

Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes

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Chapter 4 - RESOURCES FOR A MONITORING PROGRAMME

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Implementing a monitoring programme requires access to resources, including an equipped laboratory, office space, equipment for field work, transport and trained personnel.

Two important points should be considered when starting a new monitoring programme:

- It is better to have a complete record of reliable data concerning water quality at a few sampling stations than to have a lot of data of questionable quality from many sampling stations.
- If reported data are not credible, the programme and its staff will lose credibility.

In the initial stages of a new monitoring programme, therefore, it is generally advisable to proceed as follows:

- Start slowly with analyses for a few variables.
- Train staff to ensure that proper procedures are followed.
- Impose quality assurance on all procedures from the beginning.
- Take samples at stations where the water quality is of major relevance to the monitoring programme.
- Prepare reports that are factual and are written so that they can be understood by persons other than scientists.
- Increase the number of variables, the number of sampling stations and the frequency

4.1 Laboratory facilities

A number of options may be available for conducting analyses of water samples. The agency responsible for the monitoring programme may have its own laboratory or laboratories, the facilities of another agency or of a government ministry may be available, or some or all of the analytical work may be done under contract by a private laboratory. Some analytical work will inevitably be done in the field, using either field kits or a mobile laboratory. Regardless of the options chosen, the analytical services must be adequate for the volume of work expected. Some of the relevant considerations in this context are:

- *Variables to be analysed.* If only a few simple tests are required, analyses can be undertaken in the field using field kits. More complex testing programmes may require the services of specialised laboratories (see also section 3.8).
- *Sampling frequency and number of sampling stations.* The frequency with which samples must be taken and the number of sampling stations involved will obviously influence the volume of work necessary and, hence, the staff and facilities required (see also section 3.7).
- *Existing laboratory facilities.* Laboratory facilities may be under the direct control of the monitoring agency or be associated with another agency (e.g. the health ministry, a regional hospital, or a college or university). The major concern is that the laboratory is sufficiently close to the sampling stations to permit samples to be delivered without undue delay.
- *On-site testing.* Some analyses must be performed in the field (see Chapter 6). Modern field kits are available that permit analyses of a wide range of variables (see Annex). This makes it possible to run a monitoring programme without the need for a fixed laboratory, but raises certain problems of analytical quality control.
- *Temporary laboratories.* If a monitoring programme is expected to be of short duration, it may be expedient to set up a temporary laboratory. Sufficient space, water and electricity supplies are essential, but equipment and supplies can be brought in and then removed after the monitoring programme is completed.
- *Mobile laboratories.* It is possible to set up a laboratory in a suitable motor vehicle, e.g. truck or van. In effect, this is a variant of on-site testing, but may provide better facilities than field kits.

In practice, the usual arrangement is for the agency responsible for water quality monitoring to establish its own central laboratory, which can be organised to provide training and supervision of staff, repair of equipment and various other services. However, if the monitoring area is large or transportation is difficult, regional laboratories may be set up or field kits used for certain analyses. Analyses that require expensive and sophisticated equipment, or that can be undertaken only by highly trained personnel, are performed only at the central laboratory, for example analysis for heavy metals using atomic absorption spectrophotometry and analysis for pesticides and herbicides using gas chromatography.

Whatever arrangements are finally chosen, it is essential that procedures are established for quality control of analytical work (see Chapter 9). This is of particular importance in relation to all aspects of field work, including sampling, sample handling and transport, as well as on-site testing.

It is beyond the scope of this handbook to make recommendations for the size, equipment and staffing of a laboratory. However, Chapters 6, 7, 8 and 10 each contain lists of instruments, equipment, glassware, reagents and other supplies necessary for various analytical procedures.

4.2 Transport

The types of vehicle needed for sampling expeditions depend, to a large extent, on the ease of access to the various sampling stations. If access is difficult, an “off-road” vehicle with four-wheel drive may be necessary and in some remote or rural areas a light motorcycle can be useful for transporting one person (with a minimum of equipment, e.g. portable kit), although it is important to consider the safety aspects of the latter arrangement. For some

sampling programmes in large lakes and rivers, sampling stations may have to be reached by boat. It may be possible to rent a boat in the vicinity of a sampling station. Renting is generally preferable to the purchase of a boat unless there are numerous sampling stations that have to be reached regularly. If a boat must be transported by the expedition, the work of the sampling team will be slowed by the need to launch and recover it at each sampling station.

In countries or regions where reliable public transport is available, it may be possible to arrange for samples to be transported to the laboratory by bus or train. Local agents, appropriately trained and supplied with the necessary sampling equipment, can take samples at prescribed times and send them to the laboratory. This system requires careful supervision and particular attention to sample quality control.

4.3 Staffing

Staff on a water quality monitoring programme fall into four broad categories: programme management, field staff, laboratory staff and data processors. The numbers required in each category will depend on the size and scope of the monitoring programme.

4.3.1 Programme manager

The programme manager will probably require the assistance of several technical and administrative staff members during the design and planning phases of the programme. After the programme has reached the implementation stage, some of these staff members can be transferred to operations, possibly as supervisors of field and laboratory work. Others, together with the programme managers, will assume responsibility for data manipulation, preparation of reports, staff training and programme co-ordination (if other agencies are involved in the programme).

The co-ordination tasks may become quite complex if programme implementation depends on other agencies, part-time staff, temporary or rented facilities and public transport. The following description of the responsibilities of a programme manager may not be complete for any specific situation but is presented as an example of what may be expected of the manager.

The responsibilities of the programme manager will include some of the following:

- Planning of water quality monitoring activities.
- Co-ordination with regional centres, collaborating agencies, participating laboratories and others not under his or her direct control.
- Procurement of necessary equipment and consumable supplies.
- Arranging suitable transport.
- Recruitment of staff.
- Training of staff.
- Preparation of training manuals.

- Safety in the field and in the laboratory.
- Preparation of standard operating procedures (SOPs).
- Organising and managing central office facilities for the storage, handling, interpretation and distribution of data.
- Supervising and evaluating the performance of all staff.
- Reviewing and evaluating procedures.
- Preparation of reports and dissemination of the findings of the monitoring programme.

4.3.2 Field staff

Staff recruited for field work and sampling may not have had previous experience in water quality monitoring and new methods or procedures may be introduced from time to time. A short period of training is, therefore, appropriate. Assuming that candidates have a good general education, a well organised training session that includes practical field work will require 1-2 weeks. If field testing is also to be carried out, the training period will have to be somewhat longer. Staff should be evaluated after training and, if satisfactory, should work under fairly close supervision until they are sufficiently experienced to require only occasional supervision. Periodic short-term training sessions should be arranged for reviewing, reinforcing or extending knowledge.

Preliminary training for field staff may include, for example:

- Objectives of the water quality monitoring programme.
- The local, national and international importance of the programme.
- The importance of samples being of good quality and representative of the water body from which they are taken.
- How to ensure that samples are of good quality.
- Planning of sampling expeditions.
- Map-reading.
- Making field notes.
- Maintaining up-to-date descriptions of sampling sites and stations.
- Health and safety in the field.

Training sessions for the continuing education of field staff might include the following topics:

- Sampling for sediment.
- Sampling for biological analysis.
- Stream gauging.

- Microbiological field testing of samples (membrane filter method).
- Chemical tests in the field.

The responsibilities of field staff should include all or some of the following:

- Undertaking sampling expeditions in accordance with a planned programme.
- Obtaining samples according to SOPs.
- Labelling sample bottles, making notes and recording unusual conditions at the sampling station.
- Preparing samples for transport and delivering them to the local laboratory in accordance with SOPs.
- Routine maintenance of equipment used in the field.
- Preparing sample bottles (cleaning and addition of appropriate preservatives).
- Performing field tests for selected variables (see Chapter 6).

4.3.3 Laboratory staff

Two, or possibly three, types of laboratory staff may be required to undertake the required chemical, microbiological and biological analyses.

Laboratory chiefs. The chiefs of each type of laboratory, in liaison with the programme manager, would typically be responsible for:

- Laboratory management.
- Determining and procuring the equipment and supplies that will be needed.
- Ensuring that SOPs are being followed, which includes supervising laboratory staff and training them in the use of new equipment and procedures.
- Quality control of analytical procedures (see Chapter 9).
- Enforcing safety precautions and procedures, especially for fire, explosions and noxious fumes.

Laboratory technician (analyst). Laboratory technicians will usually have had formal training and possibly practical experience in analytical work. Working under the direction of the laboratory chief, a technician will be responsible for the preparation and carrying out of analytical work in the laboratory. Their duties would typically include the following:

- Care, regular maintenance and ensuring cleanliness of laboratory and equipment, especially refrigerators, freezers, incubators, water-baths, stills, ovens and work areas.
- Ensuring the cleanliness of laboratory glassware and other reusables.
- Safe storage of all equipment and glassware.

- Preparation of reagents and media, standardising as necessary.
- Storage under proper conditions of reagents and media.
- Checking accuracy of electronic equipment used in field analyses.
- Preparation (or supervising the preparation) of sample bottles (including the addition of preservatives when appropriate) and application of correct identification labels.
- Laboratory safety.
- Training of field staff in the use of field testing equipment.
- Training of junior laboratory staff.
- Recording the results of analyses.
- Performing the tests and analyses, including those necessary for internal quality control (see Chapter 9).

Laboratory assistant. Laboratory assistants may have had some formal training but are usually untrained and often learn whilst in post. Their duties are performed under the direct supervision of the laboratory technician(s). These duties typically include:

- Cleaning of the laboratory, glassware and equipment.
- Preparing sample bottles, including washing, addition of preservatives and correct labelling (and sterilising if necessary).
- Storage of laboratory and sample glassware.
- Storage and stock control of chemicals and media.

In time, and with appropriate training and experience, an assistant can be promoted to a higher level of laboratory work. The technicians will teach the assistants how to use various items of laboratory equipment, prepare reagent solutions and carry out certain analyses.

4.3.4 Quality assurance officer

Quality assurance is dealt with in detail in Chapter 9. This section is concerned only with the responsibilities of the quality assurance officer (QAO). It is considered good practice to designate a staff member as QAO, with duties which include:

- Reporting directly to the most senior manager of the organisation on matters concerning quality assurance.
- Monitoring the quality of analytical work in the laboratory and in the field.
- Auditing reports, laboratory notebooks, field notebooks and other laboratory documentation to ensure that information is correct and complete.

Where financial or organisational constraints do not allow the appointment of a specific QAO, the responsibility for quality assurance may be delegated to a member of staff, in addition to

existing duties. Quality control of work performed by the QAO and that is not itself directly concerned with quality assurance should be made the responsibility of another member of staff. In this case, senior management should ensure that conflicts of interest are minimised.

4.4 Human resources development and training

The quality of the data produced by a water quality monitoring programme depends on the quality of the work done by field and laboratory staff. It is, therefore, important that staff are adequately trained for the work they are expected to do. As a result, monitoring agencies often develop training programmes that are specific to their needs. The content and extent of training programmes depend on the previous training and experience of staff, the range of activities involved in the monitoring programme and whether analytical work will be done at a central laboratory or regional laboratories, and the extent to which analyses will be performed in the field.

For large, permanent monitoring programmes, a comprehensive strategy for personnel development is advisable. This should include:

- clear lines of responsibility and accountability,
- job descriptions,
- recruitment guidelines (qualifications, experience, skills requirements, etc.),
- career structures,
- mechanisms for enhancing the motivation of staff at all levels,
- systems for staff appraisal and feedback, and often standardised training packages, procedures manuals and training manuals as appropriate to the work of field and laboratory staff, regional and national managers.

Training is not a once-only activity but should be a continuing process. Ideally, there should be a basic framework of courses for staff at all levels, followed by short courses, seminars and workshops. Supervision of work, in both the laboratory and the field, is essential and contributes to in-service training. It is particularly valuable in water quality monitoring programmes because it permits staff to gain “hands-on” experience, thus reinforcing what was learned in formal training sessions, while taking an active part in programme operations. Laboratory staff, especially those in larger laboratories, are progressively trained and authorised to use certain items of equipment or undertake certain analyses.

Training should be flexible, responding to experience and feedback and taking account of the specific needs of individual staff members. In-house training can provide this flexibility and can be readily tailored to local requirements but it needs staff who are familiar with the necessary training techniques, usually senior laboratory and field staff (it also makes heavy demands on them). It may also make significant demands on financial resources and requires access to classrooms, field-work sites and training laboratories with appropriate equipment. For much of their staff training, therefore, many agencies will make use of courses already available at local educational establishments, supplementing these with short courses, workshops and refresher training in specific topics.

In its broadest sense, training should also be understood to include encouraging staff to join appropriate professional organisations, attend conferences and symposia, and communicate with peers in technical schools, colleges, universities and similar establishments.

4.4.1 Training documents

A training record should be maintained for each staff member. This should contain a detailed account of all training completed, of supervision required, and of authorisations granted for certain types of work. It may, for example, note initial training, supervised work and authorisation (for field staff) to take samples using a particular type of sampler or (for laboratory staff) to use a certain item of equipment or perform a certain analysis. Since it is a permanent record it should be in the form of a bound book and each new entry should be signed by both the trainer (or supervisor) and the trainee.

A procedures manual should be prepared, containing full details of SOPs for all programme activities. A loose-leaf format is preferable because SOPs are subject to revision and updating. The use of SOPs is an important element of quality assurance, which is discussed in more detail in Chapter 9.

4.4.2 Retaining staff

It is not unusual, after staff members have been recruited and trained, to have some of them leave for employment elsewhere, especially where environmental monitoring is a government activity and salaries are relatively poor. Staff turnover may be reduced if a career structure is developed which provides opportunities for promotion with increased expertise and experience. The contributions of staff to the programme should be adequately acknowledged in reports and similar documentation, especially when a report is published in the technical literature.

4.5 Communication

Good communication is important, not only for achieving programme outputs (such as data production), but also to ensure that wider aims (such as increasing awareness of environmental issues and ensuring that staff of all types see their role positively) are met. It is also indirectly important as a means of ensuring continued outside interest in, and support for, the work being undertaken.

It is good practice to ensure that responsibilities for communication are identified in every individual's job description. Communication may be aimed at a wide audience, such as writing reports or speaking at a seminar, or more specific, such as communicating results from analyst to laboratory chief or discussion of fieldwork plans between co-ordinator and field staff. In practice, much general communication should take the form of consultation and, by generating goodwill, this helps to ensure that problems are overcome through mutual interest and do not become insurmountable blocks.

Communication with external agencies (known as ESAs or External Support Agencies when they provide support to a programme) is especially important if they play a role in international assessments (as is the case in the GEMS/WATER programme) and if they provide other types of support (such as training or equipment). For consistency, liaison with such agencies, where it occurs, should be the specific responsibility of an identified member of staff. Internal communication in the form of short discussions, such as lunch time seminars

or workshops, are a good means of ensuring that all staff are kept informed about general issues and are in contact with programme progress and findings.

Representatives of monitoring programmes may attend committees at both local and national levels. This representation is important as a means of communication and to maintain the profile of the programme and, as such, should also be the specific responsibility of an identified member of staff.

Communication functions, such as those noted above may demand a significant proportion of time and this should be borne in mind when preparing job descriptions.

4.6 Inventory of sampling stations

A listing of sampling sites will have been made and sampling stations will have been chosen during the design of the monitoring programme. An inventory of the sampling stations should be prepared that includes the following:

- A map of the general area showing the location of the sampling station.
- A narrative description of how to get to the sampling station.
- A full description of the sampling station.
- Notes concerning means of access and whether permission is needed to gain access to the station.
- Notes on any times of year when access may be difficult or impossible.
- If a boat is needed to get to the station, whether a boat can be rented locally and what other arrangements need to be made.
- Special equipment (e.g. ropes, lifebelts) and clothing (e.g. waders) that are required when sampling at this station.
- Time or times of day when samples are to be obtained.
- Tests that are to be made on-site.
- Volume of sample required and any preservative treatment needed for sample bottles.
- Travel time from the sampling station to the nearest laboratory.

Changes should be made to the inventory when, for example, the specific location of the sampling station is to be changed or some change is to be made to the sampling programme.

4.7 Schedules for sampling expeditions

Schedules for field work must take into account local conditions, travel time from laboratory to sampling stations and return, seasonal weather and travel problems, qualifications of field staff, availability of transport, and the maximum time permitted between collection and

analysis of samples. This last point will probably determine the required length of the sampling trips and whether on-site testing is necessary. There are three principal options:

- Short trips are made and samples are returned quickly to the laboratory. This option probably requires the most travel time overall but samples would arrive at the laboratory in good condition.
- Long trips are made, samples are tested on-site with portable equipment for certain variables and separate portions of samples are “fixed” with a preservative chemical and returned to the laboratory later by the field staff or by public transport. This option reduces the distances to be travelled. However, the limitations of on-site sample preservation or field testing methods must be recognised.
- Long trips are made (perhaps for several days) and samples are tested on-site with portable equipment. No samples are returned to the laboratory. This option minimises the total distance to be travelled but, as above, the limitations of on-site testing must be recognised. This option also requires well-trained staff.

4.8 Source literature and further reading

WHO 1984 *Human Resources Development Handbook*. Unpublished document WHO/CWS/ETS/84.3, World Health Organization, Geneva.

WHO 1986 *Establishing and Equipping Water Laboratories in Developing Countries*. Unpublished document WHO/PEP/86.2, World Health Organization, Geneva.
