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WATER QUALITY MONITORING AND ASSESSMENT OF GROUNDWATER

Technical Guidance Document

Prepared by the UNEP GEMS/Water Capacity Development Centre for the United Nations Environment Programme

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University College Cork, Ireland
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The views expressed in this publication are those of the authors and do not necessarily reflect the views of the United Nations Environment Programme.

UNEP GEMS/Water Capacity Development Centre
Environmental Research Institute
University College Cork
Lee Road
CORK
Ireland
e-mail: gemscdcadmin@ucc.ie
Tel: +353 21 4205276

FOREWORD

This technical guidance document is intended for scientists and practitioners who work with freshwaters in the field and in the laboratory but who do not have specialist knowledge of hydrogeology. It will guide water resource managers in planning and implementing a groundwater monitoring programme that will generate information to support management action and policy development towards sustainable use of groundwater resources.

This document is part of a series of guidebooks that address various aspects of monitoring and assessment of freshwater. It describes the main features of groundwater that govern its quantity, availability and chemical quality. Understanding these features assists in the development of a monitoring programme that will provide information for management and sustainable use. Important principles for monitoring are explained together with methods for obtaining and interpreting water quality data from boreholes and wells. Sources and pathways of contamination in groundwater are discussed, together with approaches to assessing their impact on the quality of the resource. It is recommended that the other guidebooks in the series are consulted for more detail on other related topics, such as monitoring programme design and quality assurance.

Other guidance documents in the series to be released in 2022 include:

- An Introduction to Freshwater Quality Monitoring and Assessment
- Water Quality Monitoring and Assessment in River, Lakes and Reservoirs
- Quality Assurance for Freshwater Quality Monitoring
- Freshwater Quality Monitoring with Biota
- Freshwater Quality Monitoring using Particulate Matter

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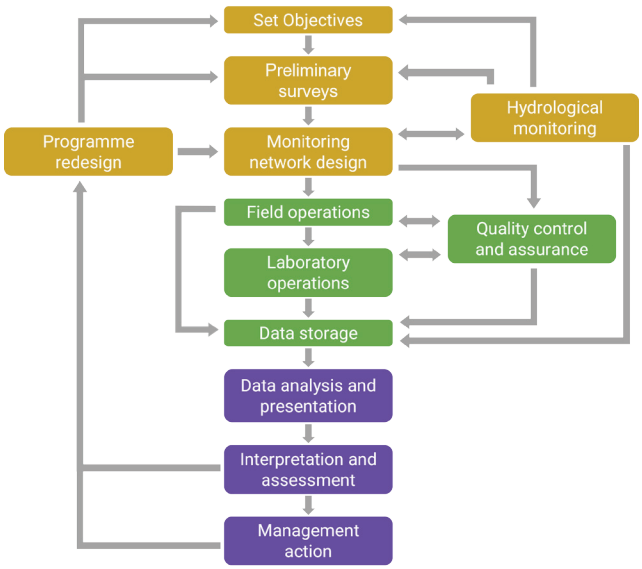
CHAPTER 1

INTRODUCTION

In many countries, groundwater is an essential source of domestic water supplies due to its generally good quality and minimal requirement for treatment prior to use. In arid regions it is often the main or only source of useable freshwater. Even in countries with plentiful surface waters and advanced treatment and distribution systems, groundwater is important for domestic supplies in remote and rural locations that are not served by distribution networks. The limited data available suggest that between 2 per cent and 95 per cent of national water needs are supplied from groundwater, with the higher proportion being used in water-scarce countries (Margut and van der Gun 2013). Globally groundwater accounts for approximately 26 per cent of total water abstractions (WWQA 2021). It is essential that groundwater resources are managed to ensure their quantity and quality meet human needs and support freshwater ecosystems. In arid regions where groundwaters are the main source of freshwater supplies, concern has mainly focussed on the amount of water available and on trying to manage the sustainable use of that water. There is growing evidence, however, that groundwaters are becoming contaminated and no longer meet required quality characteristics, potentially posing a threat to human health (WWQA 2021). The extent and nature of the contamination is unclear, due to the limited monitoring of groundwater quality at a global scale, especially in the Global South (WWQA 2021). In addition, the risk posed to human health from naturally occurring contaminants, such as arsenic and fluoride, are often unknown due to a lack of monitoring (WWQA 2021). Better information and understanding of groundwater will help to guide public health interventions, also in view of how contaminated water affects women, men and children in different ways.

Most groundwater monitoring is focussed on the suitability of the water for drinking water supplies but monitoring programmes should also take into account other uses of groundwater, such as irrigation, ecosystem support and industrial use. The monitoring programmes should, therefore, be targeted and designed accordingly. This guidebook provides fundamental information on the occurrence and behaviour of groundwaters and how to use that information in the development of a groundwater monitoring programme. As for all freshwater monitoring programmes there are a chain of steps that need to be followed (Fig. 1.1) to ensure the programme generates meaningful

Figure 1.1 The chain of activities in designing and implementing a freshwater quality monitoring programme (adapted from Chapman *et al*. 2005)

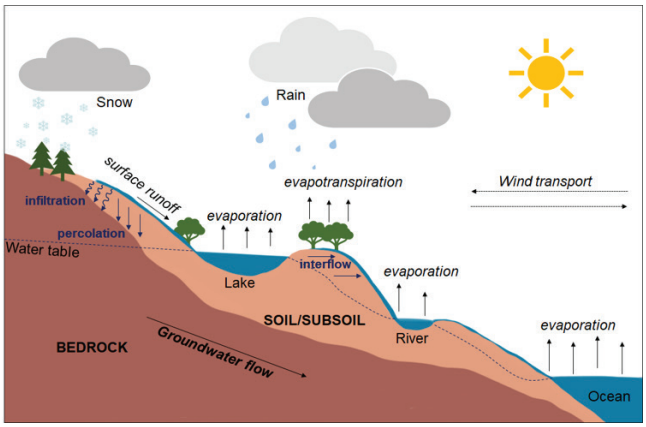


data that will support an assessment of the state of the groundwater resources that, in turn, will inform management and policy. The chain starts with the critical element of defining the objectives of the monitoring programme, i.e., what information it is expected to generate and for what purpose. The design of the programme, i.e., the selection of sampling locations, parameters to be measured (quantity and quality) and the frequency of measurement, will need to ensure that the objectives are met. Looking at existing information and data, as part of a preliminary survey, can save a lot of time and effort by identifying whether existing boreholes can be used for sampling or whether new wells will need to be drilled. Also, as women and girls are often tasked with water collection in developing countries, their intimate knowledge of local conditions is invaluable; thus, engaging with them as key stakeholders in water planning, management and monitoring exercises is crucial.

The results obtained through field and laboratory work need to be stored in a database that facilitates easy access and sharing of the data, in order to facilitate data analysis and presentation in a way that is useful for management purposes. An important element of all water quality monitoring programmes is the application of a quality assurance plan that includes all steps in the data process, from field sampling to laboratory analysis and data storage. A comprehensive quality assurance plan provides confidence in the data and is essential where data are shared between agencies, for example in the case of transboundary groundwaters. This guidebook focusses on the information needed to design a groundwater monitoring programme and to

and rivers (0.26 and 0.0057 per cent respectively) and in wetlands and soil and atmosphere moisture (0.13 per cent). The addition of water into groundwater storage is known as recharge. This occurs naturally from precipitation, from surface runoff, and from surface water bodies, such as lakes and reservoirs (Fig. 1.2). In addition, human activities can also make important contributions to recharge as a result of, for example, surplus irrigation, pipe and canal leakage, and aquifer augmentation schemes.

Figure 1.2 The hydrogeological cycle of water between atmosphere, land surface, groundwater and the oceans



Once water enters the soil through the process of infiltration (see Box 1.1), it can flow in a variety of directions depending on the soil type and other local conditions. In the upper layers of soil and rock, pores and voids are filled with air rather than water. This is known as the unsaturated or vadose zone. In this zone, groundwater tends to flow vertically downwards