- 3.1 -
CONCEPTS OF MONITORING
3.1. CONCEPTS OF MONITORING

Diederik Rousseau/Peter Kelderman

UNESCO-IHE Institute for Water Education

Online Module Water Quality Assessment
Objectives of the OLC; of Course 3

After successful completion of the course, participants will be able to:

- Understand and apply concepts of water quality and pollution processes in rivers and lakes
- Understand and apply the different steps of the monitoring cycle in rivers and lakes
- Understand and apply basic groundwater quality monitoring concepts
- Apply common statistical techniques for water quality data evaluation
- Design sound and sustainable freshwater quality monitoring and assessment programmes under specified conditions.
Module philosophy: DPSIR

The DPSIR Framework
(Driving forces-Pressures-State-Impacts-Responses)

Driving Forces
Socio-economic and socio-cultural forces driving human activities, which increase or mitigate pressures on the environment.

Pressures
Pressures that human activities place on the environment (e.g., wastewater).

State of the Environment (SoE)
The condition of the environment (e.g., the assessment of air or water quality).

Impacts
Effects of environmental degradation (e.g., biodiversity loss, economic damage).

Responses
Responses by society to the environmental situation (e.g., cleaner production, regulations).


Water Quality Monitoring and Assessment
Definitions

Water Quality Monitoring:

= the collection of the relevant information on water quality

Water Quality Assessment:

= the overall process of evaluation of the physical, chemical and biological nature of the water
Objectives of monitoring

Setting up a monitoring programme requires a clear definition of the objectives, in order to avoid waste of time, efforts and money.

Need to know and not would be nice to know

Necessary information will depend on various users of water.
Types of monitoring (1)

MONITORING
Long-term, standardised measurement and observation of the aquatic environment in order to define status and trends

SURVEY
A finite duration, intensive programme to measure and observe the quality of the aquatic environment for a specific purpose

SURVEILLANCE
Continuous, specific measurement and observation for the purpose of water quality management and operational activities
Types of monitoring (2)

**Ambient monitoring**
- Status and trend detection
- Testing of water quality standards
- Calculation of loads

**Effluent monitoring**
- Calculation and control of discharge standards
- Monitoring of plant performance

**Early warning**
- Warning for calamities
- Protection of downstream functions

**Operational monitoring**
Monitoring for operational uses such as irrigation, industrial use, inlets for water treatment works.
Types of monitoring (3)

**Single-objective monitoring** which may be set up to address one problem area only.

This involves a simple set of variables, such as:
- pH, alkalinity and some cations for acid rain
- Nutrients and chlorophyll pigments for eutrophication
- Na, Ca, Cl and a few other elements for irrigation.

**Multi-objective monitoring** which may cover various water uses and provide data for more than one assessment programme, such as drinking water supply, industrial manufacturing, fisheries or aquatic life, thereby involving a large set of variables.
Levels of water quality assessment

**Simple monitoring**
based on a limited number of samples, simple analysis or observations, and data treatment which can be performed by simple software

**Intermediate-level monitoring**
requiring more variables, stations, and specific laboratory equipment and PCs/software for data handling

**Advanced level monitoring**
involving sophisticated techniques and highly trained technicians and engineers for sample analysis (e.g. micropollutants) and data handling, often using mainframe computer systems.
The monitoring cycle

1: "what do you want to know?"

2: "how to find out"

3: "the real field and labwork"

4: "evaluation"

5: "feedback; changes"
The ten basic rules for a successful assessment programme

1. The objectives must be defined first and the programme adapted to them and not *vice versa* (as was often the case for multi-purpose monitoring in the past). Adequate financial support must then be obtained.
2. The type and nature of the water body must be fully understood (most frequently through preliminary surveys), particularly the spatial and temporal variability within the whole water body.
3. The appropriate media (water, particulate matter, biota) must be chosen.
4. The variables, type of samples, sampling frequency and station location must be chosen carefully with respect to the objectives.
5. The field, analytical equipment and laboratory facilities must be selected in relation to the objectives and not *vice versa*.
6. A complete, and operational, data treatment scheme must be established.
7. The monitoring of the quality of the aquatic environment must be coupled with the appropriate hydrological monitoring.
8. The analytical quality of data must be regularly checked through internal and external control.
9. The data should be given to decision makers, not merely as a list of variables and their concentrations, but interpreted and assessed by experts with relevant recommendations for management action.
10. The programme must be evaluated periodically, especially if the general situation or any particular influence on the environment is changed, either naturally or by measures taken in the catchment area.
Key elements of an assessment programme (1)

**Key element 1: Appropriate objectives**
These should take into account the hydrological factors, the water uses, the economic development, the legislative policies etc. Necessary decisions involve whether the emphasis should be put on concentrations or loads, or spatial or time distributions, and the most appropriate monitoring media.

**Key element 2: Preliminary surveys**
These are short-term, limited activities to determine the water quality variability, the type of monitoring media and pollutants to be considered, and the technical and financial feasibility of a complete monitoring programme.
Preliminary survey (1)

Clear description of the study area should be made:

- Definition of the area, and schematisation in clear, not-overloaded maps

- A summary of the environmental conditions and processes, including human activities, such as population, land use, industries, hydraulic structures, (ground)water extraction sites and recreational areas

- Meteorological and hydrological information, including hydrographs of river flows, and precipitation/evaporation data at stations as close as possible to the water course

- A summary of actual and potential water uses (5 year horizon).
Preliminary survey (2)

Figure 2.1. A pollutant source inventory for the Lake Vättern basin, Sweden (After Hakanson, 1977)
Key elements of an assessment programme (2)

Key element 3: Monitoring design
This includes the selection of types of pollutants, station location, sampling frequency, sampling apparatus, etc.

Key element 4: Field monitoring operations
These include in situ measurements, sampling of appropriate media (water, biota, particulate matter), sample pretreatment and conservation, identification and shipment.

Key element 5: Hydrological monitoring
This includes water discharge measurements, water levels, thermal profiles, etc., and should always be related to the water quality assessment activities.
Key elements of an assessment programme (3)

Key element 6: Laboratory activities
These include concentration measurements, biological determinations, etc.

Key element 7: Data quality control
This must be undertaken by using analytical quality assurance within each laboratory, and amongst all laboratories participating in the same programme, and by checking field operations and hydrological data.

Key element 8: Data storage treatment and reporting
This is now widely computerised and involves the use of databases, statistical analysis, trend determinations, multi-factorial correlation, etc., and presentation and dissemination of results in appropriate forms (graphs, data disks, etc.).
Key element 9: Data interpretation

This involves comparison of water quality data between stations (water quality descriptors, fluxes), analysis of water quality trends, development of cause-effect relationships between water quality data and environmental data (geology, hydrology, land use, pollutant sources inventory), and judgement of the adequacy of water quality for various uses etc. For specific problems, and the evaluation of the environmental significance of observed changes, external expertise may be needed. Publication and dissemination of data and reports to relevant authorities, the public, and the scientific community is the necessary final stage of assessment activities.
Key element 10: Water management recommendations
These decisions should be taken at various levels from local government to international bodies, by water authorities as well as by other environmental authorities. An important decision is the re-design of assessment operations, to improve the monitoring programme and to make it more cost-effective.
Case study: the European Union Water Framework Directive
EUROPEAN UNION
Water Quality Management in the European Union


Now every 5 years new Environment Action Programme, each time with stricter goals. Evaluation in next summit; however no legally binding force.

Improving water quality by conventional or advanced wastewater treatment plants (P, N, for sensitive nature areas)

EU Water Framework Directive (EU-WFD) was implemented in the year 2000. Aim: good surface and groundwater quality in all member states, by the year 2015
Water Framework Directive (WFD)

Environmental Objectives (Article 4):

- Member States shall protect, enhance and restore all bodies of surface water with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of this directive (2015)

- (International) River Basin approach
- Good Ecological Status by 2015
- In every water body
- Monitoring is a MUST
- “One out, all out”
- Programmes of measures
Particular Features of the EU-WFD

- Administrative coordination within international river basin districts (RBD)
- Characterisation of surface water body types (natural, heavily modified or artificial) with specific ecological objectives
- Aiming for zero discharges for priority micropollutants
- Cost recovery for water services ("polluter pays")
- Stakeholder participation (for acceptance; know-how; avoid errors, etc.)
- Integration of "all" uses; stakeholders; water types (groundwater/surface/brackish,...)
Further contents of this Course

• Rivers
• Lakes and Reservoirs
• Water Quality Variables
• (Optimization of) Monitoring frequencies
• Field and laboratory work
• Water quality assessment and Reporting
• Groundwater pollution and monitoring
• Cost aspects