Government of India & Government of The Netherlands

Technical Assistance
HYDROLOGY PROJECT

DHV CONSULTANTS & DELFT HYDRAULICS with HALCROW, TAHAL, CES, ORG & JPS

Protocol for

Water Quality Monitoring

August 1999

Version 1.0

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1 Introduction

The main objectives for water quality monitoring for Surface and Groundwater Agencies under the HP were identified as:

- monitoring for establishing baseline water quality
- observing trend in water quality changes
- calculation of flux of water constituents of interest
- surveillance for irrigation use
- control and management of water pollution (for groundwater only)

The networks of monitoring stations were designed/upgraded accordingly with the above objectives in mind.

The present document summarises the design approach and delineates actions necessary to operationalise the monitoring programme.

The document is meant to be used as a ready reference by the field staff, water quality laboratory personnel and managers of the water quality monitoring programmes.

2 Frequency and Parameters

2.1 Groundwater

- Initially all stations will be classified as *baseline* stations.
- About 20 to 25% of the baseline stations will also be classified as *trend* or *trend-cum-surveillance* stations.
- Table 1 gives the frequency of sampling and parameters for various types of stations.
- After data are collected for three years, the stations may be reclassified. Some *baseline* stations may be discontinued for a fixed number of years and some *baseline-cum-trend* stations may be operated only as *trend* stations. Suspect wells may be operated as *trend-cum-surveillance* stations.

2.2 Surface Water

- Since not much is known about the present water quality status at various stations, to start with, all stations will be a combination of *baseline* and *trend* stations.
- Samples will be collected every two months: May/June, August, October, December, February, and April. This will generate six samples from perennial rivers and 3-4 samples from seasonal rivers, every year.
- After data are collected for three years, the stations will be classified either as *baseline, trend* or *flux* station.
- Those stations, where there is no influence of human activity on water quality, will be reclassified as *baseline* stations. Others will remain as *trend* stations.
- If a station is classified as a *baseline* station, it will be monitored, after every three years, for one year every two months.

- If a station is classified as *trend* station, it will continue to be monitored but with an increased frequency of once every month.
- Stations will be classified as *flux* stations where it is considered necessary to measure the mass of any substance carried by the flow. The frequency of sampling at such stations and analyses of constituents of interest may be increased to 12 or 24 times per year. Measurement of discharge at such stations is necessary.
- The recommended parameters for analysis are given in Table 2.
- Other inorganics, metals, organics and biological parameters will be determined as part of special *survey* programmes.
- The *survey* programmes may include some of the trend stations where there is a need for determination of any of these groups of parameters.
- The *survey* programmes will ordinarily be of one year duration. The sampling frequency may be the same as that for trend stations.
- Special arrangements for sampling and transport of the samples would be necessary for the *survey* programmes and microbiological samples.

Table 1 Parameters of analysis for groundwater samples

Type of station	Frequency	Parameter
Baseline	Once every year, (pre-monsoon, May-June)	Temp, EC, pH, NO_2^- + NO_3^-, total P, K^+, Na^+, Ca^{++}, Mg^{++}, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--}, COD, SiO_2, F, B.
Trend	Four times every year, (pre-monsoon, May-June & after intervals of 3 months)	Temp, EC, pH, NO_2^- + NO_3^-, total P, Cl^-, COD.
Trend–cum–surveillance – *Fluoride* – *Iron* – *Industrial, mining* – *Salinity due to irrigation, natural contribution or sea water intrusion* – *Urban* pollution	Minimum four times a year (as above), higher frequency if dictated by importance of water use	According to the problem under surveillance (e.g. Heavy metals in mining areas) F^- Fe As, Cd, Hg, Zn Na^+, K^+, Ca^{++}, Mg^{++}, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--} Total and faecal coliforms

Table 2 Parameters of analysis for surface water samples[a]

Parameter Group	Initially	Baseline	Trend
General	Temp, EC, pH, DO,TDS	Temp, EC, pH, DO,TDS	Temp, EC, pH, DO
Nutrients	NH_3-N, NO_2 + NO_3, total P	NH_3-N, NO_2 + NO_3, total P	NH_3-N, NO_2 + NO_3, total P
Organic matter	BOD, COD	None	BOD, COD
Major ions	Ca^{++}, Mg^{++}, K^+, Na^+, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--}	Ca^{++}, Mg^{++}, K^+, Na^+, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--}	Cl^-
Other inorganics	None	None	None
Metals	None	None	None
Organics	None	None	None
Microbiological[b]	Total coliforms	None	Total and faecal coliforms
Biological	None	None	None

a- based on 'Surface Water Quality Network Design, Guidelines and an Example', June 1997
b- depending on workload, analysis frequency may be reduced upto 2 samples per year

3 Sample Collection

3.1 GENERAL

- At least one day before sampling, make sure that all the arrangements are made as per the check list given in Annexure I.
- Make sure that you know how to reach sampling site(s). Take help of location map for the site which shows the sample collection point with respect to prominent landmarks in the area. In case there is any deviation in the collection point, record it on the sample identification form giving reason.
- Rinse the sample container three times with the sample before it is filled.
- Leave a small air space in the bottle to allow mixing of sample at the time of analysis.
- Label the sample container properly, preferably by attaching an appropriately inscribed tag or label. The sample code and the sampling date should be clearly marked on the sample container or the tag.
- Complete the sample identification forms for each sample, Figures 1 and 2 for ground and surface water, respectively.
- The sample identification form should be filled for each sampling occasion at a monitoring station. Note that if more than one bottle is filled at a site, this is to be registered on the same form.
- Sample identification forms should all be kept in a master file at the level II or II+ laboratory where the sample is analysed.

3.2 Groundwater

- Samples for groundwater quality monitoring would be collected from one of the following three types of wells:
  - *Open dug wells* in use for domestic or irrigation water supply,
  - *Tube wells* fitted with a hand pump or a power-driven pump for domestic water supply or irrigation
  - *Piezometers*, purpose-built for recording of water level.
- Open dug wells, which are not in use or have been abandoned, will not be considered as water quality monitoring station. However, such wells could be considered for water level monitoring.
- Use a weighted sample bottle to collect sample from an open well about 30 cm below the surface of the water. Do not use a plastic bucket, which is likely to skim the surface layer only.
- Samples from the production tube wells will be collected after running the well for about 5 minutes.
- Non-production piezometers should be purged using a submersible pump. The purged water volume should equal 4 to 5 times the standing water volume, before sample is collected.
- For bacteriological samples, when collected from tubewells/hand pump, the spout/outlet of the pump should be sterilized under flame by spirit lamp before collection of sample in container.

3.3 Surface Water

- Samples will be collected from well-mixed section of the river (main stream) 30 cm below the water surface using a weighted bottle or DO sampler.
- Samples from reservoir sites will be collected from the outgoing canal, power channel or water intake structure, in case water is pumped. When there is no discharge in the canal, sample will be collected from the upstream side of the regulator structure, directly from the reservoir.
- DO is determined in a sample collected in a DO bottle using a DO sampler. The DO in the sample must be fixed immediately after collection, using chemical reagents. DO concentration can then be determined either in the field or later, in a level I or level II laboratory.

3.4 Sample Containers, Preservation and Transport

- Use the following type of containers and preservation:

Analysis	Container	Preservation
General	Glass, PE	None
COD, NH_3, NO_2^-, NO_3^-	Glass, PE	H_2SO_4, pH<2
P	Glass	None
DO	BOD bottle	DO fixing chemicals
BOD	Glass, PE	4 ^oC, dark
Coliform	Glass, PE, Sterilised	4 ^oC, dark
Heavy metals	Glass, PE	HNO_3, pH<2
Pesticides	Glass, Teflon	4 ^oC, dark

- Samples should be transported to concerned laboratory (level II or II+) as soon as possible, preferably within 48 hours.
- Analysis for coliforms should be started within 24 h of collection of sample. If time is exceeded, it should be recorded with the result.
- Samples containing microgram/L metal level, should be stored at 4^oC and analysed as soon as possible. If the concentration is of mg/L level, it can be stored for upto 6 months, except mercury, for which the limit is 5 weeks.
- Discard samples only after primary validation of data.

Figure 1 Sample identification form for groundwater samples

Sample code		
Observer	Agency	Project
Date Time	Station code	
Source of sample: o Open dug well o Hand pump o Tube well o Piezometer		

Parameter code	Container				Preservation				Treatment		
	Glass	PVC	PE	Teflon	None	Cool	Acid	Other	None	Decant	Filter
(1) Gen											
(2) Bact											
(3) BOD											
(4) COD, NH_3, TO_xN											
(5) H Metals											
(6)Tr Organics											

Field determinations			
Temp °C	**pH**	**EC μmho/cm**	**DO mg/L**

Odour code			Colour code		
(1) Odour free	(6) Septic		(1) Light brown	(6) Dark green	
(2) Rotten eggs	(7) Aromatic		(2) Brown	(7) Clear	
(3) Burnt sugar	(8) Chlorinous		(3) Dark brown	(8) Other (specify)	
(4) Soapy	(9) Alcoholic		(4) Light green		
(5) Fishy	(10) Unpleasant		(5) Green		

IF WELL IS PURGED, COMPLETE BELOW:

Office Well Data			
Diameter	φ		cm
Depth	D		m
Static water level (avg)	SWL		m
Water column (D-SWL)	H		m
Initial volume well	V		L
Projected pump discharge	PQ		L/s
Projected time of purging (V/PQ)	PT		min
Field Flow Measurements			
Static water level on arrival	SWL		m
Actual pump setting			m
Purging duration			min
Pump Discharge before sampling	Q		L/min
Pump Discharge after sampling	Q		L/min
Volume purged	V		L
Dynamic water level	DWL		m
Field Chemical measurement			
Time at start of sampling started	T (°C)	EC(μmho/cm)	pH
+10 min			
+20 min			
+30 min			
+40 min			

Figure 2 Sample identification form for surface water samples

Sample code											
Observer					Agency			Project			
Date Time					Station code						
Parameter code	**Container**				**Preservation**				**Treatment**		
	Glass	**PVC**	**PE**	**Teflon**	**None**	**Cool**	**Acid**	**Other**	**None**	**Decant**	**Filter**
(1) Gen											
(2) Bact											
(3) BOD											
(4) COD, NH_3,NO_3^-											
(5) H. Metals											
(6)Tr. Organics											

Source of sample				
Waterbody	***Point***	***Approach***	***Medium***	***Matrix***
o River o Drain o Canal o Reservoir	o Main current o Right bank o Left bank	O Bridge O Boat O Wading	o Water o Susp matter o Biota o Sediment	o Fresh o Brackish o Salt o Effluent
Sample type	o Grab o Time-comp o Flow-comp o Depth-integ o Width-integ			
Sample device	o Weighted bottle o Pump o Depth sampler			

Field determinations			
Temp °C	**pH**	**EC μmho/cm**	**DO mg/L**

Odour code	(1) Odour free (2) Rotten eggs (3) Burnt sugar (4) Soapy (5) Fishy	(6) Septic (7) Aromatic (8) Chlorinous (9) Alcoholic (10) Unpleasant	**Colour code**	(1) Light brown (2) Brown (3) Dark brown (4) Light green (5) Green	(6) Dark green (7) Clear (8) Other (specify)

Remarks	
Weather	o Sunny o Cloudy o Rainy o Windy
Water vel. m/s	o High (> 0.5) o Medium (0.1-0.5) o Low (< 0.1) o Standing
Water use	o None o Cultivation o Bathing & washing o Cattle washing o Melon/vegetable farming in river bed

4 Analysis and Record

4.1 Sample Receipt Register

- Each laboratory should have a bound register, which is used for registering samples as they are received.
- An example of headings and information for such a register is given in Figure 3.

Figure 3: Sample receipt register

Date/Time received at lab.	Date/Time collected	Station code	Project	Collecting agency/collector	Preservation	Parameter code	Lab. Sample No.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
02.07.99/1400	01.07.99/1100	M 22	WQ monitoring	SW Div II/ Singh	No	1	28-1
02.07.99/1400	01.07.99/1700	M 24	WQ monitoring	SW Div II/ Singh	No	1	29-1
02.07.99/1400	01.07.99/1700	M 24	WQ monitoring	SW Div II/ Singh	Yes	4	29-4
05.07.99/1100	02.07.99/1300	S 44	Survey A	SPCB/ Bhat	Yes	5	30-5

- Column 3 gives the station code conventionally followed by the monitoring agency.
- Column (4) gives the project under which the sample is collected.
- Column (7) corresponds to the parameter(s) code given in the sample identification form.
- Column (8) gives the laboratory sample number assigned to the sample as it is received in the laboratory. Note that the numbering has two parts separated by a hyphen. The first part is assigned in a sequential manner as samples are received from various stations. If two samples are collected at the same time from a station for different sets of analysis, the first part of the number is the same. The second part corresponds to the parameter code.
- The results of the analyses of all the samples having the same first part of the code would be entered in the data entry system as one sample having the same station code and time of sample collection.

4.2 Work Assignment and Personal Registers

- The laboratory incharge should maintain a bound register for assignment of work. This register would link the lab. sample number to the analyst who makes specific analyses, such as pH, EC, BOD, etc.
- An estimate of time needed for performing the analyses may also be entered in the register.
- Each laboratory analyst should have his/her own bound register, where all laboratory readings and calculations are to be entered.
- When analysis and calculations are completed, the results must be recorded in a register containing data record sheets described in the next section.

4.3 Analysis Record and Data Validation

- A recommended format for recording data is given in Figure 4. It includes all parameters, except heavy metals and trace organics, that may be analysed in the water quality monitoring programme currently envisaged. Note that ordinarily a sample would NOT be analysed for all the listed parameters.
- Record of analyses for heavy metals and trace organics, which would be performed on a limited number of samples, would be kept separately in a similar format.
- Columns (2) – (3) are filled from the entries in the Sample Receipt Register.
- Columns (4) – (9) pertain to the field measurements. This information would be available from the Sample Identification Forms.
- Columns (10) – (36) would be filled in by the analyst(s) whom the work has been assigned (see Work Assignment Register).
- The format also includes primary data validation requirements, columns (37) – (53). The laboratory incharge should perform these validation checks as the analysis of a sample is completed. In case the analysis results do not meet any one of the validation checks, whenever possible, the analysis should be repeated. She/he would also fill in Columns (54) – (55).
- The results of the laboratory analyses would be entered from these records in the data entry system.

Figure 4: Data record and validation register

Data record **Laboratory / organisation** **Laboratory code**

Lab sample No	Station code	Date of collection	Field determinations						General				Nutrients			Org matter		Alkalinity		Hardness		Major ions								Other inorganics			Coliforms		Biol
			pH	EC, µmho/cm	DO, mg/L	Temp, °C	Colour, code	Odour, code	pH	EC, µmho/cm	TDS, mg/L	TSS, mg/L	NH_3, mg N/L	$NO_2^-+NO_3^-$, mg N/L	Total P, mg/L	BOD, mg/L	COD, mg/L	Phen, mg $CaCO_3$/L	Total, mg $CaCO_3$/L	Total, mg $CaCO_3$/L	Ca^{++}, mg $CaCO_3$/L	Ca^{++}, mg/L	Mg^{++}, mg/L	Na^+, mg/L	K^+, mg/L	Cl^-, mg/L	SO_4^{--}, mg/L	CO_3^{--}, mg/L	HCO_3^-, mg/L	Si, mg/L	F^-, mg/L	B, mg/L	Total, MPN/100 mL	Faecal, MPN/100mL	Chlorophyll-A, µg/L
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)

Data validation

Lab sample No	Station code	Cations					Anions						Ion balance		EC bal	Carbon bal	CO_3^{--} bal	Verification criteria	Checked by	Remarks
		Ca^{++}, meq/L	Mg^{++}, meq/L	Na^+, meq/L	K^+, meq/L	Total cations	Cl^-, meq/L	SO_4^{--}, meq/L	CO_3^{--}, meq/L,	HCO_3^-, meq/L	$NO_2^-+NO_3^-$, meq/L	Total anions	{(41)-(47)} / {(41)+(47)}	(39) / (42)	(12) / (11)	(18) / (17)	If (10) < 8.3, is (19)=0 ?			
(1)	(2)	(37)	(38)	(39)	(40)	(41)	(42)	(43)	(44)	(45)	(46)	(47)	(48)	(49)	(50)	(51)	(52)	(53)	(54)	(55)
																		(48) < 0.1 (49) = 0.8-1.2 (50) = 0.55-0.9 (51) > 1 (52) = yes		

Annex I

Checklist for sampling

- The following is a list of items, which should be checked before starting on a sampling mission.

- Itinerary for the trip (route, stations to be covered, start and return time)
- Personnel and sample transport arrangement
- Area map
- Sampling site location map
- Icebox
- Weighted bottle sampler
- DO sampler
- Rope
- BOD bottles
- Sample containers
- Special sample containers: bacteriological, heavy metals, etc.
- DO fixing and titration chemicals and glassware
- Thermometer
- Tissue paper
- Other field measurement kit, as required
- Sample identification forms
- Labels for sample containers
- Field notebook
- Pen / pencil / marker
- Soap and towel
- Match box
- Spirit lamp
- Torch
- Drinking water
- Knife

- Note that depending on the local conditions, water body, analysis requirements, etc., all items may not be necessary, or other items, not listed, may be required.
- Decide on the number of each item that would be required depending on the number of samples to be collected. It is always safer to carry a few numbers in excess.
- Ensure that the concerned laboratory is informed of the programme and ready to receive samples, particularly those, which would need immediate attention.