

ACTIVITIES OF CENTRAL WATER COMMISSION IN WATER QUALITY MONITORING

Central Water Commission is monitoring water quality at 371 key locations covering all the major river basins of India .CWC is maintaining a three tier Laboratory system for analysis of the parameters .The Level-I Laboratories are located at 258 field water quality monitoring stations on various rivers of India where physical parameters such as temperature, colour, odour, specific conductivity, total dissolved solids, pH and one Dissolved Oxygen of river water are observed . There are 24 Level-II Laboratories located at selected Division Offices to analyse 25 nos. physico-chemical characteristics and bacteriological parameters of river water. Four (04) Level-III / II+ Laboratories are functioning at Varanasi, Delhi, Hyderabad and Coimbatore where 41 parameters including heavy metals / toxic parameters and pesticides are being analysed.

The list of 41 parameters and the corresponding desirable equipment provided in the Level-I, Level-II & Level-III/II+ Laboratories for the analysis of these parameters is given in **Table-1** below :

Table-1

Water Quality Parameter and the Equipment required for analysis in Lab Level-I,II ,II+/III

S. No.	Parameter	Equipment Required for Analysis
Level- I Lab		
1.	Temperature	Thermometer/ Water Analysis Kit
2.	Colour	Visual / colour kit
3.	Odour	Physiological Sense
4.	Electrical Conductivity/ Total Dissolved Solids (TDS)	Conductivity Meter/ Water Analysis Kit
5.	pH	pH Meter/ Water Analysis Kit
6.	Dissolved Oxygen	Titration/ Water Analysis Kit
Level-II Lab (In addition to Level-I Parameters)		
1.	Temperature	Thermometer/ Water Analysis Kit
2.	pH	pH Meter/ Water Analysis Kit
3.	Electrical Conductivity/ Total Dissolved Solids (TDS)	Conductivity Meter/ Water Analysis Kit
4.	Calcium	Complexometric Titration
5.	Magnesium	Complexometric Titration
6.	Sodium	Flame Photometer
7.	Potassium	Flame Photometer
8.	Iron	Spectrophotometer
9.	Carbonate	Titration
10.	Bicarbonate	Titration
11.	Sulphate	Nephelometer / Turbidity meter
12.	Chloride	Argentometric Titration
13.	Fluoride	U.V.Visible Spectrophotometer/ Ion Meter
14.	Nitrate	U.V.Visible Spectrophotometer/ Ion Meter

15.	Nitrite	U.V.Visible Spectrophotometer/ Ion Meter
16.	Silicate	U.V.Visible Spectrophotometer /Ion Meter
17.	Phosphate	U.V.Visible Spectrophotometer/ Ion Meter
18.	Boron	U.V.Visible Spectrophotometer
19.	Dissolved Oxygen	Titration/ Water Analysis Kit
20.	Biochemical Oxygen Demand (B.O.D.)	Incubation followed by Titration
21.	Chemical Oxygen Demand (C.O.D.)	C.O.D. digester
22.	Total Plate Count	Colony Counter
23.	Total Coliform	By Culture Technique
24.	F. Coliform	
25.	E.. Coliform	
Level-II+ /Level-III (In addition to Level-I & II Parameters)		
1.	Total Kjeldhal Nitrogen	Kjeldahl Apparatus
2.	Cyanide	Ion Meter
3.	Ammonia (Nitrogen)	U.V.Visible Spectrophotometer/ Ion Meter
4.	T.O.C. (Total Carbon Analyser)	T.O.C.Analyser
Pesticides (4 to 9) (06 Nos.) including :		
5.	2,4-D	Gas Chromatograph
6.	Aldrin	Gas Chromatograph
7.	D.D.T.	Gas Chromatograph
8.	Endo Sulphan	Gas Chromatograph
9.		
10.		
11.	Arsenic	Atomic Absorption Spectrophotometer/ Inductively Coupled Plasma Spectrophotometer
12.	Cadmium	
13.	Mercury	
14.	Chromium	
15.	Lead	
16.	Zinc	

The following procedure is followed in CWC for classification of stations, frequency of monitoring, identification of parameters and their analysis:

- (A) Classification:** Stations are classified as Base, Trend and Flux Stations or Impact Stations and are defined as follows:
- (i) **A Base Station** means the monitoring location whether there is no influence of human activities on water quality.
 - (ii) **A Trend Station** means a monitoring location designed to show how a particular point on a water course varies over time due, normally, to the influence of man's activities.
 - (iii) **A Flux Station or Impact Station** means the location for measuring the mass of particular pollutant on main river stem for measuring the extent of pollution due to human interference or geological feature at any point of

time and is necessary for measuring impact of pollution control measures adopted.

CWC has 164 Base stations, 179 Trend stations and 28 Flux stations.

(B) Frequency of Monitoring :

- **Base Station:** One sample is collected every two months and total six samples in a year.
- **Trend Stations:** Sample are collected once in every month.
- **Flux Stations:** Samples are collected thrice in a month, However toxic and trace metal are analyzed once in a month.

(C) Special Experiments:

Special experiments on longitudinal variation and depth variation for D.O. and B.O.D of various pollutants are carried out once in year at all flux and trend stations.

(D) Methodology For Sampling

(a) Samples for Base line and Trend stations shall be collected from well mixed section of the river or main stem 30 cm below the water surface using a Dissolved Oxygen (DO) sampler or weighted bottle.

(b) Samples for Impact stations shall be collected from the point of interest, such as bathing ghat, down stream of point discharge , water supply intakes and other sources.

(c) The dissolved Oxygen (DO) in the sample shall be fixed immediately after collection and Dissolved oxygen(DO) analysis shall be done either in the field or in laboratory.

(d) For longitudinal surveys, the samples are collected from the river in the affected reaches particularly, which have city drains' inlets. The locations are selected before and after the joining of drains. Care is taken to ensure that there is reasonable mixing of wastewater with water. Such samples are analyzed for DO and BOD only.

samples remain abnormal and invite immediate attention of a keen observer and so, such results should be qualified by nature of sample also.

Sampling Point Location:

Sample are collected from the mid stream for Base and Trend stations and 1/4, 1/2, 3/4 of the river width for flux stations.

Sample preservation and transportation:

(1) The type of containers and sample preservation to be adopted shall be as mentioned below :

Analysis	container	Preservation
1	2	3
General	Glass, PE	4°C,dark
BOD	Glass, PE	4°C,dark
COD,NH ₃ ,NO ₂ ,NO ₃	Glass, PE	H ₂ SO ₄ ,Ph<2
DO	BOD bottle	DO fixing chemicals
Coliform	Glass, PE, sterilised	4°C,dark
Fluoride	PE	None
P	Glass	None
Pesticides	Glass, Teflon	4°C,dark
Toxic metals	Glass, PE	HNO ₃ ,Ph<2

Methodology for Measurement of Various Parameters

Temperature: It is measured in-situ. The bulb of 0-50⁰ C thermometer is dipped in flowing river water for a suitable length of time (2-3 minutes) till it attains the river temperature. The level of mercury is then read while keeping the bulb in water. Alternatively, the river water is collected in the bucket and temperature of water is read as above.

pH: It is measured at the Divisional Laboratory(Level-II) with the help of pH meter having combined Glass-calomel electrode. The approximate range of pH is also measured at Level-I Laboratory with the help of pH strips or universal indicator, or pH meter. However, the values reported in data are taken in Level-II Laboratory. Before measuring the pH value of the sample, the instrument is standardized with buffer solutions of pH 7.0 and 9.2.

EC (Electrical Conductivity): It is measured in Level-II Laboratory with the help of EC meter which measures the resistance offered by the water between two platinized

electrodes. The instrument is standardized with known values of conductance observed with standard KCl solution.

Calcium: It is measured in Level-II Laboratory by complexometric titration with standard solution of EDTA(Ethylene Diamine Tetra Acetic Acid) using Patton's and Reeder's indicator under the pH conditions of more than 12.0. These conditions are achieved by adding a fixed volume of 4N Sodium Hydroxide. The volume of titre (EDTA solution) against the known volume of sample gives the concentration of calcium in the sample.

Magnesium: It is also measured in Level-II Laboratory by complexometric titration with standard solution of EDTA using Eriochrome black T as indicator under the buffer conditions of pH 10.0. The buffer solution is made from Ammonium Chloride and Ammonium Hydroxide. The solution resists the pH variations during titration. The value of titre (EDTA solution) against the known volume of sample gives sum of the Calcium and Magnesium concentration. From this value, the concentration of Calcium is subtracted to get the concentration of Magnesium.

Sodium: It is also measured at Level-II Laboratory with the help of flame photometer. The radiation emitted by the sample is measured through yellow filters. The instrument is standardized with the known concentration of sodium ion (1 to 100 mg/litre). The samples having higher concentration are suitably diluted with distilled water and the dilution factor is applied to the observed values.

Potassium: It is also measured at Level-II Laboratory with the help of flame photometer. This instrument works on the principle of measurement of specific radiation emitted by potassium atoms when the solution is aspirated in soot less flame of gas burner. The instrument is standardized with known concentration of potassium solution, in the range of 1 mg to 5 mg/litre. The sample having higher concentration is suitably diluted with distilled water and the dilution factor is applied to the observed values. Violet glass filter is used for measuring potassium.

Iron: It is measured spectroscopically at 396 nm radiation by making a colour complex with ortho phenanthroline under the buffer conditions of 3.9. Both ferrous and ferric ions form complex and absorb radiation at 396 nm. In addition, ferrous ions complex being orange red also absorbs radiation at 516 nm. The concentration of ferrous ion is then subtracted from the concentration of total iron to get the concentration of ferric ion in solution. The buffer conditions are achieved by potassium hydrogen phthalate or sulphuric acid /potassium phthalate solution. The conditions of turbidity before the test should be observed as in case of aluminium.

Carbonate: Whenever the pH touches 8.30, the presence of carbonates is indicated. It is measured by titration with standardized hydrochloric acid using phenolphthalein as indicator. Phenolphthalein is colourless below pH 8.3 and becomes pink above this pH gradually. Below pH 8.3, the carbonates are converted into equivalent amount of

bicarbonates. The titration can also be done pH metrically or potentiometrically with hydrogen electrode in pH, mode or ORP mode.

Bicarbonate: It is also measured by titration with standardized hydrochloric acid using methyl orange as indicator. Methyl orange turns yellow below pH 4.0. At this pH, the carbonic acid decomposes to give carbon dioxide and water. The total consumption of acid (for carbonate and bicarbonate is divided suitably into separate components).

Sulphate: It is measured by nephelometric method in which the concentration of turbidity is measured against the known concentration of synthetically prepared sulphate solution. Barium chloride is used for producing turbidity due to barium sulphate and a mixture of organic substance (Glycerol or Gum acetia) and sodium chloride is used to prevent the settling of turbidity.

Chloride: It is measured by titrating a known volume of sample with standardized silver nitrate solution using potassium chromate solution in water or eosin/fluorescein solution in alcohol as indicator. The latter indicator is an adsorption indicator while the former makes a red coloured compound with silver as soon as the chlorides are precipitated from solution.

Fluoride: It is measured spectroscopically by the reaction of fluoride on the colour developed by Zirconium-alizarin or Zirconium -SPADNS complex. Fluoride irreversibly combines with zirconium and reduces the intensity of complex. The reduction is proportional to concentration of fluoride. The instrument is calibrated with the known concentration of fluoride.

Silicates & Phosphate: These are also measured spectroscopically. Yellow colour is developed from the action of phosphates and silicates on molybdate ion under strong acidic conditions. The intensity of colour is directly proportional to the concentration of phosphate and silicates in the sample. In order that the complexes of two parameters are made selectively, separate reducing agents such as ascorbic acid and bisulphite are adopted. Phosphate complexes are reduced by weak reducing agents such as ascorbic acid or tartaric acid (potassium antimonyl tartarate) where as silica complexes require strong reducing conditions of hydrazine or bisulphite. The colour of reduced complex is sky blue. The intensity is blue complex is proportional to the concentration of phosphate or silicate.

Boron: It is determined spectroscopically by measuring the intensity of colour developed due to action of boron(as borate) on curcumin. The red dye (Rosaniline) is formed in acidic conditions and is extracted by absolute alcohol. As boron is present in borosilicate glass, the apparatus used for sample treatment and colour development must be boron free. The silica dishes/crucibles can be used for this purpose and the liquid handling equipment should be made of polypropylene. The calibration is done with known concentrations of boron.

Dissolved Oxygen: It must be measured at the river site as it changes with time. If it is not possible then the amount of dissolved oxygen in water should be fixed

chemically. The Winkler's method is used for its measurement titrimetrically. However, as this method has interference from the oxygen bubbles in plankton/algae, the electrode method is being adopted.

Biochemical Oxygen Demand: Remaining DO in sample is measured titrimetrically by Winkler's method after 5 days incubation at 293 K. The difference in initial and final DO gives the amount of oxygen consumed by the bacteria during this period. The value is calculated for one litre of sample. This procedure needs special BOD bottles which seal the inside environment from atmospheric oxygen. The polluted samples need appropriate dilution and seeding also.

Total Coliform: The bacteria present in water grow very fast in specially prepared nutritive medium(agar-agar). The numbers of bacteria growing under these conditions remain confined to the sample, as their movements are restricted due to viscous medium. The large numbers of bacteria grown from single bacteria form a colony. Such colonies are counted to give the total number of coliform in the sample.

Ammonia (Nitrogen): It is measured spectroscopically at 425 nm radiation by making a colour complex with Nessler's reagent. The conditions of reaction are alkaline and cause severe interference from hardness in water. The colour complex solution must be centrifuged to remove the turbidity formed due to precipitation of magnesium calcium hydroxide carbonates or the hardness should be removed by prior precipitation or passing the solution through sodium resin to achieve better results. The addition of EDTA or Rochelle salt also inhibits the precipitation of metals causing hardness.

Analysis of Data :

The samples are being analysed as per APHA guidelines/ manual. The brief methodology is given as under:

Natural flowing water has a benign property of sustaining different form of life. It also has a habit of retaining nutrients and discarding undesirable materials such as precipitation of metal hydroxide and bubbling of carbon dioxide, hydrogen sulphide and organic compounds containing nitrogen in aromatic groups and which have very distinctive foul smell. Under normal circumstances, the natural water system does not receive much of undesirable material unless the river passes through specific reach having a high concentration of such chemicals or such mineral are added to the river by the run-off caused by the precipitation. However, with the advent of industrialization and unplanned human settlements, the addition of large amount of undesirable chemicals to the river system is quite frequent, with the result that the quality of river water is at premium.

The basic aim of any river water quality-monitoring programme is to assess its suitability for drinking, bathing, irrigation and industrial uses including pisciculture and other aquatic flora & fauna. The suitability of water for irrigation changes with type of crop and soil conditions and requirements for each purpose has been considered at the monitoring stations and suitability of water enumerated in Table- 2 is briefly as follows:

For the suitability of water for different purposes the following aspects are taken into account.

The value of BOD is taken as 3 mg/l to assign fitness for drinking and bathing. The values in the range of 3-5 mg/l are taken as boundary cases. DO less than 2 mg/l is taken as negative factor for aquatic life and between 2-4 mg/l is taken as boundary case.

Nitrate more than 20 mg/l, fluoride more than 1.0 mg/l and selenium more than 0.01 mg/l are the negative factors in deciding its use for drinking purpose. Hardness of more than 200 mg/l to 400 mg/l invariably requires softening for most uses in industries.

Salinity as indicated by electrical conductance up to a value of 2000 micro-Siemen is considered to assign fitness for agricultural purpose. Residual sodium carbonate values more than 0.5 are taken as negative consideration for the suitability of water for agricultural uses. Similarly Boron more than one ppm, SAR more than 5 and sodium percentage more than 40% are negative factor for agricultural uses.

E. C. more than 2000 micro-Siemen, BOD more than 30 mg/l and colour, if any, are boundaries for utilization in industrial activities.

The data generated is computerized in Data Base system and disseminated in the form of Hydrological Year Books, Status Reports and Bulletins. Water Quality Year Books are published and WQ Bulletins are issued regularly.

Chemical indices: Chemical indices such as hardness, sodium percentage, sodium adsorption ratio and residual sodium carbonate are calculated on the strength of concerned ions. The river water is also classified for salinity hazard on the basis of internationally accepted norms. To maximize the knowledge on the health of river system, variable frequency and scope of monitoring of water quality have been adopted depending upon the extent of point/non point sources of pollution in the water.

Formulae : Formulae utilized for conducting calculations for Sodium Adsorption Ratio (S.A.R.), Sodium Percentage (S.P.), Residual Sodium Carbonate (R.S.C.) and Hardness Number are given here under:

(i) Sodium Adsorption Ratio (S.A.R.):

$$\text{S.A.R.} = \frac{\text{Na}^+}{\frac{(\text{Ca}^{++} + \text{Mg}^{++})^{1/2}}{2}}, \text{ Ionic Concentration in meq./l}$$

(ii) Sodium Percentage (S.P.):

$$\text{S.P} = \frac{\text{Na}^+ \times 100}{(\text{Ca}^{++} + \text{Mg}^{++} + \text{Na}^+ + \text{K}^+)}, \text{ Ionic Concentration in meq./l}$$

(iii) Residual Sodium Carbonate (R.S.C.) :

$$\text{R.S.C.} = (\text{CO}_3^- + \text{HCO}_3^-) - (\text{Ca}^{++} + \text{Mg}^{++})$$

(iv) Hardness Number (H.No.):

$$\text{H. No.} = (\text{Ca}^{++} + \text{Mg}^{++}), \text{ Concentration in mg/l as CaCO}_3$$

(I) Water Quality Monitoring Work carried out under Hydrology Project

Under hydrology project, protocol for water quality was developed incorporating the following :-

- Frequency of sampling
- Parameters for analysis of different kinds of monitoring stations
- Specifications of sample containers
- On-the-spot analysis of field parameters
- Recording of field conditions at the time of sampling
- Transportation of samples to laboratory with appropriate preservatives
- Coding procedure for receipt of samples
- Analytical procedures
- Data entry system
- Data validation at laboratory before data transfer
- Designing of laboratories (Level-I,II & III/II+)
- Development of specifications for the state-of-art instrument/equipment
- Preparation of guidelines for standard analytical procedures for 40 parameters
- Development of 50 training modules for sampling, analysis of various water quality parameters, data validation, data analysis and interpretation
- Development of software for “Water Quality Data Entry System(WQDES)” for surface water and ground water
- Development of a manual for application of the WQDES software
- Stabilization of the water quality monitoring programme through frequent visits to laboratories
- Evolving procedure for ‘within laboratory’ and ‘inter laboratory’ Analytical Quality Control (AQC) and conducting 2 rounds of each of the AQC exercises in collaboration with CPCB

CWC has taken necessary action to carryout AQC exercises for its all 27 water quality laboratories.

(II) Water Quality Assessment Authority (WQAA)

The declaration of constitution of Water Quality Assessment Authority reads as :

In exercise of the powers conferred by sub-sections (1) and (3) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986) (hereinafter referred to as the said Act), the Central Govt. hereby constitutes an authority to be known as “Water Quality Assessment Authority” consisting of 12 members for a period of three years w.e.f. the date of publication of this notification in the Official Gazette. Secretary, MOEF is the Chairman of WQAA and Chairman, CWC is its Member.

The first meeting of WQAA was held on 26th Sept., 2001 under the Chairmanship of Secretary, MOEF. In the meeting, it was decided to form State Level Water Quality Review Committees where Chief Engineers/Superintending Engineers will function as Member Secretary. State Level Water Review Committees have been constituted in 34 States/Union Territories.

Seven meetings of WQAA have been held so far. Based on the decisions taken in the second meeting of the WQAA, a WQMC and a Task Force were constituted under WQAA to recommend measures for optimum water quality observation network and coordinate data collection and dissemination system to assist the WQAA. The recommendations of the Expert Group have been accepted by WQAA in its fourth meeting. Three Specific Groups (Group-I, Group-II, Group-III) have also been formed to deal with the specialized functions of WQAA on a continuous basis. A Working Group has also been constituted by WQAA to deal with issues relating to minimum flows in riverine systems. The Working Group has submitted its report to WQAA in 2007..

A sub-committee was also formed by WQAA to look into aspects of “Legal and Institutional implications of implementation of the recommendation of Working Group on minimum flow of rivers in India”. The sub-committee has also submitted its report to WQAA during 2009.

(III) Ganga River Basin Authority

At a meeting chaired by Prime Minister, Dr. Manmohan Singh with Ministries of Water Resources, Environment and Forests and Urban Development in New Delhi on November 04, 2008, a decision was taken to declare the Ganga as a National River and also set up a Ganga River Basin Authority as an empowered planning, implementing and monitoring authority for the Ganga River. The proposed Authority would be chaired by the Prime Minister and would have as its Members Chief Ministers of States through which the Ganga flows.

The Prime Minister referred to the special place Ganga has in the hearts and minds of all Indians and stated that this emotional link needs to be recognized and that the country should set up a model for river cleaning through the new institutional mechanism. It was decided that there is a need to replace the current piecemeal efforts taken up in a fragmented manner in select cities with an integrated approach that sees the river as an ecological entity and addresses issues of quantity in terms of water flows along with issues of quality. The details of the Authority to be vested with appropriate powers would be worked out in consultation with State Governments and Central Ministries.

The unit of planning, it was felt, should be the river basin and action related to pollution abatement, sustainable use of water and flood management should be integrated. The proposed Authority will promote intersectoral coordination for comprehensive planning for the river. Various agencies working in different aspects of river conservation and pollution management would be brought together under this proposed Authority.

Central Water Commission will have an important role to play in the day to day activities of Ganga River Basin Authority.