THEME PAPER

Networks and Mandates for Water Quality Monitoring

Introduction

The term ‘water quality’ is generally used to express the physical, chemical or biological state of water. This, in turn, may be related to the suitability of water for a particular use or purpose.

The quality of water is characterised by a range of physical, chemical and biological parameters which arise from a variety of natural and human influences. Normally quality is determined by field or laboratory analysis, or in-situ measurement, of the water for one or more parameters of interest.

Monitoring is defined by the International Standards Organisation (ISO) as:

‘The programmed process of sampling , measurement and subsequent recording or signalling, or both, of various water characteristics, often with the aim of assessing conformity to specified objectives.’

Monitoring, in the practical context, is expected to provide information for various purposes including the assessment and management of water quality.

Ideally, the monitoring for water quality should only be attempted once the objectives of the exercise are established. For example, one or more of the following objectives could apply:

1. To build up an overall picture of the aquatic environment thus enabling pollution cause and effect to be judged.
2. To provide long term background data against which future changes can be assessed.
3. To detect trends.
4. To provide warnings of potentially deleterious changes for specific use.
5. To check for compliance or for charging purposes.
6. To characterise an effluent or water body (e.g., lake, river, groundwater)
7. To investigate pollution.
8. To collect sufficient data to perform in-depth analysis of an observed or predicted phenomenon.

Three main categories are usually envisaged in this regard :

- Monitoring: long term standardised measurements (1, 2, and 3 as above).
- Surveillance: continuous specific measurements for management and operational activities (4 and 5 as above).
- Survey: finite duration, intensive program for a specific purpose (6,7 and 8 as above)

It is possible to further divide the above monitoring categories into various sample types for surface water and groundwater as can be seen in Table 1 and Table 2 respectively.

The consideration of sampling objectives leads to producing a comprehensive water quality monitoring programme as understanding the reasons for sampling makes the selection of suitable sites and sampling frequencies much easier. As an example of this, Table 1 and Table 2 also highlight, for surface water and groundwater respectively, possible sample network densities and sampling frequencies designed to meet the objectives of a number of different sample types within each category of monitoring.

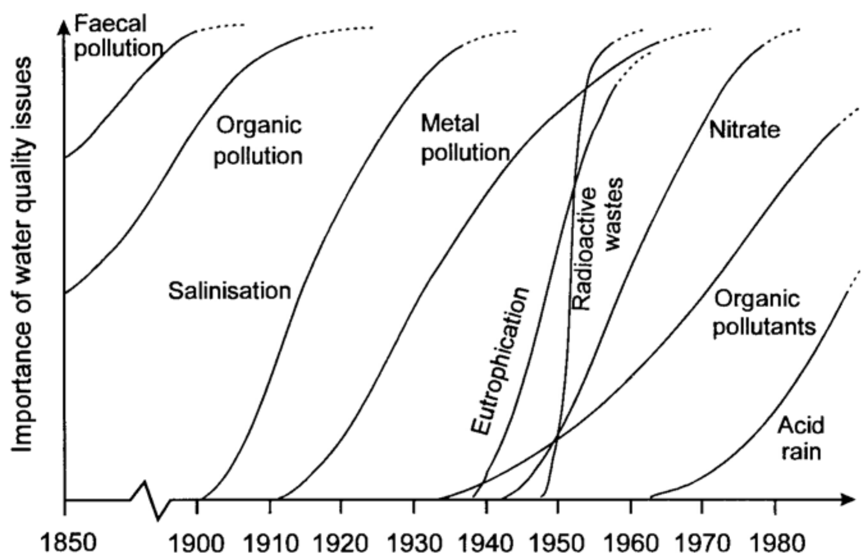
In addition to the consideration of network density and sampling frequency it is necessary to formulate a suite of quality parameters which will meet the objectives of the category of monitoring under consideration. As an example, Table 3 gives suggested parameters designed to meet the monitoring objectives of each sample type. For convenience, the parameters have been arranged into the following groups:

- General (basic parameters many of which can be measured instrumentally either in the field or in the laboratory)
- Nutrients (nitrogen and phosphorus parameters which will measure the nutrients available for plant growth and eutrophication)
- Organic matter (parameters capable of estimating the likely effect on watercourses of the discharge of organic matter)
- Major ions (the inorganic anions and cations which can describe the chemical composition of the water and help to assess pollution)
- Other inorganics (miscellaneous inorganic species which are important for certain water uses or for classification purposes)
- Metals (three metal species which are important because of their toxicity or because they are useful indicators for the presence of other metals)
- Trace organics (particular species which are important due to their toxicity, effect on potability of water or effect on the natural river processes)
- Microbiological (one indicator species for the presence of faecal pollution of water)
- Biological (one chemical which is present in plants, is a good indicator of algal growth and, therefore, eutrophication of waters)

Where resources are limited (and resources for the monitoring of water are nearly always limited), it is often necessary to choose a limited number of the above parameter groups. To aid this choice it is instructive to consider the graph plotted in Figure 1 which shows how water quality issues have been monitored and dealt with over the last 150 years in the industrialised countries of the world. From this figure it can clearly be seen that such nations have progressed from monitoring and controlling basic faecal and organic pollution to dealing with the more esoteric pollutants presumably because the greatest benefit for the least cost can be gained from prioritising in this way. This diagram can also be used to set monitoring priorities, however, as once it is known where a particular country, or body of water, is on the horizontal scale in terms of monitoring pollution a suitable sampling and analysis programme can be set for the next priority issue. Once sufficient monitoring information has been built up to assess the scale of pollution by particular contaminants suitable control measures can be devised.

Figure 1: sequence of water quality issues in industrialised countries

from 'Water Quality Assessments', Chapman D (Ed), E & F N Spon, Madras, 1996



Clearly, the above discussion of water quality monitoring represents an ideal situation where the proposed programme can be developed and initiated from scratch by a single body.

With regard to the current situation in India, there have been comprehensive studies of the state of faecal and organic pollution of many rivers. Data on other water quality issues is, however, lacking with only limited information available on pollution by metals, nutrients and organic contaminants. Nevertheless, it is known that such problems exist as there have been a few studies aimed at characterising such pollutants. Under HP, many laboratories are being equipped with advanced level instrumentation, and their staff trained, to determine some of these more esoteric pollutants. It is therefore expected that, in future, such pollutants will be monitored as a matter of course.

Current Water Quality Monitoring Under Hydrology Project (HP)

In India, because monitoring has been carried out historically for a number of reasons, the situation is far from the ideal described above with a number of different bodies taking samples to satisfy their own particular objectives as can be seen from the following:

- Pollution Control Boards : Central & State
- Central Water Commission & State Irrigation Departments
- Central Ground Water Board & State Ground Water Department
- National River Conservation Directorate
- Research Institutions (e.g., NEERI)
- Others (State Public Health and Environmental Departments, Water Supply and Sewerage Boards etc.)

If such monitoring effort is not co-ordinated in some way, considerable effort can be wasted because:

- the monitoring programmes may not always be commensurate with the original organisational mandates and study objectives meaning that data is of limited use
- unnecessary duplication of sampling, analysis and data processing can result
- limited resources are not used most effectively

The challenge for HP is to encourage the maximum inter-organisation co-operation in water quality monitoring. This should benefit all by reducing wasted time and effort thus allowing precious resources to be directed where they can be most effective. It is particularly important in the context of this project as, under HP, a number of organisations are upgrading existing water quality monitoring networks or starting new ones. The first step toward greater monitoring co-operation should be an objective assessment of organisational mandates and their underlying monitoring objectives and sampling networks.

Periodic Review of Data

Periodic analysis and review of data is essential in any water quality monitoring programme. It may lead to new or redefined information needs as networks often tend to 'grow' without defined measurement objectives. An objective analysis of data may lead to 'pruning' if correlations can be established between stations. This saving of effort can be directed towards an increase in frequency of measurement for greater reliability and/or introduction of new water quality parameters for characterisation.

The releasing of spare monitoring capacity through regular data review, is particularly important in the context of the present project. The problem of water pollution due to trace contaminants has not yet been quantified as India's monitoring programmes are not, to any large extent, set up to detect this type of pollution. Now, however, with laboratories being established and upgraded with advanced level equipment under HP, there is a major opportunity to monitor trace contaminants and it is therefore essential that maximum use is made of this opportunity.

Objective of the meeting

The objective of this meeting is:

> To identify and define the mandates and objectives for water quality monitoring networks for surface water and groundwater organisations under HP. This will then lead to optimum and cost-effective network design and form a basis for future inter-agency cooperation in operation of water quality networks.

It is expected that after this meeting, state organisations under HP will be able to achieve better design or rationalisation of their monitoring networks. This should prove valuable both to organisations within HP and those outside of the project's remit.

Proposed Approach

It is proposed to have a two day meeting at each of the following four centres:

Ahmedabad (for Gujarat and Maharashtra)
Raipur (for Madhya Pradesh and Orissa)
Hyderabad (for Andhra Pradesh and Tamil Nadu)
Thiruvananthapuram (for Karnataka and Kerala)

Each centre will cater for two participating HP states. The major activities, as highlighted below, will be spread across four sessions (two per day):

1. Presentation of the information collected and compiled regarding the agencies presently operating water quality networks.

    - Questionnaires were circulated and information was obtained by the consultants from various organisations on several aspects in this regard. The same has been consolidated and is proposed to be presented to provide an overview to the participants.
    - Presentations have also been invited from the participants belonging to different organisations operating water quality networks delineating their mandates.

2. Presentations on topics for improving the understanding of water quality related aspects. Topics such as the following are likely to be covered:

    - water quality issues in HP states
    - integration of water quantity and quality in hydrology
    - use of water quality data in policy formulation and management
    - accreditation of water quality laboratories

3. Exercise sessions for assessment of mandates/objectives and attempting rational design of networks for example basins.

- It is proposed to split up the participants in two workgroups (per domain: SW, GW). Each workgroup will try to assess the mandates /objectives and the rationale behind the existing networks. Further, they would attempt to design a network for an example basin.

Table 1: Surface water quality monitoring objectives, network densities and sampling frequencies

Category	Type	Objectives	Network density	Sampling frequency (per year)
Monitoring	Baseline	Natural background concentrations	One for each mainstream stem and one for each major tributary (20% of flow at confluence)	Initially 3 – 4 X , then repeat every 2 – 3 years
	Trend	Detection of changes over time due to anthropogenic influences	<u>Mainstream :</u> After each 1 ½-2 days travel time or after each major infiltration (whichever is sooner) <u>Tributary :</u> Before confluence if >20% of mainstream flow	12 X (if river catchment area >100,000 sq. km.) 24 X (if river catchment area <100,000 sq. km.)
	Flux	Calculation of load Calculation of mass flux	State or border crossings Outflows into lakes, seas and oceans	Simultaneously with flow measurement (ie. 24 X)
Surveillance	Water use	Check that water is fit to use	At all points of use or intake	Depends on use
	Pollution control	Check effects of discharges Check water quality standards	Upstream and downstream of discharge point In river after mixing	For discharges with significant effects : 12 X (or 52 X for high significance) Annually for others. For river waters : 12 X
Survey	Classification	Classification of reach	Within each reach	Annually (less frequently if reach unchanged, more frequently if considerable changes)
	Management and research	Investigation of pollution and need for corrective measures Special interest Filling in knowledge gaps	Dependent upon scale of survey required	Sufficient to characterise problem and likely solution

Table 2: Groundwater quality monitoring objectives, network densities and sampling frequencies

Category	Type	Objectives	Network density	Sampling frequency (per year)
Monitoring	Baseline	Baseline concentrations	Initially to correspond 1:1 to water table monitoring networks provided the analytical capacity is available.	1 (unless special circumstances apply) 4 – 6 temporarily for shallow wells
	Trend	Early tracing of slow and rapid quality changes and deterioration processes	As above	1 (unless special circumstances apply) 4 – 6 temporarily for shallow wells
Surveillance	Water use	Check that water is fit to use	At all points of use or intake	Drinking water : 12 Irrigation water : 1 Livestock watering : 1
Survey	Management and research	Reconstruction of water and solute evolution Investigation of pollution and need for corrective measures Characterise water bodies Filling in knowledge gaps	Dependent upon scale of survey required	Sufficient to characterise problem and likely solution

Table 3: Quality parameters for typical surface water (S) and typical groundwater (G) analyses for various monitoring categories

Parameter Group	Parameter	Baseline	Trend	Flux	Water Use[1]					Pollution Control[2]	Classification
					D	I	B	L	F		
General	Temperature	S, G	S, G		S, G	S, G			S	S	
	Suspended Solids	S, G	S, G	S	S, G				S	S	
	Conductivity	S, G	S, G		S, G	S, G		S, G	S	S	S, G
	pH	S, G	S, G		S, G	S, G	S	S, G	S	S	S, G
	Dissolved Oxygen	S	S				S		S	S	S
	Total Dissolved Solids	S				S, G					G
Nutrients	Ammoniacal Nitrogen	S	S	S	S, G				S	S, G	S, G
	Total Oxidised Nitrogen	S, G	S, G	S				S, G			G
	Total Phosphorus	S, G	S, G	S							
Organic Matter	Chemical Oxygen Demand		S							S, G	
	Biochemical Oxygen Demand		S, G	S	S, G		S		S	S	S
Major Ions	Sodium	S, G				S, G					S, G
	Potassium	S, G									
	Calcium	S, G				S, G					S, G
	Magnesium	S, G				S, G					S, G
	Carbonates and Bicarbonates	S, G									G
	Chloride	S, G	S, G	S	S, G	S, G				S	G
	Sulphate	S, G									
Other Inorganics	Silica	G									
	Fluoride	G			S, G						G
	Iron	G									G
	Boron	G				S, G					S,G
Metals	Cadmium	G	S	S					S		
	Arsenic	G			G						
	Mercury	G	S	S					S		
	Zinc	G	S	S							
Organics	Pesticide (Indicator)	S	S	S	S, G				S		
	Synthetic Detergents		S								
	Organic Solvents				S, G						
	Phenols				S, G						
Microbiological	Total coliforms	S	S		S, G	S, G	S	S, G		S, G	S, G
Biological	Chlorophyll ‘a’	S	S		S				S		

[1] D = for treatment as Drinking Water, I = Irrigation, B = Human Bathing, L = Livestock Watering, F = Fish and aquatic life

[2] Suggested ‘organic pollution’ suite. For guidance only, specific parameters sampled will depend upon the discharge being monitored.

Networks and Mandates of Water Quality Monitoring

January 1999

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Foreword

Four Technical Meetings on “Networks and Mandates for Water Quality Monitoring” were held to generate discussions regarding Mandates of various organisations who are monitoring water quality. The meetings were held region-wise and each meeting covered two HP states, to obtain opinions country wide and at all levels. A number of HP and non-HP agencies participated and some presented case studies or summary of the work and needs of their organisations.

The Technical Meetings were held at:

- **Ahmedabad, June 4 – 5, 1998,** covering Gujarat & Maharashtra
- **Raipur, June 11 - 12, 1998,** covering Madhya Pradesh & Orissa
- **Bangalore, July 27 - 28, 1998,** covering Karnataka and Kerala
- **Hyderabad, July 30 – 31, 1998,** covering Andhra Pradesh and Tamil Nadu

The present report is not an attempt to reproduce all discussions and formal and informal presentations. The report includes only key presentations, and the findings and recommendations arrived at the meetings.

As a follow up of the meetings, the Consultants will facilitate implementation of the recommendations. For this purpose, necessary approval of the recommendations and active co-operation of agencies under HP will be required.

The design and rationalisation of water quality monitoring networks for HP states has been started In the light of the recommendations

J. G Grijsen
Team Leader, Hydrology Project

List of Participating Organisations:

HP Agencies

Project Coordination Secretariat, MOWR
Central Ground Water Board
Central Water Commission
State Departments

Andhra Pradesh

State Groundwater Department
Irrigation & Command Area Development Department

Gujarat

Ground Water Resources Development Corporation
Narmada & Water Resources Department

Karnataka

Department of Mines & Geology
Water resources Development Organisation

Kerala

Ground Water Department
Irrigation Department

Maharashtra

Groundwater Surveys & Development Agency
Irrigation Department

Madhya Pradesh

Ground Water Survey, WRD
Hydrometerology, WRD

Orissa

Irrigation Department
Ground Water Surveys & Investigation

Tamilnadu

Water Resources Organisation, PWD

DHV & DH, Consultants

Non-HP Agencies

Central Pollution Control Board
National River Conservation Directorate
Andhra Pradesh Pollution Control Board
Gujarat Pollution Control Board
Kerala Pollution Control Board
Maharashtra Pollution Control Board
Madhya Pradesh Pollution Control Board
Tamilnadu Pollution Control Board
SJ College of Engineering, Mysore
Gujarat Water Supply & Sewerage Board
Chennai Metropolitan Water Supply & Sewerage Board
Public Health Department, AP
Hyderabad Metro Water Supply & Sewerage Board

Executive Summary

Under HP a number of chemical laboratories are being upgraded and some new ones are being established for various agencies. While some of these agencies are operating water quality networks for some time others will start now. In addition, organisations outside HP are also operating water quality monitoring networks. Many a times reasons for such work are not well defined. This results in collection of data of limited use and where two or more agencies are working in the same area, duplication of effort as well.

With a view to rationalise the water quality networks being operated by organisations under HP and those which are to be started, regional level technical meetings were held at four locations in the country, each covering two HP states. Representatives of state and central HP agencies and those of organisations outside HP collecting water quality data in the region participated in these meetings. The mandates of various organisations operating water quality monitoring networks and their objectives for monitoring were discussed. Findings and recommendations arrived at through presentation of papers and group discussions are given below:

1. Mandates and objectives

The following mandates related to water quality monitoring were identified for organisations that participated in the technical meetings:

(i) assessment of water resources
(ii) control and management of water pollution
(iii) preservation of ambient water quality
(iv) supplying water of acceptable quality for different uses, particularly for domestic consumption and irrigation
(v) training in water quality management
(vi) dissemination of water quality information

The HP agencies identified (i), (iv) and (vi) above as their prime mandates. In view of formation of Central Ground Water Authority the mandate of CGWB may be expanded to include (ii) and (iii) also.

It was recommended that water quality monitoring networks should be designed with objectives in consonance with the mandates. Thus the objectives for HP agencies would be:

- *monitoring for establishing baseline water quality, observing trend in water quality changes and calculation of flux of water constituents and*
- *surveillance for drinking water and irrigation use (in comparison with standards).*
- *dissemination of water quality information*

Further, it was recommended that naming of objectives as routine monitoring, multipurpose, etc. should be replaced by well defined terms as noted above.

2. Historical data

CWC, CGWB and some state agencies have historical water quality data collected over the past several years. These data are reported in the form of water quality yearbooks. In the case of ground water, maps showing isopleths of electrical conductivity (EC) are prepared. Further, problem areas are also identified with respect to occurrence of fluorides and nitrates. There is a need to review the data in greater detail for both surface and ground water and carry out statistical analysis to establish trends and correlation between parameters and between stations. This will lead to an objective reappraisal of the existing network and may result in modifications in regard to location of stations, frequency of sampling and choice of water quality parameters. Whereas about five year old data may be analysed initially, older data may also be considered as per the review needs.

It was recommended that working groups, separately for surface and ground waters, might be formed to carry out the review of historical data with the goal of rationalising the water quality networks. In this task the working groups will be assisted by the Consultants who will provide a protocol for the review and worked-out examples of review of historical data of surface and ground water quality. This will also bring in uniformity among the working groups in their approach to the review. The groups for groundwater may be formed on the basis of regions, while those for surface water on the basis of river basins.

3. Future network reviews

For regular assessment of monitoring needs and optimisation of monitoring efforts, review of monitoring data should be carried out periodically.

It was recommended that review of all water quality networks should be done at a regular interval of three years.

4. Newly introduced water quality parameters

Indiscriminate discharge of municipal and industrial wastes in the environment along with intensive utilisation of water resources has resulted in pollution of surface and ground waters. Under HP, the capability of laboratories is being enhanced to monitor pollution related water quality parameters, namely, aggregate organic matter, faecal bacteria, trace heavy metals and trace organics.

It was recommended that a selected number of pollution related water quality parameters should be included in the monitoring networks but only as dictated by the objectives of monitoring.

5. Ground water pollution

Only a limited number of ground water quality monitoring stations for surveillance for pollution control are being operated by CPCB and state PCBs. These stations are not adequate to detect trend in deterioration of water quality. Further, the groundwater agencies primarily monitor major cations and anions which are not sufficient to indicate pollution.

It was recommended that CGWB and state GW agencies should set up surveillance cum trend stations in areas where there are possibilities of ground water contamination, such as mining, industrial and agricultural areas, urban centres, etc.

6. Recognition of water quality problem areas

Many a times water quality deterioration is noticed only when the damage, which may be irreversible, becomes obvious. A case in point is fluoride bearing ground waters. There is a need to scan water quality for detecting such problems.

It was recommended that water quality monitoring agencies should include short term surveys in their monitoring programmes designed to identify water quality problem areas.

7. Improved co-operation among agencies

Organisations, other than HP agencies, which are operating water quality monitoring networks include, CPCB, NRCD, state PCB, PHED and WSSB. Often there is no communication among the various agencies, with the result that there is duplication of effort. Also one agency does not draw upon the experience of the other.

It was recommended that for each state a co-ordinating committee of members drawn from all agencies engaged in water quality monitoring in the state should be formed, in which each member would present activities of their organisation.

8. Analytical quality control (AQC) for water quality laboratories

It was realised that the credibility of information generated from the water quality monitoring network and its acceptance by users would directly depend upon the quality of data. Further, quality assurance of data is important when a number of laboratories are involved in characterising the same waterbody at different locations.

A within-laboratory AQC exercise comprising 4 parameters, in which 21 laboratories from HP agencies participated was completed recently. A second round of the exercise, comprising 10 parameters, is already under progress. It is planned to start an inter- laboratory AQC exercise in which CPCB laboratory will serve as the reference laboratory for the initial two years. It is expected after this period, some of the HP laboratories may be in a position to take up this responsibility.

It was recommended that within- and inter-laboratory Analytical Quality Control programmes should be instituted in all HP laboratories on a continuing basis. Further, all HP laboratories were urged to join in the ongoing exercises.

1 Hydrological Information System (HIS)

1.1 General

A Hydrological Information System (HIS) within a given Hydrological Service can be considered as an information system providing a conceptual basis for the development of proper approaches which ensure that the right data are available in the right form at the right place and time.

In India, such a hydrological information system is currently operated by a number of Central and State, surface water and groundwater, agencies. The state agencies operate within the respective states whereas the Central agencies operate in all the states. The present system as a whole is not adequately developed and maintained so as to provide the information services as per the desired standards. The shortfall of the system performance has been on various aspects like: inadequate observational network, wasteful use of resources by having duplication in the observational set-up by different agencies, absence of common standards for observational procedures, lesser emphasis on the reliability of the data produced, long time gap between observation of data and its dissemination to the users etc. The need for necessary upgradation and development of the existing system has thus been noticed for a very long time.

1.2 The Hydrology Project (HP)

The Hydrology Project aims at developing/improving the existing set-up of hydrological information system available with various state and central agencies for the eight states of Andhra Pradesh, Gujarat, Kerala, Karnataka, Madhya Pradesh, Maharashtra, Orissa and Tamil Nadu. This would assist in the development of more reliable and spatially intensive data on the quantity and quality of water resources, and in making information available, from computerised databases, for planning, designing and management of water resources and water use systems. Special attention would be paid to standardisation of procedures for the observation of variables and validation of so that it is of acceptable quality and thus compatible between different agencies and hydrological regions. Adequate facilities would be build up for proper storage, archival and dissemination of data for the system to be sustainable for the long-term use. The infra-structural development and implementation of the proposed HIS in the project area is vested with the concerned Central and State agencies operative in the project area.

An improved HIS will assist in the development of more reliable and spatially intensive data on the quantity and quality of water resources, and in making information available, from computerised databases, for planning, designing and management of water resources and water use systems. Special attention would be paid to standardisation of procedures for the observation of variables and validation of so that it is of acceptable quality and thus compatible between different agencies and hydrological regions.

For any such attempt, comprehensive information with respect to various aspects of the hydrological cycle, which is the object system for the HIS, is essential. To be able to provide this information the first step is to obtain the information on the temporal and spatial characteristics of this object system by having a network of observational stations. The basic data collected for different hydrometeorological phenomenon through this observational network is called the raw or observed data. Such observed data has to be validated for ensuring the reliability of the resulting information. The resulting raw and processed data sets have to be properly stored so that they can be easily disseminated to the users whenever required.

The primary role of the HIS is to provide the reliable data sets for the purpose of long term planning, designing and estimation of water resource and water use systems and for research activities in the related aspects. It is also desired that the system will function in such a manner that it provides the information to the users in time and in proper form. The scope of HIS is not extended to provide the data to the users on a real-time basis for short-term forecasting or operational purposes.

It is also stressed that the HIS includes mathematical modelling only to the extent of validating the raw data and not for any operational, design or research purposes. It rather produces the required data and boundary conditions for any such modelling exercises.

1.3 HIS Set-up under HP

The schematic layout exhibiting the structure of HIS is given in Fig. 1.1.The Hydrological Information System (HIS) comprises the infrastructure of physical and human resources to collect, process, store and disseminate data on (geo-)hydrological and hydrometeorological variables. A large public funding and effort is required for the operation of a hydrological information system. And therefore, the efficiency of the system should be such that more and more data users make use of the available data so that the spent resources are utilised in the most optimal manner.

The activities under HIS can be broadly classified under the following categories:

- Assessment of user needs and HIS objectives
- Establishment of observational network
- Data collection
- Data validation, analysis and reporting
- Data exchange and communication
- Data storage and dissemination
- Institutional and human resources development.

To provide timely reliable space-, location-, time- and relation-oriented data of the water resources/water use system, the HIS comprises the following components:

in each State

- Hydrometeorological, Surface Water and Ground Water Observation Networks,
- Water Quality Laboratories,
- Sub-divisional/District Data Processing Centres, one in each Sub-division/District,
- Divisional/Regional Data Processing Centres, one in each Division/Region,

- State Data Processing Centres, one in the State Surface Water Department and one in the State Groundwater Department, and
- State Data Storage Centre, one in the State

in the Central Water Commission (CWC)

- Surface Water Observation Networks,
- Water Quality Laboratories,
- Divisional Data Processing Centres, one in each Division,
- Circle Data Processing Centres, one in each Circle,
- Regional Data Processing and Data Storage Centre, one in each Region and
- National Data Centre, one at National level.

in the Central Ground Water Board (CGWB)

- Groundwater Observation Networks,
- Water Quality Laboratories,
- Data Processing Centre, one for each Unit,
- Regional Data Processing and Data Storage Centre, one in each Region and
- National Data Centre, one at National level.
- Communication System, for data exchange within and between the states and central organisations.

Briefly, for the operation of HIS of a state, the following activities take place at the various levels:

- At the ***stations/wells*** in the hydrometeorological, surface water and groundwater observation networks field data and water quality samples are collected. The water samples are brought to the Water Quality Laboratories. At regular intervals (monthly/quarterly) the field data are submitted to the Sub-divisional/District Data Processing Centres.

- In the ***Water Quality Laboratories***, beside the analysis of water quality samples, the analysis results and the field data are entered in the computer by the chemists and subjected to primary validation. At regular intervals, the laboratory passes the information on to the nearest Divisional or Regional Data Processing Centre.

- In the ***Sub-divisional/District Data Processing Centres*** all field data are entered in the computer and stored in a temporary database. Next, primary validation of hydrological data (entry control and reach checks) takes place on the data and feedback is given to the field stations. The computerised data are passed on to the Divisional/Regional Data Processing Centre immediately after finalisation of the primary processing. For purpose of validation and analysis of groundwater data the District Data Processing Centre also makes use of the data collected by CGWB, these are retrieved regularly from the Data Storage Centre.

- In the ***Divisional/Regional Data Processing Centres***, given their larger spatial coverage, more advanced secondary data validation is carried out. The data are stored in temporary databases. After validation, the surface water and groundwater data are transferred to their respective State Data Processing Centres.

- In the ***State Data Processing Centres***, after reception of the data from its Divisions/Regions, a copy of the field data is transferred to the State Data Storage Centre. The main activity of the State Data Processing Centre is final data validation, completion, analysis and reporting. Here, the data are stored in temporary databases. At the end of the hydrological year, once the data have been properly validated, the (authenticated) processed data is transferred to the State Data Storage Centre. To improve the effectiveness of the final validation, in the State Centres also use is made of the relevant data collected by the Central Agencies.

- The ***State Data Storage Centre*** stores and administers the storage of all field and (authenticated) processed hydrological data collected in the State, and makes the data available to authorised Hydrological Data Users. As a State archive, it also maintains a HIS-Catalogue of all data stored in its own database and those stored in the databases of the other states and of the Central Agencies.

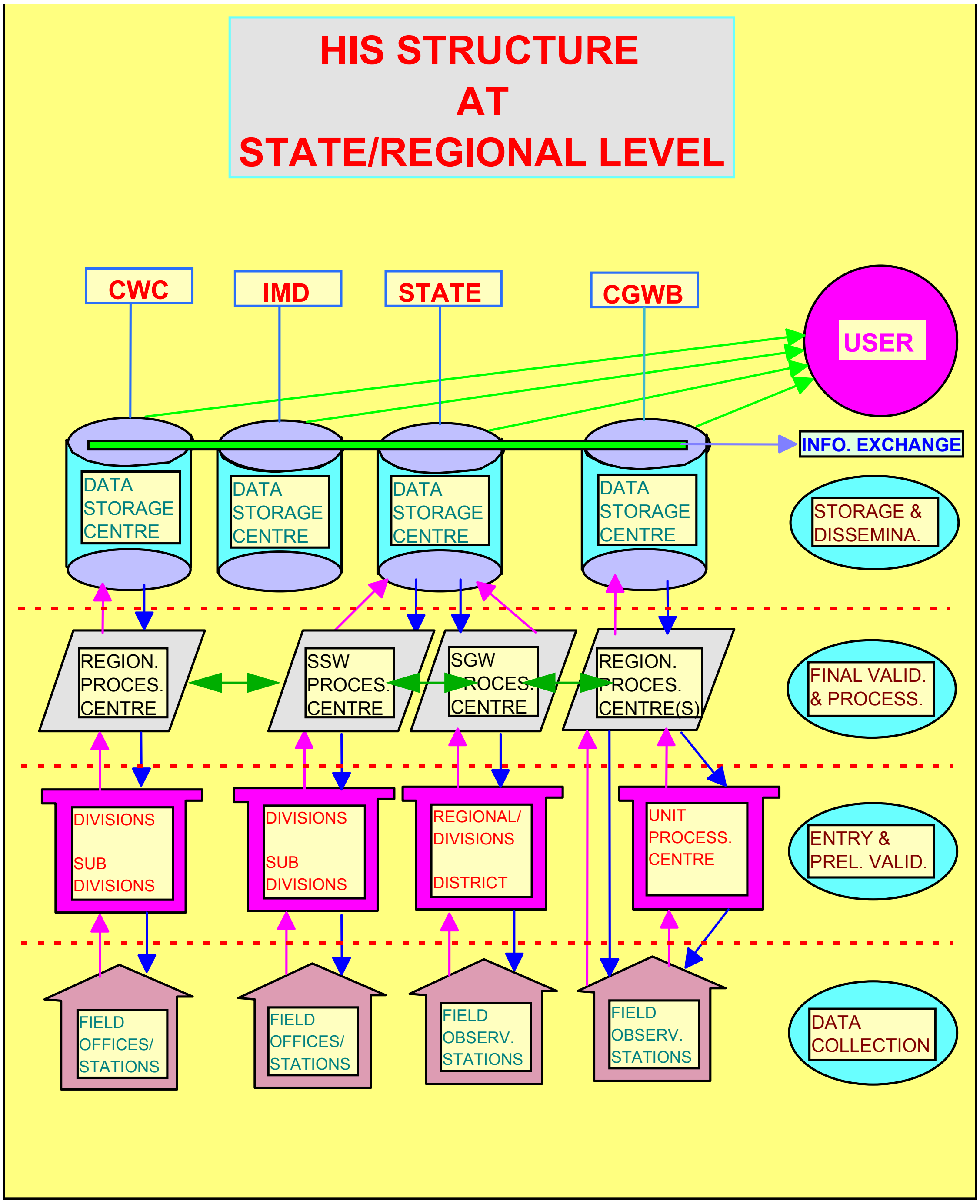

Figure 1.1 HIS structure at State/Regional level

2 Networks and Mandates for Water Quality Monitoring

2.1 Water Quality Monitoring

The term ‘water quality’ is generally used to express the physical, chemical or biological state of water. This, in turn, may be related to the suitability of water for a particular use or purpose.

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1. To build up an overall picture of the aquatic environment thus enabling pollution causes and effects to be judged.
2. To provide long term background data against which future changes can be assessed.
3. To detect trends.
4. To provide warnings of potentially deleterious changes for specific use.
5. To check for compliance or for charging purposes.
6. To characterise an effluent or water body (e.g., lake, river, ground water)
7. To investigate pollution.
8. To collect sufficient data to perform in-depth analysis of an observed or predicted phenomenon.

Three main categories of monitoring are usually envisaged:

Monitoring: long term standardised measurements (1, 2, and 3 as above).

Surveillance: continuous specific measurements for management and operational activities (4 and 5 as above).

Survey: finite duration, intensive program for a specific purpose (6,7 and 8 as above)

The consideration of sampling objectives leads to producing a comprehensive water quality monitoring programme as understanding the reasons for sampling makes the selection of suitable sites and sampling frequencies much easier.

In addition to the consideration of network density and sampling frequency it is necessary to formulate a suite of quality parameters which will meet the objectives of the category of monitoring under consideration. For convenience the parameters can be arranged in the following groups:

General: basic parameters many of which can be measured instrumentally either in the field or in the laboratory.

Nutrients: parameters, which measure the nutrients available for plant growth and eutrophication.

Organic matter: parameters capable of estimating the likely effect on watercourses of the discharge of organic matter.

Major ions: the inorganic anions and cations, which can describe the chemical composition of the water and help to assess pollution.

Other inorganics: miscellaneous inorganic species that are important for certain water uses or for classification purposes.

Heavy metals: metal species which are important because of their toxicity or because they are useful indicators for the presence of other metals.

Trace organics: particular species, which are important due to their toxicity effect on potability of water or the natural river processes.

Microbiological: indicator species for the presence of faecal pollution of water.

Biological: chlorophyll-a, which is present in plants, as an indicator of algal growth and, therefore, eutrophication of waters.

Where resources are limited (and resources for the monitoring of water are nearly always limited), it is often necessary to choose a limited number of the above parameter groups.

Figure 2.1 shows sequence of water quality issues as they gained importance and were dealt with over the last 150 years in the industrialised countries of the world. It is seen that such nations have progressed from monitoring and controlling basic faecal and organic pollution to dealing with the more esoteric pollutants presumably because the greatest benefit for the least cost can be gained from prioritising in this way. Further, advanced level instruments capable of measuring trace levels of some of the toxic pollutants were developed only in the recent past.

With regard to the current situation in India, there have been comprehensive studies of the state of faecal and organic pollution of many rivers. Data on other water quality issues are, however, lacking with only limited information available on pollution by metals, nutrients and organic contaminants. Nevertheless, it is known that such problems exist, as there have been a few studies aimed at characterising such pollutants. Under HP, many laboratories are being equipped with advanced level instrumentation, and their staff trained, to determine some of these more esoteric pollutants. It is therefore expected that, in future, such pollutants will be monitored as a matter of course.

from 'Water Quality Assessments', Chapman D (Ed), E & F N Spon, Madras, 1996

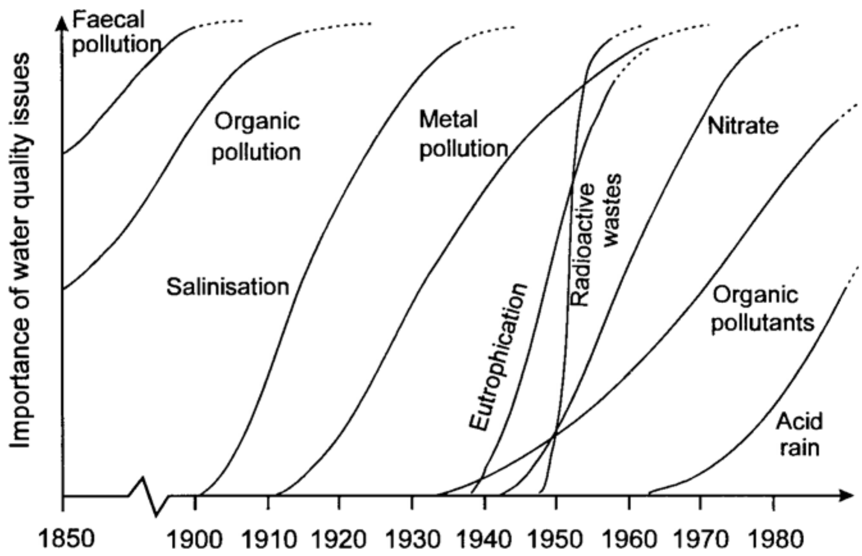


Figure2.1: Sequence of water quality issues in industrialised countries

2.2 Current Water Quality Monitoring under Hydrology Project (HP)

In India, water quality monitoring has been carried out historically for a number of reasons. Different organisations listed below are operating networks to satisfy their own particular objectives.

- Central & State Pollution Control Boards
- Central Water Commission & State Irrigation Departments
- Central Ground Water Board & State Ground Water Departments
- National River Conservation Directorate (NRCD)
- Research Institutions (e.g., NEERI)
- Others (Academic Institutions, State Public Health and Environmental Departments (PHED), Water Supply and Sewerage Boards (WSSB), etc.

If such monitoring activities are not co-ordinated in some way, considerable effort can be wasted because:

- the monitoring programmes may not always be commensurate with the original organisational mandates and study objectives meaning that data is of limited use
- unnecessary duplication of sampling, analysis and data processing can result
- limited resources are not used most effectively

The challenge for HP is to encourage the maximum inter-organisation co-operation in water quality monitoring. This should benefit all by reducing wasted time and effort thus allowing precious resources to be directed where they can be most effective. It is particularly important in the context of this project as, under HP, a number of organisations are upgrading existing water quality monitoring networks or starting new ones. The first step toward greater monitoring co-operation should be an objective assessment of organisational mandates and their underlying monitoring objectives and sampling networks.

2.3 Periodic Review of Data

Periodic analysis and review of data is essential in any water quality monitoring programme. It may lead to new or redefined information needs as networks often tend to ‘grow’ without defined measurement objectives. An objective analysis of data may lead to ‘pruning’ if correlation can be established between stations or between parameters. This saving of effort can be directed towards an increase in frequency of measurement for greater reliability and/or introduction of new water quality parameters for characterisation.

The releasing of spare monitoring capacity through regular data review, is particularly important in the context of the present project. The problem of water pollution due to trace contaminants has not yet been quantified as India’s monitoring programmes are not, to any large extent, set up to detect this type of pollution. Now, however, with laboratories being established and upgraded with advanced level equipment under HP, there is a major opportunity to monitor trace contaminants and it is therefore essential that maximum use is made of this opportunity.

3 Objectives and Conduct of the Meetings

A number of agencies in the country are operating water quality monitoring networks. Some organisations have been collecting data for the last two decades or more. However, mandates of organisations for such activity and objectives of monitoring are not always clearly defined. There is also a need to expand the networks both in terms of spatial coverage and introduction of new pollution related water quality parameters.

In order to achieve cost effective network designs or rationalisation of existing networks four regional meetings, each covering two HP states were held. Agencies outside HP also participated in the meetings. The objectives of the meetings were:

- To identify and define the mandates and objectives for water quality monitoring networks for surface water and groundwater organisations under HP.
- To provide a platform for inter-agency dialogue to assess overlaps and gaps in monitoring programmes.
- To evolve guidelines for designing of new networks and to rationalise the existing programmes.

In each meeting the Consultants first highlighted the objectives of the meeting and its significance in view of the activities under Hydrology Project and setting up of the Hydrological Information System. This was followed by the presentation of water quality monitoring activities of agencies, both outside and within HP, in the region.

Evaluation of on going programmes and discussion of mandates was carried out, separately for surface and ground water and example designs were attempted to highlight the requirements of network design. Finally, findings and recommendations were drafted.

4 Major Water Quality Issues

4.1 Introduction

Contamination can enter the water bodies through one or more of the following ways:

- Direct point sources: Transfer of pollutants from municipal - industrial liquid waste disposal sites and from municipal and household hazardous waste and refuse disposal sites.

- Diffuse agricultural sources: Wash off and soil erosion from agricultural lands carrying materials applied during agricultural use, mainly fertilisers, herbicides and pesticides.

- Diffuse urban sources: Run off from city streets, from horticultural, gardening and commercial activities in the urban environment and from industrial sites and storage areas.

Water quality issues needing to be addressed with respect to different water bodies are presented below.

4.2 Rivers

Change in Physical Characteristics

Temperature, turbidity and total suspended solids (TSS) in rivers can be greatly affected by human activities such as agriculture, deforestation and the use of water for cooling. For example, the upward trend in soil erosion and the related increase in TSS in rivers can be seen in most of the mountainous regions in India.

Contamination by Faecal and Organic Matter

In India, faecal contamination is still the primary water quality issue in rivers, especially where human and animal wastes are not adequately collected and treated. Although this applies to both rural and urban areas, the situation is probably more critical in fast-growing cities.

The release of untreated domestic or industrial wastes high in organic mater into rivers results in a marked decline in oxygen concentration (sometimes resulting in anaerobic conditions) and a rise in ammonia and nitrogen concentrations downstream of the effluent input. The most obvious effect of the release of organic matter along the length of the river is the depletion of oxygen downstream of the discharge as shown by the so-called ‘oxygen-sag curve’ which plots dissolved oxygen concentration against distance. Industrial activities which discharge large organic loads include, pulp and paper production and food processing. Faecal matter affects the use of water for drinking water source or bathing water, as well as ecological health of river.

Toxic Pollutants: Organics and Heavy Metals

Organic pollutants (mostly chemicals manufactured artificially by man) are also becoming an important water quality issue. They enter rivers as:

- point sources directly from sewers and effluent discharges (domestic, urban and industrial sources)
- diffuse sources from the leaching of solid and liquid waste dumps or agricultural land run-off
- indirectly through long-range atmospheric transport and deposition

Uncontrolled discharge of industrial wastewaters often causes pollution due to toxic metals. Other sources of metal pollution are leachates from urban solid wastes land fills and mining waste dumps.

Rivers such as the Yamuna, which pass through large towns and cities are often badly affected with organic pollutants. Another example is that of Damodar River which is polluted with heavy metals arising mostly from electroplating, tanning and metal based industries.

River Eutrophication

During the 1950s and 1960s, eutrophication (nutrient enrichment leading to increased plant and algal growth) was observed mostly in lakes and reservoirs. Since the 1970s the increasing levels of phosphates and nitrates entering rivers, particularly in developed countries, were largely responsible for eutrophication occurring in running waters. In India, isolated reports have appeared for some river reaches especially in plains around agriculture tracts of land.

In small rivers eutrophication is said to promote macrophyte (large plants) development, whereas in large rivers phytoplankton (algae) are usually more dominant than macrophytes. In such situations the chlorophyll concentration of the water may reach extremely high values due to the fact that this pigment is present in all plants.

Eutrophication can result in marked variations in dissolved oxygen and pH throughout the day. The changes in water quality caused by eutrophication can be a major cause of stress to fish due to the release, at high pH, of highly toxic gaseous ammonia and depletion of oxygen after sunshine hours.

Salinisation

Increased mineral salts in rivers may arise from several sources:

- pollution by mining waste waters
- pollution by certain industrial waste waters
- increased evaporation in the river basin (mainly in arid and semi-arid regions)

Industrial and mining waste pollution results in increase in specific ions. Evaporation, however, increases the concentration of all ions.

Changes in River Hydrology

Many human activities, directly or indirectly, lead to modifications of river channels, which can, in turn, induce changes to the aquatic environment. Major modifications to river systems include the following:

- changes to depth and width for navigation
- creation of flood control ponds
- creation of reservoirs for drinking water supply
- damming for hydroelectric power generation
- diversion for irrigation purposes

All of the above affect the hydrology and related uses of the river system and so have a great potential to affect water quality. It must be remembered, however, that not all such water quality changes are necessarily deleterious.

4.3 Groundwater

Unsewered Domestic Waste

Under certain hydrogeological conditions, unsewered domestic waste can cause severe groundwater contamination by pathogenic bacteria, nitrate and other pollutants. Unsewered waste normally means septic tanks or pit latrines of the ventilated, dry or pour-flush types. There are important differences between the two in relation to the risk of groundwater contamination. Septic tank soakaways discharge at a higher levels in the soil profile than pit latrines and such conditions are preferable as far as the elimination of bacteria is concerned. Pit latrines are often deep excavations (to allow a long useful life) and the soil may be entirely removed thus offering less opportunity for bacterial death. Further, the loading from septic tank soakaways is likely to be less than for some of the pit latrine types. Septic tanks are lined and their solid effluent of high nitrogen content is periodically removed, whereas most pit latrines are unlined and the solid material remains in the ground. The impact of unsewered domestic waste is felt particularly in relation to the contamination of groundwater drinking water supplies.

In India, the percentage of sewered population is nearly negligible in most of the rural areas and is quite meagre (0 to 50%) in most medium and small towns. As a result, the contamination of groundwater by pollution from unsewered areas is one of the most important environmental problems facing the country.

Disposal of Liquid Urban and Industrial Waste

Methods of wastewater disposal include infiltration ponds, spreading or spraying onto the ground surface and discharge to stream or dry stream beds, which if not carefully regulated may provide a rapid pollution pathway to underlying, shallow aquifers. In some areas, deep soakaways or abandoned wells are used for the disposal of liquid domestic, industrial or farming wastes into aquifers. Lack of monitoring, supervision or management adds to the problem.

Even if the intention is to dispose of the waste at depth, improper sealing or corrosion of well linings often produces leaks and subsequent pollution of the shallow groundwater which is used for water supplies. In urban areas covered by sewerage systems, an economical, and common, method of partial treatment of sewage is wastewater stabilisation by retention in shallow oxidation lagoons before subsequent discharge into rivers or onto land for irrigation systems. These lagoons are often unlined and, if constructed over coarse-textured soils, may have high rates of seepage loss. Further, the use of such effluent in irrigation may also lead to similar problems. Most of the unplanned industrial complexes and scattered industrial units in urban areas and the agricultural-related industries in remote villages are good examples of this type of pollution.

Disposal of Solid Domestic and Industrial Waste

The most common method of disposal of solid municipal waste in India is by deposition in landfills. In order to minimise the impact of such landfills on groundwater quality and the environment in general it is necessary to properly design and build these facilities to prevent pollution and put in place strict management controls to ensure they are operated correctly. Unfortunately this is rarely done as few towns and industries in the country make the necessary effort to ensure that their solid waste is treated or disposed of in a proper manner.

The principal threat to groundwater comes from inadequately controlled landfills where leachate generated from the fill material is allowed to escape to the surrounding and underlying ground. The chemical composition of such leachate depends on the nature and age of the landfill and the leaching rate. Most leachates emanating from municipal solid wastes are not only high in organic content but also contain some toxic material. Leachates from solid wastes of industrial origin, however, often contain a much higher proportion of toxic constituents, such as metals and organic pollutants.

Cultivation with Agrochemicals

Agricultural land use and cultivation practices have been shown to exert major influences on groundwater quality. Under certain circumstances, serious groundwater pollution can be caused by agricultural activities the influence of that may be very important because of the large areas of aquifer affected. Of particular concern, in India, is the leaching of fertiliser chemicals (e.g., nitrate) and pesticides from regular, intensive cultivation of crops. The impact of cultivation practices on groundwater quality is greatest, as are most anthropogenic effects, where relatively shallow, unconfined aquifers are used for potable supply.

In India, a high proportion of the rural population in agricultural areas obtain their domestic water supplies from shallow, private boreholes, which suffer the impact of nitrate pollution to a much greater extent than the deeper, public supply aquifers utilised for urban water supply. These deeper aquifers can also be affected by nitrate contamination although this pollution often takes much more time to percolate to these depths.

Much less attention has been given in this country to the leaching of pesticides from agricultural land to the underlying groundwater in spite of the dramatic increase in the use of pesticide formulations over the last years. There are currently few laboratories with the capability of analysing pesticides.

Salinity from Irrigation

Increasing salinity resulting from the effects of irrigated agriculture is one of the oldest and most widespread forms of groundwater pollution. It is caused by the dissolved salts in irrigation water being deposited following evaporation of the water. The addition of further excess irrigation water merely leaches salts from the soil and transfers the problem to the underlying groundwater.

Mining Activities

A range of groundwater pollution problems can be associated with mining activities. The nature of the pollution depends on the materials being excavated and extracted. Both surface and underground mines usually extend below the water table and often dewatering is required to allow mining to proceed. The water pumped, either directly from the mine or from specially constructed boreholes, may be highly mineralised and its usual characteristics include low pH (down to pH 3) and high levels of iron, aluminium and sulphate. Disposal of this mine drainage effluent to surface water or groundwater can cause serious impacts on water quality for all uses. Pollution of groundwater can also result from the leaching of mine tailings and from settling ponds and can, therefore, be associated with both present and past mining activity.

Geological Formations

Groundwater in certain geological formations may not be of desired quality for specific uses. Naturally occurring fluorides, arsenic and salinity are known to adversly affect the quality of water for drinking watersupplies.

4.4 Lakes and Reservoirs

Pollution Pathways

The following pathways, in addition to the ones mentioned above, assume special significance in the case of lakes and reservoir pollution:

- Riverine sources: pollutants in solution in the inflow or adsorbed onto particulate matter, or both. The cumulative input is the sum of contaminants from all of the rivers draining the watershed into a lake.
- Groundwater sources: groundwater systems polluted from point and diffuse sources (noted above) flowing into rivers, and directly into lake beds.
- Atmospheric sources: direct wet and dry atmospheric deposition of contaminants to the lake surface and wash off of similar pollutants from the land. This latter process is defined as secondary cycling.

In addition to the above, lakes serve as traps for pollutants carried by rivers and groundwater draining the watershed. The pollutant concentration in the lake usually builds up due to evaporation of water from the lake's surface unless there is a natural flushing with good quality water.

Eutrophication

Simply speaking, eutrophication is the biological response to excess nutrient input to a lake. The production of biomass and its death and decay results in a number of effects, which individually and collectively result in impaired water use. The most important of these effects are decreased dissolved oxygen levels, release of odorous compounds (e.g. H_2S) and siltation.

Many important lakes in India (e.g., Husseinsagar (Hyderabad), Nainital (Uttar Pradesh) and Dal (Jammu and Kashmir) have reportedly progressed to advanced eutrophication levels.

Lake Acidification

One of the major issues related to lakes in particular, and to freshwaters in general, is the progressive acidification associated with deposition of rain and particulates (wet and dry deposition) enriched in mineral acids. The problem is characteristic of lakes in specific regions of the world, which satisfy two major critical conditions: the lakes must have soft water (i.e. low hardness, conductivity and dissolved salts) and be subjected to 'acid rain'.

To date, lake acidification has not been reported as a problem in India.

Bioaccumulation and Biomagnification

The processes of bioaccumulation and biomagnification are extremely important in the distribution of toxic substances (discharged in waste effluents) in fresh water ecosystems. The concentration of pollutants within the organism due to bioaccumulation and biomagnification depends on the duration of exposure of the organism to the contaminated environment and its trophic level in the food chain. Several fold increases in trace contaminant concentrations have been commonly observed in lakes and estuarine environments.

5 Rationalisation and Optimisation of Monitoring Programmes

5.1 Surface Water: River Cauvery[a]

5.1.1 Background

The Cauvery River is one of the 14 major rivers of India and ranks number 8 among the Indian Rivers. The catchment area of the river is 87,900 sq. km. spread over Karnataka (41.2%) Kerala (3.3 %) and Tamil Nadu (55.5%). The river travels a distance of 354 km. through Karnataka and 416 km. through Tamil Nadu, totalling 770 km. to discharge into Bay of Bengal.

The monitoring of river Cauvery started in the year 1980 at two locations in Karnataka. Presently the monitoring is conducted at 20 locations. The growth of monitoring net work is presented in figure 5.1.

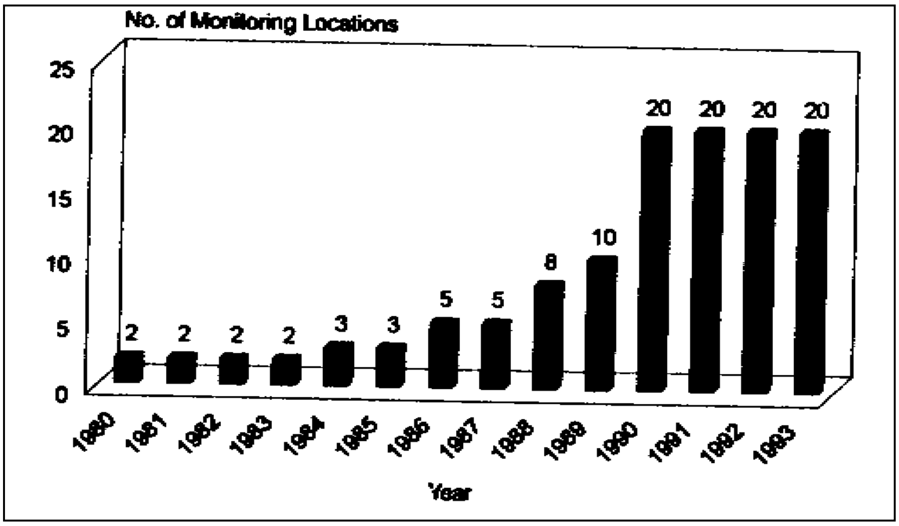


Fig 5.1 Growth of Monitoring Locations

Monitoring is not only an expensive exercise but is time consuming and tedious. The monitoring programme needs to be drawn very carefully to get the optimum results. Based on the data collected on the Cauvery River, it is attempted to rationalise and optimise the monitoring programme.

[a] Extracted from 'Optimisation of Monitoring Programme for River Cauvery', Monitoring of Indian National Aquatic Resources Series, MINARS/11/1995-96, CPCB, Delhi

5.1.2 Objectives

The objective of the present exercise is to rationalise and optimise the monitoring programme in terms of the following:

- to suggest deletion/addition of parameters to the existing parametric list;
- to suggest deletion/relocation of certain sampling sites, if necessary;
- to suggest minimum frequency at which the monitoring should be conducted.

5.1.3 Existing Monitoring Programme

Monitoring Sites

The monitoring on Cauvery River is conducted at 20 sites from Napokulu in Karnataka to Pitchavaram in Tamilnadu over a distance of 766 km.

Parameters Monitored

Presently 24 parameters are analysed to study the water quality of river Cauvery at 20 monitoring stations. A list of the parameters is presented in Table 1.

TABLE 1 LIST OF PARAMETERS PRESENTLY MONITORED

1.	Temperature	13.	Hardness
2.	pH	14.	Calcium
3.	TSS	15.	Magnesium
4.	Velocity of flow	16.	Alkalinity
5.	Dissolved Oxygen	17.	Sulphate
6.	Biochemical Oxygen Demand	18.	Sodium
7.	Total Kjeldahl Nitrogen	19.	Chemical Oxygen Demand
8.	Nirogen,nitrate + nitrite	20.	Total Dissolved Solids
9.	Total Coliform (MPN)	21.	Fixed Dissolved Solids
10.	Fecal Coliform (MPN)	22.	Phosphate
11.	Conductivity	23.	Boron
12.	Chloride	24.	Free Ammonia

Monitoring Frequency

At present the monitoring is conducted once a month at all the monitoring sites.

5.1.4 Methodology Adopted

The logistic approach backed by statistical analyses of data has been adopted to rationalise/optimise the monitoring programme of river Cauvery. The statistical techniques used are Correlation Analysis, Analyses of Variance, Least Significance Difference test. A brief description of the methodology adopted to undertake different tasks is given below.

Rationalisation of Parametric List

Firstly the existing parametric list has been reviewed, keeping in mind, the primary criteria requirement of the different classes of water and major agricultural and industrial polluting sources. For the remaining conventional parameters, correlation analyses have been used to decide whether or not to continue analysing these parameters.

Optimisation of Monitoring Sites

The existing monitoring sites have been scrutinised to identify the stations existing in close proximity to each other without having a significant polluting source between them. Subsequently correlation analyses for the major parameters have been performed to decide whether to continue or discontinue monitoring at one of the neighbouring sites.

Optimisation of Monitoring Frequency

In this case, the year has been divided into different seasons and analysis of variance has been conducted for different seasons at different stations for the major parameters. The objective of the analyses was to test whether variations among different months of the same season were significant. If the monthly variations for the major parameters at most of the sites for a particular season were significant, the frequency of monitoring for the particular season could be reduced. For other cases, least significance difference (LSD) test was conducted to identify the sub-groups having similar values. This analysis has two fold objectives firstly to decide about the frequency depending upon the number of subgroups and second to select the months for monitoring.

All the statistical analyses were conducted by using the software package "SPSS" for windows".

5.1.5 Recommendations and Conclusion

Recommendations

- The determinations of the following parameters have been recommended for water quality monitoring of river Cauvery at all the locations.

Temperature	Boron
pH	Nitrogen (nitrate+nitrite)
Magnesium	Free Ammonia
Sodium	Total Coliform (MPN)
Dissolved Oxygen	Conductivity
Chemical Oxygen Demand	Calcium
Biochemical Oxygen Demand 3 days, 27^0c	Indicator of Total Pesticides
Phosphate	Indicator of Toxicity
Total Kjeldahl Nitrogen	
+3 Optional Location Specific Parameters	

- As the parameters defining primary water quality criteria for the different Designated-Best-Use classes have been included in the recommended list of parameters as such, the parametric list need to be modified whenever the water quality criteria will be modified.

- To have baseline data the monitoring site located at D/S Napakula Bridge may be shifted to U/S of Bhagmandala.

- The monitoring at the 5 sites viz., 1386 at Karekuara village, 1322 at 1 km D/S R. Bhavani confluence, 1324 at Mohanur, 1325 at D/S Tiruchirappali, and 1326 at Coleroon may be discontinued because the values of most of the parameters could be estimated from the nearby sites. Thus it is recommended to monitor 15 sites in place of 20 monitored at present.

- The recommended 15 monitoring sites are shown in Figure 5.2.

- It is recommended to conduct the monitoring at a frequency of twice per season i.e., eight times per year against monthly i.e., twelve per year.

- The Months recommended for monitoring in various seasons are given below.

Season	Months recommended for monitoring
Winter (December, January, February)	January, February
Summer (March, April, May)	April, May
SW Monsoon (June, July, August, September)	June, August
N E Monsoon (October, November)	October, November

Conclusion

With the recommended programme, the total number of samples will be reduced from 240 per year to 120 per year. Accordingly the expenditure on monitoring of river Cauvery will be reduced by 50 percent, while the information gained from monitoring will remain essentially the same.

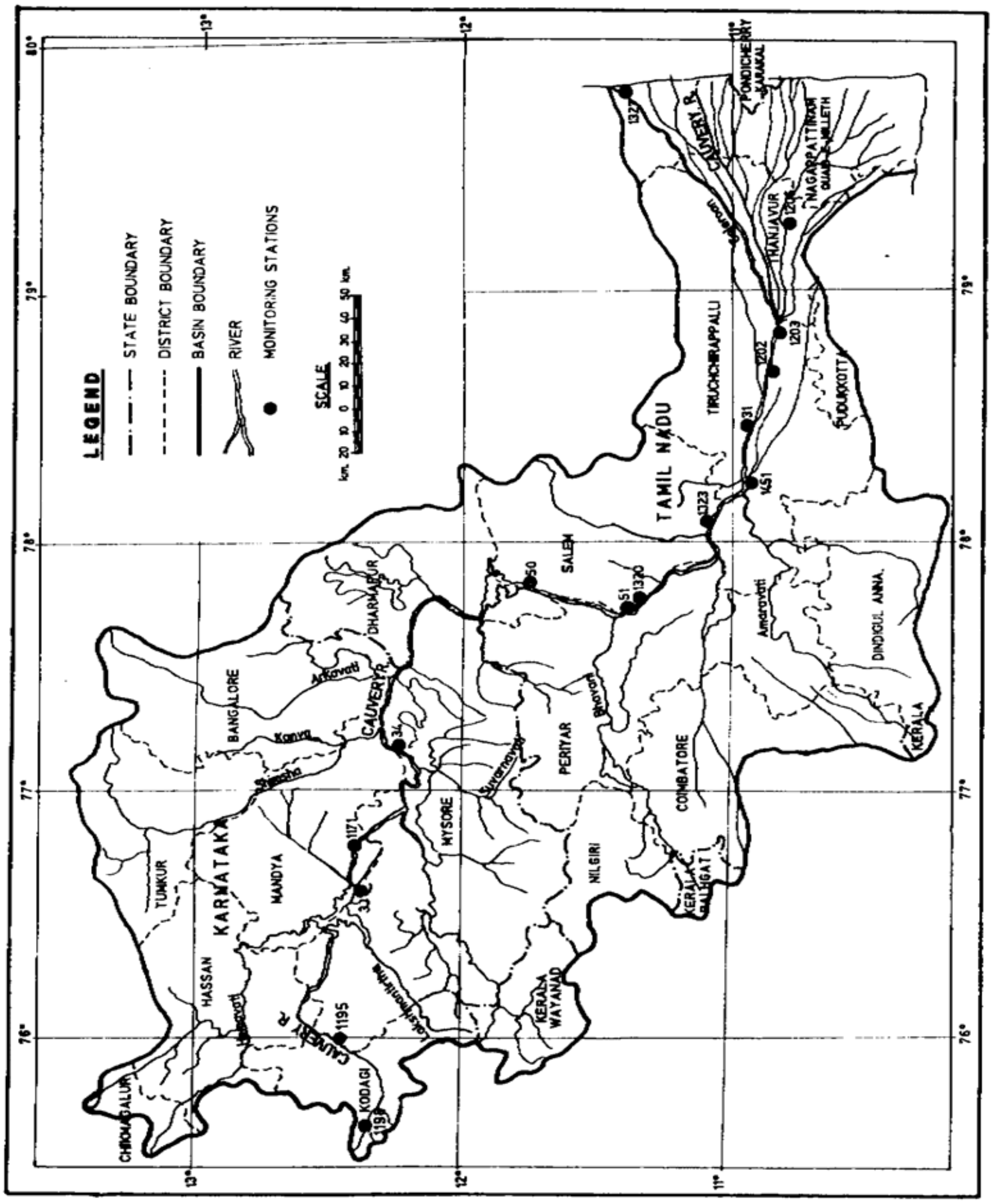


Fig 5.2 Recommended monitoring locations for Cauvery River

5.2 Groundwater Ghataprabha Basin, Karnataka

Groundwater quality in Ghataprabha basin has been measured for the last several years by CGWB. A preliminary analysis of the data was made to find out if the monitoring network could be optimised with respect to number of parameters and stations. A few conclusions, which need to be tested statistically, are presented here.

Figures 5.3 and 5.4 show the isopleths for chloride concentration in the groundwater and its EC value, respectively, over an area of approximately 10,000 km^2. These lines were drawn for measurements taken during the period 1970 to 1993.

In order to find out if there is any change in the water quality over time, the contours could be plotted for two periods of shorter span, say 1974 to 1983 and 1984 to 1993, and compared. In case no change is noted, only a few key stations may be continued and other stations could be discontinued for a few years. After a gap, once again the whole basin could be covered. Resources saved in this manner can be used to include intensive monitoring of areas where water quality problems are known to exist or are perceived or include new parameters of relevance.

Figures 5.5 and 5.6 show relationships between EC and bicarbonate and EC and chlorides, respectively, for some wells in the basin between 1970 and 1993. It may be noted that EC could be used to estimate the concentration of the two constituents fairly accurately. Similar plots for other parameters could also be obtained.

The decision whether to discontinue the measurement of any parameter would ultimately depend on the accuracy with which the parameter need to be determined and the confidence level with which it can be predicted from the available relationship. In the present case, it may be noted that the data points for bicarbonate have a greater scatter compared to the chloride data. The bicarbonates in a water sample are in equilibrium with the partial pressure of carbon dioxide in the atmosphere. Its concentration therefore may change on storage of samples, while there would not be any such change in chloride concentration.

In summary, the above remarks show that there is a need to examine the available data in greater depth and draw conclusions regarding optimisation of the network.

Data source CGWB

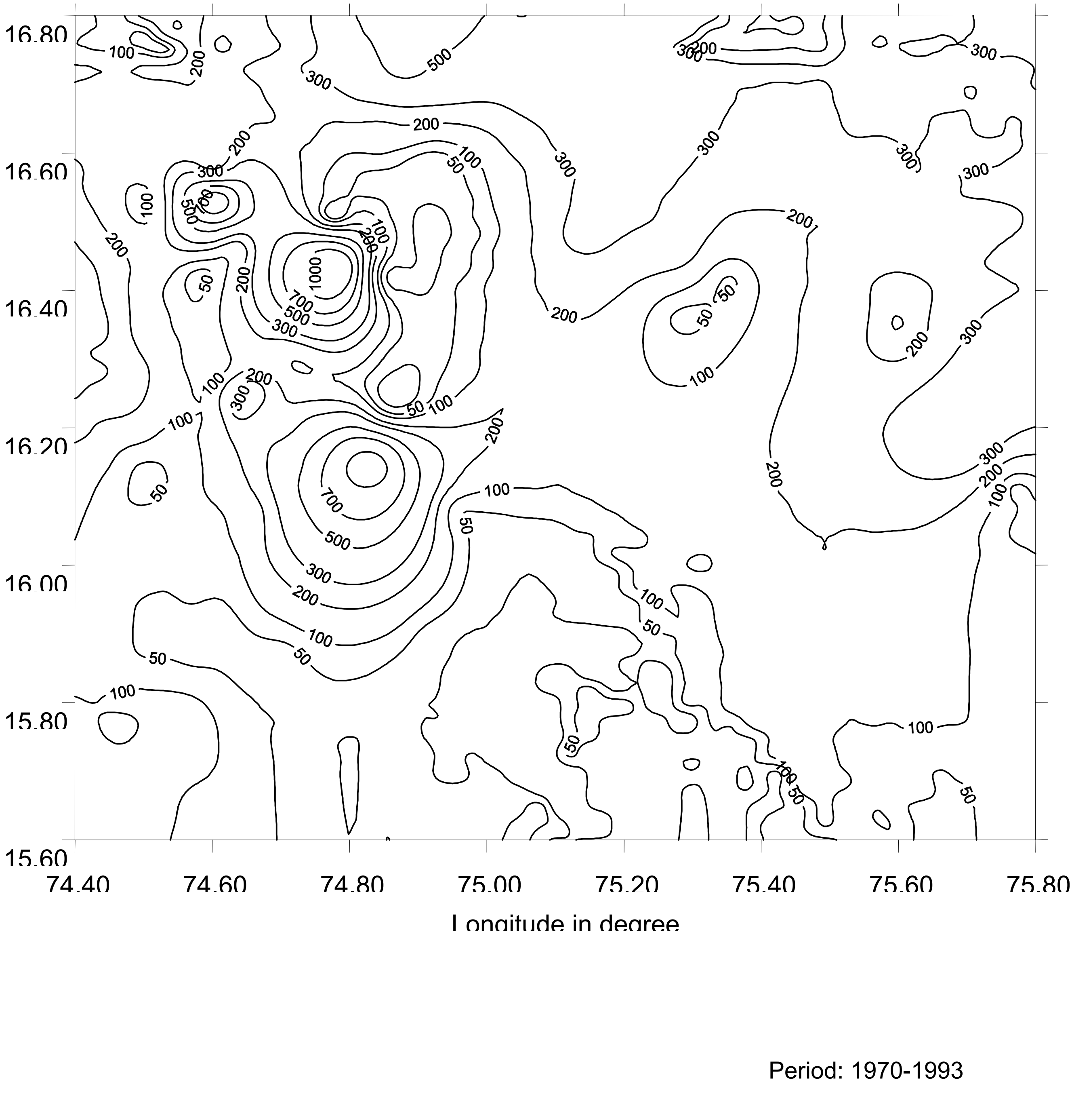
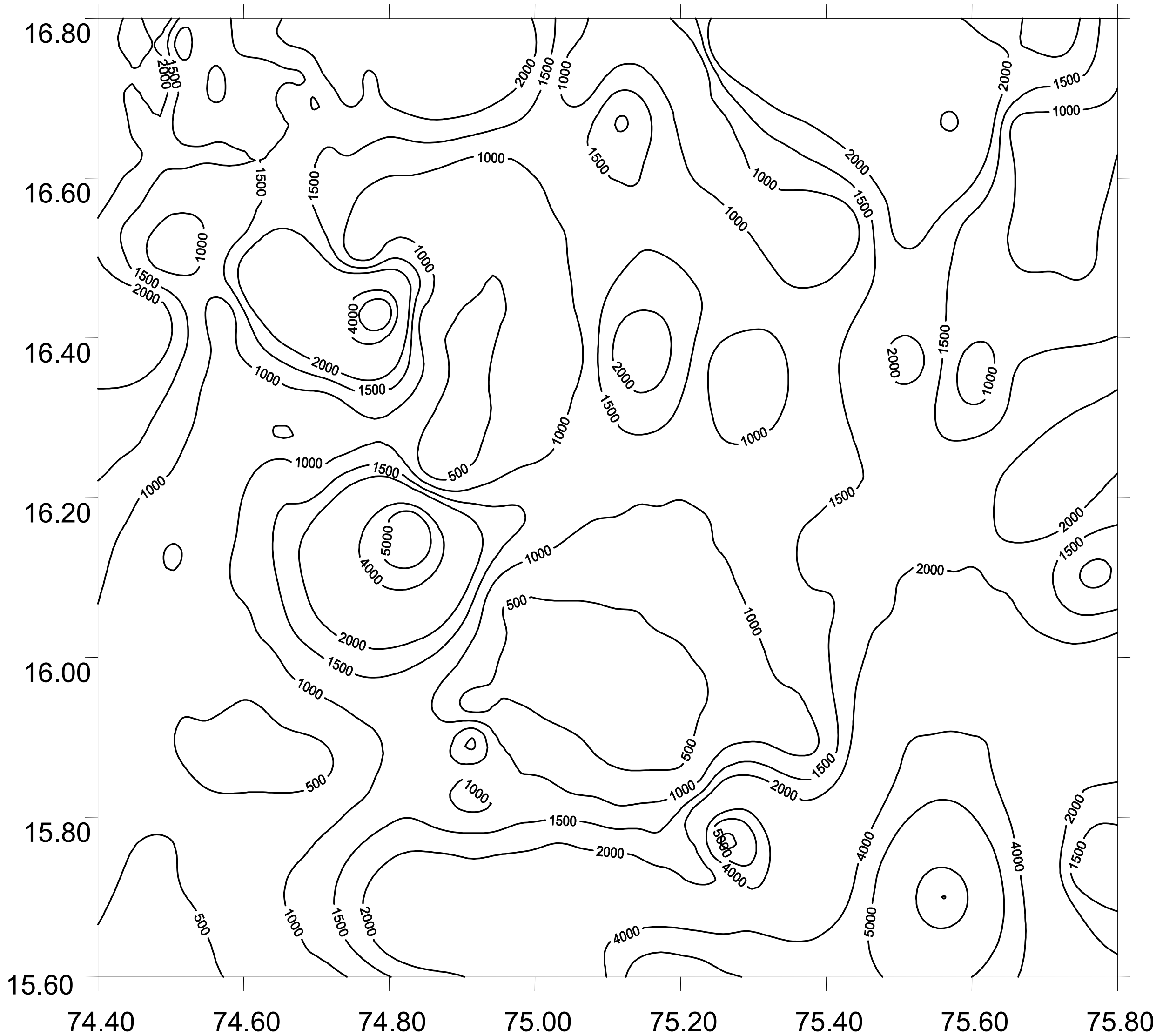


Fig 5.3 Chloride (mg/l) map of Ghataprabha Basin, Karnataka

Data source: CGWB



Period : 1970-1993

Fig 5.4 Conductivity (micro-mhos/cm) map of Ghataprabha Basin, Karnataka

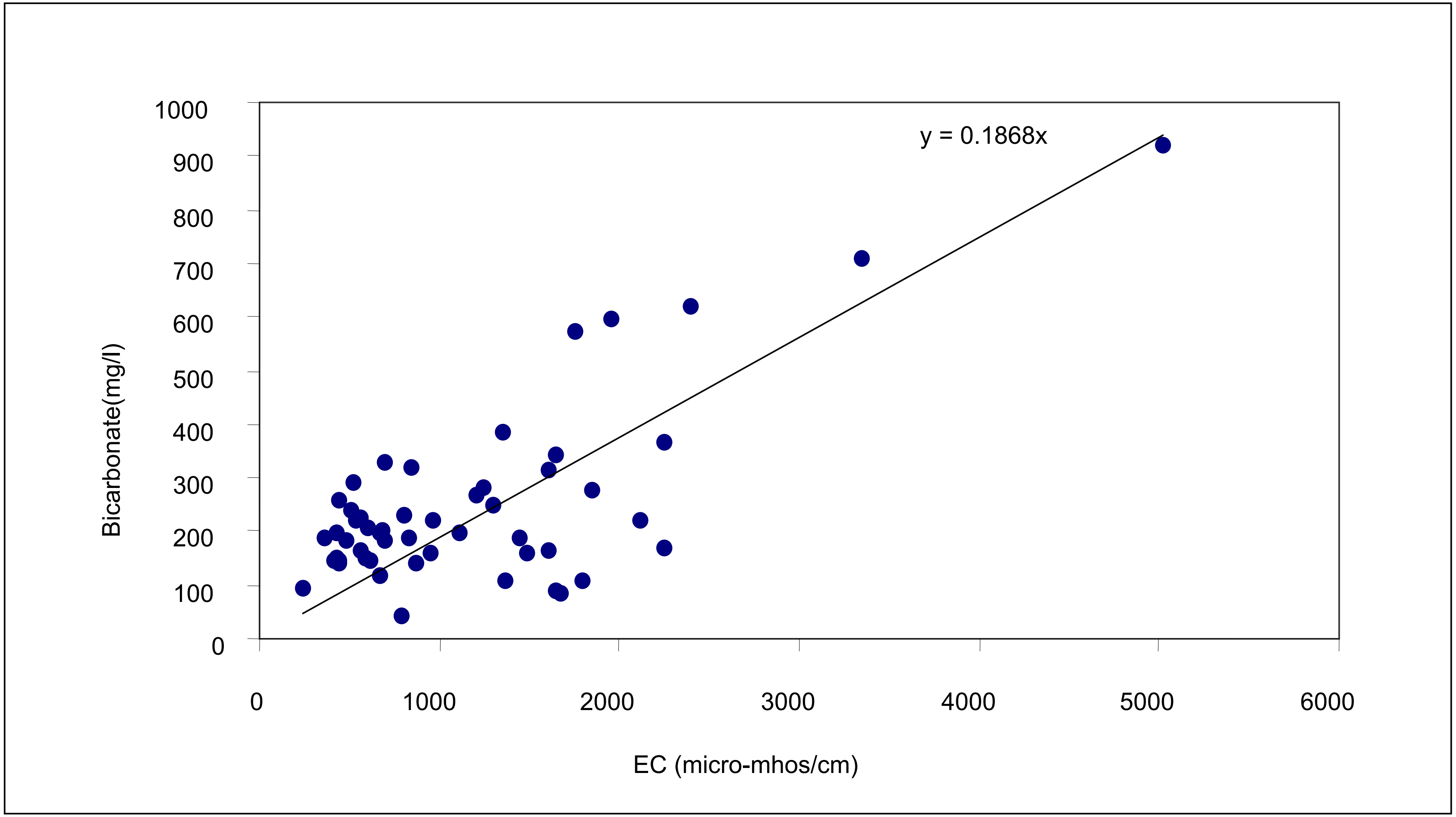


Figure 5.5 EC-Bicarbonate, Data: CGWB, Karnataka, Ghataprabha Basin, Period: 1970-97

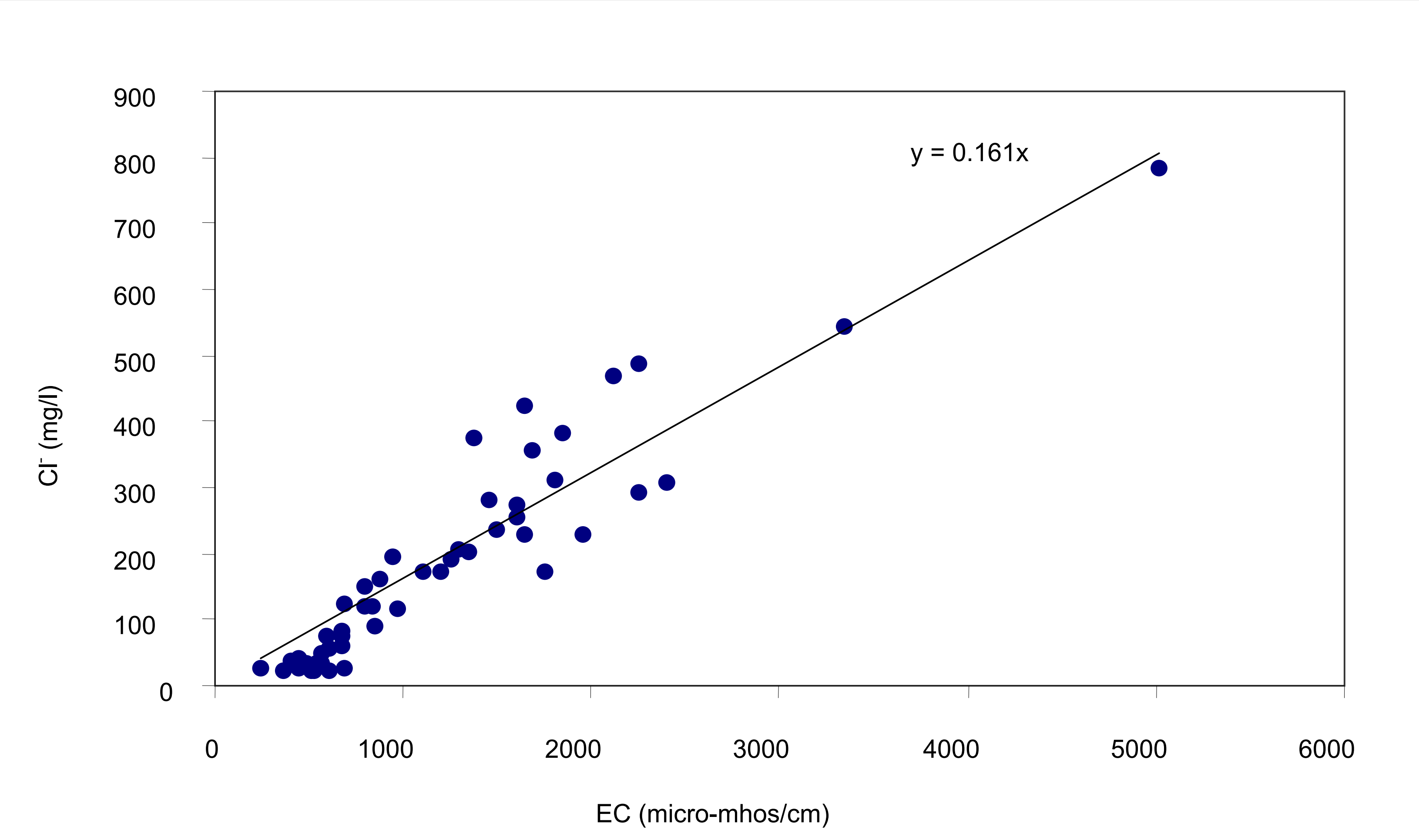


Fig 5.6 EC-Chloride, Ghataprabha Basin, Data: CGWB, Karnataka, Period 1970-93

6 Mandates and Objectives

6.1 Central Pollution Control Board[a]

6.1.1 General

The Water (Prevention and Control of Pollution) Act, 1974, was passed for restoration and maintenance of wholesomeness and cleanliness of national aquatic resources. The Central Pollution Control Board (CPCB) was constituted in September 1974.

Since the parliament has no powers to make laws for the states, all the Houses of Legislature of 25 states of the Union of India adopted the Act and respective State Pollution Control Boards (SPCBs) were formed. For Union Territories, initially the Central Board exercised the powers and performed the functions of pollution control. Later, for each Union Territory pollution control committees under the local administration were formed and the functions and powers of the Central Board were delegated to the respective committee.

The Air (Prevention and Control of Pollution) Act was passed in 1981 for the control of air quality.

In order to adopt stronger environmental policies and new laws, the Environment (Protection) Act, 1986, was enacted. The act empowered the Central Government to take all necessary measures to protect and improve the environment.

6.1.2 Mandates and Objectives

Under the Environment Act the 'environment' includes air, water and land and the inter-relationship which exists among and between the biotic and abiotic components.

Its functions in relation to objective of prevention and control of pollution of water environment and to maintain and restore wholesomeness of water can be summarised as:

- Advise Central and State governments with respect to location of any industry, which is likely to pollute a stream or ground water.
- Advise Central Government on restriction of areas in which certain types of activity shall not be carried out or shall be carried out subject to prescribed safeguards.
- Lay down standards for treatment of municipal and industrial wastewaters and the treated effluents.
- Co-ordinate activities of State Pollution Control Boards and provide technical assistance where necessary.
- Sponsor investigation and research.
- Organise training and awareness programmes.
- Plan and cause to be executed national programmes on pollution control.

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[a] Extracted from ' Water Quality Monitoring, the Indian Experience' Assessment and Development Studies of River Basins Series: ADSORBS/12/1984-85, CPCB and 'Pollution Control Acts, Rules and Notifications Issued Thereunder', September 1997, CPCB

6.1.3 Water Quality Monitoring Network

Water quality monitoring is one of the important activities of CPCB. It helps in the identification of waterbodies, which are in need of quality improvement. It also helps in formulation of national pollution control programmes.

National water quality monitoring was started by CPCB in 1977, when under Global Environmental Monitoring System (GEMS), Water Programme, 24 surface water and 11 groundwater stations were started.

Parallel to GEMS, a national programme of Monitoring of Indian Aquatic Resources (MINARS), was started in 1984, with a total of 113 stations spread over 10 river basins.

Presently the inland water quality monitoring network is operated under a three tier programme:

GEMS:	51 stations
MINARS:	402 stations
SPCBs:	27 stations

Out of the 480 stations 422 are on rivers, 32 on lakes and creeks and 26 are groundwater stations.

The stations operated by SPCBs are mostly to monitor the effect of specific waste discharges and to evaluate the impact of water pollution control programmes.

The water quality data are reported in Water Quality Statistics yearbooks.

6.1.4 Approach to Pollution Control

The basic objective of Environment Protection Act is to maintain and restore the wholesomeness of water by prevention and control of water pollution. The act does not define 'wholesomeness'. Taking a pragmatic approach, the Board has identified predominant uses, calling them designated best use, of different water bodies or stretches of river and also defined water quality criteria for different uses of water. These criteria are given in Table 1.

Based on the monitoring data the existing water quality is compared with the criteria for the designated best use. Where the designated best use requires better quality water than what is existing, an action plan is prepared.

Ganga action plan was the first such plan. Now the National River Conservation Directorate, Ministry of Environment & Forests has prepared other action plans also.

6.1.5 Analytical Quality Control

An important activity of CPCB related to water quality monitoring, which needs special mention is its analytical quality control programme. With a large number of laboratories participating in the water quality monitoring programme, it is necessary that their procedures are assessed by an independent agency.

For the last 7 years CPCB has been conducting inter-laboratory exercises in which now more than 70 laboratories are participating. Such exercises have brought out shortcomings in the performance of some laboratories and highlighted the necessity for care in determination of certain parameters which seem to be very simple to measure. It is expected that it would result in improvement of performance of laboratories.

Table 1 Primary water quality criteria for various uses of fresh water

Designated best use	Class	Criteria
Drinking water source without conventional treatment but after disinfection	A	1. Total coliform organisms MPN/100mL shall be 50 or less. 2. pH between 6.5 and 8.5 3. Dissolved oxygen 6 mg/L or more 4. Biochemical oxygen demand 2 mg/L or less
Outdoor bathing (organised)	B	1. Total coliform organisms MPN/100mL shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved oxygen 5 mg/L or more 4. 4. Biochemical oxygen demand 3 mg/L or less
Drinking water source with conventional treatment followed by disinfection	C	1. Total coliform organisms MPN/ 100mL shall be 5000 or less 2. pH between 6 and 9 3. Dissolved oxygen 4 mg/L or more 4. Biochemical oxygen demand 3 mg/L or less
Propagation of wild life, fisheries	D	1. pH between 6.5 and 8.5 2. Dissolved oxygen 4 mg/L or more 3. Free ammonia (as N) 1.2 mg/L or less
Irrigation, industrial cooling, controlled waste disposal	E	1. pH between 6.0 and 8.5 2. Electrical conductivity less than 2250 micro mhos/cm 3. Sodium absorption ratio less than 26 4. Boron less than 2mg/L

6.2 National River Conservation Directorate[a]

6.2.1 General

Surveys carried out by Central Pollution Control Board indicated that large stretches of many of the Indian rivers were grossly polluted, particularly from municipal wastewaters. While the rules and regulations under the Environment Protection Act could be applied to industrial establishments, their enforcement for the municipal discharges was not feasible, as the municipalities do not have sufficient resources to undertake large scale sewerage and sewage treatment works.

The Ganga Action Plan (GAP) was started in 1985 as a 100% Centrally funded scheme to restore the water quality of River Ganga to the bathing class. To accomplish this task pollution abatement works related to 25 class I towns in Uttar Pradesh, Bihar and West Bengal, located on the river banks were undertaken. Later in 1991, important tributaries of River Ganga were also included in the action plan. In 1994 the GAP model with suitable modifications was extended to the national level through a National River Conservation Plan (NRCP) and Ganga Project Directorate was renamed National River Conservation Directorate (NRCD).

6.2.2 NRCD Programmes

At present 10 states are covered under NRCD programmes.This includes all HP states except Kerala. For each river action plan, a number of schemes are undertaken, such as:

- Sewage interception and diversion.
- Sewage treatment.
- Low cost sanitation.
- Electric crematoria.
- River front development
- Other schemes

Formulation and execution of schemes has started in 12 major river basins of the country. The schemes were identified on the basis of water quality surveys carried out by CPCB under its water quality monitoring programme. Table 1 lists some of the grossly polluted river stretches and proposed actions.

6.2.3 Water quality monitoring

NRCD is contracting with various organisations in the country such as CPCB, SPCBs, and academic institutions to measure water quality of river stretches where it has taken up pollution abatement schemes. So far the major monitoring thrust has been in the Gangetic basin. With schemes being taken up on other rivers, the monitoring programme of the Directorate is also extending.

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[a]Extracted from 'National River Action Plan' 1994 and 'Status Paper on River Action Plans' 1998 Ministry of Environment & Forests, GOI, New Delhi

The objective of the monitoring programme is to establish the water quality in the rivers before the schemes are taken up and then compare it with the quality as the implementation of scheme progresses in order to check the efficacy of the actions taken. The stations are usually closely spaced downstream of cities and wastewater outfalls. The stations may be classified as surveillance type for pollution monitoring. The water is analysed mainly for pollution related parameters, BOD, DO and coliforms. At some places analysis for heavy metals is also included.

Due to a number of organisations participating in the analysis programme it has become necessary to conduct AQC exercises for the laboratories. CPCB laboratory is acting as reference laboratory for inter-laboratory exercises.

Table 1 Grossly polluted stretches of some major national rivers

River	Stretch	Existing class	Desired class	Critical parameters
Sabarmati	Immediate u/s Ahmedabad city to Sabarmati Ashram Sabarmati Ashram to Veutha	E E	B D	BOD, DO coliforms - ditto -
Sutlej	d/s Ludhiana to Harike d/s Nangal	D to E E	C E	BOD, DO Ammonia
Yamuna	Delhi to confluence with Chambal City limits of Delhi, Agra & Mathura	D to E - ditto -	C B	DO, BOD, coliforms - ditto -
Subarnarekha	Hathi dam to Baragora	D to E	C	- ditto -
Godavari	d/s Nasik to Nanded City limits of Nasik & Nanded	D to E - ditto -	C B	- ditto - - ditto -
Krishna	Karad to Sangli	D to E	C	BOD
Chambal	d/s Nagda & Kota, 15 km each	D to E	C	BOD, DO
Damodar	Dhanbad to Haldia	D to E	C	BOD, DO, Toxic
Gomti	Lucknow to confluence with Ganga	D to E	C	BOD, DO, coliforms
Kali	Modinagar to confluence with Ganga	D to E	C	- ditto -
Khan	City limits of Indore d/s Indore	D to E D to E	B C	- ditto -
Kshipra	City limits of Ujjain d/s Ujjain	E E	B D	- ditto -
Hindon	Saharanpur to confluence with Yamuna	E	D	- ditto - Toxic

6.3 Central Ground Water Board

6.3.1 General

The Central Ground Water Board was created in 1972 by the amalgamation of Exploratory Tubewells Organisation, which was established in 1954, with a cadre from Geological Survey of India. It is the national apex body concerned with planning the development of groundwater resources throughout India. The main activities of the Board are hydrogeological surveys, exploration, monitoring of water table and water quality and assessment of development of groundwater resources.

In the eight HP States there are nine regions, two in Madhya Pradesh and one in each of the remaining seven States. Out of the total of about 16000 observation points in the country, nearly 9000 points are located in the HP States. The water level in these wells is measured four times a year during fixed 10 day periods. Water quality measurements are carried out once a year in the pre-monsoon period.

6.3.2 Mandate

The mandate of the board, briefly stated, is to 'Develop and disseminate technologies and monitor and implement national policies for the scientific and sustainable development and management of India's groundwater resources, including their exploration, assessment, conservation, augmentation, protection from pollution and distribution, based on principles of economic and ecological efficiency and equity'.

The CGWB was also constituted as an authority for the purpose of Regulation and Control of Groundwater Management and Development under official gazette notification in Part II – Section no. 30 on 14th January, 1997, to perform the following functions:

- exercise powers under Environment Protection Act, 1986 for issuing directions
- resort to penal provisions under the act
- regulate indiscriminate boring and withdrawal of groundwater.

6.3.3 Water Quality Monitoring Network

Most of the monitoring network of the Board comprises open dug wells tapping the phreatic aquifer. Only about 5% wells are tubewells, which are in the phreatic or deeper aquifers.

As noted above, the water quality of all the network wells is measured once a year during pre-monsoon period. It was reported that in some cases where there was localised pollution of the open well, water quality measurements were not representative of aquifer water. Further, purging of small bore, non-production, tubewells was not done before collecting samples for water quality analysis. Purging of such wells was considered to be necessary specially when contaminants present in low concentration are monitored.

Except at one location the laboratories in the HP States do not have the capability to monitor micro-level organic and inorganic pollutants. Water samples are routinely analysed for the major anions and cations. In some cases special studies were conducted to monitor for the presence of nitrates and phosphates as a result of urban and agricultural pollution and naturally occurring fluorides.

The water quality data are used to prepare water quality maps of EC and in some cases specific ions. The data are also used for classification of waters according to various diagrams and water quality indices.

6.4 Central Water Commission

6.4.1 General

The Central Water Commission has a national network of hydrological observations in all the major river basins of the country. It is operating 570 gauge discharge observation stations in the 12 basins or zones. The following table lists State wise numbers of the stations on the peninsular rivers. It is seen that out of 295 stations, water quality measurements are carried out at 146 stations.

Table: State wise details of hydrological observation stations[a]

S. No.	State	GD	GDS	Total	WQ
1	Andhra Pradesh	26	14	40	19
2	Bihar	1	3	4	3
3	Daman	1	-	1	1
4	Gujarat	12	10	22	11
5	Goa	2	-	2	2
6	Karnataka	22	15	37	19
7	Kerala	6	13	19	13
8	Maharashtra	45	22	67	24
9	Madhya Pradesh	27	24	51	24
10	Orissa	8	12	20	12
11	Rajasthan	9	2	11	2
12	Tamilnadu	13	8	21	16
	Total	**172**	**123**	**295**	**146**

GD – gauge discharge
GDS – gauge discharge & silt
WQ – water quality (including gauge discharge)

6.4.2 Mandates and objectives of water quality monitoring

Being the appex national body for development of water resources in the country, its mandate is assessment of water resources in general. This would include the following objectives in regard to water quality monitoring:

- Establishment of baseline water quality
- Assesment of suitability of water for various uses, particularly for irrigation
- Detection of trends in water quality changes.
- Dissemination of water quality information upon request

[a] source: GOI, Central Water Commission, River Data Directorate, New Delhi, April 1992

CWC has no mandates with respect to managerial measures like informing the public, checking discharges for compliance with regulations or corrective measures. quality data collected are not used for data analysis and presentation other than tabular listings in the yearbooks.

6.4.3 Water Quality Monitoring Network

The CWC has been involved in surface water quality monitoring since 1972. It operates several level I and level II laboratories in the Peninsular Area. The analyses are generally limited to a standard list of 20 classical parameters. A few irrigation related water quality indices are calculated from the measurements of chemical quality of the water. The samples are collected from rivers and adjacent groundwater wells through the level I site laboratories (located at a limited number of gauging sites) where in situ parameters (T, pH, EC and DO) are determined. Remaining parameters are determined in some 11 level II laboratories in the Peninsula. At some locations pollution related parameters, BOD and coliforms are also measured.

Sampling frequency ranges from every 10 days (thrice monthly) to every fortnight (twice monthly). So far surface water pollution with toxic metals and organic micro pollutants has not received attention.

The results of the monitoring programme are computerised in the regional offices in different packages (spreadsheet or word processor). Annual reports (in tabular form only) are produced and contain monthly averaged data, not the original measurements

6.5 Other Organisations

Other organisations, which are interested in water quality measurements, include

- Academic Institutions
- National and State Research Organisations
- State Health Departments
- State Public Health Engineering Departments
- Municipalities
- Water Supply and Sewerage Boards

The first two named organisations usually do not conduct long term monitoring. They take up surveys for research studies or investigation of water quality management problems. The remaining organisations carry out water quality surveillance on a regular basis usually for use related objectives. Monitoring of raw and treated water for drinking water supply was identified as the major reason.

6.6 Summary

Tables 1 and 2 summarise information regarding mandates and objectives of water quality monitoring as given by various agencies.

Expecting an enhancement in the capability of water quality analyses, both the SW and GW agencies under HP showed a keen desire to expand their scope of objectives to include pollution monitoring in greater detail. Tables 1 and 2 summarise information regarding mandates and objectives of water quality monitoring as given by various agencies.

Table 1: Mandates

Mandates	CWC	CGWB	NRCD	CPCB	sSW	sGW	sPCB	WSSB
Monitoring (directly or through sponsored studies) of water quality and subsequent assessment	✓ assessment of water resources, implying quality	✓	✓	✓	✓	✓	✓	✓
Storage and processing of water quality data	✓	✓	✓	✓	✓	✓	✓	✓
Management / control of pollution		✓ through CGWA[a]	✓	✓			✓	
Dissemination of water quality information /mass awareness	✓ upon request , official use	✓ upon request , official use	✓ restricted	✓ regular publications	✓ upon request, official use	✓ upon request, official use	✓	✓
Imparting training in water quality management to target groups.				✓			✓	✓

a – Central Ground Water Authority, formed recently.

Table 2: Monitoring Objectives

Objectives	CWC	CGWB	NRCD	CPCB	sSW	sGW	sPCB	WSSB
Estimation of natural background or baseline concentrations	✓	✓	✓	✓	✓	✓	✓	✓
Estimation of trends in quality changes due to anthropogenic or other influences	✓	✓	✓	✓	✓	✓	✓	✓
Routine evaluation of fitness of water for its designated use (specify the uses addressed)	✓ irrigation	✓ irrigation drinking	✓ various	✓ various	✓ irrigation	✓ irrigation drinking	✓ various	✓ drinking
Provide warnings of potentially deleterious changes for specific use		✓		✓		✓	✓	✓
Calculation of mass loads / flux				✓			✓	
Check effects of effluent discharges for compliance or charging				✓			✓	
Characterisation/ Classification of water bodies		✓		✓		✓	✓	
Specific investigations and corrective measures		✓	✓	✓		✓	✓	✓

7 Findings and Recommendations

7.1 Mandates and objectives

The following mandates related to water quality monitoring were identified for organisations that participated in the technical meetings:

(i) assessment of water resources
(ii) control and management of water pollution
(iii) preservation of ambient water quality
(iv) supplying water of acceptable quality for different uses, particularly for domestic consumption and irrigation
(v) training in water quality management
(vi) dissemination of water quality information

The HP agencies identified (i), (iv) and (vi) above as their prime mandates. In view of formation of Central Ground Water Authority the mandate of CGWB may be expanded to include (ii) and (iii) also.

It was recommended that water quality monitoring networks should be designed with objectives in consonance with the mandates. Thus the objectives for HP agencies would be:

- *monitoring for establishing baseline water quality, observing trend in water quality changes and calculation of flux of water constituents and*
- *surveillance for drinking water and irrigation use (in comparison with standards).*
- *dissemination of water quality information*

Further, it was recommended that naming of objectives as routine monitoring, multipurpose, etc. should be replaced by well defined terms as noted above.

7.2 Historical data

CWC, CGWB and some state agencies have historical water quality data collected over the past several years. These data are reported in the form of water quality yearbooks. In the case of ground water, maps showing isopleths of electrical conductivity (EC) are prepared. Further, problem areas are also identified with respect to occurrence of fluorides and nitrates. There is a need to review the data in greater detail for both surface and ground water and carry out statistical analysis to establish trends and correlation between parameters and between stations. This will lead to an objective reappraisal of the existing network and may result in modifications in regard to location of stations, frequency of sampling and choice of water quality parameters. Whereas about five year old data may be analysed initially, older data may also be considered as per the review needs.

It was recommended that working groups, separately for surface and ground waters, might be formed to carry out the review of historical data with the goal of rationalising the water quality networks. In this task the working groups will be assisted by the Consultants who will provide a protocol for the review and worked-out examples of review of historical data of surface and ground water quality. This will also bring in uniformity among the working groups in their approach to the review. The groups for groundwater may be formed on the basis of regions, while those for surface water on the basis of river basins.

7.3 Future network reviews

For regular assessment of monitoring needs and optimisation of monitoring efforts, review of monitoring data should be carried out periodically.

It was recommended that review of all water quality networks should be done at a regular interval of three years.

7.4 Newly introduced water quality parameters

Indiscriminate discharge of municipal and industrial wastes in the environment along with intensive utilisation of water resources has resulted in pollution of surface and ground waters. Under HP, the capability of laboratories is being enhanced to monitor pollution related water quality parameters, namely, aggregate organic matter, faecal bacteria, trace heavy metals and trace organics.

It was recommended that a selected number of pollution related water quality parameters should be included in the monitoring networks but only as dictated by the objectives of monitoring.

7.5 Ground water pollution

Only a limited number of ground water quality monitoring stations for surveillance for pollution control are being operated by CPCB and state PCBs. These stations are not adequate to detect trend in deterioration of water quality. Further, the groundwater agencies primarily monitor major cations and anions which are not sufficient to indicate pollution.

It was recommended that CGWB and state GW agencies should set up surveillance cum trend stations in areas where there are possibilities of ground water contamination, such as mining, industrial and agricultural areas, urban centres, etc.

7.6 Recognition of water quality problem areas

Many a times water quality deterioration is noticed only when the damage, which may be irreversible, becomes obvious. A case in point is fluoride bearing ground waters. There is a need to scan water quality for detecting such problems.

It was recommended that water quality monitoring agencies should include short term surveys in their monitoring programmes designed to identify water quality problem areas.

7.7 Improved co-operation among agencies

Organisations, other than HP agencies, which are operating water quality monitoring networks include, CPCB, NRCD, state PCB, PHED and WSSB. Often there is no communication among the various agencies, with the result that there is duplication of effort. Also one agency does not draw upon the experience of the other.

It was recommended that for each state a co-ordinating committee of members drawn from all agencies engaged in water quality monitoring in the state should be formed, in which each member would present activities of their organisation.

7.8 Analytical quality control (AQC) for water quality laboratories

It was realised that the credibility of information generated from the water quality monitoring network and its acceptance by users would directly depend upon the quality of data. Further, quality assurance of data is important when a number of laboratories are involved in characterising the same waterbody at different locations.

A within-laboratory AQC exercise comprising 4 parameters, in which 21 laboratories from HP agencies participated was completed recently. A second round of the exercise, comprising 10 parameters, is already under progress. It is planned to start an inter-laboratory AQC exercise in which CPCB laboratory will serve as the reference laboratory for the initial two years. It is expected after this period, some of the HP laboratories may be in a position to take up this responsibility.

It was recommended that within- and inter-laboratory Analytical Quality Control programmes should be instituted in all HP laboratories on a continuing basis. Further, all HP laboratories were urged to join in the ongoing exercises.