

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

4,800

Open access books available

122,000

International authors and editors

135M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.

For more information visit www.intechopen.com



Chapter

Water Quality Monitoring Infrastructure for Tackling Water-Borne Diseases in the State of Madhya Pradesh, India, and Its Implication on the Sustainable Development Goals (SDGs)

Abhishek Parsai and Varsha Rokade

Abstract

It is estimated that around 37.7 million Indians are affected by water-borne diseases annually, 1.5 million children are estimated to die of diarrhoea alone, and 73 million working days are lost due to water-borne disease each year. The resulting economic burden is estimated at \$600 million a year. Owing the largest share, India has a significant role to play in achieving global Sustainable Development Goals. In such scenario, monitoring of drinking water quality and its improvement plays a significant role in ensuring public health and reducing economic burden. Taking cue from this, a study was designed to assess the efficiency of water quality laboratories established under the National Rural Drinking Water Programme in the State of Madhya Pradesh. In the state, which tops the list of states in the country with the highest infant mortality rate (IMR), the drinking water quality assessment infrastructure is not in a position to monitor the water quality in rural areas. The study assessed that none of the 56 laboratories was able to perform a minimum of 3000 tests per year (annual analysis load) in the state for monitoring water quality. This paper presents the findings of the statewide status of water quality in rural areas and also qualitative assessment of 56 water quality laboratories in 16 districts.

Keywords: water quality, water-borne diseases, water quality laboratories, field test kits, SDGs, MDGs

1. Introduction

Sources of good quality water for drinking and domestic use, whether surface or groundwater, are fundamental to human health. Water quality is naturally influenced by the climatological and geochemical location of the water body through temperature, rainfall, leaching and runoff of elements from the Earth's crust. Consumption of water containing pathogens or elements that are potentially toxic can lead to health impacts ranging from discomfort to death [1]. Though the global

Millennium Development Goals (MDGs) target for drinking water was met in 2010, 663 million people still lack improved drinking water sources. 96% of the global urban population uses improved drinking water sources, compared with 84% of the rural population. 84% of the people who don't have access to improved water lives in rural areas, where they live principally through subsistence agriculture. Eight of 10 people without improved drinking water sources still live in rural areas. In developing countries, as much as 80% of illnesses are linked to poor water and sanitation conditions [2]. Besides the current target (achieved) was based solely on access to an improved facility, the definition of "improved" does not take into account other important parameters such as drinking water quality, adequacy of quantities available for domestic or productive uses, distance to water source, time spent to access and use facilities, reliability and maintenance of services, affordability and social barriers to access and safe disposal and treatment of wastewater. Furthermore, any recalibration of targets and/or adoption of stricter definitions of improved would result in significantly higher estimates of population receiving services below a basic standard [2].

With 78.5 million people, India is at the top amongst countries with the largest number of people without access to safe water. Most of those people are living on around £3 a day. India is also amongst the top ten worst countries for household water access. Besides these distinctions, the country has the State of Madhya Pradesh with the highest infant mortality rate (IMR) (57 deaths of children less than one year of age per 1000 live births) [3], which is worse than some of the African countries often cited for poor health indices. According to the World Bank, the IMR for Rwanda for the same year was 33, Ethiopia 43 and Zambia 45. Increased access to improved water sources is significantly associated with decreased under-five mortality rate, decreased odds of under-five mortality due to diarrhoea, decreased IMR and decreased odds of MMR. Access to water and sanitation independently contributes to child and maternal mortality outcomes [4]. If the world is to seriously address the Sustainable Development Goals (SDGs) of reducing child and maternal mortality, then improved water and sanitation accesses are key strategies.

2. Policy framework governing water quality in rural India

The 12th Five-Year Plan (2012–2017) [5] has placed a greater thrust on coverage of the water quality-affected habitations, in order to address water quality issues in rural areas. As per the NRDWP guidelines (water quality) [6], 20% of the annual NRDWP funds are allocated for tackling water quality problems to enable rural communities to have access to potable drinking water. The NRDWP guidelines further stipulate that 3% of NRDWP funds on a 100% central share basis are to be used for water quality monitoring and surveillance activities at the field level and for setting up and operating water quality testing laboratories at the state, district and sub-district levels.

The Bureau of Indian Standards (BIS) has specified drinking water quality standards in India to provide safe drinking water to the people. As per the Bureau of Indian Standards, IS-10500-2012 [7], 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 (e.g. excess 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.).

The Uniform Drinking Water Quality Monitoring Protocol of the Government of India [8, 10, 11] describes specific requirements for monitoring drinking water

	Total no. of habitations		No. of habitations where all sources have been tested		No. of habitations where no source has been tested		No. of habitations where 75% of sources have been tested	
	Number		Number	%	Number	%	Number	%
India	1,692,133		113,781	6.72	1,088,514	64.33	155,583	9.19
Madhya Pradesh	127,169		22,924	18.03	69,918	54.98	32,052	25.20
16 districts	59,087		11,217	18.98	34,231	57.93	14,545	24.62

Source: www.indiawater.gov.in.

Table 1. Habitation status based on lab testing. Madhya Pradesh state (as of 31 March 2014).

quality in rural areas. In addition, this document also includes requirements for setting up laboratories at state, district and sub-district levels and quality control for regular testing and surveillance of drinking water sources. The purpose of this document is to describe various elements of laboratory management practices.

Following the various provisions in the protocol and with funding provided by the Government of India, 51 district laboratories, 3 block laboratories and 106 sub-divisional laboratories have been established in 51 districts of the State of Madhya Pradesh. In the month of July 2014, an assessment of implementation of various provisions of the protocol with regard to (1) availability of space for analytical purpose; (2) availability of office equipment, instruments, glassware and chemicals; (3) availability of human resource; (4) sampling; (5) use of field test kits; and (6) safety measures was undertaken. The objective of the assessment was to find gaps in the above-mentioned six areas and also to suggest measures, so that each laboratory achieves the target of minimum 3000 water quality tests per year.

It is evident from **Table 1** that in the State of Madhya Pradesh there are only 22,924 (18.03%) habitations where all sources have been tested in laboratories, whereas in the case of 16 districts, it is 11,217 (18.98%). In the statewide number of habitations where no source has been tested in the laboratory, it is 69,918 (54.98%), whereas in the case of 16 districts, it is 57.93%. The number of habitations where 75% of sources have been tested in laboratories is 32,052 (25.20%) in the state and 14,545 (24.62%) in 16 districts. It is a point of concern that in 69,918 habitations (54.98%), quality of water and potential risks are not known either to nodal department or to common people, i.e. water users.

3. Methodology

The Uniform Drinking Water Quality Monitoring Protocol prescribes various provisions with regard to availability of space for analytical purpose, availability of office equipment, instruments, glassware and chemicals, availability of human resource, sampling, use of field test kits and safety measures for water quality laboratories. Based on various provisions of the protocol, a structured questionnaire was designed. The questionnaire was used to collect data from chief/head chemists of all 56 water quality laboratories in 16 districts (Annexure I). The data collected in each category was analysed against the respective provision in the protocol. For example, absence of separate analytical space for biological testing of water samples against space as prescribed in the protocol highlights a gap. Absence of office equipment such as computer and internet connectivity highlights a gap in data entry and so on.

4. Results and discussion

This section highlights data collected from 56 laboratories against prescribed provisions in the protocol. Column 1 depicts provision prescribed in the protocol, whereas Columns 2 and 3 show data collected from the laboratory staff on the respective provision of the protocol. The information has been analysed in five categories altogether (**Table 2**).

Categories	As prescribed in the protocol	Survey data (% of labs)		Figure
		1	2	
		Yes	No	
Space	Space for analysis (district level 60m ² including 20m ² for bio and block level 50m ² including 20m ² for bio)	26.79	73.21	1
	Separate space for biological testing	17.86	82.14	
	Space for storage (inm ²) (district—25 and block—20)	12.50	87.50	
	Space for office and library (inm ²) (district—15 and block—10)	12.50	87.50	
	Total space requirement (inm ²) (district—100 and block—80)	25.00	75.00	
Office equipment	No. of computers (district—1 and block—1)	41.07	58.93	2
	Internet	39.29	60.71	
	No. of UPS (at least 1)	30.36	69.64	
	Inverters (backup time = 3 hours) (district—2 and block—1)	16.07	83.93	
	Printer	37.50	62.50	
	Telephone facility	28.57	71.43	
	Fax	3.57	96.43	
Minimum requirement	Instruments	48.21	51.79	3
	Glassware	82.14	17.86	
	Chemicals	57.14	42.86	
	Air conditioner	10.71	89.29	
Human resource	Chemist/water analyst	75.00	25.00	4
	Microbiologist/bacteriologist	21.43	78.57	
	Laboratory assistant	51.79	48.21	
	Lab attendant	14.29	85.71	
	Data entry operator	17.86	82.14	
	Person engaged exclusively for sample collection	9.00	91.00	5
	Mobility allowance to sample collectors	8.93	91.07	
Sampling	Availability of written code/guidelines for sample collection in laboratories	52.00	48.00	6
	Retesting of positively tested samples for analysis validity and confirmation of results	66.07	33.93	7
	Maintaining record of test results	60.71	39.29	8

Categories	As prescribed in the protocol	Survey data (% of labs)		Figure
		1	2	
		Yes	No	
Field test kits	Purchase of FTKs in the last one year	26.79	73.21	9
	Distribution of FTKs to gram panchayats	25.00	75.00	10
	Checking FTKs for reliability and validity of testing	37.50	62.50	11
Safety measures	Staff awareness on precautions with hazardous chemicals	82.14	17.86	12
	Staff awareness on precautions with hazardous equipment	85.71	14.29	
	Availability of fire extinguisher	10.71	89.29	
	Availability of first-aid kit	26.79	73.21	
	Fume hood in the laboratory	7.14	92.86	

Source: Survey data.

Table 2.
 Provision vs. survey data.

4.1 Availability

Out of 56 laboratories, 73.21% of laboratories do not conform to the space norms for analytical and related purposes as prescribed in the protocol. About 82.14% of laboratories do not have separate space for biological testing of water samples as prescribed. In 87.50% of laboratories, sufficient space is not available for storing necessary chemicals, instruments, office equipment and furniture. About 58.93% laboratories devoid of computer, and 60.71% laboratories don't have internet facility. About 71.43% laboratories don't have the telephone and fax facilities.

The minimum instruments, glassware and chemicals required for testing of 13 basic parameters are not available in 51.79, 17.86 and 42.86% of laboratories, respectively. About 89.29% of laboratories do not have sufficient resources for testing of parameters (other than 13 basic parameters) such as heavy metals.

4.2 Human resource

Though survey data show posting of a chemist/water analyst in 75.00% of laboratories, they are not the regular staff. About 78.57% of laboratories don't have a microbiologist/bacteriologist for bacteriological testing of samples and their interpretation. In 48.21% of laboratories, laboratory assistants are not posted to assist a chemist/water analyst in analytical work. About 85.71% laboratories don't have a lab attendant. The posts of data entry operators for entering analysis data are vacant in 82.14% of laboratories. A 91% of laboratories don't have sampling assistants for collection, transportation and coding of sample. In 91.07% of laboratories, sample collectors are not paid mobility allowance for meeting basic travel expenses in sample collection.

4.3 Sampling

A 48.21% of laboratories don't have written code/guidelines to be followed during collection of samples. A 66.07% of laboratories reported to have conducted retesting of positively tested samples for validation, but the lab staff failed to

produce any documentary evidence in support of their claim. In 39.29% of laboratories, though staffs maintain separate register for positively tested samples, it was not found updated in 62.50% of such cases (62.50% of 39.29%).

4.4 Field test kits (FTKs)

In the last one year (prior to survey), 73.21% laboratories did not purchase FTKs for distributions to Gram Panchayats. Though 26.79% laboratories reported to have purchased FTKs in the last year, out of that only 37.50% of laboratories distributed them to Gram Panchayats. In 71.43% of laboratories, FTKs are not tested for validity and reliability of testing.

4.5 Safety measures

The staff in 82.14 and 85.71% of laboratories were found aware on safety measures while dealing with hazardous chemicals and equipment, respectively, but requisite safety measure, viz. fire extinguishers, first-aid kits and fume hood, was not available in 89.29, 73.21 and 92.86% of laboratories, respectively).

5. Discussion

5.1 Space crunch putting laboratory's staff and performance at risk

The unavailability of exclusive space especially for biological testing makes samples vulnerable for contamination, which in turn decreases the reliability of test results. Unavailability of sufficient space for storing necessary chemicals, instruments, office equipment and furniture is creating difficulty for staff to perform and also posing threat to them (Figure 1).

5.2 Devoid of office equipment

Because of the unavailability of computer and internet facilities, the laboratory staff have to visit PHE division or subdivision offices, which simply wastes time and energy, and it is also responsible for delayed and poor data entry. The lack of

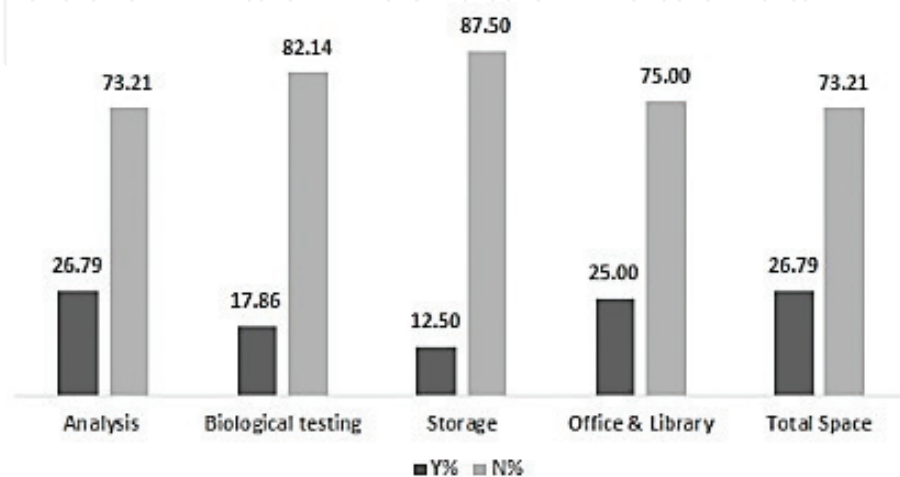


Figure 1. Availability of space in laboratories.

telephone and fax facilities results in irregular and delayed communication among different stakeholders such as sample collectors in field, community water users and higher officers (**Figure 2**).

5.3 Insufficient instruments/glassware/chemicals for testing of 13 basic parameters and heavy metals

Unavailability of minimum instruments, glassware and chemicals required for testing of 13 basic parameters and heavy metals is causing laboratories to under-perform. In the absence of air-conditioner or cooling facility, it is impossible to maintain optimum temperature for achieving accuracy in testing results. Because of the above gaps, none of 56 laboratories is able to achieve a minimum target of 3000 tests per year (**Figure 3**).

5.4 Dearth of qualified human resource

The lack of a regular chemist/water analyst in all 56 laboratories is making the undertaking of analytical work difficult. The absence of a microbiologist/bacteriologist is creating a problem in bacteriological testing of samples and their interpretation. It poses more threat in the case of drinking water sources, having damaged infrastructure like dilapidated hand pump apron, associated drainage systems and leaky distribution lines (**Figure 4**).

5.5 Faulty sample collection and record maintenance

Because of the unavailability of sampling assistants in laboratories, the work of sample collection, transportation and coding are severely affected. Not receiving payment for collecting and delivering samples even for meeting basic travel expenses is discouraging sample collectors. This ad hoc arrangement for sample collection has a negative effect on the performance of laboratories (**Figure 5**). The absence of written code/guidelines for sample collection is responsible for violation of sampling protocols, and it also raises serious questions on the accuracy of test results. Not retesting positively tested samples for validation raises doubts on the test results. Poor documentation especially of positively tested samples leaves no scope for future reference.

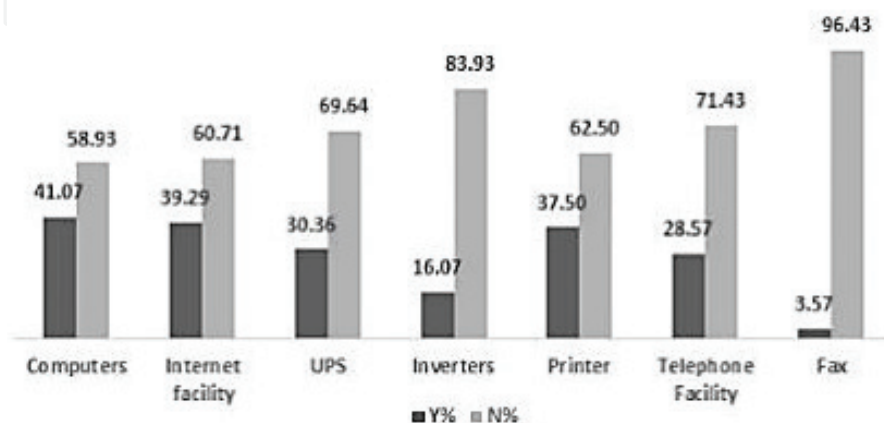


Figure 2.
Availability of office equipment in laboratories.

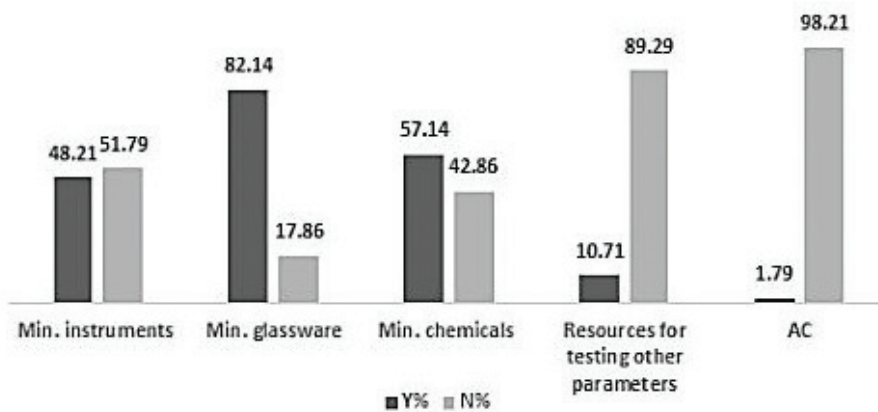


Figure 3. Availability of instruments/glassware/chemicals.

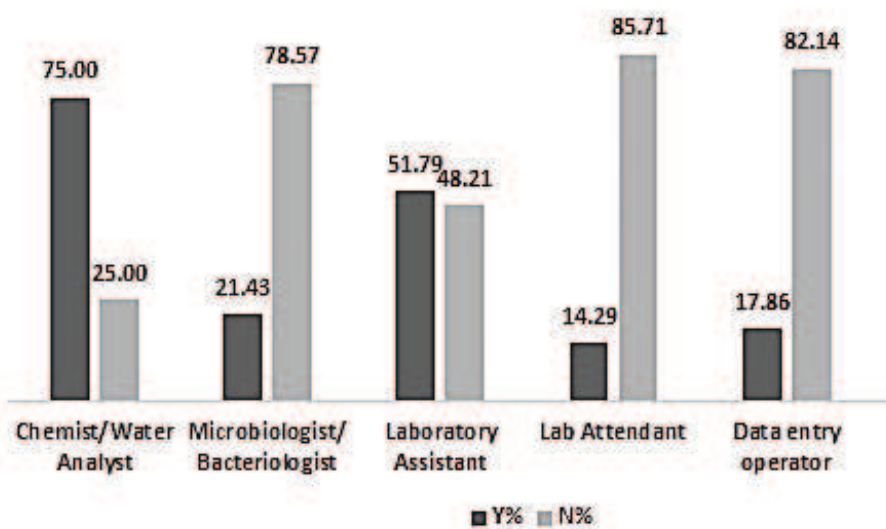


Figure 4. Availability of human resource in laboratories.

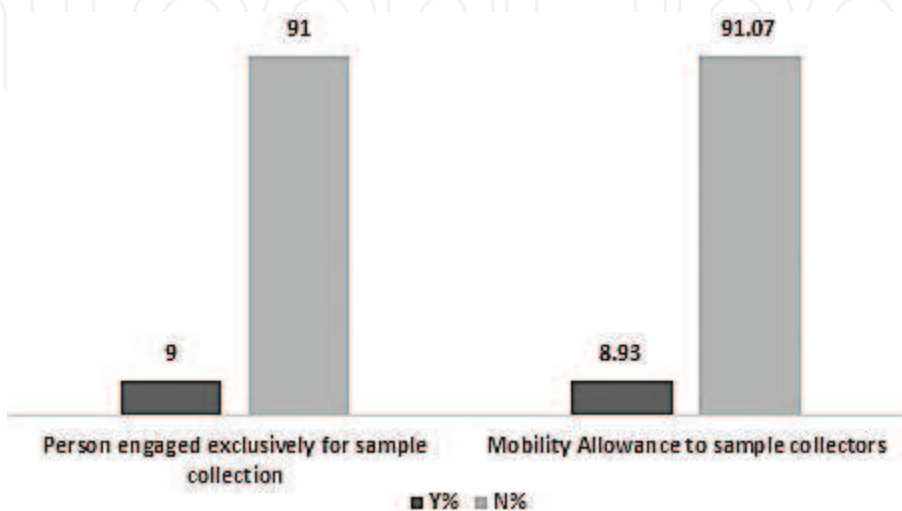


Figure 5. Sample collectors and mobility allowance.

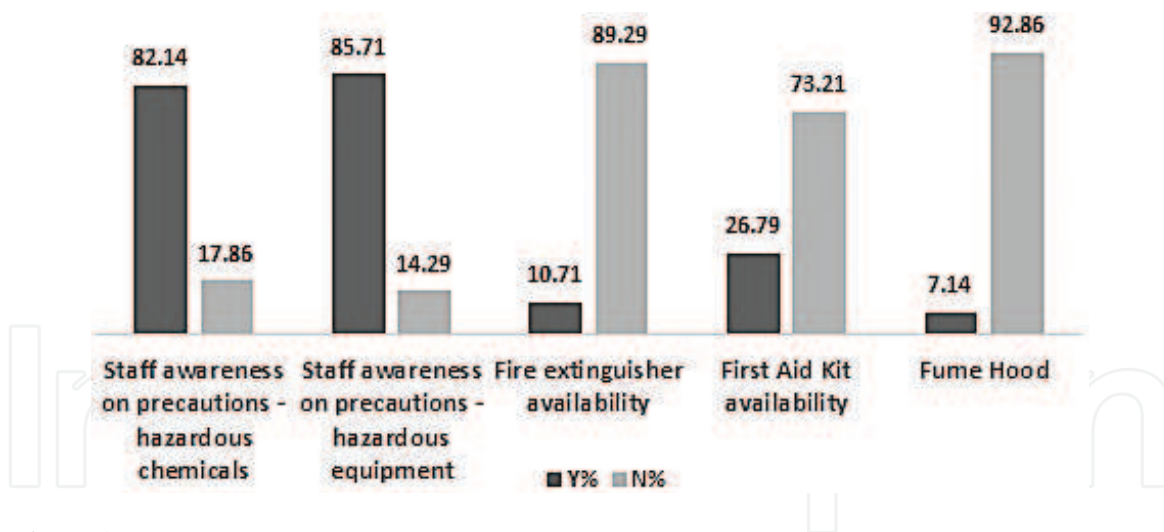


Figure 6.
 Awareness on and availability of safety measures in laboratories.

5.6 Nonexisting community participation in water quality monitoring through field test kits (FTKs)

FTKs serve the purpose of initial screening of contamination, but they also are an effective tool for awareness generation amongst the community to consume only safe drinking water. Since majority of laboratories did not purchase FTKs in the last 1 year (prior to survey), it raises serious question on community participation in water quality monitoring through FTKs. Not testing FTKs in laboratories for checking their validity and reliability for water quality testing results in wastage of resources.

5.7 Insufficient safety measures

Though survey data indicate high level of awareness amongst the laboratory staff on the safety measures while dealing with hazardous chemicals and equipment, in majority of laboratories, the absence of safety measures such as fire extinguishers, first-aid kits and fume hood in laboratories is posing threat to the safety of the laboratory staff. It also puts psychological stress on the staff while working in laboratories (**Figure 6**).

Because of the above gaps, none of the 56 laboratories in 16 districts is able to perform a minimum of 3000 water quality tests per year (annual analysis load).

6. Conclusion

6.1 Interdepartmental coordination for space sharing or availability

Since most of the district and sub-district offices of the Public Health Engineering Department are not having their own lands except for offices, land may be availed on lease from the District Land Revenue Department.

6.2 Development of procurement system

Minimum chemicals, glassware, instruments and office equipment as prescribed in the protocol must be made available in laboratories. For this a procurement

system may be put in place. This system will help laboratories in periodic need assessment, product quantification and forecasting, budgeting and procurement planning. The procurement function may also be outsourced to an external specialised agency.

6.3 Recruitment of qualified human resource and their capacity building

In order to achieve efficiency in functioning of laboratories, qualified staff in sufficient number must be posted on a regular basis. If it is not possible for the entire state for the want of finances, it may be ensured at least for districts having more number of quality-affected sources. For capacity building of the laboratory staff and community water users, capacity building module based on the “Uniform Drinking Water Quality Monitoring Protocol” of the Government of India comprising salient features may be used.

6.4 Developing cadre of sample collectors and their capacity building

Amongst community members, a group of people especially the youth may be selected for developing them as a cadre of sample collectors. Their services may be incentivised through pecuniary or non-pecuniary measures. The capacity of this cadre may also be built on the use of FTKs for preliminary investigation of water samples. Ground staff of other departments such as ASHA, Anganwadi workers, school teachers, GP members, social workers, etc. may also be involved in collection of water samples from the field.

6.5 System development for random checking of positively tested samples

A separate register may be maintained for positively tested samples. From this register, samples may be chosen on random basis and may be retested. This random checking of samples should be made a routine activity for the laboratory staff. Results of positively tested samples need to be conveyed to the staff of the Public Health Engineering Department for taking remedial actions. Water users fetching water from such sources must be informed immediately, and necessary actions should be initiated.

6.6 Availability of safety measures in laboratories

Safety measures in sufficient quantity should be made available in laboratories for the safety of the laboratory staff. Standards operating procedures (SoPs) to be followed during emergency situations may also be developed, and staff should be oriented on the same.

6.7 Technological intervention for real time data and information management

Considering the dynamic nature of water sources and prevalence of water-borne diseases, it is very difficult for nodal department/agency to monitor and maintain the water resources and schemes spread over a large geographical area. This herculean task may be made simple and effective with the involvement of local water user communities. The use of FTKs by the local community provides an excellent opportunity for this kind of participation. But it has some limitations such as availability of FTKs, replenishment cost, frequency, etc. The modern Information and Communication Technology (ICT) for information sharing may also be applied in the field.

6.8 Upgradation of laboratories to national or global standards

The National Accreditation Board for Testing and Calibration Laboratories (NABL) is a constituent board of the Quality Council of India. NABL has been established with the objective to provide the government, industry associations and industry in general with a scheme for third-party assessment of the quality and technical competence of testing and calibration laboratories. Some of the laboratories of the state may be thought of upgrading to the NABL standards and may be used for exposure and training purposes.

There are certain risk factors that are associated with increased mortality and morbidity. The unsafe water and lack of sanitation are included in those preventable risk factors. Unsafe water supplies and inadequate levels of sanitation and hygiene increase the transmission of diarrhoeal diseases (including cholera), trachoma and hepatitis [9].

In such state, the infrastructure which is responsible for assessing and monitoring the water quality is in dismal condition. Though the world is on track to reach the drinking water target, it is projected to miss the sanitation target if trends remained unchanged; global rate of progress will be negatively influenced especially by poor progress in populous countries like China and India.

In order to reduce the rates of important health indicators such as IMR and MMR, strengthening of water quality monitoring infrastructure is of utmost important. If done properly, this would have a positive impact on global goals such as the SDGs, because India has a large share in these goals to be achieved by the year 2030.

Annexure I

List of districts and number of laboratories assessed.

S. no.	District	District laboratories	Subdivision laboratories
1	Alirajpur	1	2
2	Barwani	1	1
3	Chhatarpur	1	3
4	Damoh	1	2
5	Dhar	1	4
6	Dindori	1	2
7	Jabalpur	1	2
8	Jhabua	1	1
9	Mandla	1	4
10	Panna	1	1
11	Rewa	1	4
12	Sagar	1	4
13	Satna	1	3
14	Sehore	1	3
15	Sidhi	1	2
16	Tikamgarh	1	2
Total		16	40

IntechOpen

IntechOpen

Author details

Abhishek Parsai* and Varsha Rokade
Maulana Azad National Institute of Technology, Bhopal, India

*Address all correspondence to: abhishek.parsai@gmail.com

IntechOpen

© 2019 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] UNEP. A Snapshot of the World's Water Quality: Towards a Global Assessment. 2016. Available from: https://uneplive.unep.org/media/docs/assessments/unep_wwqa_report_web.pdf [Accessed: March, 2017]
- [2] Slaymaker T. Framing Paper for JMP post-2015 Working Group on Water Last Updated: May 2012. WaterAid, Catarina Fonseca. IRC—International Water and Sanitation Centre [Accessed: March, 2017]
- [3] SRS. 2014
- [4] Cheng et al. 2013. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3293047/>
- [5] GoI. Faster Sustainable and More Inclusive Growth: An Approach to the Twelfth Five Year Plan (2012-2017). New Delhi: Planning Commission, Government of India; 2011 Available from: http://www.planningcommission.gov.in/plans/planrel/12appdrft/approach_12plan.pdf
- [6] MDWS. NRDWP Guidelines, 2013. Ministry of Drinking Water and Sanitation, Government of India. 2013. Available from: http://www.mdws.gov.in/sites/default/files/NRDWP_Guidelines_2013.pdf [Accessed: July, 2014]
- [7] BIS. Definition of Drinking Water Quality as per BIS Specifications—IS 10500:2012 (Revised) Standards for Drinking Water. 2012. [Accessed: July, 2014]
- [8] MDWS Protocol. Uniform Drinking Water Quality Monitoring Protocol of Ministry of Drinking Water and Sanitation, Government of India. 2013. [Accessed: July 2014]
- [9] UNICEF and World Health Organisation. Progress on Sanitation and Drinking Water, 2015 Update and MDG Assessment. 2015. Available from: <https://www.unicef.pt/progressos-saneamento-agua-potavel/files/progress-on-sanitation-drinking-water2015.pdf> [Accessed: March, 2017]
- [10] <http://pib.nic.in/newsite/PrintRelease.aspx?relid=98399>—This information was given by Union Minister of Health & Family Welfare Shri Ghulam Nabi Azad in written reply to a question in the Lok Sabha today
- [11] WaterAid. Drinking Water Quality in Rural India: Issues and Approaches. 2008. Available from: http://www.indiawaterportal.org/sites/indiawaterportal.org/files/Drinking%20Water%20Quality%20in%20Rural%20India_Issues%20and%20Approaches_WaterAid_2008.pdf [Accessed: March, 2017]