Report
on

ASSESSMENT OF WATER QUALITY MONITORING & SURVEILLIANCE (WQMS) IN THE WATER TESTING LABORATORIES OF GUJARAT

BY

SIGMA FOUNDATION

In Collaboration with

WASMO Gujarat & UNICEF Gujarat State Office

Acknowledgement

We are grateful to UNICEF, Gujarat State Office for giving an opportunity to SIGMA Foundation for being the technical partner in the assessment of performance of the water quality monitoring system in Gujarat. We would like to extend our heartfelt gratitude to the Principal Secretary, Water Supply Department of the state, CEO WASMO, Chief Engineer WASMO and other officials of WASMO for providing us all supports for the completion of the study.

We are also obliged to Director SRL, Gandhinagar and Chief Scientific Officer SRL, Gandhinagar for their extending support during the visit to the SRL and the other water testing laboratories of Gujarat. We are immensely thankful to other senior officials District Level and Taluka Level Laboratories who facilitated the laboratory assessments.

We would also like to extend sincere thanks to GP functionaries and Pani Samiti members for extending due support in capturing the grass root level data. We are also grateful to the community members who participated in the IDIs and the FGDs and provided valuable insights on water quality as per their perception.

(Dr. M.N. Roy)
President
SIGMA Foundation

Dated the 17th April, 2020

LIST OF ABBREVIATION

NRDWP	National Rural Drinking Water Programme
WASMO	Water Supply and Management Organization
HQ	Headquarter
MPN	Most Probable Number
IEC	Information Education and Communication
FTK	Field Test Kit
SRL	State Referral Lab
DLL	District Level Laboratory
QC	Quality Control
NIST	National Institute of Standards and Technology
RMFT	Rapid Membrane Filtration Technique
ID	Identity
COC	Chain of Custody
GLP	Good lab Practise Model
GP	Gram Panchayat
MDWS	Ministry of Drinking Water and Sanitation
BIS	Bureau of Indian Standards
TDS	Total Dissolved Solids
NABL	National Accreditation Board for Testing and Calibration Laboratories
WQMS	Water Quality Monitoring System
CEO	Chief Executive Officer
SOP	Standard Operating Procedure
GOI	Government of India
PT	Proficiency Test
ILC	Inter Lab Comparison
AMC	Annual Maintenance Contract
CMC	Comprehensive Maintenance Contract
ISO	International organization for Standardization
ATC	Automatic Temperature Control
LCD	Liquid Crystal Display
OTD	Orthotolidine testing method
BOD	Biological Oxygen Demand
JMM	Jal Jeevan Mission
HR	Human Resource
QA	Quality Assurance
MTD	Multiple Tube Dilution Technique
AAS	Atomic Absorption Spectroscopy
PHED	Public Health & Engineering Department

Executive Summary

1. The State of Gujarat faces several problems of chemical contaminations of water due to presence of Fluoride, Nitrate etc. in water, Salinity and bacteriological contamination due to presence of Coliform and E.coli. The water quality needs to be tested in a systematic manner. However, safe water can only be guaranteed not merely through testing of water quality but through a comprehensive water quality monitoring and surveillance system, which are distinct but closely related activities.

2. The State has established one Central Lab, thirty three District Labs and forty nine Taluka Labs for testing water quality. The labs need to function efficiently and maintain good standard for producing standard and replicable results and there should be sound system of surveillance to ensure that water samples are brought for testing covering the entire geographical area and more emphasis is given on areas with higher incidence of water contamination.

3. The State Government is in the process of improving the water testing labs but the quality of performance of the labs judged by NRDWP Guidelines and Jal Jeevan Mission's norms are not known to the state. So, the Water Supply and Management Organization (WASMO) of the State, desired to have an independent assessment of the performance of the water testing laboratories. UNICEF Gujarat State office came forward to extend support and partnered with SIGMA Foundation, a 'not for profit' organization working across the country for taking up the assessment.

4. It was decided, in consultation with WASMO, to select labs of each type, i.e., District labs and Taluka labs for studying and those are to be from different types of districts especially tribal and non-tribal. Functioning of the Central Lab at Gandhinagar was also studied. The District and Taluka labs selected were the following: (i) Mehsana District Laboratory (Non-Tribal), (ii) Chhota Udaypur District Level Laboratory-DLL (Tribal), (iii) Vadodara District Laboratory-DLL (Estd: 1975, oldest Lab-Non-Tribal), (iv) (v) Bodeli Taluka Laboratory (District Chhota Udaypur) (Tribal), (vi) Vijapur Taluka Laboratory (District Mehsana) (Non-Tribal) and Kadi Taluka Laboratory (District Mehsana).

Quick View of Major Findings of the Study

- The assessment was to find out status in the above-mentioned labs and to suggest measures, so that each laboratory achieves the target of minimum 3,000 water quality tests per year as per Uniform Drinking Water Quality Monitoring Protocol. The study formats looked into (i) laboratory operation team, (ii) system of sample collection and receipt, (iii) lab infrastructure, (iv) equipment status, (v) methods of testing and (vi) availability of documents and records.

- *For Central Lab or State Referral Laboratory:* Though Central laboratory is responsible for analys the district level referral samples but there were very few samples received in a routine manner other than special drive (pre and post monsoon). Importantly, requisition of consumable was irregular and little communication was observed from the HQ on policy and other aspects. Using Field Test Kit for bacteriological quality checking at the laboratory level was a wrong practice when the lab had the facility of using MPN technique. Testing of Fluoride through Spectrophotometer was observed but the actual technique should be the Ion method. This will also be applicable not only for the SRL lab but also at the district and Taluka level laboratory. Testing equipment were almost all in place but lack of calibration as required was also found. The record keeping and documentation was well organized at the SRL.

- *For Districts Level Laboratory:* Few samples were being received other than the special drive at the district level labs. Importantly, the requisition of consumables was irregular and no uniform system was observed during the lab visit. Lack of communication related to the instruction from the Department/vision of the Water Quality testing programme Direct control/supervision on lab activities from the Head Quarter was not observed. Also, knowledge on IEC at the field level was totally absent. Keeping water samples for 3-5 days before testing in the lab is against the protocol. Using FTK for bacteriological quality checking and using Spectrophotometer for Fluoride testing are also to be changed. The calibration on a regular basis was absent but the record keeping was well organized at district labs.

- *For Taluka Level Laboratory:* Water Quality Samples were the major constraint at the Taluka Level Laboratories also. Very few samples were being received for testing except during pre-monsoon and post-monsoon seasons. Irregularity of consumables and lack of uniformity were also common at Taluka Labs. Interaction with senior officials for guidance was less frequent. Also, Taluka labs were not sending the samples to district labs for referral checking.

- Total number of tests conducted per year by the SRL as well as DLLs and Taluka Labs of Gujarat were below the recommended norm. Water samples were tested moslty during Pre and Post Monsoon period, which is only six around months. In the remaining six months little samples were collected and tested. The Human Resources (HR) of the laboratories (SRL, DLL and Taluka Lab) was found to be satisfactory but not as per Uniform Drinking Water Quality Monitoring Protocol. Also, they were not being fully utilized for performing as per their capacity because of lack of adequate samples round the year.

Key Recommendations

- Considering the various challenges faced by Gujarat in respect of water quality, there is need for appropriate improvement of several aspects of the water quality monitoring system.
- *Quality assurance:* For quality of water testing, assurance is very important by strictly following prescribed norms during sample collection, transportation, preservation/storage and analysis for getting desired quality of results. There should be QA policy for being followed at every lab in the State.
- *Quality control:* All water testing analysts should use some Quality Control (QC). A good quality control programme consists of certification of operator competence, recovery of known additions, analysis of externally supplied standards (NIST), analysis of reagent blanks, calibration with standards, analysis of duplicates and maintenance of control charts.
- *Quality of the specimens and the reagents:* The specimens should be fresh. Similarly, the reagents and the glassware should be of good quality, which is often compromised because of delayed procurement following government procedures.
- *Method for Bacteriological analysis:* Instated of the use of FTK for bacteriological quality checking, all lab should use Rapid Membrane Filtration Technique (RMFT)/ Most Probable Number (MPN) at lab level. It is recommended that all the labs should adopt the Rapid Membrane Filtration Technique (RMFT) for quantitative assessment of bacteriological quality of drinking water. The system can detect Total Coliform & E. coli quantitatively in a single incubation. Sample preparation, handling & analysis as well as the autoclaving procedure are easier and faster in this method compared to the MPN method.
- *Sample Collection Plan:* A proper sample collection plan is needed for every water testing laboratory so that there is steady and calculated number of samples which reach the lab every day to match its capacity. That will also avoid storing the sample which is not recommended. A systematic plan should be adopted for Districts and Taluka Labs, which are also underutilized due to lack of samples. As per plan 5% of the district referral samples should be tested by SRL and 5% of the Taluka/Block level samples should be tested by District Level Lab. The same should be followed by putting an appropriate referral system in place. The state may consider to upgrade a selected District lab of each zone to function as referral labs for easier sending of the referral samples.
- *Improvement in the process of validation:* The sample should be sent for re-testing and the referral lab should ask for the original test report after it has conducted the re-test. Each sample should be given unique identity so that there is no difficulty in relating the test results conducted by the testing lab and the referral lab. Both the results should be compared by the referral lab to work out the variation.
- *Staffing Pattern:* It is important that to analyse the larger quantity of water quality samples requires a greater number of staffs as per norms. But the number of samples

are few in all the labs of the State, so no need to have more recruitment or fresh appointment till a higher volume of performance is achieved.

- *Record Keeping System:* The record keeping system should include equipment maintenance record, instrument logbook, instrument calibration data, standard preparation logbook, standards operating procedure etc.
- *Analytical records:* Labs should maintain laboratory sample ID, date and time of analysis, instrumentation identification and instrument operating conditions/parameters etc.
- *Other records:* The lab related other records should be kept properly including administrative records, chain of custody (COC) records etc.
- *Lab Manual:* The water quality lab manual should be prepared by the lab professionals.
- *Adoption of Good Lab Practice Model:* Certain good lab practices as recommended in the GLP Model should be adopted by every lab. Apart from certain scientific processes there are many managerial practices to be followed and there must be change in culture and attitude of the lab functionaries.
- *Coverage of all Habitations for Proper Surveillance on Water Quality:* The system of sample collection should be such that there is proper surveillance on the entire State, which means samples are to be collected from each habitation on a regular basis (once a year for chemical contamination and at least twice a year for bacteriological parameters).
- *Feedback of the Analysis to the Policy Makers/Key Officials for Follow up:* There must be a system of providing feedback of the analysed data to the GP/Pani Samiti/private owner from whom the samples were received. There has to be also feedback of the analysed data aggregated over the Taluka, District and the State to the authorities. The feedback will be very critical for the WASMO to make appropriate interventions in ensuring safety of drinking water.
- *Decentralization of the system of sample collection:* It is possible to give the responsibility of collecting water samples on the GPs/Pani Samitis so that they remain responsible for sending samples of water to be collected from the source as well at the point of consumption and covers the entire jurisdiction over the year.
- *Involvement of the Panchayats and the Community:* The surveillance of spot sources should be carried out by the GPs/Pani Samitis for which there should be appropriate order of the state government.
- *Sanitary survey of the drinking water sources:* Community is to ensure that the drinking water sources are protected from contamination due to unsafe management of liquid and solid waste.
- *Coordination with other Departments:* There is need for coordination with the Rural Development and Panchayati Raj Department for involvement of the Panchayats, particularly the GPs/Pani Samiti in water quality monitoring as well as in taking mitigation measures. There is also need for coordination with Health & FW Department for taking prompt measures on outbreak of diseases caused by water contamination.

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Chapter I: Background of the Study

"Without laboratories men of science are soldiers without arms"

---Louis Pasteur

Introduction

1.1 Gujarat is a water stressed State characterized by wide variations in annual rainfall and it has a long history of droughts. Three fourth of the area of the State is unsuitable for ground water withdrawal due to rocky terrain and coastal region. Further, the supply of surface water is limited. The rainfall pattern in Gujarat is erratic and uneven across different regions of the State, which leads to imbalances in distribution of water in different regions. The State possesses only 2% of the country's water resources with 5% of the country's population. Gujarat has made serious efforts in improvement of all the important areas of water sector such as source augmentation, source management and water supply management to reduce dependence on the scarce ground water resources. This has been achieved through development of water grid based on a master plan and implementation of several schemes under Saradar Sarovar project, Sujalam Sufalam Yojana and Multi-village rural water supply schemes.

1.2 Though the State of Gujarat is one of the front runners in the economic and agricultural development, but it faces a big challenge to not only supplying water to all the consumers but also to ensure safety of the water since it faces several problems of water quality. Along with use of water for agriculture and domestic purposes, heavy industrialization also exerts pressure on both the quantity and quality of water, urging greater attention from the planners, service providers and water quality managers responsible for the governance of water supply in Gujarat. It would be, thus, imperative for all concerned to not only be aware of water quality in various parts of the State but to also intervene appropriately for total elimination or minimization of the levels of critical contaminants in the existing water resources. The success of these efforts is measured by systematic testing of water qualities in the laboratories based on the Uniform Drinking Water Quality Monitoring Protocol[1]. The protocol also prescribes various provisions regarding availability of equipment, instruments, glassware and chemicals, availability of human resources, sampling, use of field test kits and safety measures for water quality laboratories etc.

1.3 Safe water can only be guaranteed not merely through testing of water quality but through a comprehensive water quality monitoring and surveillance system, which are distinct

[1] Uniform Drinking Water Quality Monitoring Protocol, 2013

but closely related activities. Usually, water quality monitoring is carried out by the service provider while surveillance is done by the regulatory agencies. In order to monitor the water quality, the state has developed a system of water testing laboratories. Continuous monitoring and surveillance and analysis of the data to guide water quality related interventions are the cornerstones of ensuring proper water quality. Further, water quality monitoring through laboratory is the foundation on which water quality management is based. Good water quality monitoring & surveillance system provides information on the nature and extent of the water quality problem as well as geographic variations that permits rational decision to be made on the following: i) emerging new problems of quality of drinking water, ii) priority based water quality management and formulating new action plan, iii) implementing Uniform Drinking Water Quality Monitoring Protocol under water quality management system as per MDWS[2], iv) evaluating the monthly performance and measures to enhance effectiveness of functioning of the laboratories and required improvement to match the need.

Need for ensuring water quality monitoring at lab level

1.4 Water quality monitoring involves both collection of water sample from the field as well as conducting tests in the labs following established protocols. It provides essential information which is required for assessment of the quality of drinking water of a particular source or at a particular point of consumption (safe/unsafe with the quantitative value). The water quality sample analysis in labs is generally expressed in terms of physical, chemical and bacteriological variables. The Bureau of Indian Standards (BIS) has specified drinking water quality standards in India to ensure that proper quality of water is supplied for drinking and the people can consume safe water[3]. As per IS-10500-2012 of the BIS water is defined as unfit for drinking purpose if it is bacteriologically contaminated (presence of indicator bacteria particularly *E. coli*, viruses, etc.) or if chemical contamination exceeds maximum permissible limits specific for each contaminant. The limits set for different contaminants are Fluoride (>1.5 mg/l), Total Dissolved Solids (TDS >2000 mg/l), Iron (>0.3 mg/l), Manganese (>0.3 mg/l), Arsenic (>0.05 mg/l), Nitrates (>45 mg/l) etc[4]. In addition, this document also includes requirements for setting up laboratories at state, district and Taluka levels and quality control for regular testing for replicable results and surveillance of drinking water sources. Following the various provisions in the protocol 33 district labs and 49 Block/Taluka labs have been established in the State of Gujarat. The labs need to function efficiently and maintain good standard for producing standard and replicable results and there should be sound system of surveillance to ensure that water samples are brought for testing covering the entire geographical area and more emphasis is given on areas with higher incidence of water contamination. There should also be a system for dissemination of results for guiding interventions in improving water quality.

[2] Ministry of Drinking Water and Sanitation (MDWS), Government of India has become a part of the Ministry of Jal Shakti.
[3] Indian Standard-Drinking Water Specification, IS 10500:2012
[4] ibid

1.5 The State Government is in the process of improving the quality of the labs and eight labs of this state are already accredited by the National Accreditation Board for Testing and Calibration Laboratories **(**NABL**)** for water quality testing as per GOI protocol. The quality of performance of other labs are not known to the state and even the NABL labs need regular assessment as to how those are performing. So, the Water Supply and Management Organization (WASMO), a specialized organization created by the State government of Gujarat to develop drinking water supply system in every village, desired to have an independent assessment of the performance of the water testing laboratories. UNICEF Gujarat state office came forward to extend support and partnered with SIGMA Foundation, a 'not for profit' organization working across the country for taking up the assessment.

Objectives of the study: "9 Folds"

1.6 The objectives of the assessment were:

(i) To assess the status of functioning of the laboratories;

(ii) To identify the system of ensuring quality and referral arrangement;

(iii) To assess the availability of testing equipment, instruments, glassware and chemicals;

(iv) To check the availability of human resource and their qualification standard;

(v) To understand the sampling procedure;

(vi) To examine the testing methodology being used;

(vii) To assess the maintenance of the equipment and other accessories;

(viii) To gain knowledge about the safety measures being followed in the labs, and

(ix) To check the quality of surveillance and ways for improving the Water Quality Monitoring System (WQMS).

SIGMA Foundation took up the assessment of implementation of various provisions of the protocol by the labs of Gujarat as a partner of UNICEF Gujarat. In order to accomplish the said objectives, the methodology mentioned in Chapter II was adopted.

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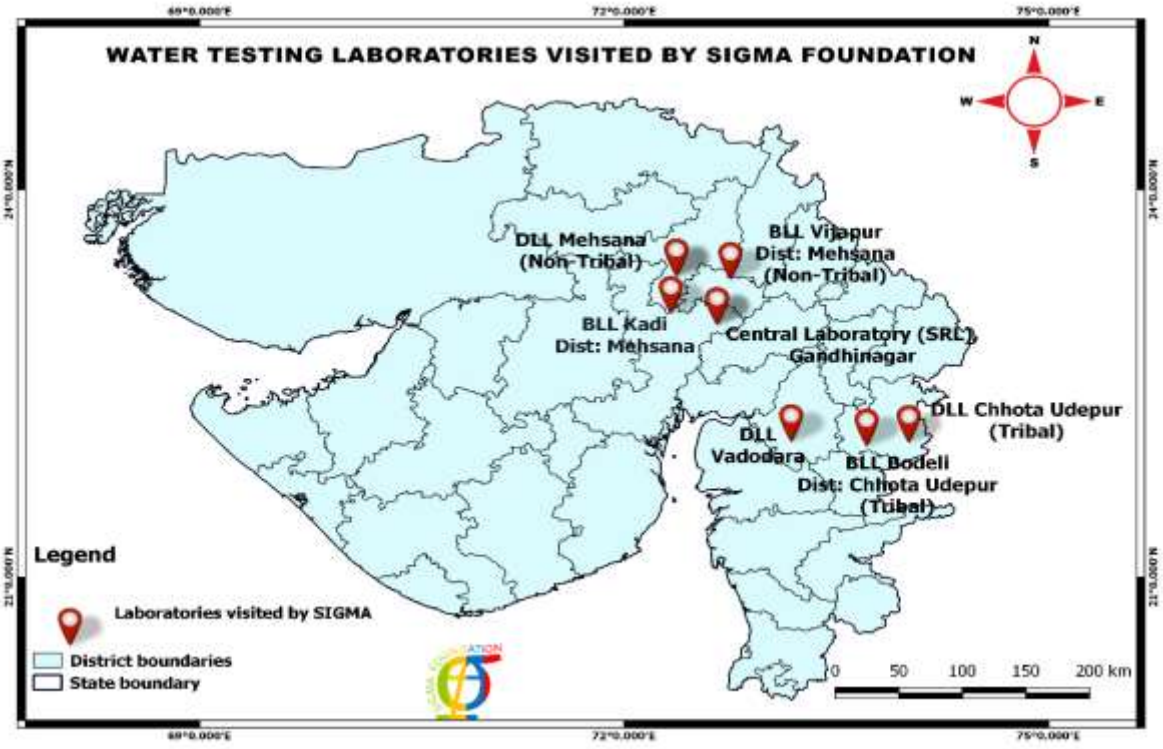
Chapter II: Methodology and the Exploratory Visits

Methodology

2.0 The functioning of the water testing laboratories will have similar system of functioning since those are under the same administrative arrangement serving a common purpose in the context of the state. So, there is no need to study the functioning of all the labs, which will be very costly and time consuming. However, there may be some variations because of local contexts depending on where the laboratory is located. It was, therefore, decided to select labs of each type, i.e., District labs and Taluka labs for studying and those are to be from different types of districts. After discussing with officials of WASMO it was decided that there should be District and Taluka labs from both tribal and non-tribal districts. Since functioning of the referral system is very critical and the SOP and the total monitoring system is controlled by the State Referral Lab for all labs in the State, it was also decided to assess the functioning of the State Referral Lab (SRL) of Gandhinagar. The District and Taluka labs selected were the following: (i) Mehsana District Laboratory (Non-Tribal), (ii) Chhota Udaypur District Level Laboratory-DLL (Tribal), (iii) Vadodara District Laboratory-DLL (Estd: 1975, oldest Lab-Non-Tribal), (iv) (v) Bodeli Taluka Laboratory (District Chhota Udaypur) (Tribal), (vi) Vijapur Taluka Laboratory (District Mehsana) (Non-Tribal) and Kadi Taluka Laboratory (District Mehsana). Map 1 shows the location of the labs studied by SIGMA Foundation.

Map1: Water Testing Labs Studied for the Assessment



2.1 The objective of the assessment was to find out status in the above-mentioned nine thematic areas and to suggest measures, so that each laboratory achieves the target of minimum 3,000 water quality tests per year as per Uniform Drinking Water Quality Monitoring Protocol[5]. The assessment was carried out in two phases. An exploratory visit was made to the SRL Gandhinagar, District Water Quality Testing Lab Mehsena and Taluka Lab (Block lab) at Kadi during 18th to 20th July. The objective was to have good understanding of the major areas of concern like the water sample collection, water samples testing methods, quality assurance, maintenance of equipment, availability of quality glassware and reagents used for testing. The visit helped to identify the specific areas of investigations required for the subsequent study which was made in the month of September 2019. Based on the learning from the exploratory visit and various provisions of the protocol, a structured format for collecting information was designed, which is placed as Annex I. The format was used to collect data from Scientific Officer/Chief/Head Chemists/Chemist/Bacteriologist of the visited water quality testing laboratories in four districts (Gandhinagar, Mehsana, Chhota Udaypur and Vijapur) during the final visit.

2.2 The formats looked into (i) availability of human resources and their qualification, (ii) availability of equipment, (iii) parameter-specific equipment status, (iv) distilled water quality, (v) performance of temperature controlled instruments, (vi) standards of regents, (vii) status of consumable, (viii) measuring equipment, (ix) testing method adopted, (x) status of sample collection and related issues (mainly sample bottles used, sample storage, replicates, retest), (xi) availability of safety equipment, (xii) available documents and records and (xiii) the difficulties being faced.

2.3 Documents available in the public domain and relevant information available with the laboratories were studied to understand the existing infrastructures for testing water quality in Gujarat State. This provided a broad idea of the available infrastructure for testing water quality, geographical distribution of the labs and the system of collection of water samples to appreciate the nature of access in getting the drinking water samples tested.

2.4 From the exploratory visit, it was clear that the officials responsible for proper functioning of the water quality monitoring system in the State possess valuable insights on the nature of problems and the possible solutions in the local context. The study team met and interacted with the Principle Secretary Water Supply Department, CEO WASMO, Chief Scientific Officer, the Chief Water Quality Analyst, Senior officials of the WASMO, Scientific officials at the Central Lab, who were known to have in depth knowledge of the problem of drinking water quality management. The interactions helped to gain insight about the status/challenges as well as possible ways for improvement of the water quality monitoring system in overall Gujarat State. During the exploratory visit to the State by the study team, the Director of the State Referral Lab, who was also the responsible official for maintaining safety of drinking water, suggested

[5] Uniform Drinking Water Quality Protocol, 2013, erstwhile MDWS, GOI

that all the water quality testing labs in Gujarat were using similar kind of approaches and equipment for water quality testing. According to her the SRL had the quality policy and inter lab performance system, which helped to visualize the performance of the lab. Through the interaction it was also clear that the State Referral Lab also had mobile testing facilities especially to be used during any disaster.

2.5 Problems faced at the policy and managerial level were also captured through interaction with the senior officials. However, there could be many problems in day to day functioning of the laboratories and other micro-level issues, which were critical in determining the nature of water quality surveillance in terms of coverages, the nature of tests the laboratories were actually carrying out, the scientific processes being adopted in conducting various tests, the way equipment were being handled and maintained, the protocols followed to ensure quality of the results (specially for Fluoride and bacteriological quality checking), the system of reporting and many other ground levels issues and challenges.

2.6 During the exploratory visit, it was clear that maintenance of water quality as well as its monitoring requires strong community involvement. The Pani Samiti at the village level also had to play an important role in taking measures for preventing contamination of water, ensuring proper surveillance on water quality by testing drinking water samples from all the habitations and in taking appropriate community-based mitigation measures. Therefore, two representative Pani Samiti were visited by the study team for interacting with the GP/Pani Samiti functionaries and the community members. The team visited Debinapura GP and Mitha GP of Mehsana district and interacted with the Sarpanch and other functionaries of the Pani Samiti. There was also interaction with the community members who were present in the discussion and the team got a good insight of the community level issues related to water quality, water supply management and the monitoring procedure.

2.7 Finally, the study was to provide an understanding of the way forward in strengthening the water quality monitoring system and improved functioning of the laboratories. It was conducted by visiting districts and Taluka level laboratories, collecting primary as well as secondary data and interaction with the key functionaries for possible improvement of the water quality management system in the state.

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Chapter III: Key Findings from Study of the Labs

3.1 Key Findings on functioning of the SRL Gandhinagar

3.1.1 The State Referral Laboratory is accredited with NABL for testing 13 parameters namely pH, Colour, Turbidity, Dissolved Solids, Alkalinity, Total Hardness, Calcium, Sulphate, Magnesium, Chloride, Fluoride, Nitrate & Presence/Absence test for Coliform bacteria. Additional parameter testing facility was also conducted using Spectrophotometer Kit of Hach. The processes followed in the lab was discussed in depth and equipment were also examined. The main indicators related to functioning of the Lab are illustrated under Table 3.1.

Table 3.1: Monitoring Indicators for SRL Assessment

Sl. No.	Monitoring indicators for assessment
1	Laboratory operation team
2	Sample collection and receipt
3	Lab infrastructure
4	Equipment status
5	Availability of documents and records
6	Methods of testing

3.1.2 Laboratory operation team: The SRL Gandhinagar was headed by the Chief Scientific Officer, which was a permanent post. The other staffs were contractual, but they were qualified as per Uniform Drinking Water Quality Monitoring Protocol. In this lab five personal were working namely Chemist (BSc-Chemist), Bacteriologist (BSc-Microbiology), Lab Assistant (BSc), Computer Operator (BA) and Sampling Assistant (BSc). All lab personal were trained and had a good understanding of laboratory operation especially the calibration procedure and its significance. They were interested to learn new methods of testing for better performance. Though the number of referral samples were few, but they were interested to monitor referral sample testing as a routine work. The lab personnel had an interest in IEC activities also for generation of awareness on water quality. They were also willing to impart on-site training to the district level and Taluka level labs to extend the technical support.

SRL Lab Visit – the Lab Personnel

3.1.3 Sample collection and receipt: It was learnt that there was no system of collecting samples for re-testing for validation of results so that all the labs could refer their samples in a planned manner and the SRL could receive a steady flow of samples for re-testing from the entire state. In absence of any such system, it tested only those samples which were voluntarily referred to the SRL and samples were coming to SRL only from the district labs. Further, those were only the pre-monsoon and post- monsoon referral samples, which extended for around six months. It was also observed that a huge gap exists between the number of sample collection day and, the number of sample testing day. Referral samples received in the SRL or at the district level take more than 25 days to be tested, which was not allowed as per the SOP of GOI

guideline (referral samples should be tested within 6-7 days after the collection). Due to this condition the test results even vary between 60-70%. In such case objective of referral sample test gets diluted. It was found that there was no specific plan for referral sample testing. There were little testing activities during the remaining six months of the year due to lack of samples. SRL had own sample collector. He got transportation support from WASMO during Pre-Monsoon and Post-Monsoon programme. The number of samples received was much less than the capacity of the SRL leading to underutilization of the facility. The lab did not analyse the variation between the values obtained in the lab from where the sample was referred and their own results from re-testing for judging the quality of testing by the labs which referred the samples. Only such analysis could help in guiding the labs and/or taking other measures for ensuring that quality of tests being carried out were of acceptable standards. There was also need for Proficiency Test (PT). Only, the Inter-Lab-Comparison (ILC) for validation of results were found being done on a regular basis at their own cost. Importantly, the ILC reports were available in all labs of Gujarat where Z score <2 for all parameters. For bacteriological quality checking the lab uses the P/A test by Himedia P/A Colafar Kit. Though the lab has the provision for MPN technique but due to time constraint the lab personal use P/A test kit. No validation had been observed for P/A test kit. Importantly, the SRL lab was not NABL accredited for bacteriological quality checking, so no calibration was found for Incubator/Autoclave.

3.1.4 Lab infrastructure: The lab infrastructure of the SRL was quite good and organized. Also, the NABL norms were being maintained. It had one chemical testing laboratory, one sample storage room, one instrument room and one bacteriological quality checking room. It had a separate office space for data entry and other lab related official activities. There was an office room for Chief Scientific Officer who monitored the lab work and helped to support the lab personnel for performing well.

3.1.5 Equipment status: Major instruments were in running condition. However, few instruments were out of order. Centralized assessment of repairing of instrument was ongoing and the maintenance of inhouse equipment was under AMC/CMC. The lab personnel had a satisfactory knowledge about water quality testing instrument. But no autometer for pipetting had been visible. To upgrade the lab status there was need to adopt suitable policy for maintenance of the equipment from the time of installation for ensuring that all equipment are in working condition and procurement should be made keeping this factor in mind.

3.1.6 Availability of documents and records: The water quality testing raw data, sample register, test reports, SOP for operating procedure were available as an important documents and records in the lab. Keeping of those documents followed the ISO/IEC 17025 norms. Good number of training calendar was visible in SRL for regular training programme.

3.1.7 Methods of water testing: The SRL used the latest method for water quality testing. Some important parameters and the methods being followed at the SRL are stated below:

- **Testing of Fluoride**

i. Total Ionic Strength Buffer Solution-III for Fluoride Estimation, 475 ml bottle for about 425 samples- Orion-Thermo make.
ii. Fluoride Standard solution 100 mg/Lit or 1000 mg/L 500 ml, NIST traceable-Thermo/Merck make.

iii. Variable volume Micropipette, which had calibration certificate and re-calibrated with capacity range 1000 µl to 5000 µl along with 200 numbers compatible micro-tips were provided.
iv. Used Spectrophotometer for testing.

➢ Testing of Nitrate

Only the SRL had facility for testing the presence of Nitrate, which was conducted using Spectrophotometer. For that purpose, Nitrate Ion selective electrodes were procured along with total ionic strength buffer for Nitrate & Nitrate standard solution.

➢ pH Meter

The meter available in SRL had the following features:

i. Multi-Point Calibration (up to 5 points) with Auto-Buffer Recognition - pure water buffer standards with ±0.01 pH accuracy.
ii. Automatic Temperature Control (ATC) for the highest accuracy under fluctuating temperatures.
iii. Hold Function momentarily freezes reading for easy viewing and recording.
iv. Auto-Power Off saves battery power after non-use.
v. Self-Diagnostic with message codes for easy troubleshooting.
vi. Large Custom LCD provides optimum viewing even at a distance.
vii. Protective Rubber Boot shields meter from accidental knocks and features a sturdy built-in stand for easy bench-top operation.

➢ TDS Meter

The TDS meter available in SRL had the following features:

i. Multi-Point Push-button Calibration (up to 5 points) with ±1% full scale accuracy.
ii. Automatic or Manual Calibration - for quick, easy calibration; use automatic mode with pre-set calibration points at most popular values or manually set values in the manual mode for more flexibility.
iii. Auto-Ranging for Conductivity/TDS measurements for fast response and best resolution over wide measurement range.
iv. Adjustable TDS Factor for more accurate measurement.
v. Automatic Temperature Control (ATC) for the optimum accuracy under fluctuating temperatures.
vi. Hold Function momentarily freezes reading for easy viewing.
vii. Auto-Power Off saves battery power after non-use.
viii. Self-Diagnostic with message codes for easy trouble-shooting.
ix. Large Custom LCD provides optimum viewing even at a distance.
x. Electrode with Built-in ATC designed for minimal air bubble entrapment during measurement.

- **Turbidity Meter**

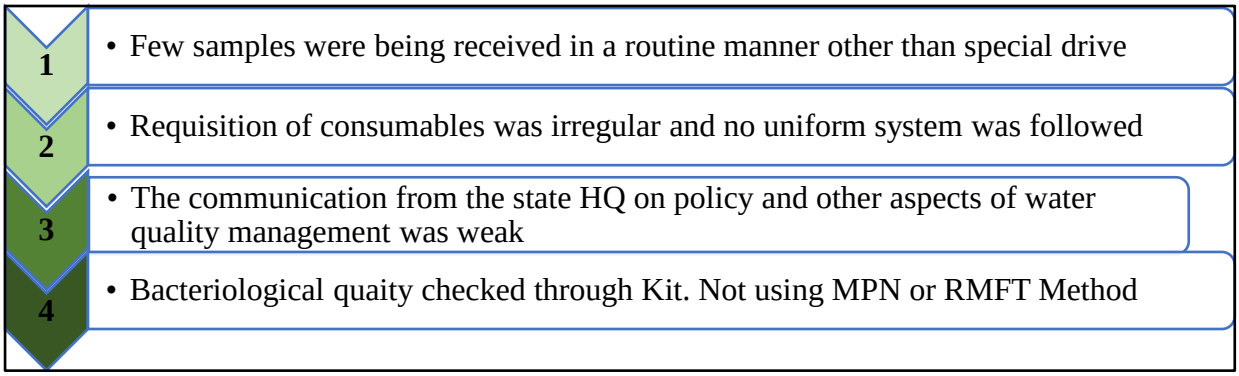
  The microprocessor based Digital Turbidity meter used in the lab allows fast and precise on site or laboratory based measurements. The unit measures scattered light at 90° angle as stipulated in ISO 7027.

- **Bacteriological quality checking**

  For bacteriological quality checking the lab uses the P/A test by Himedia P/A Colafar Kit. Though the lab had the provision for using MPN technique but due to time constraint the lab personal used P/A test kit. Importantly, no validation has been observed in context of P/A test kit.

3.1.8 Future Plan: The SRL had a plan to include testing under NABL accreditation of iron in future. The lab was focussing on its transformation to ISO 17025: 2017.

3.1.9 Major Challenges: The Central Lab/SRL also faced significant challenges in testing water quality, which are as follows:



3.1.10 Feedback on requirement: During visit to the SRL the study team received certain feedback from the lab personnel, which are as follows:

3.2 Key Findings on Functioning of the DLL-Chhota Udaypur

3.2.1 The District Level Laboratory (DLL) was visited to check whether the labs were following the Uniform Drinking Water Quality Protocol and maintaining the ISO 10500:2012.

Similar indicators as mentioned in Table 3.1 were used for assessing the functioning of the DLLs in monitoring water quality. Chotta Udaypur DLL was not NABL accredited yet.

3.2.2 Laboratory operation team: The lab personnel were competent for their jobs. The Chemist, Bacteriologist and the Sample Assistant were BSc (Chemistry-Major) by qualification. On the other hand, the Lab Assistant had class 10 pass certificate and the Computer Operator had BA degree. All the lab personnel were trained about the laboratory operation though they needed to know the calibration procedure and its significance, which would improve their understanding. Further, all the lab personnel were regular on their job and interested to learn new things specially IEC related activities.

Technical Discussion with Lab Personnel

3.2.3 Water sample collection plan and receipt of samples: The water samples were mainly coming from three blocks namely Chhota Udaypur, Pavijetpur and Kawant. The annual testing plan was for 3000 water samples. However, 95% testing activities were in 6 months (pre-monsoon & post-monsoon programme), which were project based. Total 800-900 samples were collected in a month at a rate of 25-30 samples per day. There were hardly any testing activities in the remaining six months due to lack of samples. The Lab had own sample collector. He got transportation support from WASMO during Pre-Monsoon and Post-Monsoon programme. The sample collector generally used one litre jerrican for collecting the samples for chemical analysis from the field. For bacteriological analysis, they used 150 ml BOD bottle for collection of samples from the field. After collecting the samples for bacteriological quality checking they put it in the ice box and carried it by a car to the lab for analysis. However, the lab personnel mentioned that they kept the water samples for 2-3 days before testing it. Also, they disposed of the tested water sample into the basin after quality assessment, which is not recommended.

3.2.4 Lab infrastructure: The DLL Chhota Udaypur had one chemical analysis room, one bacteriological analysis room, one room for analytical instrument and one separate office space for lab related official and administrative work. During the lab visit it was observed that the refrigerator and the sample storage cabinet were in good condition, but the fire extinguisher was not available in the lab and that was considered a major gap from the safety point of view.

3.2.5 Equipment status Major equipment for water quality testing were in running condition. However, few equipment were out of order. It was observed during the visit that the centralized assessment of repairing of instrument was on-going for a flawless analysis. Also, observed that the in-house maintenance of equipment was in a decent condition. After discussing with the lab

Major Equipment at Chhota Udaypur

personnel, it was clear that the understanding of instrument operation was satisfactory to maintain the quality. Table 3.2 below illustrated the equipment status:

Table 3.2: Equipment Status of DLL Chhota Udaypur					
Equipment	**Equipment type/ Condition**	**Age of the Equipment**	**Calibration frequency**	**Parameter Tested**	**Physical Verification**
Spectrophotometer	DR 6000 OK	5 years	NA	Fe	Training Record
pH Meter	pH 31	5 Years	15 days	pH	Keypad Issue
Conductivity Meter	EC 7	5 Years	Not done	TDS	LCD problem
Ion Meter	MM 340	4 years	Before test	Nitrate	No problem
Fluoride ISE	Spectrophotometer	Resent	Not done	F	No problem
TISAB & Ref. electrolyte	Own TISAB	6 months	No need		No problem
Analytical Balance	Bad Condition	5 years	Not done	NA	Problematic
Distilled Water Plant	Aqua Nigbo	5 years	No need	Testing	No problem
Hot Air Oven	Working	5 years	Not done	Testing	No problem
Hot Plate	Working	5 years	Not done	Testing	No problem
Refrigerator	OK	5 years	Not done	-	No problem
Sample Storage Cabinet	OK	4 years	No need	-	No problem
Lab Furnitures	OK	5 years	No need	Maintained	No problem

It was clear from the Table 3.2 that many of the equipment were procured five years ago but were in working condition. But the calibration status was poor. Only the pH meter was being calibrated once in 15 days and the ion meter was being calibrated before sample testing. Importantly, the condition of the analytical balance was in a bad condition. For bacteriological quality checking this lab had two bacteriological incubators but one incubator was in a working condition and another incubator was non-functional because this lab used the kit for bacteriological quality checking. On the other hand, autoclave 1 and Laminar Flow Bench were in a working condition. During the lab assessment it was also observed that the keypad of the pH meter was having some problem and the LCD of the conductive meter was also in a problematic condition.

Equipment Status at Chhota Udaypur Lab

3.2.6 Available documents and records: The important documents including the raw data, sample register, test reports, operating procedure etc. were available at the lab. According to the lab assessment a detail format was prepared for cross checking the actual status of the lab documents and records, which is illustrated under Table 3.3 below:

Table 3.3: Lab Documents/Records of DLL Chhota Udeypur

DOCUMENTS & RECORDS	Availability
Master List of documents	NA
Master List of Technical Documents	SOP
Method List & SOP	Available
Equipment Records	OK
Verification of Method	NA
Verification of Tested Samples	NA
Training Calendar	Available
Training Record	NA
Attendance Sheet	Available
Calibration Records & Format	NA
Product suitability Evaluation record	NA
Sample Receipt Register	Available
Sample Collection & Receipt Plan	NA
Test Request Form	NA
Awareness of BIS recommendation of desirable limit & cause of rejection of test parameters	Available
Awareness on Health-hazard by consuming water which are not complying BIS recommendation	Available
Feed-back from owner of the samples	NA

Out of 24 records (as per Lab protocol) only 8 records were available in this lab, which covered only 33% of the important information and rest of the 67% records were not visible in the lab which is a significant gap of any good lab practice. However, the training calendar and the SOP for water quality testing were available in the lab and considered a good part of the protocol.

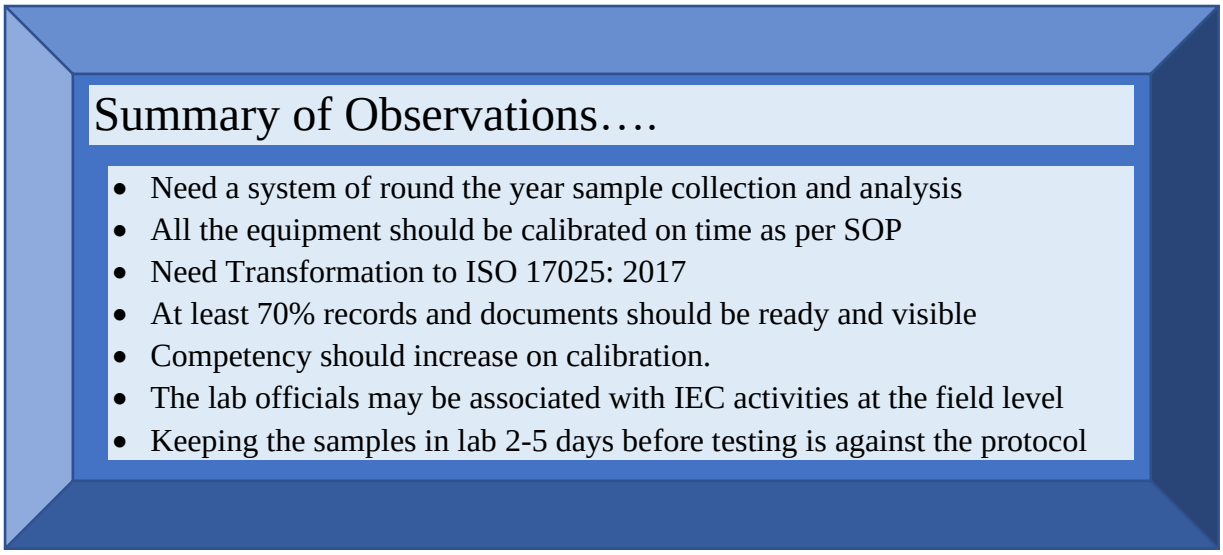
3.2.7 Methods of water testing According to the scope of work the water testing parameters were pH, Colour, Turbidity, Dissolved Solids, Alkalinity, Total Hardness, Calcium, Sulphate, Magnesium, Chloride, Fluoride, Nitrate & Presence/Absence Test for Coliform bacteria. The Table 3.4 illustrates the methods of testing of each of the parameters and how those conform to the IS 10500: 2012.

Table 3.4: Methods of Water Testing at Chhota Udaypur DLL

Sl. No.	Parameter	Method of Testing	Whether satisfactory
1	Turbidity	Nephelometer	Yes
2	pH	pH meter	Yes

3	Total Hardness as CACO3	Titration	Yes
4	Dissolved Solids	Conductivity	Yes
5	Chloride	Titrimetric	Yes
6	Free Residual Chlorine	OTD	Yes
7	Alkalinity as CaCO3	Titration	Yes
8	Iron	Spectro-photometer	Yes
9	Manganese	Spectro-photometer	Yes
10	Fluoride	Spectro-photometer	Yes
11	Nitrate	Spectro-photometer	Yes
12	Total Coliform	P/A	Yes

The Table 3.4 indicates that all the methods, which were being used for testing water quality was guided by the SRL. Importantly, Nephelometer for Turbidity, pH meter for pH, Titration for Total Hardness, OTD for Residual chlorine, and Spectrophotometer for Iron, Manganese, Fluoride and Nitrate were used to get realistic results as per protocol. For bacteriological quality checking the P/A method was used. Though this lab adopted the uniform method, but the calibration & validation of method was not observed.



3.3 Key Findings on Functioning of the DLL--Vadodara

3.3.1 The Vadodara District Laboratory is the oldest water quality testing laboratory in Gujarat, which was established in 1975. A detail assessment was done based on the performance indicators mentioned before.

3.3.2 Lab operation team: DLL Vadodara had three permanent lab officials including Chief Scientific Officer, Scientific officer and Junior lab officer holding degree in M.E in Environment, BSc (Zoology and Environment) and MSc (Chemistry). Rest of the staffs were contractual employees. There were two chemists (BSc in Chemistry), and one microbiologist (MSc in Biochemistry) for water quality testing. There were also two lab attendant (12^{th} standard) and one sample collector (12^{th} standard) involved in the lab activities. All lab

personnel were trained by SRL Gandhinagar and were performing their duties dedicatedly. It was, however, observed that there was lack of awareness about IEC activities at the field level related to water quality and water supply management. But the lab personnel were interested to participate in IEC programme and willing to impart on-site training to Taluka Labs which were non-accredited.

Lab personnel at Vadodara Lab

3.3.3 Water sample collection system: The water samples were mainly collected from eight talukas namely Savli, Vadodara, Waghodia, Dabhoi, Padra, Karjan, Shinor & Desar of the district. The annual testing plan was 3000 water samples. 95% testing activities were taken up in 6 months (pre-monsoon & post-monsoon programme), which were project based. During the project drive the lab tested at least 30 samples per day from the community level and 50-60 samples from the schools and industrial area. In the remaining six months there was hardly any testing due to lack of samples. Lab had its own sample collector. He got transportation support from WASMO during Pre-monsoon & Post-monsoon programme. The sample collector generally used one litre jerrican for collecting the samples for chemical analysis from the field. For bacteriological analysis, they used 150 ml BOD bottle for collection of samples. After collecting the samples for bacteriological quality checking the same was put in the ice box and carried it by a car to the lab for analysis. However, the lab personnel mentioned that they kept the water samples for 3 days before testing it in the lab and left the tested water samples into the sewage after 7 days of the testing. According to the lab personnel, they were over-burdened during the project drive because they had to test more than 50 samples per day and upload the data accordingly.

SIGMA Team in Discussion with the Lab Officials

3.3.4 Lab infrastructure: The lab space of the Vadodara DLL was enough to conduct all the activities. It had one chemical laboratory cum office, one bacteriological laboratory, one instrument room, and one digestion/distillation room. Apart from all theses there was room for the scientific officer who monitor the day to day activities. Further, the lab refrigerator, sample storage cabinet and lab furniture were in a satisfactory condition.

3.3.5 Equipment status: Most of the equipment for water quality testing were in good condition. Importantly, centralized calibration activity started few months back. It was observed during the lab visit that the in-house maintenance of equipment was good and the lab personnel had a clear understanding of the instrument handling. In this context, Table 3.5 below illustrates the equipment status:

Table 3.5 Status of Equipment of Vadodara DLL

Equipment	Condition of Equipment
Spectrophotometer	OK
pH Meter	OK
pH Electrode	Ok
pH Calibration standards	Ok
Conductivity Meter	Ok
Conductivity Cell	OK
Turbidity Meter	OK
Ion Meter	OK
Fluoride Standard	Self
TISAB & Ref. electrolyte	Self
Analytical Balance	OK
Standard Weight Box	OK
Distilled Water Plant	OK
Hot Air Oven	OK
Hot Plate	OK
Bacteriological Incubator 1	OK
Bacteriological Incubator 2	OK
Autoclave- 1	Ok
Autoclave-2	Ok
Laminar Flow Bench	OK
Water Bath	OK
Microscope	OK
Refrigerator	OK
Sample Storage Cabinet	OK
Lab Furniture	OK

Equipment Status of Vadodara DLL

It was highlighted from this assessment that out of 28 equipment (as per SOP) in this water testing lab 22 equipment were in full working condition, showed a 79% equipment satisfaction to fulfil the target of testing. Most the equipment for physical and chemical quality testing like Conductivity meter, pH meter, Turbidity meter, and Ion meter were in a running condition. Also, for bacteriological quality checking both the bacteriological incubators, the two autoclaves, Laminar Flow Bench, Water Bath and Microscope were also in functional condition though this lab also used the kit for bacteriological quality checking. The calibration was done by the 3rd Party for the smooth running of spectrophotometer as per norms. And, the Ion metre was calibrated before any testing. This lab also conducted the physical verification for Ion meter and Fluoride ISE, which was a rare example and showed a good practice at the lab level.

3.3.6 Availability of documents and records: Lab related documents and reports were available in a good condition. All the test reports, testing methods, SOP etc. were visible in the lab. Table 3.6 illustrates the actual status of maintenance of the lab documents and records below:

Table 3.6: Documents Maintenance Status as per ISO/IEC 17025 in Vadodara DLL

Documents & records	Availability
Master List of documents	Available
Master List of Technical Documents	Available
Method List & SOP	Available
Calibration Programme / Plan	Available
Equipment Records	OK
Verification of Method	OK
Verification of Tested Samples	OK
Proficiency Test results	Available
Internal Quality Control Plan & Record	Available
Training Calendar	Available
Training Record	Available
Attendance Sheet	Available
Calibration Records & Format	Available
Product suitability Evaluation record	Available
Sample Receipt Register	Available
Sample Collection & Receipt Plan	Available
Test Request Form	Available
Standard Test Report Format	Available. Very Good
Awareness of BIS recommendation of desirable limit & cause of rejection of test parameters	Available
Awareness on Health-hazard by consuming water which are not complying BIS recommendation	Available
Feed-back from owner of the samples	Available

It was clearly understandable that out of proposed 23 documents/records, 21 records were available at the lab level, which indicated 91% coverage of the documents/records for good lab practice. DLL Vadodara set an example to keep the Standard Test Report Format in a unique way, which was really helpful for the lab personnel to analyse the water quality data and produce good and authenticated quality of data.

3.3.7 Method of water testing: This lab was NABL accredited and the parameters like pH, Colour, Turbidity, Dissolved Solids, Alkalinity, Total Hardness, Calcium, Sulphate, Magnesium, Chloride, Fluoride, Nitrate & Presence/Absence Test for Coliform bacteria were under its' scope of work. The Table 3.7 illustrates the details methods of testing of the parameters also supported of ISO 10500: 2012.

Table 3.7 Methods of Water Quality Testing at Vadodara DLL

Sl. No.	Parameter	Method of Testing	Remarks
1	Turbidity	Nephelometer	Yes
2	pH	pH meter	Yes
3	Total Hardness as CACO3	Titration	Yes
4	Dissolved Solids	Conductivity	Yes
5	Chloride	Titrimetric	Yes
	Free Residual Chlorine	OTD to DPD	Yes
6	Alkalinity as CaCO3	Titration	Yes
7	Iron	Spectro-photometer	Yes
8	Manganese	Spectro-photometer	Yes
9	Fluoride	Spectro-photometer	Yes
10	Nitrate	Spectro-photometer	Yes
11	Total Coliform	P/A	Yes
13	SO_4	Turbidity	Yes

The Table 3.7 indicates that all the methods, which were used for testing water quality were being guided and monitored by the State Referral Laboratory Gandhinagar. Importantly, Nephelometer for Turbidity, pH meter for pH, Titration for Total Hardness and Alkalinity, OTD for Residual chlorine, and Spectrophotometer for Iron, Manganese, Fluoride and Nitrate were used. On the other hand, for bacteriological quality checking the P/A method was used. The lab was performing calibration of the instrument and validation of the test result on a regular basis. But no statistical analysis was conducted after chemical/bacteriological quality checking of the water quality samples.

Summary of Observation….

- Few samples were being received other than the special drive
- Requisition of consumables were irregular and no uniform system observed
- Lack of communication related to the instruction from the Department/vision of the Water Quality testing programme
- Direct control/supervision on lab activities from the Head Quarter was not observed
- Lack of knowledge on IEC at the field level
- Keeping samples 3-5 days before testing in the lab is against the protocol

3.4 Key Findings on Functioning of the DLL-Mehsana

3.4.1 Mehsana was a non-tribal district and the water testing was generally conducted on a regular basis. SIGMA Team visited this lab on the 25th September 2019 to assess the performance and quality monitoring as per Uniform Drinking Water Quality Protocol and the

status of maintenance of the ISO 10500:2012. Similar monitoring indicators were used like other labs to assess the quality and competency level as per norms.

3.4.2 Operation team: Seven (7) lab personnel were available for functioning of the laboratory. Out of them, one was against a permanent post (Junior Scientific Officer, who was a BSc) and rest of the personnel were contractual. There were two chemists (MSc in Chemistry), one microbiologist (BSc in Zoology) engaged for water quality testing. Apart from them, one computer operator (MA), one sample assistant (12th standard), and one lab attendant (10th) were involved in the lab activities. All lab personnel were trained by SRL Gandhinagar and were performing their duties dedicatedly. All the staffs were getting salary on time and were found motivated for improving performance. But due to lack of awareness about IEC activities on water quality monitoring and management, the lab personnel were interested to participate in the IEC related activities at the field level. Though this lab had the basic facilities for water quality testing but due to lack of water samples the capacity of lab infrastructure including lab personnel were underutilized.

Lab Operation Team at Mehsana DLL

3.4.3 Water sample collection: The water samples for quality testing were mainly coming from 8 Talukas namely Mehsana, Unjha, Kheralu, Visnagar, Becharaji, Jotana, Bhatnagar & Nasvadi. The annual testing plan was 3000 water samples as per GOI norms. 95% testing activities were performed in 6 months (pre-monsoon & post-monsoon programme). During the project drive this lab tested at least 20-25 samples per day received from the community level. In the remaining six months as such no testing activities were being performed due to lack of samples. DLL Mehsana also did not have any sample collection plan. Some samples were coming from the Mechanical Division for testing water samples from the Headworks. Lab had own sample collector. He got transportation support from WASMO during Pre-Monsoon and Post-Monsoon programme. The sample collector generally used 1 litre jerrican for collecting the samples for chemical analysis from the field. For bacteriological analysis, they used 150 ml BOD bottle for collection of samples from the field. After collecting the samples for bacteriological quality checking they put it in the ice box and carried it by a car to the lab for analysis. However, the lab personnel mentioned that they kept the water samples for 5 days before testing it in the lab and after analysis they disposed of the sample into the sewage. According to the lab personnel, there were immense pressure during the project drive. The private water samples were not tested in these labs as per government policy, but it could be done with the recommendation from Panchayat.

3.4.4 Lab infrastructure: The lab space was enough to conduct the test activities and quite satisfactory. It had one chemical laboratory cum office, one bacteriological laboratory, one instrument room, and one sample collection. But it did not have any room for scientific officer who would monitor the daily activities. Again, the lab refrigerator and lab furniture were in a satisfactory condition. The sample storage facility was perfect as per protocol.

3.4.5 Equipment status: Equipment for water quality testing were in good condition. Importantly, centralized calibration activity started few months back. It was observed during the lab visit that the in-house maintenance of equipment was good and the lab personnel had a clear understanding of the instrument handling. Table 3.7 illustrates the equipment status of the lab.

Table 3.8: Equipment Status of Mehsana DLL

Equipment	Condition of Equipment
Spectrophotometer	Ok
Ref standards of Spectrophotometer check	Available
pH Meter	Ok
pH Electrode	Ok
pH Calibration standards	Ok
Conductivity Meter	Ok
Conductivity Cell	Ok
Turbidity Meter	Ok
Calibration Std for Turbidity	NA
Ion Meter	Ok
Fluoride Standard	Self
TISAB & Ref. electrolyte	Self
Analytical Balance	Ok
Standard Weight Box	Ok
Distilled Water Plant	Ok
Hot Air Oven	Ok
Hot Plate	Ok
Bacteriological Incubator 1	Ok
Bacteriological Incubator 2	Ok
Autoclave- 1	Ok
Autoclave-2	Ok
Laminar Flow Bench	Ok
Water Bath	Ok
Microscope	Ok
Refrigerator	Ok
Sample Storage Cabinet	Ok
Lab Furnitures	Ok

100% equipment availability was observed in the lab, which were used for water quality testing. Equipment for physical and chemical quality testing like Conductivity meter, pH meter, Turbidity meter, Ion meter, Distilled water plant, Hot Air oven, Hot plate, and Analytical balance were all functional. Also, for bacteriological quality checking both the Incubators and the two autoclaves, Laminar Flow Bench, Water Bath and Microscope were also in a good condition. In spite

Assessment of Equipment Status

of availability of those equipment the lab used the kit for bacteriological quality checking. The calibration was done for Ion Meter before testing as per norms. This lab also conducted the physical verification for Ion meter and Fluoride ISE, which was a good example for maintaining a lab equipment status as per GOI norms.

3.4.6 Availability of documents and records: Lab related documents and reports were available and were in a good condition. All the test reports, testing methods, SOP etc. were visible in the lab. Table 3.9 shows the actual status of the lab documents and records

Table 3.9: Available Documents and Records at Mehsana District Laboratory

Documents & records	Availability
Master List of documents	Available
Master List of Technical Documents	Available
Method List & SOP	Available
Calibration Programme / Plan	Available
Equipment Records	OK
Verification of Method	OK
Verification of Tested Samples	OK
Proficiency Test results	Available
Internal Quality Control Plan & Record	Available
Training Calendar	Available
Training Record	Available
Attendance Sheet	Available
Calibration Records & Format	Available
Sample Receipt Register	Available
Awareness of BIS recommendation of desirable limit & cause of rejection of test parameters	Available
Awareness on Health-hazard by consuming water which are not complying BIS recommendation	Available

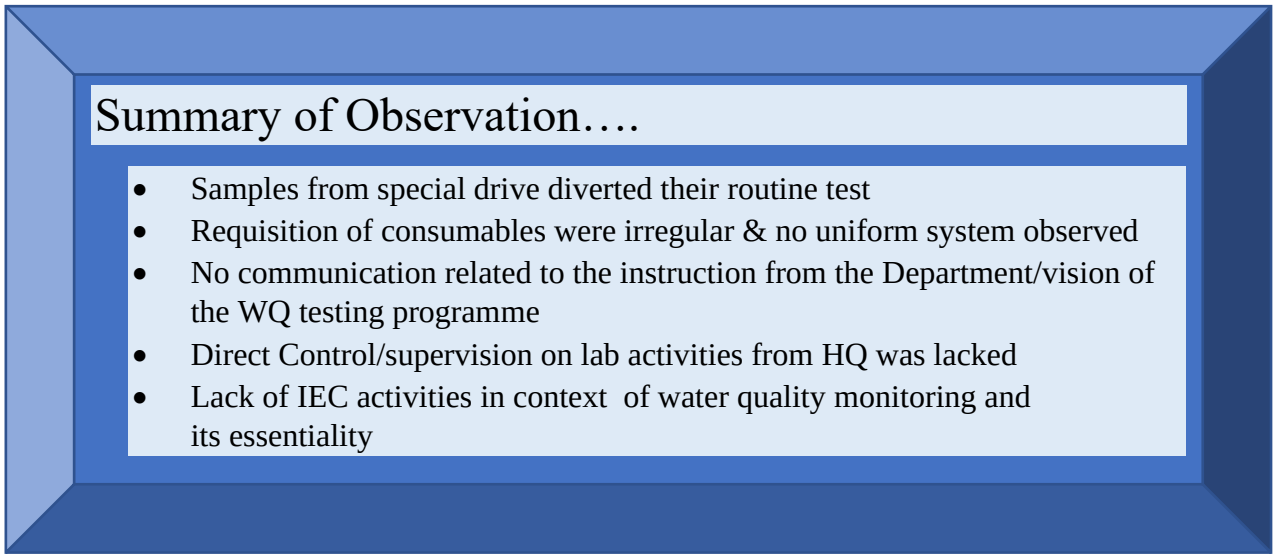
It is clear from the above table that out of proposed 23 documents/records, 16 records were available which indicated around 70% coverage of the documents/records for analytical testing. Importantly, Proficiency Test Result (PT Result) was also available, for conducting the test as per rule. On the other hand, inter-laboratory comparisons, feed-back from owner of the samples and Lab operation surveillance records were not visible and was an important gap in the context of water quality monitoring.

3.4.7 Method of testing: Mehsana District Laboratory (DLL) was NABL accredited and the parameters like pH, Colour, Turbidity, Dissolved Solids, Alkalinity, Total Hardness, Calcium, Sulphate, Magnesium, Chloride, Fluoride, Nitrate & Presence/Absence Test for Coliform bacteria were under its' scope of work. The Table 3.9 illustrates the detail methods of testing of the parameters, which were in conformity with the ISO 10500: 2012 protocol.

Table 3.10 Methods of Testing as per Protocol

Sl	Parameter	Method of Testing	Remarks
1	Turbidity	Nephelometer	Yes
2	pH	pH meter	Yes
3	Total Hardness as CACO3	Titration	Yes
4	Dissolved Solids	Conductivity	Yes
5	Chloride	Titrimetric	Yes
6	Alkalinity as CaCO3	Titration	Yes
7	Iron	Spectro-photometer	Yes
8	Manganese	Spectro-photometer	Yes
9	Fluoride	Spectro-photometer	Yes
10	Nitrate	Spectro-photometer	Yes
11	Total Coliform	P/A	Yes

All the methods, which were being used for testing water quality was guided and monitored by the State Referral Laboratory Gandhinagar. Importantly, Nephelometer for Turbidity, pH meter for pH, Titration for Total Hardness and Alkalinity, and Spectrophotometer for Iron, Manganese, Fluoride and Nitrate were used to get the realistic results as per protocol. But DLL Mehsana did not check for free residual chlorine regularly. On the other hand, for bacteriological quality checking the P/A method used, which was a kit-based assessment (safe/unsafe). But there was no statistical analysis after chemical/bacteriological quality checking of the water quality samples.



3.5 Key Findings on Functioning of the Bodeli & Vijapur Taluka Lab

3.5.1 Apart from the Central/State Referral laboratory and district level laboratory assessment, SIGMA Team also visited two Taluka labs namely Bodeli Taluka Lab at Chotta Udaypur district and Vijapur Taluka Lab at Mehsana district for assessing the lab status and competency of the lab personnel as per ISO 10500:2012. Selected monitoring indicators were used for both the Taluka labs.

3.5.2 Lab operation team: Because of the fewer samples tested in these Taluka Labs, the number of lab personnel were also not bigger in size. The Table 3.10 illustrated the details of human resources and their qualification below:

Table 3.11 Human Resources and Qualification

Bodeli Taluka Lab				Vijapur Taluka Lab		
Sl. No.	**Human Resources**	**No.**	**Qualification**	**Human Resources**	**No.**	**Qualification**
1	Chemist	1	BSc (Chemistry)	Chemist	1	BSc (Chemistry)
2	Microbiologist	1	BSc (Microbiology)	Microbiologist	1	BSc (Microbiology)
3	Computer Operator	1	BA	Computer Operator	0	0
4	Lab Assistant	1	BA	Lab Assistant	1	BA
5	Sample Assistant	1	10^{th}	Sample Assistant	1	10^{th}

All these lab personnel were qualified according to their position, but they needed more training on methods of testing and instruments handling. They also needed training on calibration procedure and its significance. They had lack of role of IEC activities in improving water quality and they needed training about IEC for water quality monitoring and management at the field.

3.5.3 Water sample collection: The Bodeli Taluka lab covered the tribal district and the Vijapur Taluka lab was under the non-tribal district in the State of Gujarat. The Bodeli Taluka lab collected water samples from three blocks namely Bodeli, Sankheda & Naswadi, whereas the Vijapur Taluka Lab collected samples from only one block namely the Vijapur Taluka. The annual plan for water sample testing for both the labs was 3,000; however 95% testing activities were conducted in 6 months (Pre-Monsoon and Post-Monsoon Programme). The capacity of testing for Bodeli Taluka lab was 25-30 samples and for Vijapur Taluka Lab was 15-20 samples per day. Remaining six months of the year there was little testing activities due to lack of samples. Both the lab had its own sample collectors who got transportation support from WASMO during the programme. The sample collector generally used 1 litre jerrican for collecting the samples for chemical analysis from the field. For bacteriological analysis, they used sterilized bottle for collection, but the collection and storing method of the samples were wrong. Both the lab personnel mentioned that they kept the water testing samples for three days before testing it in the lab and disposed the samples into the sewage after 7 days of the testing.

Bodeli Taluka Lab

3.5.4 Lab infrastructure: The working space for both the Taluka labs were smaller than the District labs and the buildings were rented in both the cases. Bodeli Taluka Lab had one Chemical cum Bacteriological Lab and one Instrument room cum Office Space. Vijapur Taluka Lab had one Chemical Lab cum office, one Instrument room, and one Bacteriological testing room. The refrigerator for both the labs were functional but they did not have the sample storage cabinets. The lab furniture was in a better condition.

3.5.5 Equipment status: Some of the equipment were in a running condition and producing the test results during project drive for both the lab. Table 3.11 illustrated below to show the status of the equipment for both the Taluka lab:

Table 3.12: Availability of Equipment and Status of Functioning in Taluka Labs

Bodeli Taluka Lab						Vijapur Taluka Lab				
Equipment	**Condition of Equipment**	**Age of the Equipment**	**Calibration frequency**	**Physical Verification**	**Remarks**	**Equipment**	**Condition of Equipment**	**Calibration frequency**	**Physical Verification**	**Remarks**
Spectrophotometer	DR 6000 OK	6 years	NA	Not done	Ok	Spectrophotometer	OK	NA	Not done	Ok
pH Meter	pH 31	5 Years	15 days	✓	OK	pH Meter	OK	4 years	15 days	OK
pH Electrode	Ok	Not known	NA	Not done	Ok	pH Electrode	OK	Not done	Not done	Ok
pH Calibration standards	Ok	Not known	NA	Not done	Ok	pH Calibration standards	NA	Not done	Not done	No
Conductivity Meter	EC 7	5 years	NA	✓	Ok	Conductivity Meter	OK	✓	Not done	OK
Conductivity Cell	OK	5 years	NA	Not done	NO	Conductivity Cell	OK	Not working	Not done	OK
Turbidity Meter	Lamp Error	5 years	NA	Not done	Ok	Turbidity Meter	OK	NA	Not done	OK
Ion Meter	MM 340		Before test	✓	OK	Ion Meter	OK	Before test	Not done	OK
TISAB & Ref. electrolyte	Self			Not done	Ok	TISAB & Ref. electrolyte	NA	NA	Not done	No
Analytical Balance	OK	5 years	Not done	Not done	Ok	Analytical Balance	OK	Not done	Not done	OK
Distilled Water Plant	OK	Not known	No need	No need	Ok	Distilled Water Plant	OK	Not done	Not done	OK
Hot Air Oven	OK	5 years	Not done	Not done	Ok	Hot Air Oven	OK	Not done	Not done	OK
Hot Plate	OK	5 years		Not done	Ok	Hot Plate	OK	Not done	Not done	OK

Refrigerator	OK	5 years	No need	Not done	Ok	Refrigerator	OK	Not done	Not done	OK
Lab Furnitures	OK	5 years	No need	Not done	Ok	Lab Furnitures	Ok	Not done	Not done	OK

Major equipment for water quality testing were in running condition for both the labs. But for bacteriological quality checking both the incubators were not functional at Bodeli Lab and one of the two incubators was not working at the Vijapur Lab. Also, in Bodeli Lab only one out of the two Autoclaves was functional. Similar situation was observed for Vijapur Lab. Not following MPN method for testing bacteriological quality of water might be one of the reasons for non-maintenance of the equipment. Equipment, which were being used for testing were procured 4-6 years ago and the calibration standard was also poor. Lack of physical verification was observed in every step of assessment. Although, centralised assessment of repairing of instruments were on-going and the understanding of instruments handling was satisfactory.

Vijapur Lab

3.5.6 Availability of documents & records: Most of the documents, which both the labs used were in a good condition and easily available. But as per SOP, they did not keep all the relevant document/records for a smooth functioning of the lab. Table 3.12 shows the detail status of maintenance of the documents and records.

Table 3.13 Available Documents/Records in Bodeli and Vijapur Taluka Lab

Available Documents and Records			
Bodeli Taluka Lab		**Vijapur Taluka Lab**	
Documents & records	**Availability**	**Documents and records**	**Availability**
Method List & SOP	Available	Method List & SOP	✓
Equipment Records	OK	Equipment Records	✓
Attendance Sheet	Available	Attendant sheet	✓
Sample Receipt Register	Available	Sample Receipt Register	✓
Test Request Form	Available	Test Request Form	✓
Standard Test Report Format	Available. Very Good	Standard Test Report Format	✓
Awareness of BIS recommendation of desirable limit & cause of rejection of test parameters	Available	Awareness of BIS recommendation of desirable limit & cause of rejection of test parameters	✓
Awareness on Health-hazard by consuming water which are not complying BIS recommendation	Available	Awareness on Health-hazard by consuming water which are not complying BIS recommendation	✓

As per SOP, 23 documents/records should be available in the lab. But both the Taluka labs maintained 8 documents only, which only covered 35% of the requirement and indicated a serious gap in this respect.

3.5.7 Water testing methods: Bodeli Taluka lab and Vijapur Taluka lab were not NABL accredited as per lab evidences. The parameters like pH, Colour, Turbidity, Dissolved Solids, Alkalinity, Total Hardness, Calcium, Sulphate, Magnesium, Chloride, Fluoride, Nitrate & Presence/Absence Test for Coliform bacteria were under the scope of work, which also supported the ISO 10500:2012 protocol. Table 3.14 illustrated the method of water testing for both the lab below:

Table 3.14 Methods of Water Testing followed at Bodeli & Vijapur Taluka Labs

Bodeli Taluka Lab				**Vijapur Taluka Lab**		
Sl. No.	**Parameter**	**Method of Testing**	**Status**	**Parameter**	**Method of Testing**	**Status**
1	Turbidity	Nephelometer	✓	Turbidity	Nephelometer	✓
2	pH	pH Meter	✓	pH	pH Meter	✓
3	Total Hardness	Titration	✓	Total Hardness	Titration	✓
4	Alkalinity as $CaCO_3$	Titration	✓	Alkalinity as $CaCO_3$	Titration	✓
5	Iron	Spectrophotometer	✓	Iron	Spectrophotometer	✓
6	Manganese	Spectrophotometer	✓	Manganese	Spectrophotometer	✓
7	Fluoride	Spectrophotometer	✓	Fluoride	Spectrophotometer	✓
8	Nitrate	Spectrophotometer	✓	Nitrate	Spectrophotometer	✓
9	Total Coliform	P/A	✓	Total Coliform	P/A	✓

It was clear from the above Table that the common parameters were tested following the prescribed methods as per ISO 10050:12. But some important parameters like dissolved solid particles and residual chlorine were not being tested for both the Taluka labs.

3.6 Key Findings on Functioning of the Kadi Taluka Lab

3.6.1 During the exploratory visit, the SIGMA Team also visited Kadi Taluka Lab at Mehsana district. The basic findings are illustrated in Table 3.15 below:

Table 3.15: Key Findings at Kadi Taluka Lab

Sl. No.	**Key Findings**
1)	The infrastructure of Taluka lab is satisfactory though it was not NABL Accredited

2)	The number of tested samples were also higher than DLL/SRL because it tests samples from the Headworks of surface water supply
3)	The sample collector collects the samples during the pre-and post-monsoon season
4)	There was no sample collection plan to collect the ground water samples on a regular basis
5)	The competency of the Chemist and bacteriologist were high, and they were confident to analyse the water samples at any circumstances.
6)	The documentation of the lab records was not organized, and the lab personnel needed training on that aspect

3.7 Critical Observation at Taluka Lab

3.7.1 Very few samples were received for testing except Kadi Taluka Lab.

3.7.2 Irregularity of consumables and lack of uniformity.

3.7.3 Interaction with senior officials for guidance was less frequent.

3.7.4 Not sending samples for referral checking.

3.8 Specific Feedback on Lab Requirements

3.8.1 Expectations of the lab personnel related to technical aspects: SIGMA Team also collected specific feedback on requirement from all the studied labs, which are mentioned under Table 3.16 below:

Table 3.16: Specific Requirement Expressed by Different Labs

Sl. No	Water Quality Testing Labs	Feedback on Requirement
1	SRL-Gandhinagar	• Interested to understand Water Treatment Process by site visit • Android based application for data management • Interested to take part in Surveillance & IEC activities
2	DLL-Chhota Udaypur	• Android based application for direct reach to HQ
3	DLL-Vadodara	• Interested to understand Water Treatment Process by site visit • Android based application for data management • Interested to take part in Surveillance & IEC activities
4	DLL-Mehsana	• Interested to understand Water Treatment Process by site visit • Local purchase facility for consumables • Android based application for data management • Interested to take part in Surveillance & IEC activities
5	Taluka Lab- Bodeli	• Android based application for direct reach to HQ
6	Taluka Lab- Vijapur	• Android based application for direct reach to HQ • Interested to take part in IEC activities
7	Taluka Lab-Kadi	• Android based application for direct reach to HQ

Though all these labs had a common goal to perform but their requirements were different. Besides the android based application for communicating with the Head Quarter, they also felt the importance of exposure visits to learn different analytical methods, local purchase facilities and they were interested to take part in IEC activities for spreading awareness. The last one is an important issue. The labs should not function in isolation and should be in touch with the

community to whom they were providing services for providing safe water. They need to understand the community level issues and to also use their expertise in sensitizing the community, particularly the Pani Samitis on water quality related issues.

3.9 Overall Understanding of Water Quality Monitoring & Surveillance

3.9.1 The lab assessment in Gujarat State, as mentioned before, is based on study of a few representative labs, which helped to understand the system related issues and overall scenario of water quality monitoring and surveillance. Out of 83 labs (including SRL, DLL and Taluka Labs) 8 labs were studied thoroughly to assess the various aspects of functioning of the labs which gave a fair idea of the system in place in the state as well as the gaps and what should be done for future to bridge the gaps and to improve performance of the labs. In this connection the secondary data from Jal Jeevan Mission (JMM) was also analysed and found that water quality is a major issue in all over Gujarat State. Jal Jeevan Mission, GOI reported that at least 27 districts are highly affected by fluoride (>1.5 mg/l), 32 districts are affected by nitrate (>45 mg/l) and 32 districts are affected by salinity (as a TDS form: desirable limit of 500 mg/L and a permissible limit of 2000 mg/L) in the state of Gujarat[6, 7]. According to 2018-19 data out of 7,94,902 public sources 3,515 sources (0.44%) were contaminated by fluoride, 9,108 sources (1.15%) by nitrate and 2,488 sources (0.31%) were contaminated by salinity[8]. Importantly, maximum sources are contaminated by fluoride in the district of Dohad (528 sources) followed by Chhotaudeypur (482 sources), Banaskantha (451 sources) and Panch Mahals (420 sources)[9]. In case of nitrate contamination out of total above stated sources 9,108 sources were contaminated by nitrate. The district scenario indicated that 1,278 sources in Dohad, 1,022 sources in Chhota Udeypur, 952 sources in Banaskantha and 642 sources in Narmada district were affected by nitrate contamination[10]. The geogenic contamination and heavy industrial activities are affecting the drinking water sources with moderate to severe level of contamination by fluoride and nitrate. Further, out of the total sources 2,488 sources were contaminated by salinity. The E format clearly indicated that the maximum sources (458 sources) were contaminated by salinity in Kachchh followed by Vadodara (248 sources), Banaskantha (172) and Patan (165 sources)[11].

3.9.2 Regarding bacteriological contamination total 1,931 sources were affected out of 794,902 public water sources in 8,942 habitations of 33 districts[12]. Sources were majorly affected in five districts namely Devbhumi Dwarka (253 sources), Surendranagar (196 sources), Bhavnagar (146 sources), Sabarkantha (144 sources) and Kachchh (131 sources) by TC/FC/E.coli contamination[13].

[6] Format E 21-Water quality testing in laboratory. E Jal Shakti.gov.in 2018-19 (above IS-10500 permissible limit)
[7] IS 10500: 2012
[8] Format E 21-Water quality testing in laboratory. E Jal Shakti.gov.in 2018-19 (above IS-10500 permissible limit)
[9] ibid
[10] Format E 21-Water quality testing in laboratory. E Jal Shakti.gov.in 2018-19(above IS-10500 permissible limit)
[11] ibid
[12] ibid
[13] ibid

3.9.3 Gujarat State has 33 district labs and 49 Taluka (block) labs for managing the water quality testing. Out of these 33 labs 8 labs are NABL accredited for chemical quality checking. Apart from all, the state has 6 mobile laboratories, which are mostly engaged for disaster management program. The pre-monsoon and the post monsoon test are generally conducted by those labs with the help of WASMO Gujarat. All these labs are mostly testing 13 water quality parameters includes TDS, hardness, fluoride, nitrate, chlorine, calcium sulphate, turbidity, magnesium, colour, odour, pH and bacteriological quality. The private water sources are also tested on demand.

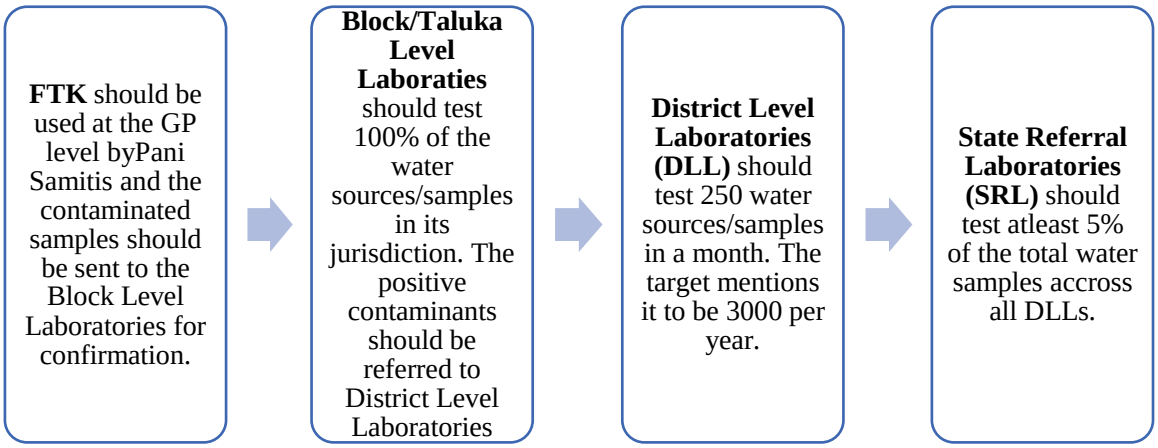
3.9.4 In addition to this water quality test by GWSSB Labs, sanitary inspection is also carried out in the state by water quality staff at the district level. During 2018-19 as many as 1,805 sanitary surveys were conducted by the water quality staff[14]. Highest number of sanitary surveys was conducted by Panch Mahal (871 sources) followed by Dang (314 sources), Junagadh (202 sources), Jamnagar (149 sources), Morbi (133 sources) and Ahmadabad (42 sources) district Labs[15]. Rest of the districts showed zero performance on this significant issue.

3.9.5 The JJM mentions the need for a plan of upgradation of the water quality testing laboratories through NABL accreditation (as per IS/ISO/OEC: 17025)[16] in every state. The water samples from Functional Household Tap Connections (FHTCs) needs to be analysed at the water quality testing labs, which is also applicable for Gujarat. It is important to note that the community accords great priority for access to water, but water quality issues do not attract similar attention. This is because, at grassroots, water quality is usually ascertained only by colour, odour and taste of the water. The presence of most of the chemical contaminants does not exhibit any change in terms of colour, odour or taste and the communities continue to consume the quality-affected water in ignorance of potential threats of consuming such contaminated water. There is strong need for sensitization of the Pani Samitis and the community on various aspects of water quality and their role in preventing contamination of water. In cases of contamination induced through industrial activities there is need to have strong advocacy on how their activities are affecting the water quality and the need for management of the effluent so as to prevent pollution of water. The water testing labs need to play a proactive role in awareness generation and advocacy.

3.9.6 It also requires identification of appropriate methods for water quality testing at state, district and block/Taluka level. The JJM provides a tree model of water sample testing, which is quite significant for the State of Gujarat to maintain its water quality standard/protocol and increase the geographical coverage of the sample collections.

[14] Format E 20-Comprehensive Progress on HRD, FTK, Sanitary Survey (March 2018-19). E Jal Shakti.gov.in
[15] Format E 21-Water quality testing in laboratory. E Jal Shakti.gov.in 2018-19 (above IS-10500 permissible limit)
[16] Government of India, Department of Drinking Water & Sanitation, Jal Jeevan Mission, Har Ghar Jal, Operational Guidelines, December, 2019.

Tree Model of Water Sample Testing as per JJM



3.9.7 In the real time scenario, the SRL as well as DLLs and Taluka Labs of Gujarat failed to meet the target of water sample collection due to its Pre and Post Monsoon protocol, which is only six months-based activities. Rest of six months are generally no samples to be collected and tested[17]. SIGMA Team found that though water professionals were interested to work for round the year but their technical protocol did not permit it. So, all these labs were unable to reached the norm of 3000 water samples per year.

3.9.8 Field Test Kit is permissible at the GP level but once a sample is found to be positive it needs to be referred to the nearest laboratory for confirmatory tests by standard methods with the help of MPN or RMFT. But the laboratories were using Field Test Kit (FTK) for bacteriological test at the lab level, which is not permissible as per Uniform Drinking Water Quality Monitoring Protocol 2013. Importantly, FTK is recommended only for field level especially for disaster management. To use the MPN or RMFT (Rapid Membrane Filtration Technology) method for testing the bacteriological quality at the lab level requires adequate training on MPN and RMFT method for generating quality assured results, which is missing in all labs in Gujarat. It is advisable to adopt the RMFT method which is faster and cheaper and will help much wider coverage of testing water for bacteriological quality.

3.9.9 The Central Lab or the State Referral Laboratory in Gandhinagar has enough capacity to fulfil the target of testing. According to NRDWM 2013 and JJM 2019, the State Referral Lab should test at least 5% of the total drinking water samples across all district level laboratories with random and uniform geographical spread including positively tested samples referred by district/ sub-division/ block/ mobile lab. If the number of the districts is large (>50) then the testing of samples/ sources may be restricted to 3% for the State referral lab. Remaining 2% may be integrated with other regional/ district laboratories. But due to lack of samples from the District Lab or the Taluka Labs the performance of SRL is still very low as found by in the study.

[17] Findings of SIGMA Foundation from laboratory visits

3.9.10 It is suggested under NRDWP and JJM that all district lab should test minimum 250 water sources/ samples per month (i.e. 3,000 in a year as per the target of roster available on Department/ National Mission IMIS) covering all sources randomly spread geographically including the positively tested samples referred by the sub-division/ block laboratory/ mobile laboratory on at least for 13 basic water quality parameters. The district lab will also refer the positively tested samples to the State laboratory immediately. The other parameters may be tested as per local contamination at district level. But the number of test sample are very few; maximum 50 samples has been tested in a day, which represented a small number of testing. The number of referral samples are also few in numbers.

3.9.11 It is also suggested under NRDWP and JJM that Sub-divisional/ Block lab/Taluka Lab should test 100% water sources under its jurisdiction; once for chemical parameters and twice for bacteriological parameters (pre and post monsoon) in a year, covering all sources of a block/Taluka at least for 13 basic water quality parameters. The positively tested samples will be referred to the district laboratory immediately. The other parameters may be tested as per local contamination. But no referral samples go to district labs from Taluka level and the daily testing is also few.

3.9.12 Gram Panchayat/Pani Samiti should ensure to test 100% drinking water sources including private sources and sanitary inspection under its jurisdiction using FTK (as per NRDWP & JJM). It was found that Though the Pani Samitis were performing their role sincerely to supply water at the Gram Panchayat level but they were not aware, in general, about quality of water, related protocol and the disinfection method[18]. They were not supplied with/ using FTK for testing the quality of water being consumed by the people. Ideally, they should carry out water quality testing and the test results and sanitary inspection reports are to be submitted to the WASMO.

3.9.13 The Human Resources (HR) of the laboratories (SRL, DLL and Taluka Lab) was found to be satisfactory but not as per Uniform Drinking Water Quality Monitoring Protocol. Also, they were not being fully utilized for performing as per their capacity [19]. The Table 3.16 to Table 3.18 illustrate the human resource structure as per Uniform Drinking Water Quality Protocol and present status in the study labs of Gujarat State including SRL, DLL and Taluka Lab.

Table 3.17: Human Resource Status at SRL

Sl.No.	SRL HR Status (Gandhinagar)	
	NRDWP	**Actual status**
1	Chief Chemist =1	Chief Chemist = 1
2	Senior Chemist =1	Senior Chemist = 0
3	Chemist-2	Chemist = 1
4	Microbiologist/Biologist =1	Microbiologist/Biologist = 1
5	Lab Assistant =3	Lab Assistant = 1

[18] SIGMA's 33 Pani Samiti study indicated the reality about the level of consciousness of water quality testing and disinfection at the village levl.
[19] Government of India, Ministry of Drinking Water & Sanitation, Uniform Drinking Water Quality Protocol, February 2013.

6	Data Entry Operator = 2	Data Entry Operator = 1
7	Lab Attendant = 2	Lab Attendant = 1
8	Sampling Assistant = 2	Sampling Assistant = 1

Table 3.18: Human Resource Status at DLL

Sl.No.	**DLL HR Status (Mehsana District)**	
	NRDWP	**Actual status**
1	Chemist/Water Analyst = 1	Chemist/Water Analyst = 2
2	Microbiologist/Bacteriologist = 1	Microbiologist =1
3	Lab Assistant = 2	Lab Assistant = 0
4	Lab Attendant = 1	Lab Attendant = 1
5	Data Entry Operator = 1	Data Entry Operator = 1
6	Sampling Assistant = 2	Sampling Assistant = 1
*__Note__: 1 Junior Scientific Officer is present in this lab, which is not recommended as per GOI Guidelines		
Sl.No.	**DLL HR Status (Chhota Udaypur District Lab)**	
	NRDWP	**Actual status**
1	Chemist/Water Analyst = 1	Chemist/Water Analyst = 1
2	Microbiologist/Bacteriologist = 1	Microbiologist =1
3	Lab Assistant = 2	Lab Assistant = 0
4	Lab Attendant = 1	Lab Attendant = 1
5	Data Entry Operator = 1	Data Entry Operator = 1
6	Sampling Assistant = 2	Sampling Assistant = 1
Sl.No.	**DLL HR Status (Vadodara District Lab)**	
	NRDWP	**Actual status**
1	Chemist/Water Analyst = 1	Chemist/Water Analyst = 2
2	Microbiologist/Bacteriologist = 1	Microbiologist =1
3	Lab Assistant = 2	Lab Assistant = 0
4	Lab Attendant = 1	Lab Attendant = 2
5	Data Entry Operator = 1	Data Entry Operator = 1
6	Sampling Assistant = 2	Sampling Assistant = 1
*__Note__: 1 chief Scientific Officer, 1 Scientific Officer, 1 Junior Lab Officer are present in this lab, which are not recommended as per GOI guidelines		

Table 3.19: Human Resource Status at Taluka Lab

Staffing Pattern	**Bodeli Taluka Lab**		**Vijapur Taluka Lab**		**Kadi Taluka Lab**	
	NRDWP	Actual Status	NRDWP	Actual Status	NRDWP	Actual Status
Chemist/Water Analyst	1	1	1	1	1	1
Microbiologist	1	1	1	1	1	1
Lab Attendant	1	0	1	0	1	0
Lab Assistant	2	1	2	1	2	1
Data Entry Operator	2	1	2	0	2	1
Sampling Assistant	2	1	2	1	2	1

3.9.14 Considering the above-mentioned HR status, which are currently available at the lab level in Gujarat, are mostly consistent with the recommended staffing pattern under NRDWP 2013 guidelines. On the other hand, due to few numbers of samples there is no need to add extra man power at various levels until and unless the number of water samples tested get increased to the desired level. Only thing they required is working out a plan for sample collection round the year and involving the Pani Samitis, calibration and various test protocols including the bacteriological quality checking through preferably RMFT (for which equipment has to be procured) or MPN (for which equipment is already available). Procurement of consumables and inter-tier communication are other important areas which require attention in improving the system of water quality monitoring in the state[20].

3.9.15 The burden of disease may be high due to high level of fluoride or nitrate in drinking water. Presence of bacteriological pathogen in drinking water make it unfit for drinking and causes diarrhoeal diseases in this state. The death cases from diarrhoea was 28.9% at the age group of below 5 year in 2015-16[21]. It poses a greater challenge to not only water users but also to water managers of the state. Along with other pressures heavy industrialization also exerts pressure on both the quantity and quality of water, urging greater attention from the planners and service providers who are responsible for the governance of water in the state of Gujarat. It would be, thus, imperative for all concerned to not only be aware of water quality in various parts of the state but to also locate responses necessary for the total elimination or minimization of the levels of critical contaminants in the existing water resources as per BIS norms.

3.9.16 Some villagers believe that boiling the water will secure it from harmful contaminants and continue to use quality-affected water for cooking purposes[22]. Hence, there is a definite need to generate awareness and education on water quality and engage communities in water quality surveillance. In this connection the following activities are important for behaviour change and social practices at all level:

i. Awareness and education programmes on water quality in GP, Schools, Anganwadi centres, Health centres, Pani Samiti, and higher tiers of Panchayats i.e., Taluka Panchayat and the Zila Parishad.
ii. Awareness generation and capacity building of all stakeholders at all levels on various aspects of water quality, it's importance, water borne diseases, health effects, safe handling, and safe storage.
iii. Engage Pani Samiti in surveillance activities such as mandatory sanitary inspections.
iv. Enable Pani Samiti/communities to undertake presumptive testing of water quality using FTKs.

3.9.17 Jal Jeevan Mission also clearly states that strengthening of water quality testing laboratories should be undertaking through assessment and improvement plans. The laboratory assessment will include the following issues:

- HR available and their training need analysis;

[20] Findings of SIGMA Foundation from laboratory visits
[21] India: Health of the Nation's States — The India State-Level Disease Burden Initiative. New Delhi: ICMR, PHFI, and IHME; 2017. ISBN 978-0-9976462-1-4
[22] Findings of SIGMA Foundation from field visit

- Physical infrastructure (laboratory environment);
- Equipment & instrumentation;
- Annual maintenance contract mechanisms;
- Number of samples being tested against the target and requirement;
- providing guidance and training to personnel at different managerial levels in water quality testing, monitoring, data interpretation and reporting;
- Accreditation of drinking water quality testing laboratories as per IS/ISO/IEC:17025 at least for parameters of basic water quality importance and gradually upgrading to other parameters as per local conditions;
- Cross verification of water quality data and integration with other laboratories of the State.

3.9.18 Importantly, SIGMA Foundation already assessed the status and performance of the water quality testing labs in the Gujarat State as per Jal Jeevan Mission's guidelines and the doable recommendations are presented in the next chapter.

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Chapter IV: Lessons Learnt and Recommendations for Improving WQMS in Gujarat

4.1 Approach for strengthening the water quality monitoring and surveillance

The issues and challenges related to WQMS in Gujarat have been described in detail in the previous chapters. There is need for appropriate improvement of several aspects of the system as mentioned before. These include: (i) quality assurance, (ii) quality control, (iii) quality of the specimen and reagents, (iv) methods for the bacteriological test, (v) sample collection system, (vi) record keeping, (vii) analytical records, (viii) other records, (ix) lab manual, (x) adoption of appropriate testing methodology, (xi) adoption of Good Lab Practice Model (GLPM), (xii) building competence of the lab personnel, (xiii) coverage of all habitations for proper surveillance on water quality, (xiv) data analyses and feedback of the analysis to the policy makers/key officials for appropriate follow up measures (xv) involvement of the Panchayats/Pani Samiti and the community, and (xvi) coordination with other departments. These are mentioned below for consideration of the state government.

4.2 Quality Assurance (QA): In case of water testing quality, assurance is very important by strictly following quality assurance norms during sample collection, transportation, preservation/storage and analysis for getting desired quality of results. The operating principle should be set with in-built quality assurance for all the processes and the same should be readily available as the Standard Operating Procedure (SOP) for the water quality testing lab. This should also include the analytical methods, calibration procedures, corrective actions, data validation and reporting. There should be QA policy for being followed at every level and the same should be available in all the labs and displayed in a prominent place within the lab.

4.3 Quality Control: All water testing analysts should use some Quality Control (QC) as an institutionalized effort to produce credible and replicable results. A good quality control programme consists of certification of operator competence, recovery of known additions, analysis of externally supplied standards (NIST), analysis of reagent blanks, calibration with standards, analysis of duplicates and maintenance of control charts. With proper quality control, all the water testing labs in this state will be benefitted with accurate, reliable and reproducible analytical results, which will ultimately benefit the community. There is need for ensuring better quality control to bridge the gaps.

4.4 Quality of the specimens and the reagents: The quality of the specimens should be fresh. Similarly, the reagents and the glassware should be of good quality, which is often compromised because of delayed procurement following government procedures. The media/standard solution should be prepared properly for consistency in test results. The performance of the lab personnel should be checked quarterly with reviewing of the test results (which was missing of the above studied labs). Each lab should document the test results and list of doubted results for validation and follow a transparent analytical system of assessing

performance of the laboratory. Further, all quality data control records will be retained for a period of at least two years for audit.

4.5 Method for Bacteriological analysis: It was observed that all laboratories were testing Bacteriological parameters by P/A test kit strip, which is qualitative (presence/absence test) and number of colonies cannot be counted by this method. On the other hand, the labs are required to perform the MPN/MTD method. 'Multiple Tube Dilution technique' (MTD) results in 'Most Probable Number' (MPN) of colonies present in the sample", which is a statistical data and not fit for enumeration. Besides, sample preparation process requires intensive labour and the total lead time of completion of test by MTD method is not less than 48-72 hours from the time of incubation. Even, calculation of multiple manipulations and dilutions in every step and post-test cleaning/disposal of sample is difficult. It is recommended that all the labs should adopt the Rapid Membrane Filtration Technique (RMFT) for quantitative assessment of bacteriological quality of drinking water. The system can detect Total Coliform & E. coli quantitatively in a single incubation. Sample preparation, handling & analysis as well as the autoclaving procedure are easier and faster in this method. Record of result is also easy and counting of colonies is possible in bare eyes (colour of colonies formed by presence of Coliforms & E. coli in sample are different). Those apart, results in terms of colony count (as number) can be obtained after 24 hours from the time of incubation. Once the water is highly contaminated the quality can be assessed within 12 hours by observation of formation of colonies, which can improve the warning system to avoid consumption of highly contaminated water. The cost per test by this Rapid MF method is almost one-third that of MTD technique for buying kits. Being a rapid system, the laboratory personnel will also be motivated to test bacteriological parameters in the laboratories. In fact, testing for bacteriological contamination of drinking water is much more needed to avoid ill health through prevention of water borne diseases.

4.6 Sample Collection Plan: A proper sample collection plan is needed in every water testing laboratory so that there is steady and calculated number of samples which reach the lab every day to match its capacity. That will also avoid storing the sample which is not recommended. Unplanned collection may reduce the output of the labs (which was a common phenomenon in every lab). Presently, SRL Gandhinagar is the only referral lab and it is testing the pre-Monsoon and Post-Monsoon samples from districts referral labs. It was observed that, the volume of sample tested by SRL was low and there was no schedule of referral sample submission at SRL. The huge geographic location of SRL was found to be a reason for non-receipt of referral samples and lack of planning. So, more decentralized arrangement for referral samples will help to easily send the samples by the DLLs/Taluka Labs and technical supervision on those labs will be easier. A systematic plan should be adopted for Districts and Taluka Labs, which are also underutilized due to lack of samples. As per plan 5% of the district referral samples can be tested by SRL and 5% of the Taluka/Block level samples can be tested by District Level Lab. The same should be followed by putting an appropriate referral system in place. The state may consider to upgrade a few District labs to function as referral labs.

4.7 Improvement in the process of validation: Presently there is no system of informing the re-test results to the lab, which conducted the test and sent the sample for validation. There is also no assessment of the extent of variation of the results found in the referral laboratories compared to what was found in the lab where the sample was tested first. The sample should be sent for re-testing and the referral lab should be asked for the original test report after it has conducted the re-test. Each sample should be given unique identity so that there is no difficulty in relating the test results conducted by the testing lab and the referral lab. Both the results should be compared by the referral lab to work out the variation (Z score) and the findings must be shared with the primary lab. In case of variation between the results of tests conducted over a time by any particular lab and the result found on re-testing by the referral lab is found to be beyond acceptable limit, the reason for the same has to be probed, and, if necessary, the lab should be visited by senior officer for checking the processes and equipment being followed by the primary lab. There should also be technical supervision of the labs by the officials from Head Quarter. This will include ensuring that labs within their jurisdiction regularly calibrate their instruments. The key officials of the referral labs are to be oriented on inspection of the labs tagged with them in a systematic manner. For Validation of test results the following processes need to be adopted for every lab: -

i. Calibration of measuring Instruments
ii. Replicate Testing
iii. Re-testing of tested samples
iv. Inter-laboratory comparison (In this case re-test at referral laboratory)

4.8 Staffing Pattern: According to GOI norms the SRL, DLL and Taluka Labs should have specific numbers of staffs to perform the water quality testing and other lab related activities. The studied labs in Gujarat generally followed norms for staffing pattern. Only, the present or absent of few lab personnel may not affect the whole system of WQMS. It is important that to analyse the larger quantity of water quality samples requires a greater number of staffs as per norms. But the number of samples are few in all the labs of Gujarat State, so, there is no need to have more recruitment or fresh appointment till a higher volume of performance is achieved.

4.9 Record Keeping System: The taluka water testing lab was found lagging in record keeping. The record keeping system should follow equipment maintenance record, instrument logbook, instrument calibration data, standard preparation logbook, standards operating procedure, calibration records, raw analytical data-both electronic and handwritten, quality control results, and final reports.

4.10 Analytical Records: Labs should maintain laboratory sample ID, date and time of analysis, instrumentation identification and instrument operating conditions/parameters, analysis type, all manual calculation, analyst's or operator's initial/signature.

4.11 Other Records: The lab related other records should be kept properly including administrative records, chain of custody (COC) records, custody records, sample disposal records and stock records.

4.12 Lab Manual: The water quality lab manual should be prepared by the lab professional and be always available in the lab.

4.13 Adoption **of Good Lab Practice Model (GLPM):** WASMO has a vision of upgrading the labs and attain NABL standard systematically. The process should begin with following certain good lab practices as recommended in the GLPM. Apart from following certain scientific processes there are many managerial practices to be followed and there must be change in culture and attitude of the lab functionaries for strictly following the protocols. Therefore, the recommendation is to start GLPM at DLLs and Taluka Labs as mentioned below.

- Start-up of GLPM at DLLs & Taluka Tabs

a) Laboratory should maintain the following records in uniform format which is applicable for all laboratories and should follow the protocol of Uniform Drinking Water Quality:

i. Attendance register
ii. Visitor's book
iii. Sample receipt register
iv. Test Reports File
v. List of Gram Panchayats under its jurisdiction
vi. List of sample collectors with contact number under its jurisdiction
vii. List of parameters to be tested under its scope
viii. Handbook of operating procedure of test parameters
ix. Internal calibration protocol (frequency & limit of rejection) of measuring instruments (Spectrophotometer, pH Meter, Conductivity Meter, Turbidity Meter etc.)
x. Internal calibration record of all meters.
xi. Material indent vouchers.
xii. Stock receipt/issue register.
xiii. List of Calibration solutions & its expiry.

b) The Laboratories should have the following safety gadgets:

i. Aprons for Water Analyst & Lab Assistant (2 sets per person)
ii. Laboratory Shoe (6 sets/Lab of different size)
iii. Acid Alkali proof gloves for cleaning (4 pairs/lab)
iv. Nitrile Gloves safe skin for Bacteriological work
v. Face musk (4 sets/Lab)
vi. Fire Extinguisher (2 for chemical/2 for electrical & 1 for Gas where AAS is available)
vii. Heavy-duty Exhaust system (at least in digestion room)

4.14 Building Competence of the Lab Personnel: Many training programmes are organized for the lab personnel. But all of those are classroom based with support of power point presentation. There must be hands on training in small batches which are to be organized in a systematic manner and such trainings must be essentially residential. The following steps are to be taken for imparting such training:

i. Training calendar is to be prepared for each lab.

ii. A training curriculum is to be prepared for each category of training (viz. on Fluoride/Nitrate Analysis or on Calibration method of Analytical Instrument or on Bacteriological analysis).
iii. The training should be imparted in a SRL/DLL Lab where all infrastructures are available and all the analytical instruments are in running condition/all consumables are available.
iv. The batch of trainees to be decided such that the trainees can reach to the venue within reasonable time.
v. In every batch, number of trainees should not exceed 7-8 numbers for better interaction and involvement.
vi. The Trainer should communicate with the trainees compassionately and should promote and motivate them for good and sincere performance.
vii. For training purpose, the WASMO may tie up with educational or professional organizations, Private Water Testing Laboratory or experienced resource person(s).
viii. Trainer should be oriented on the vision, mission & goal related to strengthening WQMS of the state. They should start their training from zero-level.
ix. The agenda & scheme of training is to be prepared by experts and approved by the WASMO.
x. Trainees should also be impressed upon the vision, mission, goal & expectation of the Department from them in every programme.

4.15 Coverage of all habitations for proper surveillance on water quality: The system of sample collection should be such that there is proper surveillance on the entire State, which means samples are to be collected from each habitation on a regular basis (once a year for chemical contamination and at least twice a year for bacteriological parameters). Ideally, all the drinking water sources should have unique identity number so that the status of water quality can be tracked for each source. It is recommended that the state may take an initiative for identifying each public drinking water source (and if possible, the private drinking water sources also) and give unique identity number to each source as well as capture the latitude and longitude of each source. The spatial distribution of water quality can be shown precisely up to the source level using GIS if the location of the source is captured and reported along with the test result. This will also help to generate thematic map based on quality of water for better visualization of spatial variation of water quality and it will be easier to understand the association with the external factors which are likely to make the water unsafe for drinking. WASMO may consider developing a website showing location of at least the piped water supply to start with, which will help to not only show the coverage of piped water supply but also the spatial distribution of water quality. This will help for working towards compliance to SDG related to access to water and safety of drinking water.

4.16 Feedback of the analysis to the policy makers/key officials for follow up: The test results are not analysed and shared with important stakeholders like GP/Pani Samiti. There must be a system of providing feedback of the analysed data to the GP/Pani Samiti/private owner from whom the samples were received. The test results should be sent as notification/message in the mobile phones of the Sarpanch/Chairperson of the Pani Samiti of

the GP concerned. If possible, the Medical Officer in charge of the PHC should also be given feedback on the quality of water, particularly when the water quality is below acceptable level. Suitable Real-time Android run applications may be developed to send notifications of the test results. This will be a part of the monitoring system discussed later. All these persons are to be oriented on the follow up actions if the water quality is below standard.

4.17 There also has to be feedback of the analysed data aggregated over the Taluka, District and the State to the authorities (officials of district administration and the WASMO officials) at respective level for analysis of the data and planning possible actions to mitigate the problems at their levels. The feedback will be very critical for the WASMO to make appropriate interventions in ensuring safety of drinking water. In case of chemical contamination arising out of geomorphological reasons there is need for locating alternative source, which is safe and generally a suitable surface water-based supply system has to be developed as prescribed in the guidelines for Sub-Mission for water quality under NRDWP, July 2017. In case it takes time to develop such system and the contamination is found to have reached rejection level, the supply from existing source must be stopped and a temporary arrangement must be made for providing safe water.

4.18 Decentralization of the system of sample collection: At present the sample collection system is centralized and there is no linkage with the Panchayats/community. It is possible to give the responsibility of collecting water samples on the GPs/Pani Samitis so that they remain responsible for sending samples of water to be collected from the source as well at the point of consumption and covers the entire jurisdiction over the year. They need to be empowered and equipped for which the state may follow the West Bengal model, which has been put in place as a joint initiative of the PHED and the Panchayat & RD department of the state. Under this arrangement every GP has a trained Water Facilitator, who collects water samples and takes the same to the labs in a planned manner and payment is made to them by the GP. This also make the GPs accountable to test their water quality. The planning should be such that the lab receives similar number of samples, as per daily testing capacity, from given number of GPs on a particular day as per schedule. In that case, all the Pani Samitis are to be allotted different dates for sending their samples. This will ensure availability of uniform number of samples every day and involvement of the GPs/Pani Samitis.

4.19 Involvement of the Panchayats and the community: The surveillance of spot sources should be carried out by the GPs/Pani Samitis for which there should be appropriate order of the state government. The GPs/Pani Samitis were found not much associated with the subject of drinking water quality. The GP, as the lowest level of local government, should play an important role in safety of drinking water through protection of sources, taking up mitigation measures and making the community aware of the water quality related issues. The GPs are ideally positioned to mobilize the community in taking mitigation measures as well as in sensitizing the community on safety and sustainability of drinking water sources. Keeping all these in mind, it has been already proposed that the GPs/Pani Samitis should be given the responsibility of collecting water samples and sending the same to the lab. They should also be oriented on (i) proper planning of sample collection so that drinking water of all the public

utilities like schools, Anganwadi Centres, Health Centres etc. are regularly tested along with sources from where water is either piped to the houses or collected by the households and (ii) issues related to water safety and prevention of contamination of drinking water sources as well as taking up appropriate measures where possible, if the water is found to be contaminated. Also, water samples from the consumption points are also required to be collected for analysis. Their support will also be critical in managing outbreak of water borne diseases. Along with the GPs, the members of the Pani Samiti and the Water Users Committee are to be also oriented on various aspects of water quality monitoring and management. The Labs may orient the functionaries of the Pani Samiti on various aspects of water quality monitoring. In fact, most of the lab functionaries expressed their eagerness to take part in IEC activities related to water quality. The GP should also place a report on quality of water being supplied in the area based on samples tested in the monthly meetings/Gram Sabhas.

4.20 Sanitary survey of the drinking water sources: One important activity of the community is to ensure that the drinking water sources are protected from contamination due to unsafe management of liquid and solid waste. Erstwhile MDWS has advised to conduct sanitary survey of each source for assessing the risk of each source and to take preventive measures for sources with high risk of contamination. The parameters to be monitored during the survey is placed below under Table 4.1.

Table 4.1: Sanitary Inspection as per GOI Protocol

Sl. No.	Question	Risk	
1	Is there a latrine 10m of the borehole?	No	Yes
2	Is there a latrine uphill of the borehole?	No	Yes
3	Are there any other sources of pollution within 10m of borehole?	No	Yes
4	Is the drainage faulty allowing ponding within 2m of the borehole?	No	Yes
5	Is the drainage channel cracked, broken or need cleaning?	No	Yes
6	Is the fence missing of faulty?	No	Yes
7	Is the apron less than 1m in radius?	No	Yes
8	Does spilt water collect in the apron area?	No	Yes
9	Is the apron cracked or damaged?	No	Yes
10	Is the hand pump loose at the point of attachment to apron?	No	Yes

4.21 Coordination with other departments: There is need for coordination with the Rural Development and Panchayati Raj Department for involvement of the Panchayats, particularly the GPs/Pani Samiti in water quality monitoring as well as in taking mitigation measures. There is also need for coordination with Health & FW Department for taking prompt measures on outbreak of diseases caused by water contamination. The Health & FW Department is associated with chlorination of the water and the Pani Samiti is not aware about the extent of residual chlorine and the importance of chlorination of water. There is need for improving awareness of the Pani Samities by the lab officials and they should be encouraged to measure the residual chlorine level with chlorometre and be able to watch on proper chlorination by the officials of the Health & FW Department.

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