# MONITORING OF SURFACE WATER QUALITY

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**Contents**

## Summary

Surface water quality monitoring provides an integrated evaluation of physical, chemical, and biological characteristics of aquatic system in relation to human health concerns, ecosystem, and designated uses. Monitoring of the contaminants of surface water is a matter of great importance. Therefore, monitoring encompasses planning to information use.

The parameters to be monitored depend on the purpose of the monitoring. However, similar parameters are selected in many monitoring projects. The parameters relating to pollution and chemical information can be divided into three categories, i.e. metals, anions and organic compounds.

For detection of metals, Inductively Coupled Plasma (ICP) and atomic absorption (AA) techniques are mainly used, while Ion Chromatography is used for identification of anions, such as $Cl^-$, $SO_4^{--}$and $HCO_3^-$.

Gas Chromatography (GC) for small volatile molecules, and gas chromatography-mass spectrometry (GC-MS) are used for detecting organic compounds. Liquid chromatography-mass spectrometry (LC/MS) is used for non-volatile water soluble compounds.

## 1. Introduction

On Earth, water circulation is one of the most important processes for the maintenance of the environment. Visible water on the Earth's surface is called surface water, and includes runoff water, streams, rivers, lakes, seas, etc.

Some of the surface water evaporates, and becomes cloud which changes into rainfall (and snow). Some of the rainfall runs off the surface of the Earth, and flows in to rivers, lakes and seas, and becomes groundwater, or evaporates (Figure 1).

These surface waters contribute as inputs to the oceans that make up 70% of the Earth's surface. Water is required for many needs such as drinking, cooking, transportation, recreation, electrical power production and support for aquatic life. Pollution of these waters occur through industrial or municipal discharges or runoff from agricultural land, mining operations, urban land or construction. Natural sources can also contribute as pollutants but are not as significant. In USA, a 1994 survey showed that more than 36% of the surface water does not meet water quality objectives. Increasing population and economic growth are contributing to this problem. Recently trace amounts of various chemicals such as antibiotics have become a concern due to their ability to disrupt the endocrine systems of various organisms. They are called endocrine-disrupting chemicals and their detection is highly important.

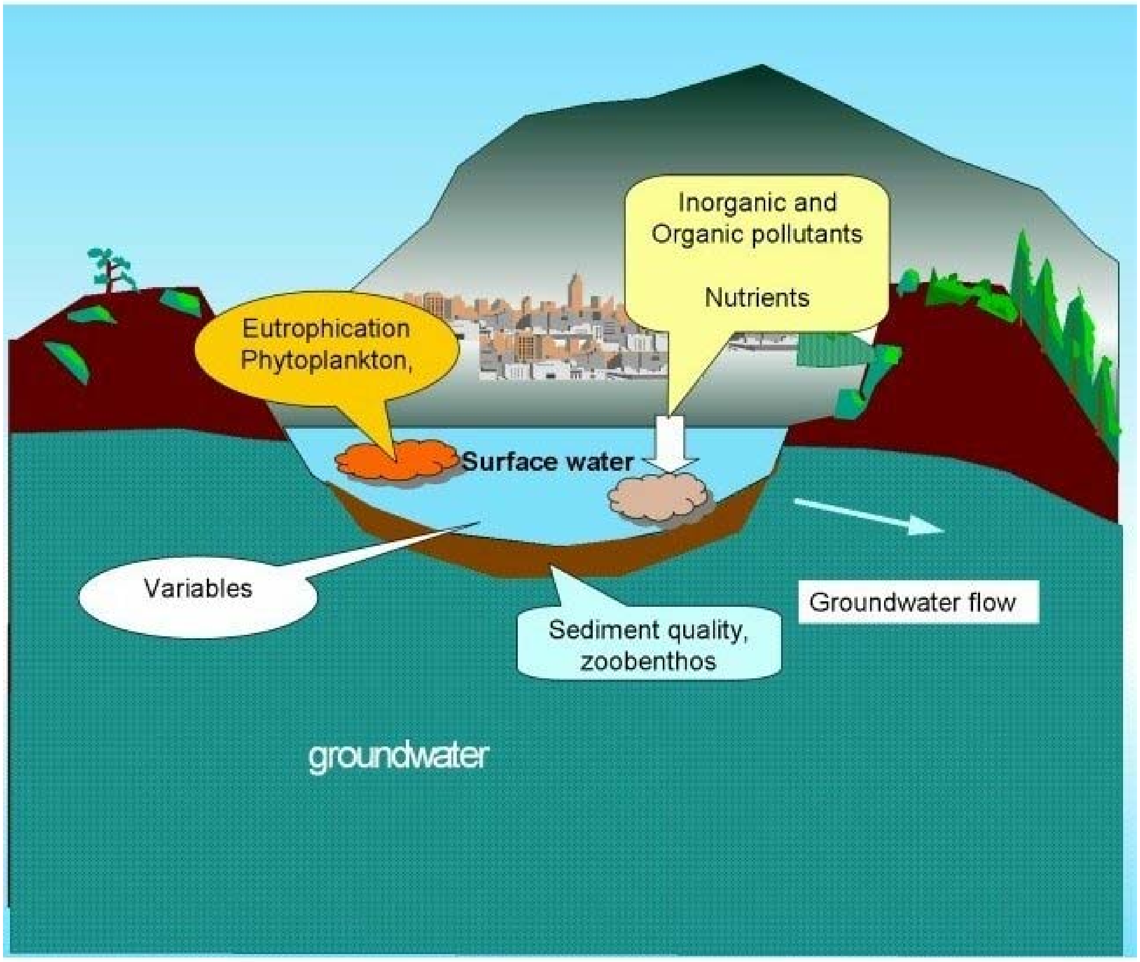


Figure 1. Surface water and ground water.



Rain dissolves nutrients produced in the forest and transports them to rivers, lakes and seas. Nutrients such as nitrogen (N) and phosphorus (P) are then taken up by algae and phytoplankton, which are consumed by zooplankton and microorganisms. This forms a starting point of a food chain. The remains of organisms at many stages of the food chain can decompose into nutrients again or are taken up by other life forms.

Various wastes produced by human activities are discharged into the environment, and some of the wastes contain toxic or hazardous substances. These can exist in surface water in various states, and can accumulate in aquatic life and sediments.

Due to the dangers posed by discharged hazardous substances in surface water, initiatives have been taken by many countries using guidelines and/or standards which presently require monitoring of surface water. In fact, many governments in various countries have set up programmes for monitoring of surface water quality.

For example, the European Environment Agency (EEA) reports an overview of the existing water quality monitoring activities in all 18 countries in the EEA area. The study covers all surface waters, i.e. rivers, lakes and reservoirs, as well as coastal and open marine waters, and provides for each country a description of the purpose of monitoring, network design, parameters measured, matrices sampled, frequency of sampling, data storage, analysis and reporting (http://reports.eea.eu.int/92-9167-001-4/en).

Many US State Governments have set up programmes of monitoring of surface water quality. Information is available at:

- http://www.tnrcc.state.tx.us/water/quality/data/wqm/,
- http://www.michigan.gov/deq/
- http://www.dep.state.fl.us/water/monitoring/

A Canadian provincial government has also set up monitoring projects from an agricultural point of view: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/wat2417.

In addition, other countries and regional governments have similar programmes with their own specifications for monitoring of surface water quality.

One of the major purposes of surface water quality monitoring is to detect harmful pollutants in water, sediments and biological tissues. Trace metals and hazardous organic compounds are major targets for detection.

## 2. Summary of monitoring of surface water quality

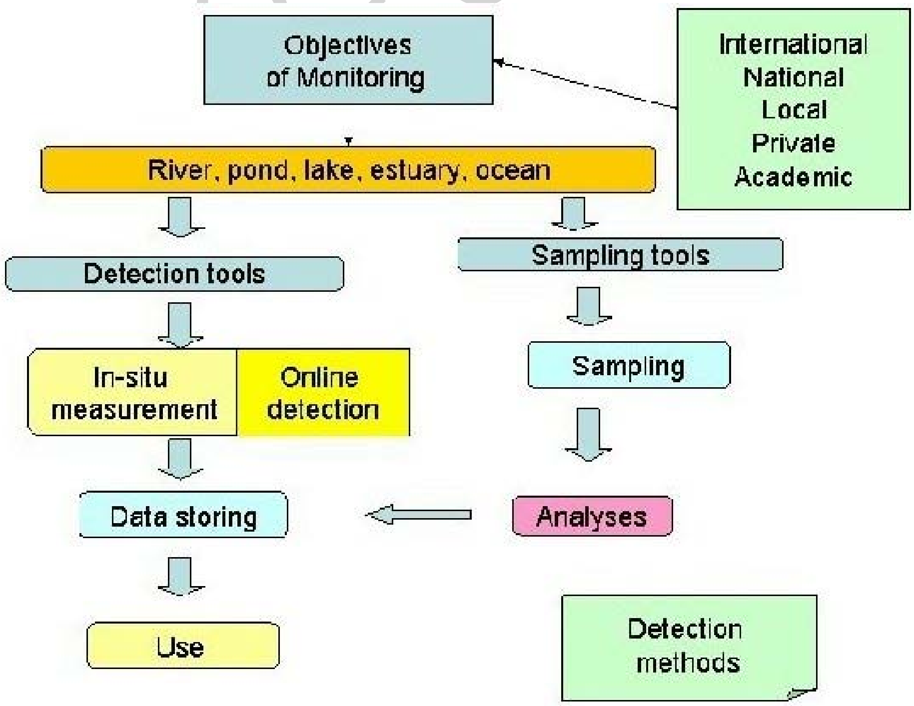


Figure 2. Flow diagram of surface water quality monitoring.

The objective of surface water quality monitoring is to obtain quantitative information concerning the physical, chemical, and biological characteristics of water via statistical sampling. The objectives and requirements range from detection of drinking water standard violations to the determination of the environmental state and analysis of temporal water quality trends. A general monitoring scheme is presented in Figure 2. The monitoring can be performed under international cooperation, nationally, locally, privately or academically. Therefore, the scale of monitoring varies from a very local area to a global range.

There are three categories of monitoring:

- routine surface water monitoring,
- periodic special surveys, and
- special surveys performed to assess pollution.

The monitoring plan includes the selection or determination of:

- parameters to be measured,
- sampling methods and tools,
- sampling frequency,
- detection methods, and
- data storage and information utilization, including data analysis and reporting.

To detect elements and compounds, techniques have been developed and standardized (EPA Manual of Manuals-Laboratory Analytical Methods Manuals). A monitoring scheme for surface water quality is shown in Figure 2. The detection methods can be separated into laboratory and in-situ and on-site measurements.

The monitoring programmes of water in oceans have been developed through international cooperation. The UNESCO's Intergovernmental Oceanographic Commission (IOC) has promoted the activities of the International Oceanographic Data and Information Exchange (IODE).

Furthermore, the Western Pacific Programme (WESTPAC), Integrated Global Ocean System (IGOSS), and Responsible National Oceanographic Data Center (RNODC) have been established to maintain data collected by international projects. Branches of these organizations have been set up in individual countries.

The U.S. Global Ocean Observing System (GOOS) is a permanent global system for observations, modelling and analysis of marine and ocean parameters to support operational ocean services worldwide.

## 3. Water quality and parameters monitored

The water quality parameters depend on the purpose of the monitoring. Different countries have used different approaches and methods to describe and to measure water quality. The parameters are grouped as shown in Figure 3.

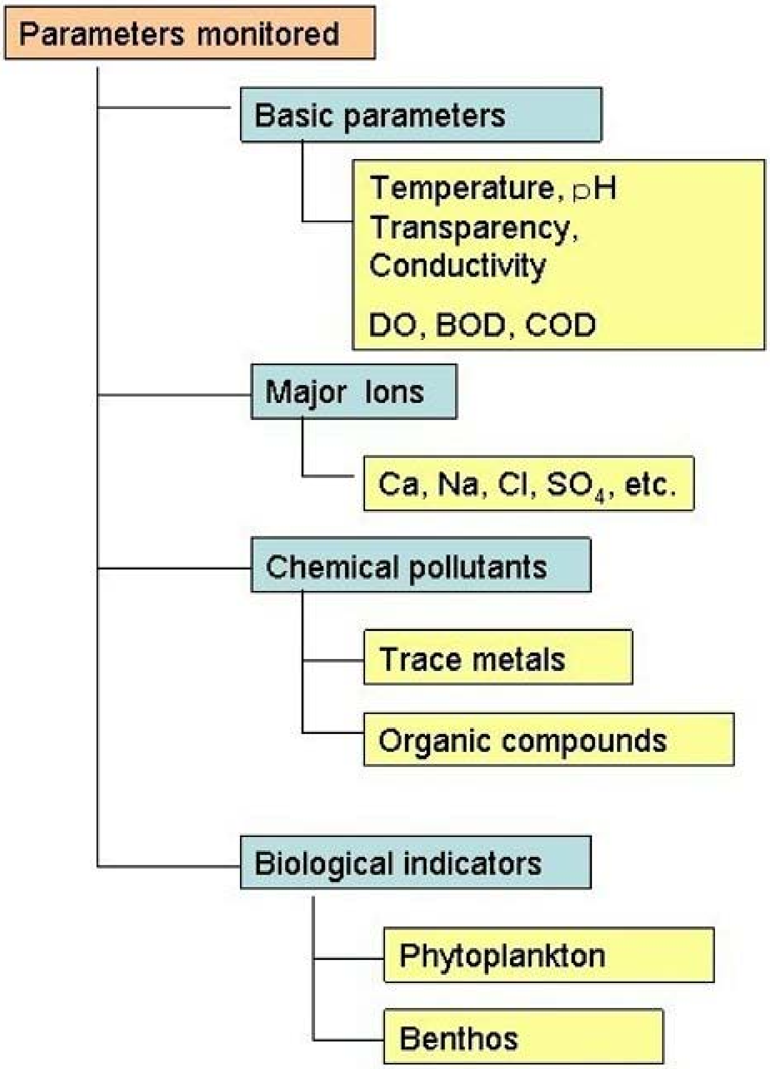


Figure 3. Grouping of parameters to be monitored.

## 3.1. Basic parameters

### 3.1.1 Water temperature

Water temperature is the one of the most basic physical parameters because it varies temporally and spatially, and affects many other factors such as conductivity, density, etc. In ocean observation, CTD instruments are the main way to measure conductivity (salinity), temperature and pressure (depth).

As the CTD instrument is lowered through the water, measurements of salinity, temperature and depth are recorded continuously. Some CTD instruments are so fast that they measure each of these quantities 24 times each second.

This provides a very detailed description of the water being tested. The sensors used to measure temperature on a CTD instrument are very accurate.

### 3.1.2 pH

The pH, which represents the $H^+$ concentration, is an important parameter that is often measured both at the sampling site and in the lab using pH meters. Portable pH meters are available for use in the field and larger ones are used in the lab. Calibration is required before the measurement, using a known pH solution, such as a buffer solution with a neutral pH of 7.0.

### 3.1.3 Conductivity

Electrical conductivity (EC) estimates the amount of total dissolved salts (TDS), or the total amount of dissolved ions in the water. In marine observation, conductivity is measured by a temperature and conductivity recorder that can convert the measurement into salinity. In estuaries, salinity is an important factor for habitats of aquatic life. Figure 4 shows a conductivity, temperature and depth recorder with water sample bottles, which is used for ocean measurements. The bottles can be opened and closed remotely, as the apparatus is lowered into the sea. Salinity in estuaries can be measured using a salinometer as shown in Figure 5, but there are also many hand-held types of digital salinometers.

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**Biographical Sketches**

**Masaharu Fukue** has B.Eng. and M.Eng. degrees in civil engineering from Tokai University, Japan and a Ph.D. in Geotechnical Engineering from McGill University, Montreal, Canada. He joined a consultant firm for a short period and then moved to Tokai University. He has given courses in geoenvironmental engineering, hydrospheric environment, shipboard oceanographic laboratory and submarine geotechnology. He is a member of the International Society for Soil Mechanics and Geotechnical Engineering, International Society for Terrain-Vehicle System, Japanese Society for Civil Engineers, The Japanese Geotechnical Society and The Japan Society of Waste Management Experts. He served as a chief editor for Japanese Standards for Soil Testing Methods and for “Japanese Standards for Geotechnical and Geoenvironmental Investigation Methods. He also served as a director of the Standard Division and a member of the Board of Directors, of the Japanese Geotechnical Society. Since 1996 he has been a member of the Editorial Board of the American journal “Marine Georesources and Geotechnology”. He is currently a chair of the Organizing Committee of 3rd International Symposium on Contaminated Sediments, sponsored by ASTM, ISCS2006-Shizuoka, Japan. He is also an advocate and a promoter of “Annual Symposium on Sea and Living Things and Rehabilitation of Coastal Environment, Japan”. He has sponsored Marine Geoenvironmental Research Association in Japan. He invented a filtration system for seawater using a 2500 ton large barge and performed a field experiment using the system for seawater purification in a small bay. He has published more than 300 scientific papers on qualities of seawater, sediments and soils.

**Yoshio Sato** has B.Sci. and Dr. Sci. degrees in oceanography from Tokai University, Japan. He has had more than 30 years of research and teaching experience in the university. His specialty is chemical analyses of the formation mechanism of manganese nodules on the ocean floor. Recently, he has become interested in preservation of the environment of enclosed sea areas, and utilization of ground seawater for fishery and deep ocean seawater. He is a member of the Chemical Society of Japan, the Oceanographic Society of Japan, the Geochemical Society of Japan, the Society of Sea Water Science, Japan, and the Japan Association of Deep Ocean Water Applications. He is a member of a committee for prevention of pollution in Shizuoka Prefecture, Committee of Environment in Shizuoka Prefecture, and Committee of Environment in Shizuoka City. He is a member of the Board of Directors, the Society of Sea Water Science, Japan. He has published more than 100 papers about seawater.

**Catherine Mulligan** has BEng. and MEng. degrees in chemical engineering from McGill University, and a Ph.D. specializing in geoenvironmental engineering, also from McGill University, Montreal, Canada. She has gained more than 20 years of research experience in government, industrial, and academic environments. She was a research associate for the Biotechnology Research Institute of the National Research Council and then worked as a research engineer for SNC Research Corp., a subsidiary of SNC-Lavalin, Montreal, Canada. She then joined Concordia University, Montreal, Canada in the Department of Building, Civil and Environmental Engineering. She has taught courses in site remediation, environmental engineering, fate and transport of contaminants and geoenvironmental engineering, and she conducts research in remediation of contaminated soils and water. She holds a Concordia Research Chair in Environmental Engineering.

She has completed a textbook as a sole author on biological treatment technologies for air, water, waste and soil and another recently with Prof. R.N.Yong on natural attenuation. She has authored more than 40 refereed papers in various journals and holds three patents. She is a member of the Order of Engineers of Quebec, Canadian Society of Chemical Engineering, American Institute of Chemical Engineering, Air and Waste Management Association, Association for the Environmental Health of Soils, American Chemistry Society, Canadian Society for Civil Engineering and the Canadian Geotechnical Society.