# Evaluation and Enhancement of Water Quality Laboratories in Rural CBOs of Sri Lanka with a Focus on Laboratory Quality Management Systems

**I.A Kalyanarathna**

**Abstract:** The majority of the Sri Lankan rural communities' drinking water requirements are managed by CBO based water supply schemes through groundwater and surface water sources. This study aims to evaluate and enhance the operational capabilities of CBO based water quality laboratories in different districts of Sri Lanka with a specific focus on the implementation and optimization of Laboratory Quality Management Systems. The need for this research is driven by the critical role these laboratories play in ensuring water safety with the limited formal education of the laboratory staff, chemical and laboratory supply deficiency, and many more limited resources that hinder the ability to provide accurate and reliable outcomes, potentially leading to water consumers' health at risk. Prior studies have pointed out the underdevelopment of laboratory capacities and also the lack of adaptability of the Laboratory Quality Management System (LQMS) to the laboratories. In these contexts, current practices and laboratory resource details were collected through laboratory analysts by a discussion and a questionnaire. The findings of the research highlighted critical operational issues in the CBO based laboratories. To overcome these issues, this study proposes a detailed approach that addresses overall issues including laboratory infrastructure, continuous awareness programs, applying LQMS to the rural laboratories, and better procurement and purchasing procedures for laboratory supplies. Moreover, this research suggests the strengthening plans for collaboration between CBOs and the government bodies in order to ensure greater adherence to water quality standards. The significance of this study emerges the potential to improve water safety monitoring in rural areas of Sri Lanka, ensuring access to clean drinking water. This research promotes sustainable water management and consumer health protection with the enhancement of the laboratory capabilities.

**Keywords:** Rural water quality, CBOs, Laboratory evaluation, Laboratory Quality Management System

## 1. Introduction

In Sri Lanka, Community Based Organizations (CBOs) regulate the accessibility of drinking water for

*I.A Kalyanarathna, Grad.Chem.,M.IchemC, PGD in Indus.Analy.Chem(USJP)*
*M & E Officer, DNCWS*
*Email: kalyanarathna.aruni@gmail.com*

the majority of rural communities. They rely on various types of water sources such as tube wells, shallow wells, streams, rivers, and rainwater harvesting systems. Due to the fact that many water sources are contaminated with various pollutants, purification of the water is done in CBOs as filtration, sedimentation, coagulation, disinfection, natural treatment systems, and a variety of other methods based on water source, water quality, and resource availability.

Nine CBO based water quality laboratories have been set up by the non-government organizations with the approval of the government to improve and ensure the quality of the water. Low cost, speed of delivering results, and convenience are some of the major reasons that CBO based laboratories are popular in rural communities.

As a developing country, Sri Lanka's rural CBO owned laboratories face significant challenges including inadequate maintenance of laboratory equipment, insufficiently trained laboratory analysts, and budgetary constraints resulting from inconsistent financial support. Those obstacles severely impact the effectiveness of the laboratory operation, affecting the reliability of water quality monitoring and assurance of safe drinking water for rural communities. (Mudalige, 2012) Laboratory process play a major role in all the key processes of detection, assessment, response, notification and monitoring. (Masanza et al., 2010)

Any testing or calibration laboratory that aims to produce technically valid data and reliable results must establish and maintain a robust management system, incorporating technical competence and impartiality as key principles. The laboratory should ensure that all quality requirements necessary to consistently deliver valid results are defined, implemented, and continuously improved through effective processes and competent personnel. (International Organization for Standardization, 2017)

Following appropriate quality control procedures can enhance accuracy and detect potential problems early on. (A. K. Buitendag et al., 2012). Within a resource limited setting, laboratories need considerable capacity development as there are many gaps in laboratory services. Finally this paper presents recommendations for an effective and reliable rural laboratory network in Sri Lanka.

## 2. Aims and Objectives

The primary aim of this research is to evaluate and strengthen the operational capacity of rural community based laboratories. By upgrading infrastructure, providing continuous training for the laboratory personnel, and implementing standardized processes through laboratory quality management systems (LQMS) with a business development plan, laboratories can improve their capability of providing the best service. Another main goal is to strengthen the partnership between CBOs and the government

organizations, ensuring the adherence to national water quality standards and promoting the collaborative approach to water safety.

Furthermore, this study emphasizes the importance of documenting the scientific data. Documented data important for future decision making in rehabilitations of the CBO water distribution systems, water quality monitoring, disaster management and for many researches also which eventually makes the rural water supply schemes more resilient and sustainable.

## 3. Literature Survey

Previous studies have highlighted that considerable challenges in resource limited rural laboratories. WHO and UNICEF jointly reports that low human resource capacity and lack of well-equipped laboratories are the key barriers for water safety monitoring in resource limited setting. (World Health Organization & United Nations Children's Fund (UNICEF), 2017)

Laboratory Quality Management System (LQMS) and long term monitoring frameworks improve laboratory operating effectiveness and compliance with water quality standards. (Allen, 2013; Wadhwa et al., 2012)

Earlier studies in Ethiopia and Kenya demonstrated that regular training and capacity development improve laboratory staff technical expertise and adherence to the regulations. (Kebede et al., 2019)

Laboratory capacity building cycle (Figure 1) has been introduced by the collaboration work of WHO and other global health initiatives. It mainly highlights the development of laboratories in main four ways. Infrastructure, Staff, System and Tools.

These findings highlights the importance of addressing the existing gaps in CBO managed laboratories. Gradual progress in filing out these gaps results, accuracy and reliability of the test results, and ultimately securing the health of the community.

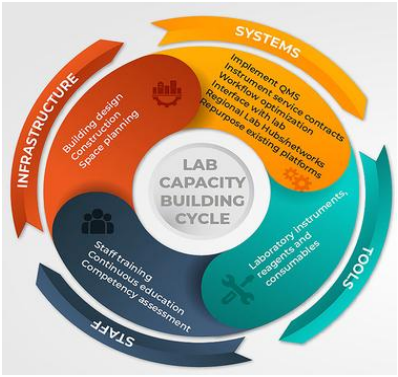


**Figure 1- Laboratory Capacity Building Cycle**

## 4. Methodology

This study used integrated methods to assess the operational capabilities of CBO based laboratories in Sri Lanka. All nine laboratories were selected for the study. Data collection involved structural discussions and questionnaires given to all nine laboratory personnel.

**Table 1- Selected CBO Based Laboratories**

| No | District | Laboratory Name |
|---|---|---|
| 1 | Kegalle | Kotiyakumbura |
| 2 | Ratnapura | Suwadiwi |
| 3 | Ratnapura | Sudarshana |

| | | |
|---|---|---|
| 4 | Monaragala | Suwashakthi |
| 5 | Nuwaraeliya | Prajashakthi |
| 6 | Nuwaraeliya | Isuru |
| 7 | Polonnaruwa | Rural Water Supply and Environmental Society |
| 8 | Kurunegala | Nildiyawara |
| 9 | Puttlam | Prajashakthi |

With those discussions and questionnaires, available laboratory resources, current laboratory practices, education of laboratory analysts, and setup of LQMS data were gathered.

The collected data was assessed qualitatively, identifying repetitive issues and common gaps in laboratory practices. This consists of the availability and maintenance of laboratory instruments, laboratory staff qualifications with experience, and the uniformity of the water testing procedures. A comparison was done with the global resource limited laboratories to identify their adaptability to address identified gaps in Sri Lankan CBO based laboratories.

According to the outcomes, a methodical plan was developed to enhance laboratory capabilities. This plan consists of laboratory infrastructure upgrades, setting up standard operating procedures that align with LQMS, continuous awareness programs for the laboratory personnel, laboratory documentation and audits, straightening the laboratory supply chain and business development plan. Moreover, fostering a plan to collaborate government bodies with the CBOs.

# 5. Results and Discussions

## 5.1 Laboratory Staffing and Training

Based on the study, all nine laboratory analysts' highest education levels are GCE A/L. Among them, five analysts have sat the GCE A/L in the science stream and the other four in the commerce and arts streams. Initial basic training has been given to laboratory analysts who were there when implementing laboratories. When considering the educational background of the laboratory analysts, all of them were minimally competent to carry out water testing with their limited knowledge in water testing. Due to a lack of training opportunities, the majority of laboratory analysts use inaccurate methods for testing without having basic knowledge. These outcomes highlight the crucial need for structured awareness programs that align with the laboratory staff education level, competency assessments, and structured audits in order to achieve reliable and consistent water testing in the CBO based laboratories.

## 5.2 Equipment and Resource Deficiencies

Most of the analyzed laboratories are going through essential chemical and consumable shortage, and over four laboratories operate under malfunctioning instruments and expired chemicals. Even though five laboratories have sufficient resources, they are in lack of the required knowledge and technical expertise to use them in proper way. This consists of laboratory operation,

instrument maintenance, and calibration. This has made a huge impact on delivering reliable water quality test reports for the community.

Cost effective solutions should be introduced due to the financial constraints of the rural laboratories. These laboratories regularly conduct test for various water quality parameters including, Color, Turbidity, pH and Electrical Conductivity (at $25^0$C), Total Alkalinity (as $CaCO_3$), Total Hardness (as $CaCO_3$), Free Ammonia (as $NH_3$), Nitrite (as $NO_2^-$), Nitrate (as $NO_3^-$), Chloride (as $Cl^-$), Sulphate (as $SO_4^{2-}$), Total Phosphates (as $PO_4^{3-}$), Fluoride (as $F^-$), Total Iron (as Fe), Total Dissolved Solids (TDS), Total Coliform at $37^0$C/100ml, E-Coli at $44^0$C/100 ml.

**5.3 Adoption of Laboratory Quality Management Systems (LQMS)**

The evaluation reveled that none of the laboratory has followed laboratory quality management system. About 6 out of nine laboratories didn't followed a standardized operational procedure and only three laboratories documented test results. All others didn't had proper documentation in calibration reports or test results. Those gaps highlights the poor reliability of the test results. Comparing with such resource limited global practices, implementing simplified LQMS focusing on essential quality management system will significantly improve the operational consistency. This would create more user friendly version of standard procedures that are easier to follow and understand.

**5.4 Proposed Interventions and Expected Outcomes**

Gradual implementation of LQMS ease the transition. Starting with basic quality assurance steps and gradual increase for complex aspects makes the analysts more confident on their work. LQMS helps in data driven decision making. Pilot project in one or two laboratories can implement and carryout in others with the lessons learned. Sustainable financial and technical support must be there to get the laboratories more success. With a proper business plan, CBO based laboratories can be success in financial way by doing water tests commercially.

To address these challenges simplified laboratory quality management system can apply as below.

(I). Prioritize key quality management elements by focusing on key factors that directly impact water testing accuracy and efficiency.

■ Process control- simplify SOPs for test methods in local language with visual aids. Introduce simplified checklists to evaluate the testing and calibration procedures.

■ Instrument management- Prioritization of essential instruments and ensure to calibrate and maintain in proper way.

(II). Laboratory Supply Chain

■ Introduce low cost, easy to use instruments and simple calibration methods by connecting suppliers or organizations with CBOs.

■ As most of the laboratories run through chemical shortage, suitable supply chain should introduced to the laboratories under government inspection

(III). Capacity development of the lab personnel.
■Personnel training- Conduct regular simplified water testing and quality awareness workshops with local experts using demonstrations. Trainings should focus on sample collection, handling, standard test procedures, simply understanding the test results and recognize the errors.
■Practical hands on training with visual aids and simple language will significantly improve the understanding of the importance of LQMS. All lab personnel should be in close contact of experienced professionals such as government chemists whom can supervise and follow-up the lab work regularly. Regular refresher trainings not only provide the knowledge, it also keeps the laboratory analysts keep engaged and capable of managing the system.

(IV). Documentation and Reporting
■Implement simple and effective record keeping templates for test results and calibration.
■Simplified SOPs and checklists will be easier for the analysts to manage the laboratory easily.
■Implement color code water quality classification and simplified test reports for easy interpretation to the community.

(V). Develop partnerships
■Collaborate with laboratories, government and privet organizations for technical support and chemical supply.

(VI). Simple audits and quality control
■Carry out simple internal audits and proficiency tests regularly to make sure the consistency of teat results.
■Implement checklists for testing process, instruments, and documents.
■Discuss the errors occurred and give solutions.
■Appreciation of the laboratory staff.

With gradual implementation of the above simplified LQMS, CBO based laboratories can deliver reliable test results with community trust. With that CBO based laboratories can get proper income and compete with other well equipped laboratories in the future. Further interventions can done using laboratory information management systems (LIMS) and artificial intelligence.

## 6. Conclusion

The primary conclusion to be drawn from this study is that the critical operational challenges faced by CBO based water quality laboratories in Sri Lanka are due to inadequate training, lack of laboratory supplies, and the absence of laboratory quality management systems. These limitations hinder the reliability of water quality testing and ultimately expose consumer health to danger.

To address these challenges, a comprehensive strategy was proposed, emphasizing infrastructure upgrades, laboratory supply chain, continuous training

programs, and the implementation of standardized procedures aligned with LQMS. Strengthening collaborations between CBOs and government bodies is essential for ensuring sustainable support and adherence to national water quality standards.

The findings underscore the importance of leveraging scientific data and structured interventions to enhance water safety monitoring. Implementing the proposed measures is expected to improve testing accuracy and reliability significantly, while fostering sustainable water management practices. This research contributes to building resilient water supply systems, ensuring reliable access to clean drinking water for rural communities, and supporting Sri Lanka's broader goals of sustainable development and public health protection.

## Acknowledgement

Heartiest gratitude to the Assistant General Manager (R&D) of the NWSDB and his team for invaluable guidance, unwavering support, and arranging a great symposium. I would like to extend my special appreciation to the Director General and Director Monitoring and Evaluation of DNCWS for the opportunity given to conduct the research. Last but not least, I extend my gratitude to the DNCWS district officers and mostly the laboratory analysts, who generously shared their time and insights, without whom this study would not have been possible. Their willingness to engage in the research enriched my understanding and added depth to the findings.

## References

A. K. Buitendag, A., S. Van Der Walt, J., Malebane, T., & De Jager, L. (2012). Addressing Knowledge Support Services as Part of a Living Lab Environment. *Issues in Informing Science and Information Technology*, *9*, 221–241. https://doi.org/10.28945/1618

Allen, L. C. (2013). Role of a quality management system in improving patient safety—Laboratory aspects. *Clinical Biochemistry*, *46*(13), 1187–1193. https://doi.org/10.1016/j.clinbiochem.2013.04.028

International Organization for Standardization. (2017). *ISO/IEC 17025:2017 – General requirements for the competence of testing and calibration laboratories*. https://www.iso.org/standard/66912.html

Kebede, M. A., Anbessie, B., & Ayano, G. (2019). Prevalence and predictors of depression and anxiety among medical students in Addis Ababa, Ethiopia. *International Journal of Mental Health Systems*, *13*(1), 30. https://doi.org/10.1186/s13033-019-0287-6

Masanza, M., Nqobile, N., Mukanga, D., & Gitta, S. (2010). Laboratory capacity building for the International Health Regulations (IHR[2005]) in resource-poor countries: The experience of the African Field Epidemiology Network (AFENET). *BMC Public Health*, *10*(Suppl 1), S8. https://doi.org/10.1186/1471-2458-10-S1-S8

Mudalige, D. (2012). Evaluation of Quality Assurance Measures

and Competency of the Staff in Non-Accredited Testing Laboratories in Sri Lanka. *Working Paper*.

Wadhwa, V., Rai, S., Thukral, T., & Chopra, M. (2012). Laboratory quality management system: Road to accreditation and beyond. *Indian Journal of Medical Microbiology*, *30*(2), 131–140. https://doi.org/10.4103/0255-0857.96647

World Health Organization & United Nations Children's Fund (UNICEF). (2017). *Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines*. World Health Organization. https://iris.who.int/handle/10665/258617