carried out with existing resources?
- ii) Is this good enough as a start, or will we have to look for more resources first?

Even if it is concluded that there are too few resources initially to make a useful start, then at least the discussion has started.

### 7.3. The Hunt for Resources

The next step will be to find resources for the different types of monitoring that is to be carried out within the CMP. Although the basic needs of the monitoring programme have to be covered by the involved countries in order to secure the continuity over time, it will undoubtedly be necessary to look for external resources to complement the national inputs, particularly in the initial phases. The sources are not necessarily the same for the various monitoring types.

The by far most efficient way of solving the problem of the costs of the extensive input monitoring (apart from the input from rivers) is to take advantage of the “polluter-pays” principle, as suggested in another report (Legal, regulatory and institutional measures for the protection and sustainable management of the Caspian Sea ecosystem in the riparian states). Thus all industries, communities and other dischargers pay for that monitoring, as it is also a part of the compliance monitoring. The very same data that is used for compliance

monitoring can be used for input monitoring as well, as the two monitoring types will overlap to a very large extent. As the input monitoring is an expensive part of the total monitoring, this will relieve the burden for the whole CMP.

Other monitoring will have to be funded from other sources. It cannot be expected that the governments of the involved countries will be able to find the necessary resources for the full programme, in particular since ship-borne sampling is a relatively expensive activity to carry out. Project proposals will thus have to be discussed and prepared, and possible donors contacted and informed about the progress of the work. For this reason there will be a need for close contacts between DOE representatives, scientists and consultants (through CMP-Mon), so that the appropriate project proposals can be written and submitted. The most probable donors include Tacis, UNDP and the World Bank. There is also the possibility to extend the “polluter-pays” principle to include the whole Caspian Sea, but it appears rather unclear whether this is a possible way forward.

Within the foreseeable future, the monitoring will thus almost certainly have to be carried out in the form of several time-limited projects, each taking over the tasks from the former project. To construct a suitable 3-year cycle for this purpose should pose no problem.

#### **7.4. The Commitment**

When funding has been found, at least for an appropriate part of the monitoring programme, it must be made very clear what the countries have committed themselves to. At the CMP-Mon, it should be made exactly clear what the countries have promised to deliver during the next year in terms of data. Any deviations from the agreed data collection should be reported to CMP-Mon as soon as possible, as there could be the possibility of asking someone else to take over the responsibility for a limited period of time.

It will also have to be made very clear to all countries that they must deliver the expected data, together with metadata and analytical quality data, according to the timetable. The database manager at the central database will also keep track of who is supposed to send in data, and when. It has to be pointed out, though, that it will be the responsibility of the relevant authorities in the respective countries to chase up missing data sets, not the responsibility of the database manager.

#### **7.5. Timetable and Involvement**

A draft task- and timetable for the start up of the new CMP is found in Annex F. In view of the number of tasks to be executed, the timetable spanning two years may appear to give too little time. Nevertheless, it is important to follow the time schedule as closely as possible, in order to produce results within the foreseeable future.

The process will require full co-operation between the countries, and it will require that the internal responsibilities within each country are made clear before the discussions start. It will also be necessary to involve potential donors as early as possible in the process. This may happen naturally, as the build-up of the laboratory capacity through the creation of a reference laboratory structure will have gone reasonably far ahead before the monitoring

programme can commence, as discussed above, and donors will thus be aware of the final goals of the laboratory capacity building. There will also be a need for involving foreign consultants, both as a link between the laboratory projects and the monitoring, but also to draw full benefit from experience in the similar monitoring programmes in, for example, the Baltic Sea, the North Sea and the Mediterranean Sea.

## References

Building a Reference Laboratory Structure for the Caspian Environment Programme, CCPC, November 2001

Development of priority list of chemical pollutants, CCPC, November 2001

COMBINE Manual for the monitoring of the Baltic Sea. Helsinki Commission, Helsinki, Finland ([www.helcom.fi](http://www.helcom.fi))

ICES, International Council for the Exploration of the Seas, Copenhagen, Denmark ([www.ices.dk](http://www.ices.dk))

ISO, International Standardisation Organization, Geneva, Switzerland ([www.iso.ch](http://www.iso.ch))

EN-norms are sold by national standardisation organisations in Europe, e.g. [www.ds.dk](http://www.ds.dk) or [www.sis.se](http://www.sis.se)

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, establishing a framework for Community action in the field of water policy

Legal, regulatory and institutional measures for the protection and sustainable management of the Caspian Sea ecosystem in the riparian states, Legal Centre, Moscow

## Appendix 1: Proposed List of Water Quality Variables to be Monitored in the CEP

Variable	Type of monitoring					Reference to international standard method
	Back-ground	Input monitoring (rivers, sewage water, industries)	Near coastal and ambient water (open sea)	Sediments and river-borne particulate material*	Biota	
<b>General:</b>						
Transparency			X			--
Temperature	X	X	X			--
pH	X	X	X			ISO 10523
Susp.Solids	X	X	X			ISO 11923
DO	X	X	X	X		ISO 5813, 5814
Conductivity	X	X				ISO 7888
Salinity			X			(Grasshoff*)
Total hardness	X					ISO 7980
Chlorophyll-a			X			DIN 38412-16
<b>Nutrients:</b>						
Ammonia	X	X	X			ISO 7150
Nitrate/nitrite	X	X	X			ISO 13395
Total nitrogen		X	X	X		ISO 11905
Phosphorus		X	X			ISO 6878, EN 1189
Total phosphorous		X	X	X		EN 1189
<b>Organic matter:</b>						
BOD <sub>5</sub>	X	X	X			EN 1899
COD <sub>Cr</sub>	X	X	X			ISO 6060
<b>Major ions:</b>						
(Na, K, Ca, Mg, F, Cl, SO <sub>4</sub> )	X					EN/ISO 10304
<b>Other inorganic:</b>						
Cyanide		X				ISO 6703
<b>Trace elements:</b>						
Trace Elements (Notably As, Cd, Cu, Cr, Pb, Hg, Ni, Zn)				X	X	ISO 16590 (Hg) ISO 5666 (Hg) ISO 15586
<b>Organic toxics:</b>						
Oil hydrocarbons			X			ISO 10301
Oil and Grease		X				--
Phenols		X	X			ISO 6439, 14402
<b>Organic contaminants:</b>						
Pesticides				X	X	ISO 6468
PCBs, HCBs etc				X	X	

Variable	Type of monitoring					Reference to international standard method
	Back-ground	Input monitoring (rivers, sewage water, industries)	Near coastal and ambient water (open sea)	Sediments and river-borne particulate material*	Biota	
<b>Bioassays:</b> Ecotoxicology		X		X		ISO 6341, 12890, 10706, 14669
<b>Microbiological:</b> Faecal coliforms Total coliforms		X (X)				ISO 4831, 4832

\* For particulate matter, only inorganic and organic pollutants should be measured

Note 1: In addition to the variables listed here, compliance monitoring will have to consider relevant variables associated with special pollution sources .

Note 2: A comprehensive list of priority pollutants is given in the report “Development of Priority List of Chemical Pollutants” (draft, May 2001), and should be consulted when choosing the exact parameters for trace elements (inorganic pollutants) and organic pollutants at different locations.

Grasshoff = “Methods of Seawater analysis”, ed. Grasshoff et al., 1999 (Verlag Chemie, Germany)

## **Appendix 2: The Approximate Expected Data Uncertainty for Laboratories that have been Updated and Personnel Trained According to the Laboratory Report.**

For comparison, and for better understanding of the difference between uncertainty introduced in the analytical step and total data uncertainty, three different figures are given:

Within laboratory uncertainty is the uncertainty on results from one single laboratory, where identical samples have been analysed under reproducible conditions (i.e. on different days but with the same equipment)

Between laboratory uncertainty is the expected figure for a series of analyses on identical samples carried out in different laboratories. This is in general 25-100% higher than the within-laboratory uncertainty. In this example, 50% has been used for all parameters.

Total data uncertainty is the figure calculated by the use of an uncertainty budget, which means that it contains the uncertainty of all elements of the analytical series, e.g. uncertainty introduced by sampling, sample handling, storage, calibration errors and several others. The total data uncertainty, also referred to as the expanded data uncertainty, is in general 2-5 times higher than the between laboratory uncertainty. In this example, a factor 3 has been used as a rather conservative estimate for the calculation. Note that the calculation of real uncertainty budgets is far beyond the scope of this project, so the figures are estimates, supported by earlier experience.

As the uncertainty figures are given in %, the table will not be valid close to the detection limit or in extremely high concentrations, but rather at levels expected to be measured near the coast in the Caspian Sea.

Variable	Expected data uncertainty (as relative std deviation, rsd%)			
	Within Laboratory	Between Laboratory	Total data Uncertainty	Remark
<b>General:</b>				
Transparency	n.a.	--	--	
Temperature	n.a.	--	--	
pH	2	3	9	
Susp.Solids	2	3	9	
DO	1	1.5	4.5	Using titration
Conductivity	2	3	9	
Salinity	0.5	1	3	
Total hardness	3	5	15	
Chlorophyll-a	6	9	27	

<b>Nutrients:</b>				
Ammonia	6	9	27	
Nitrate+nitrite	3	5	15	
Total nitrogen	4	6	18	
Phosphorus	3	5	15	
Total phosphorous	4	6	18	
<b>Organic matter:</b>				
BOD <sub>5</sub>	5	8	24	
COD <sub>Cr</sub>	5	8	24	
<b>Major ions:</b> (Na, K, Ca, Mg, F, Cl, SO <sub>4</sub> )	2	3	9	
<b>Other inorganic:</b>				
Cyanide	3	5	15	
<b>Trace elements:</b> Trace Elements (Notably As, Cd, Cu, Cr, Fe, Pb, Hg, Ni, Zn)	6	9	27	
<b>Organic toxics:</b>				
Oil hydrocarbons	7	10	30	
Oil and Grease	7	10	30	
Phenols	4	6	18	
<b>Organic contaminants:</b>				
Pesticides	7	10	30	
PCBs, HCBs etc	7	10	30	
<b>Bioassays:</b>				
Ecotoxicology	n.a.	--	--	
<b>Microbiological:</b>				
Faecal coliforms	No info	--	--	
Total coliforms				

### Appendix 3: Responsibilities in the Suggested Monitoring Programme

#### Background river monitoring – 2 times per year

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
Upstream Volga	Ru	Inspectorate, Astrakhan	Inspectorate, Astrakhan	
Upstream Ural	Kz	TOO Monitoring, Atyrau	TOO Monitoring, Atyrau	
Upstream Iranian rivers	Ir	Central DOE lab	Contral DOE lab	
Upstream Kura	Az	Azerekolab, Baku	Azerekolab, Baku	

#### Input monitoring – 24 times per year

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
Selected rivers, industries and sewers in the Astrakhan area	Ru	Inspectorate, Astrakhan	Inspectorate, Astrakhan	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Kamykia area	Ru	Agrochemical service stn, Kalmykia	Agrochemical service stn, Kalmykia	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in Dagestan	Ru	Inspectorate, Dagestan	Inspectorate, Dagestan	
Selected rivers, industries and sewers in the Atyrau area	Kz	Ministry lab, Atyrau	Ministry lab, Atyrau	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Atyrau area	Kz	Atyrau Epidemic and Sanitary station	Atyrau Epidemic and Sanitary Station	Will perform all microbiology in Kz. Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Atyrau	Kz	TOO monitoring, Atyrau	TOO monitoring, Atyrau	Inspectorate, Dagestan (Ru) responsible for analysis of metals in

<b>Station</b>	<b>Ctry</b>	<b>Responsible, sampling</b>	<b>Responsible, analysis*</b>	<b>Comments*</b>
area				particles
Selected rivers, industries and sewers in the Mangystau area	Kz	Mangystau regional lab	Mangystau regional lab	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Aktau area	Kz	TOO service project, Aktau	TOO Service project, Aktau	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in Turkmenistan	Tu	Kaspekokontrol, Turkmenbashi	Kaspekokontrol, Turkmenbashi	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Gorgan area	Ir	Gorgan DOE lab	Gorgan DOE lab	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Sari area	Ir	Sari DOE lab	Sari DOE lab	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Chaloos area	Ir	Chaloos DOE lab	Chaloos DOE lab	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Anzali area	Ir	Anzali DOE lab	Anzali DOE lab	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Anzali area	Ir	Anzali Fisheries Research Institute	Anzali Fisheries research Institute	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected petroleum industries	Ir	Research Institute of the Petroleum Industry	Research Institute of the Petroleum Industry	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Tehran area	Ir	Water and wastewater, Tehran	Water and wastewater, Tehran	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries	Az	Azerekolab Ecology, Baku	Azerekolab Ecology, Baku	Inspectorate, Dagestan (Ru)

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
and sewers in Az				responsible for analysis of metals in particles
Selected rivers, industries and sewers in Az	Az	Hydrometeorology State Monitoring	Hydrometeorology State Monitoring	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles
Selected rivers, industries and sewers in the Sumgayit area	Az	Sumgayit State Ecology	Sumgayit State Ecology	Inspectorate, Dagestan (Ru) responsible for analysis of metals in particles

#### Open sea – 18 times per year

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
Deep station in Russian sector, middle basin	Ru	Inspectorate, Dagestan	Inspectorate, Dagestan	Shipboard analysis of most components
Station in northern basin	Kz	TOO monitoring, Atyrau	TOO Monitoring, Atyrau	Shipboard analysis of most components
Deep station in Turkmen sector, middle basin	Tu	Kaspekokontrol	Kaspekokontrol	Shipboard analysis of most components
Deep station in Iranian sector, southern basin	Ir	Central DOE lab	Central DOE lab	Shipboard analysis of most components
Deep station in Azeri sector, southern basin	Az	Azerekolab, Baku	Azerekolab, Baku	Could be a Hydromet responsibility. Shipboard analysis of most components

#### Mapping stations / near coastal monitoring – 2 times per year (late summer and winter)

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
Approximately 5 stations in the shallow parts	Ru	Inspectorate, Dagestan	Inspectorate, Dagestan	Shipboard analysis of most components
Approximately 5 stations in the shallow parts	Ru	Caspian Fisheries Research Institute		Shipboard analysis of most components
Approximately 10 stations in the shallow parts	Kz	TOO monitoring, Atyrau	TOO Monitoring, Atyrau	Shipboard analysis of most components

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
Approximately 10 stations in the shallow parts	Tu	Kaspekokontrol	Kaspekokontrol	Shipboard analysis of most components
Approximately 6 stations in the shallow parts	Ir	Central DOE lab	Central DOE lab	Shipboard analysis of most components
Approximately 10 stations in the shallow parts	Az	Azerekolab, Baku	Azerekolab, Baku	Could be a Hydromet responsibility. Shipboard analysis of most components

### Sediments – contaminants every 3-5 years

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
Selected stations in the Dagestan region	Ru	Inspectorate, Dagestan	Inspectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations in remaining Russian sector	Ru	Caspian Fisheries Research Institute	Inspectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations in Kazakhstan	Kz	TOO monitoring, Atyrau	Inspectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations in the Turkmen sector	Tu	Kaspekokontrol, Turkmenbashi	Inspectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations in the Iranian sector	Ir	Central DOE lab	Inspectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations in the Azeri sector	Az	Azerekolab Ecology, Baku	Inspectorate, Dagestan (metals) Food and drug, Tehran (org)	

### Sediments – toxicity tests every year

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
Selected stations in the Dagestan region	Ru	Inspectorate, Dagestan	State Inspectorate, Baku	
Selected stations in remaining Russian sector	Ru	Caspian Fisheries Research Institute	State Inspectorate, Baku	
Selected stations in	Kz	TOO monitoring, Atyrau	State Inspectorate, Baku	

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
Kazakhstan				
Selected stations in the Turkmen sector	Tu	Kaspekokontrol, Turkmenbashi	State Inspectorate, Baku	
Selected stations in the Iranian sector	Ir	Central DOE lab	State Inspectorate, Baku	
Selected stations in the Azeri sector	Az	Azerekolab Ecology, Baku	State Inspectorate, Baku	

#### Biota – every year

Station	Ctry	Responsible, sampling	Responsible, analysis*	Comments*
Selected stations and species in the Dagestan region	Ru	Inspectorate, Dagestan	Inpectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations and species in remaining Russian sector	Ru	Caspian Fisheries Research Institute	Inpectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations and species in Kazakhstan	Kz	TOO monitoring, Atyrau	Inpectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations and species in the Turkmen sector	Tu	Kaspekokontrol, Turkmenbashi	Inpectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations and species in the Iranian sector	Ir	Central DOE lab	Inpectorate, Dagestan (metals) Food and drug, Tehran (org)	
Selected stations and species in the Azeri sector	Az	Azerekolab Ecology, Baku	Inpectorate, Dagestan (metals) Food and drug, Tehran (org)	

\* When a different laboratory is said to be responsible for the analysis, this is the reference laboratory for the parameter(s) in question. This means that the laboratory performing the sampling may choose to send all samples to the reference laboratory for analysis. Alternatively, if they have the resources to carry out the analyses within their own country, they shall at least send a small number of duplicate samples to the reference laboratory for reference analysis.

## Appendix 4: Data Quality Control, Data Flagging and Metadata

### D.1 Data quality control

All institutions reporting data to the CEP database are responsible for sending data that is quality controlled, and which is supported by quality data from the laboratory performing the analysis.

The quality control of data is performed at three different levels at the laboratory:

1. Daily check: The analyst carrying out the measurement makes every effort to ensure that the equipment works properly, and reports to the laboratory manager if any problems are encountered. The analyst makes sure that the internal quality control gives correct results, and that the analytical results appear reasonable before submitting the data to the laboratory manager.
2. Data set check: The laboratory manager (or whoever is responsible for this) checks the results from a whole data set (e.g. a sampling expedition) and uses earlier experience and knowledge about the conditions to judge if they appear reasonable or not. The laboratory manager also checks all calculations, calibrations etc. for validity and for possible mistakes. Furthermore, the laboratory manager checks that the internal quality control has been performed correctly and gives the expected results.
3. Annual overview check. Before data is submitted to the CCPC, the laboratory manager and/or other experienced scientists checks all data produced during the year, using their knowledge of local hydrographic conditions, annual cycles etc. to judge if the data appears correct. This check should contain for example plots of annual cycles, hydrographic sections and similar overviews, so that data that appears to break the expected patterns can be identified. Any such data is then checked for mistakes in calculations etc. that could lead to wrong values, and if possible corrected. Note that no data should be deleted, unless proven wrong. Suspect data should be kept and quality flagged, see below.

### D.2 Quality flagging

The system of quality flagging data, as used for example in the ICES (International Council for the Exploration of the Seas) database, makes it possible for the data producer to communicate more information on the data to the data user. The most important aspect of this system is that once a data set has left the laboratory, no data is ever deleted, even if it appears to be wrong. Instead it will be quality flagged as questionable or suspect. When extracting data from the database it is possible to exclude data that has been flagged as, for example, questionable. This is a way of ensuring that data that breaks the pattern is not deleted, as later developments might make it possible to either correct the data or to discover unexpected features in the hydrography. Quality flags can, and should, be assigned to data

at any of the three above-mentioned levels of data quality control (D.1). Examples of how a system of quality flags is used by ICES are:

Description of data	Flag
Acceptable: data found acceptable during quality control checks	A
Suspect value: data considered suspect (but not replaced) by the data originator on the basis of either quality control checks or recorder/instrument/platform performance	S
Questionable value: data considered suspect (but not replaced) during quality control checks by persons other than those responsible for its original collection, e.g. a data centre	Q
Missing value: original data erroneous or missing	M
Replaced value: erroneous or missing data has been replaced by estimated or interpolated value	R

For a complete, updated and internationally accepted set of useful quality flags, ICES should be consulted.

### D. 3 Support by analytical quality data

All data submitted to the database has to be supported by analytical quality data from the laboratory. This quality data will be stored in the database together with the results, and will provide the data users with information on its validity. The minimum requirement for the submitted analytical quality data is:

- A method reference for each reported parameter (e.g. reference to a standard method)
- Measurement uncertainty for each parameter (in the first phase this will simply be the relative standard deviation of the control charts, see the Reference Laboratory report for an explanation)
- Results from intercomparison exercises (proficiency tests)
- Results from the analysis of certified reference materials

The database manager should not accept data that is not supported by analytical quality data, as nothing will be known of the usefulness of such a data set. Consequently, all data in the database will be associated with a set of analytical quality data.

A standardised format for this reporting has to be developed, in order to make it easy to enter the information into the database. A suggestion for such a reporting format is given below.

## Quality Data submission form

**Laboratory:** The Virtual Laboratory in Exampleland

**Contact:** Dr. Q. Manager

**Year:** 2001

**Valid for the following data sets:** Wastewater data for sampling stations 2-11 during the whole year (data set 98-145)

**Additional remarks:** We have improved our method so that the ammonium results for data sets 146 and onwards will be better.

Parameter	Method reference	Measurement uncertainty (from internal quality control)	Name and provider of proficiency test	Assigned value in the exercise	Your result	Name and provider of CRM analysed	Certified value	Your result	Other information
Ammonium – Nitrogen	ISO 2331	7 % rsd from our control charts	SPIL-1 from DHI, Denmark	0.36 ± 0.1 mg/L	0.5 mg/L	WW1a from DHI, Denmark	5.05 ± 0.23 mg/L	5.8 mg/L 6.3 5.2	Test kit from Hach used

#### D. 4 Support by metadata

Apart from analytical quality data, which is data on the laboratory performance, all data has to be supported by an agreed and appropriate set of metadata. The metadata, which is also stored in the database together with the analytical data, gives the history of the sample, and is collected in connection with the sampling and, when appropriate, during the sample handling. There is a set of metadata that all data has to be supported by, and, depending on the kind of monitoring, there may be other metadata that should be reported. The main metadata, to which every single data must have a reference, is, but is not necessarily limited to:

- The date and time (local and UTC) of sampling
- Position of the sampling station (longitude and latitude)
- Name of the sampling station
- Country
- Ship
- Person or institution responsible
- Bottom depth
- Sampling depth
- Type of sampling equipment
- Weather conditions (ICES standard format)
- Water temperature (if not a parameter)

During sampling, the necessary data is simply entered into a standardised sheet, common to the whole monitoring programme. The data should be transferred to CCPC together with the analytical data in digitalised form.

Example of a metadata form (sampling form) is given below.

Example of how a sheet for collection of metadata can be designed. The metadata is collected in connection with the sampling (for some parameters metadata from the sampling treatment will also be of importance), and will be reported electronically together with the monitoring data

Sampling and metadata sheet							
Year	Ship	Country	Latitude	Longitude	Parameters determined:		
Station name:					Temp [ ]		
Date:		Time: (local)		(UTC)	Oxygen [ ]		
Person responsible for sampling:					Nutrients [ ]		
Air temp: C		Bottom depth: m		Secchi. m	TN [ ]		
Weather codes (ICES):					TP [ ]		
Wind	Wind direct.	Cloudiness	Sea	Ice	pH [ ]		
					Salinity [ ]		
Depth (m)	Temperature		Salinity Bottle	Oxygen Bottle	Nutrients Bottle	pH Bottle	Transp. [ ]
	Help T	Main T					
0							BOD [ ]
5							COD [ ]
10							[ ]
15							[ ]
20							
30							
50							
75							
100							
200							
300							
400							
500							

## **Appendix 5: The Annual Report on the Status of the Environment of the Caspian Sea**

Suggested contents:

### **Part A: Standardised statistics and trends**

- Annual cycles of all measurands at the open sea stations (with indication of the variation during the last 10 years) at 2-3 selected depth ranges (e.g. average 0-30 metres and average 150 m – bottom)
- Nutrient trends for the last 10 years and for the whole monitoring period, for the winter values in the surface water (0-30 m averaged) of the open sea stations
- Oxygen maps showing the dissolved oxygen content of the bottom water during the winter and summer mapping expeditions. Areas of oxygen deficiency (< 2 mL/L) should be marked.
- Nutrient maps showing the nutrient content in the surface water (0-30 m averaged) during the winter and summer mapping expeditions
- Trends in selected metals and organic pollutants in biota
- Trends in toxicity of sediments at contaminated sites and reference sites
- Trends in annual total (calculated from measurements) input of nutrients, selected metals and selected organic pollutants (divided into important sources and estimates of total input)

### **Part B: Theme articles and overviews**

Examples of theme articles could be:

- Results from the latest sediment survey
- Case stories from industries or communities which have decreased their output of contaminants
- Recent developments in cleaner technology
- Expected improvement in the environment, as suggested by modelling
- New legislation, standards or directives

## Appendix 6: Task- and Timetable for Start-up of the New CMP

Task to be performed	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
Domestic EPA discussions of suggestions																																					
Appointment of representatives to CMP-Mon																																					
First meeting of CMP-Mon																																					
Decision on start-up phase of monitoring																																					
Meeting of CMP-Quality to decide on details																																					
First data gathered																																					
CMP-Mon to discuss proposals for financing opportunities from external sources																																					
Proposals prepared and submitted																																					
First data submission to data base																																					
CMP-Ass to write annual report																																					

