EVALUATION OF WATER QUALITY OF COMMUNITY MANAGED WATER SUPPLY SCHEMES IN SOUTHERN PROVINCE

Dewpura Acharige Madumalie Nimal Shanthi

(168889B)

Degree of Master of Science

Department of Civil Engineering

University of Moratuwa

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Dissertation submitted in partial fulfillment of the requirements for the Degree of Master of Science in Environmental Management

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Declaration

"I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Name of the supervisor: Prof. G.G. Tushara Chaminda

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Prof. G. G. Tushara Chaminda Date:

Name of the supervisor: Prof. J.M.A. Manatunge

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Prof. J.M.A. Manatunge Date:

Abstract

Water is a crucial element that covers two-thirds of the surface area of the earth, and it is one of the main substances in the body of every living being on the earth. Thus clean, safe, and adequate freshwater is important for secure good health. The National Water Supply and Drainage Board (NWS&DB) is the main responsible institution for providing safe drinking water within Sri Lanka. However, NWS&DB is unable to provide safe water to the country's entire population. Therefore, Community Managed Water Supply Schemes (CMWSS) were implemented as a solution for the existing water scarcity issues in rural areas of Sri Lanka. It was revealed that most of the CMWSS in Southern Sri Lanka are supplying raw water without proper treatment. So continuous monitoring, management, and evaluation of water quality in these schemes are essential to supply safe potable water. There are 172 CMWSS in the Galle district, and 10,814 families benefit from those schemes. On the other hand, there are 333 schemes in the Matara district, and 26482 families benefit from these CMWSS. In Hambanthota district, there are 182 CMWSS to provide drinking water for 38157 families. In this study, the water quality of selected CMWSS (71% out of total schemes) in the southern province of Sri Lanka was assessed by applying the Canadian Council Minister of Environment Water Quality Index (CCMEWQI). Altogether, water quality (WQ) of 488 (Galle 172, Matara 172, Hambanthota 144) CMWSS was evaluated under the 14 parameters such as temperature, turbidity, pH, electrical conductivity, total hardness, nitrate, iron, fluoride, *E. coli*, total coliforms, Mn, Pb, As and Cd, using Standards method of American Public Health Association and compared with the Sri Lankan Standards for drinking water (SLS 614 2013). Water Quality Index (WQI) was also developed for each source and rated as Excellent, Good, Medium, Bad, and Very Bad. Developed WQI revealed that none of the CMWSS in the southern province categorized as "Very Bad" quality (0-25). Among 488 schemes in the province, only (2.3%) 11 schemes belonged to the "Excellent" category (91-100) based on this WQI. Majority of the schemes (39.1%) had the WQI between 26-50 and rated as "Bad" and need to have secondary treatment. There were 33.8% of CMWSS that belonged to the "Medium" category (51-74) of WQI and 24.8% in the "Good" category (75-90) which were not suitable for drinking without preliminary treatment. More than half (56.3%) of CMWSS in Hambanthota district were in the 'Bad' category. Therefore, Hambanthota district CMWSS were highly contaminated than those in Galle and Matara districts. It was noted that raw water of (97.7%) 477 CMWSS in the southern province need to be further treated for *E. coli*, total coliforms, conductivity, hardness, iron, fluoride, pH, and turbidity. The questionnaire survey revealed, that 62.6% of consumers used water without any treatment. It is recommended to educate consumers of CMWSS on basic household treatment systems so that they can treat the water before consumption. It is also required to introduce more cost-effective treatment procedures for the consumers as the majority of the household in the southern province monthly income is less than Rs.25,000.

Keywords

Water Quality, CMWSS, Southern Province, WQI, Drinking Water

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List of abbreviations

Abs	Absorbance
APHA	American Public Health Association
BOD	Biological Oxygen Demand
CBO	Community Based Organization
CCME	Canadian Council of Ministers of the Environment
CKDU	Chronic Kidney Disease Unknown
CMWSS	Community Managed Water Supply Schemes
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DS	Divisional Secretariats
EC	Electrical Conductivity
EDTA	Ethylene Diamine Tetra Acetic acid
GN	Grama Niladari
GPS	Global Positioning System
IQ	Intelligence Quotient
MDG	Millennium Development Goals
MOH	Medical Officer of Health
NGO	Non-Governmental Organization
NSFWQI	National Sanitation Foundation Water Quality Index
NTU	Nephelometric Turbidity Units
NWS&DB	National Water Supply and Drainage Board
OWQI	Oregon Water Quality Index
RWSS	Rural Water Supply and Sanitation

SLS	Sri Lanka Standards
SLSI	Sri Lanka Standards Institute
UNICEF	United Nation International Children's Emergency Fund
US EPA	United States Environmental Protection Agency
UV	Ultra Violet
UWQI	Universal Water Quality Index
WAWQI	Weight Arithmetic Water Quality Index
WBBS	Water Board Bulk Supply
WHO	World Health Organization
WQI	Water Quality Index

1. INTRODUCTION

1.1 Background

The Southern Province of Sri Lanka is a small geographical area comprised of three districts: Galle, Matara, and Hambantota which are classified into different Agro-climatic/Agro-ecological Zones mainly Low Country Wet zone (Galle and Matara districts) and Low Country Dry Zone (Hambantota district). All three districts have their natural resources and beauty while commonly one end is margined by the Indian Ocean. Farming, fishing, and tourism are the main sources of income in this province.

Water is a major element that covers two-thirds of the surface area of the earth and it is one of the main substances of the body of any living organisms on the earth (WHO, 2010). The distribution of the world's water is depicted in Figure 1.1. Water circulates throughout the land and it does dissolve, replenishing organic matter and nutrients, transporting and carrying away waste material.

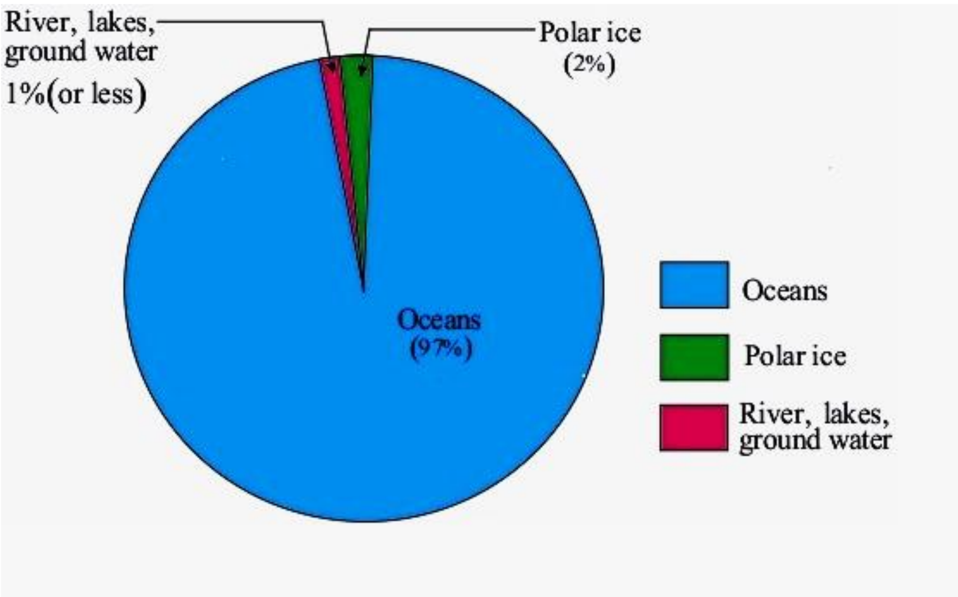

Figure 1.1: Distribution of the world's water

Source: (Ecology 6th Edition Textbook Solutions | Chegg.com)

According to Nobel Laureate Richard Smalley, water would be the second major problem among the top ten problems for humans, next to energy, in the next 50 years (Kumar et al. 2014). Water is required for a variety of domestic purposes, including drinking, cooking, bathing, washing, and gardening. In addition, people also require water for variety of other activities such as, livestock, gardening, crop cultivation, processing food, aquaculture, fisheries etc. (Timilsena, 2020; Kopper et al. 2006). Water is necessary for survival in rural and semi-urban areas of developing countries where agriculture is the major occupation. Water is also essential for survival and maintaining good health. However, people all over the world are facing with physical and economic water scarcity. Due to the scarcity of water, people were forced to use contaminated water for drinking and other domestic purposes. (WHO, 2009). Thus, clean, safe, and sufficient freshwater is crucial for the survival of all living organisms as well as the smooth and sustainable operation of ecosystems, communities, and economies of countries.

Deteriorating water quality has become a serious global issue as the world population grows and the expansion of industrial, construction, and agricultural activities. As a result, the climate is being changed and it drastically affects the hydrological cycle and water quality. Further, Water quality issues are extremely complex and various. Therefore, Urgent global attention and action are required (Obilonu, 2013)

Drinking water is mainly obtained from the sources such as surface water (e.g., rivers, natural lakes, and reservoirs) and groundwater. One of the essential components for a healthy life is drinking enough hygienic water, but in many parts of the world, particularly among children, water-borne diseases are the major cause of death. (Fawell et al. 2003). Furthermore, water quality and the risk of water-borne diseases are crucial public health issues in many developing countries. According to WHO/UNICEF (2012), about 1.0 billion people in developing countries do not have access to safe and sufficient drinking water while 2.4 billion people do not have adequate sanitation. 700.0 million do not have access to safe water in the Asia and Pacific region, and 2.0 billion people without access to adequate sanitation. The World Health Organization (WHO) also estimated that unsafe drinking water, inadequate sanitation, and poor hygienic practices cause approximately 94 percent of global diarrheal problems and 10 percent of total disease problems. (Fewtrell et al., 2007). Moreover, Due to contaminated water, and inadequate sanitation, 1.8 million people die from diarrheal diseases each year (WHO-UNICEF, 2010).

As a result, providing safe and adequate water improves productivity and personal health. Improvements in water supply and sanitation have a significant impact on the possibility of health and economic benefits (Peter, 2010). Therefore, rural water supply schemes should provide the expected service to users for a reasonable period of time Sustainability is defined in terms of quality, quantity, accessibility, coverage, and continuity (Harvey and Reed, 2004).

The quality of water delivered to users is one of the most important factors influencing service delivery and the continued use of rural water supply schemes. (Schouten and Moriarty, 2003). Human feces, wildlife, livestock, untreated wastewater from domestic and agro-industrial activities, and uncontrolled flooding have all harmed the quality of drinking water. (Lencha,2012).

When the people get intermitted water supply, deterioration is taken place in the water quality (Doria., 2010). One of the famous alternative solutions for the drinking water purpose is rainwater harvesting system, but it might have been affected by contamination of pathogens and thereby its microbial quality can be poor (Lye, 2002). When considering drinking water quality, the most important aspect causing diarrheal disease is the contamination of pathogens (especially from human fecal matters) . If the physical, chemical, and/or bacteriological requirements for drinking water are not met, people may avoid using water supply schemes and turn to hazardous sources; they will also be exposed to more chronic and acute diseases. (Karn and Harada, 2002). This will bring a challenge in meeting the Millennium Development Goals (MDGs) of ensuring environmental sustainability, improving health, and eradicating extreme poverty of the rural majority living in the developing countries (United Nations, 2005).

It is also observed that an excessive amount of fluoride in groundwater is mainly confined to the dry zone. Due to excessive amounts of fluoride in drinking water, it is reported to have dental fluorosis in residents in some places of the North-Western, Eastern, North-Central and Southern regions (Hickey, 2008).

Moreover, a significant proportion of the population has less access to improved services, and those who have access are concerned about the quality of services such as water quality, Moreover, a large proportion of the population does not have access to improved services, and those with access are concerned about the quality of services such as water quality, adequacy, reliability, and response to consumer complaints by the relevant officers of the water schemes adequacy, and response to consumer complaints by the relevant officers of the water schemes. By the year 2015, the United Nations Millennium Development Goals (MDG) aims to reduce the proportion of people without sustainable access to basic sanitation and safe drinking water by 50 %. (WHO, 2010). In line with this, the Sri Lankan government has set targets to provide 85 % of the population with safe drinking water and basic sanitation facilities by 2015. Further, it has set a goal of providing access to safe drinking water and basic sanitation to 100% of citizens and has acknowledged the importance of well-being and health of people for social and economic development by the year 2025 (Ediriweera, 2005). However, by the year 2009, 35 % of the population of the country had access to pipe-borne water and 84.8% had access to safe drinking water (Central Bank, 2009).To achieve these targets in a sustainable manner, Sri Lankan Government has focused on a significant Rural Water Supply and Sanitation (RWSS) sector reform program and invited all the non-government and government organizations as placing a high sense of beneficiary involvement in decision making at all stage of subproject implementation.

A public water supply system can be defined as a community-managed water supply that serves a minimum of 25 residents throughout the whole year and it may consist of one or multiple reservoirs or wells (Mimrose et al. 2011). One of the principal institutes under the administration of the Ministry of Water Supply and Drainage is the National Water Supply and Drainage Board (NWS&DB), which is the main responsible institution for providing safe drinking water within Sri Lanka. Anyhow, the NWS&DB is not able to provide safe water to the entire population who needs their service due to some difficulties such as lack of financial facilities to invest in such projects and the increment of demand from the urban sector. As a remedy to this problem, community-managed water supply schemes have been launched by the Government with the support given by International and National funding agencies and Non-Government Organizations (NGOs) and maintained by community-based organizations (CMWSS) in Sri Lanka (Mimrose et al. 2011).

According to NWS&DB, 90.6% of the Sri Lankan population has safe access to drinking water, of which 50.5% is covered by a pipe-borne water supply system by NWS&DB, and the remaining fulfill their requirements in alternative ways such as hand-pumped, tube wells, protected dug wells, rainwater harvesting, etc. (NWS&DB 2018). Figure1.2 and Figure 1.3 depict Access to safe water coverage and the Distribution of drinking water among the total population respectively.

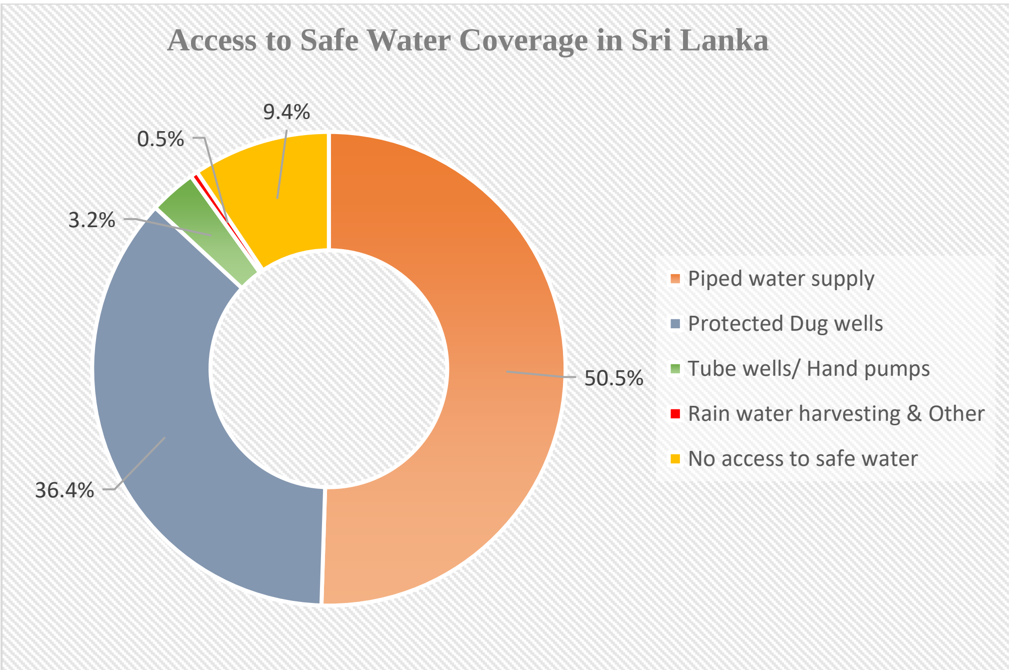

Figure 1.2: Access to safe water coverage

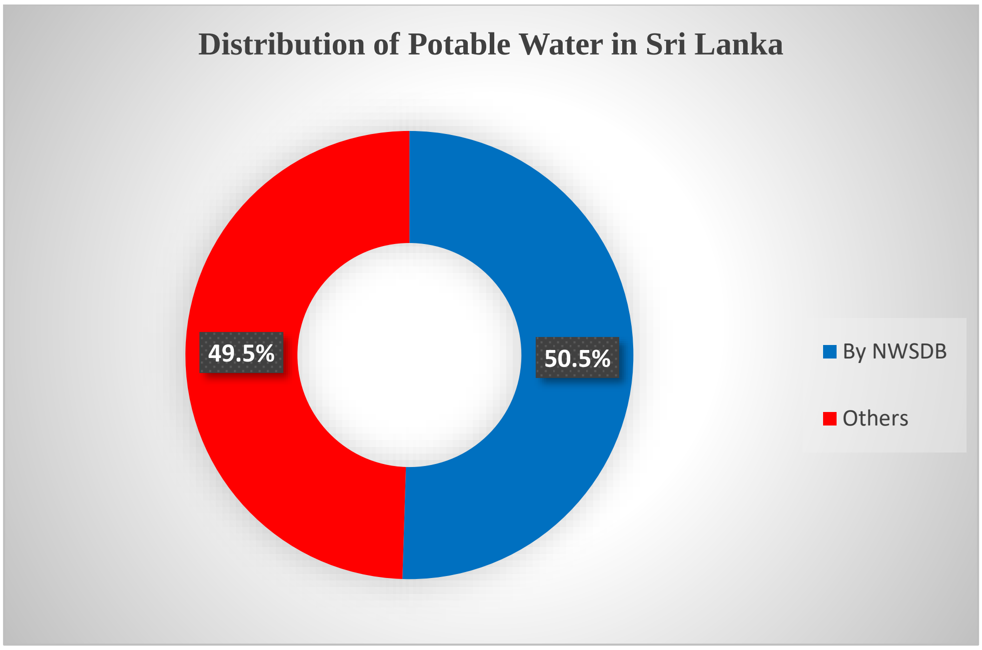

Figure 1.3: Distribution of drinking water among total population

Source: (NWS&DB Annual Report 2018)

In Sri Lanka, about 10.5% of piped-water supply and most of the rural water supply schemes are covered by the CMWSS (Mingyuan Fan, 2015). The water quality of a significant number of CMWSS in Southern Province are not at an acceptable level (NWS&DB, 2007).

Groundwater in Sri Lanka is considerably used for different purposes such as agricultural, industrial, domestic, and other purposes. Groundwater quality is considerably varied throughout the country depending on, hydro-geological conditions, geology, prevailing rainfall, and topography and agricultural, construction and mining activities as well as rapid urbanization.

In Sri Lanka, the river is the main source of water supply for the drinking purpose and anyhow in some areas boreholes and irrigation tanks are used as a source of raw water. Nilwala River is the main source of raw water in Matara district for the water supply scheme (Ellawala et al. 2016), in Galle it is 'Ginganga' river while in Hambantota it is Walawa River.

Wells in Hambantota district used for domestic purposes were evaluated from 2006 to 2007 at monthly intervals to study the water quality due to the compliant given by Medical Officer of Health (MOH), that presence of Calculi in the urinary tract causes diarrhoeal diseases and renal failure, Study results reveals that analysed parameters were within acceptable limits except for ammonium, phosphate, nitrate and sulphate (De Silva,2013).

1.2 Problem Statement

In countries like Thailand (Kruawala et al.,2005), Zimbabwe (Hoko,2008), Malawi (Mkandawire and Banda,2009), and India, various researches on drinking water quality supplies have been undertaken in both rural and urban settings (Suthar et al., 2009). But, studies in Sri Lanka have focused mainly on the technical functionality of water supply schemes, multiple uses of water infrastructure, equity and drinking water sanitation and supply.

The existing water supply systems in the country can provide water only to a limited number of households (NWS&DB 2007) due to various reasons and one of the major reasons is the lack of quantity and quality of water resources not only in the Southern province but throughout the country.

Seawater intrusion may have been the affect for the quality and quantity of groundwater resources located along the coast (all districts in Southern province) in Sri Lanka. Due to the over-extraction of groundwater near the coastal area, groundwater may have declined and it may cause an influx of saline water. This effect can be reduced by constructing salinity barriers and limiting pumping until aquifers are recharged (Mingyuan Fan, 2015).

North-Central province people have suffered from Chronic Kidney Disease Unknown etiology (CKDU) for over 20 years due to low-quality water, (Chandrajith et al,.2010) and it was also reported that the disease is spreading among other provinces which are mainly located in intermediate or dry zone (Hambantota district from Southern province). Contamination of Arsenic or Cadmium in drinking water which is present in fertilizers, pesticides, and weedicides may be the main reason for this issue. Further high levels of hardness and fluoride may also involve in this issue. As a remedy a small reverse osmosis system will be implemented to remove fluoride and hardness from groundwater. For small communities, a rainwater harvesting system can be used as an option instead of a water purification system (Mingyuan Fan, 2015).

Unfavorable water contamination and lack of water quality testing have increased the difficulties of securing safe water sources. Contaminated water sources in rural areas have led to infectious and parasitic diseases among people. The Government of Sri Lanka adopted the Community Managed Water Supply Schemes (CMWSS) in order to increase the country's water supply coverage and achieve 100 % water supply coverage in most regional areas, including the Southern province. In this regard, the government emphasizes groundwater development for the drinking water supply in these areas.

Rural Population of Southern Province (Galle, Matara, and Hambanthota districts), water supply is monitored by CMWSS. These schemes are constructed with the participation of the community. Figure 1.4 shows the involvement of consumers to raise a community water scheme in Matara.

In Galle district, 172 community-based organizations are functioning and 10,814 families consume water from the above schemes. There are 333 CMWSS functioning in the Matara district and 26482 families consume water from the above schemes. In Hambanthota district there are 182 CMWSS to cater drinking water demand of 38157 families. These CMWSS use various water sources such as streams, springs, lakes, rivers, dug wells, tube wells and water board bulk supply.

But most of the schemes are supplying raw water without proper treatment. Therefore, many consumers of this province have complained regarding taste, colour, and the deposition of white layers in cooking appliances due to the high amount of hardness. MOHs of these Divisional Secretariats and related health organizations also have complained to the relevant authorities regarding water-borne diseases among these people. Although the quality of water is monitored physically that is not monitored numerically by relevant local authorities of Southern province. So continuous

Figure 1.4: Community participation for construction work of water scheme

monitoring, management, and evaluation of water quality in these schemes are essential to supply safe drinking water.

In the country, systematic research on water quality parameters and the connection between water quality and the viability of Community Managed Drinking Water Supply Schemes ha been lacking.. Therefore, the aim of this study was to evaluate the quality of drinking water from CMWSS, develop the water quality index and suggest solutions to solve the problem of water quality issues. This research was conducted by the Faculty of Engineering, the University of Ruhuna in collaboration with the ministry of irrigation and water supply, Southern Provincial Council, and the Department of National Community Water Supply.

1.3 Objectives of the research study

The aim of this study was to evaluate the water quality of Community Managed Water Supply Schemes (CMWSS) in three districts (Hambanthota, Galle, Matara) in Southern Province. Three objectives of this study are,

i. To study the Physical, Chemical and Biological quality of CMWSS in southern province Sri Lanka.
ii. To develop a water quality index (WQI) for CMWSS in southern province.
iii. To recommend to improve CMWSS in southern province.

2. LITERATURE REVIEW

2.1 Southern province

Southern province consists of three districts such as Galle, Matara and Hambantota which are located along the sea. Figure 2.1 is depicted location of southern province.

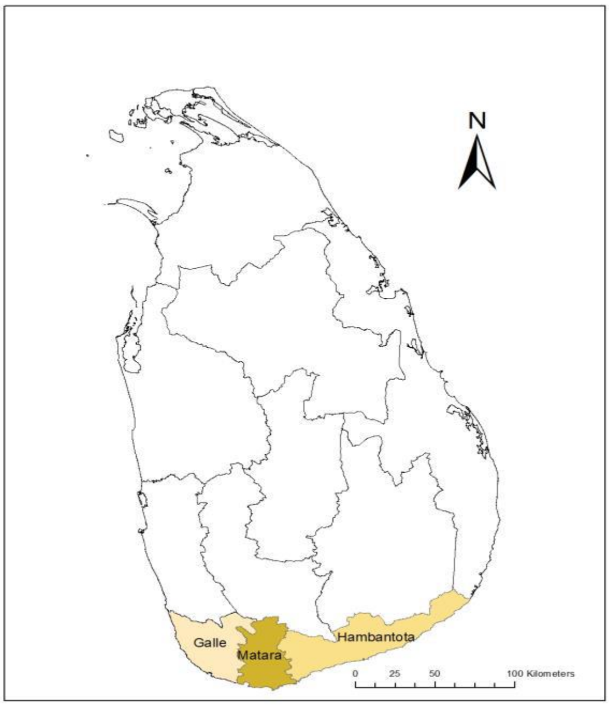

Figure 2.1: Location of Southern Province

Southern province represents twelve percent (2,477,285) of Sri Lankan population. Out of the total population in the province, 1,063,334 (42.92 %) belongs to Galle district. Matara district population is 814,048 (32.86%) and Hambantota district population is 599,903 (24.22%) (Department of Census and Statistics, Sri Lanka, 2012). Galle has 19 District Secretarial (DS) divisions while Matara and Hambantota have 12 and 9 respectively. More than 85% of the people in each district (87.7% of the population of southern province) live in rural sector. Literacy level of the province is 95.3% (in each district it is more than 94%) while computer literacy level is around 22.4%. According to Provincial Planning Secretariat, Southern Province and statistic data (2018), total population of southern province is 2,637,000. Out of the total Galle

1,124,000, Matara 858,000 and Hambanthota 655,000. Population of southern province in 2018 is depicted in Figure 2.2.

Important landmarks of the province include the wild sanctuaries of Yala, Udawalawa national park and Sinharaja the tropical virgin rain forest. Further, three major rivers i.e., Ginganga, Nilwala and Walawa run through Galle, Matara and Hambantota districts respectively. Ussangoda in Amabalangoda is a panoramic view of the beach and the sea and others are the holy city of Kataragama and the ancient cities of Tissamaharama, Kirinda and Galle. Historic Dutch fort, natural harbour and international cricket ground add extra beauty and economic value to Galle city. Tourism, farming and fishing are the major occupations.

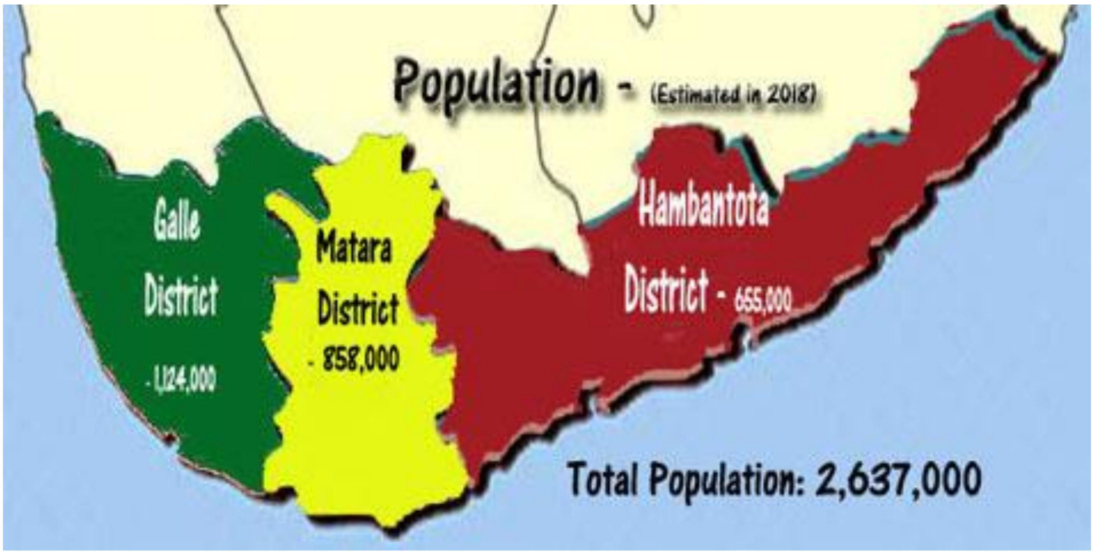

Figure 2.2: Population - Southern province 2018

Source: (Provincial Planning Secretariat, Southern Province-Sri Lanka)

2.2 Safe water scarcity (physical and economical) and related problems

Physical water scarcity means the lack of enough safe water for the population while economic scarcity related with the lack of enough financial facilities to establish safe water supply schemes and related institutes.

Water in sufficient quantity and safe quality is necessary for human survival. Rapid population growth and economic development puts tremendous pressure on limited freshwater resources. Climate change is also threatening the availability and safety of water resources. Water is a medium for disease transmission in all countries, hence drinking water quality is a public health concern worldwide.

2.2.1 World

Even though water supply and sanitation coverage has increased in many developing countries including Sri Lanka, there is uneven progress between urban and rural areas (Hutton & Bartram, 2008). Access to safe drinking water is the proportion of people using improved drinking water sources such as household connections, public standpipes, boreholes, protected dug well, protected springs, and rainwater (WHO, 2010). About 94 % of the urban population of developing regions uses improved sources while only 76 % of rural populations have access to improved sources. Poor or absence of safe water may lead to creating many problems, such as more time and energy consumption for collecting and carrying water and insufficient water to maintain good hygiene practices (Hunter *et al*., 2010). World Health Organization (WHO, 2010) estimated that 1.6 million deaths per year in the world are attributed to the use of unsafe water.

Only 71%of the global population (5.2 billion) used a safely managed drinking-water service while 89% used at least a basic service. 844 million people lack even a basic drinking-water service including 159 million people who collect untreated surface water from lakes, ponds, rivers, and streams. At least 2 billion people in the world use a drinking water source contaminated with feces (WHO, 2015).

Contaminated water (chemical and biological) and poor sanitation are linked to the transmission of diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid, polio, acute and chronic diseases caused by parasitic worms (ex. schistosomiasis), and other insects that live or breed in water transmit diseases (ex. dengue, malaria, etc. fevers), cancer and kidney diseases. Improved more accessible and good water sources mean spending less time and effort to physically collect water and less expenditure on health and hence people are better able to remain economically productive.

Increasing water scarcity, climate change, demographic changes, population growth, and urbanization put challenges on water supply systems. Half of the world's population will live in water-stressed areas by 2025. Hence, re-use of wastewater (after proper treatments) to recover water, rain-water harvesting, and use of community-managed small water schemes, etc. are becoming some important strategies.

2.2.2 Sri Lanka

Because of human activities, the major problems facing today are the depletion and degradation of water resources in the country. When considering surface inland waters, in urban areas are polluted with domestic sewage and industrial effluents while in rural areas with agricultural run-off and land mining. Groundwater in urban areas is mainly contaminated with unwanted micro-organisms and some heavy metals and in other areas especially in the dry zone, groundwater contains high fluoride contents, while some areas contain high calcium, chlorine, or iron.

Approximately 75% of the population of Sri Lanka lives in rural environments obtaining their drinking water directly from the ground (Dissanayake, 2005). Six main types of groundwater aquifers have been identified and demarcated by studies conducted during the last 25 years. They are; the Shallow Karstic Aquifer of Jaffna Peninsula, Deep Confined Aquifers, Coastal Sand Aquifers, Alluvial Aquifers, Shallow Regolith Aquifer of the Hard Rock Region, South-Western Lateritic (Cabook) Aquifer (Panabokke & Perera, 2005). Groundwater contamination is described by Harter (2003) as an undesirable change in groundwater quality caused by human activities. Considering the quality of groundwater depends on certain factors such as the quality of recharged water, atmospheric precipitation, inland surface water, and subsurface geochemical processes.

Unplanned garbage disposal becomes a severe threat to groundwater quality in Sri Lanka. Currently, Sri Lanka does not have a single sanitary garbage disposal ground that meets the internationally recommended standards. Open dumping sites in natural areas cause pollution of both ground and surface water.

Though pipe-borne water supply, irrigation, and hydropower schemes are well managed, other water resources are in general very poorly managed (Bandara. 2003). Waterborne and vector-borne diseases (mainly dengue fever) are common, especially among urban low-income communities due to poor sanitary and drainage facilities while CKDU is seriously spreading among rural low-income communities in dry and intermediate zones like North-central, North, East, and South-Eastern provinces.

2.3 Water supply and human health

A secure, easily accessible and reliable water supply is vital for preserving a healthy life. The protective role of water is unseen and it plays a significant role in developed countries to essence wellbeing of the people and to alleviate poverty. Water and health are considered as precious resources which worked together to enhance the development prospects of a country. But billions of people in developing countries lack access to a sustainable and safe water supply. According to the projections for 2025, a lot of countries in the African and Asian region will be faced an absolute water shortage of fresh and safe water. At least fifty liters per day is required by an individual to ensure all domestic uses, laundry and personal hygiene (Hunter et al., 2010). However, much of the disease burden in developing countries are related to inadequate amounts of clean and quality water for domestic purposes and poor hygiene standards (Hoek et. al., 2002).

The main reasons for limited progress in universal access for sufficient and sustainable water supply in developing countries like Sri Lanka are high population growth, low capital investments and ineffectiveness of policies and institutions to mandate sustainable community managed water supply in urban and rural areas and to increase the coverage of community management systems (Howard, 2003). Therefore, energetic efforts should be made to enhance sustainable and safe water supply in these countries. Consequently, the development of different aspects of water supply accelerates public health.

2.4 Problems related with water supply in Sri Lanka

According to Department of Census and Statistics data (2012), 40.6% of Sri Lankans have organized water supply systems and 59.4% have depended on other water resources. In general, in different provinces like the southern, the deterioration of quality and quantity in both ground and surface is an emerging issue. Therefore, the affordability of safe water supply is dramatically decreased. Due to that many people suffer from a lack of access to a safe water supply.

So, the Sri Lankan government has set a goal of providing a secure drinking water supply by 2025 for all citizens. But various obstacles have been encountered by the government in extending the coverage throughout the country. Some of them are rapid urbanization, water scarcity and degradation, insufficient capital resources to expand the coverage, high maintenance cost and high cost for purification process, deficiency in cost recovery and lack of effective institutional systems to distribute water resources among consumers (Seneviratne, 2000). To scale up the water coverage and to ensure sustainable water supply, the Sri Lankan government moved towards Community Managed Water Supply Schemes.

2.5 Importance of commencing CMWSS in Sri Lanka

Drinking water supply of Sri Lanka is self-sustained. The demand for drinking water increased greatly in the recent decade due to its growing population (Shayan et al., 2020). National Water Supply and Drainage Board has raised the responsibility of supplying drinking water and maintaining the quality of water. However, rural areas in Sri Lanka have low access to drinking water when compared with urban areas because National Water Supply and Drainage Board (NWS&DB) cannot cater to the potable water demand. According to the statistical data of NWS&DB (2011), NWS&DB provides water to 34% of the population in Sri Lanka. Also, local government water supply systems provide water to 10% of the population in the country. NWS&DB is supplied water according to the standards in SLS 614 in 2013.

Globally, there is a growing trend towards a participatory approach that involves citizens in managing local environmental resources (Agrawal, 2001). Therefore, community management is also seen as a part of the solution if all citizens have access to potable drinking water (Calzada et al, 2017; Whittington et al, 2009). However, NWS&DB is faced many difficulties when providing its services to the entire population in Sri Lanka. Also, they do not have enough investment to cover the entire population. Not only that but also NSWDB is overwhelmed by rising demand from urban areas. Due to the inadequacy of potable water, the Sri Lankan government has introduced the concept of Community Managed Water Supply Schemes (CMWSS) to supply water to rural areas. High expenditures and the complexity of water supply management in rural and suburbs by the Line Ministry have led many governments to think about community involvement as a tactful strategy to provide a sustainable water supply system (Ademiluyi and Odugbesan, 2008).

According to Montgomery et al. (2009) people in these communities worked together to obtain safe drinking water by collecting their resources and extracting water from on-site water sources near this community. The public water supplies that serve at least 25 inhabitants throughout the year are defined as Community-managed water supplies. These systems can include one or more reservoirs or wells (Mimrose et al., 2011). There are a lot of different definitions of CMWSS. As specified by NWS&DB (2011), municipalities with up to 5000 feeders can be categorized under this scheme.

2.6 Limitations in CMWSS

Assessment and progress monitoring is a significant tool for managing various kinds of projects. Therefore, communities must raise the management responsibilities to develop appropriate monitoring and evaluation tools for such a project. Because the effectiveness of the project is mainly linked with community involvement. Often, agency monitoring and evaluation are primarily concerned with the technical aspects and quantitative aspects of system development, operation and maintenance. Although a broader approach has been taken, the information gathered is often the primary use for agencies. The community has its information requirements to perform administrative functions.

Community is a complex social reality. Therefore, in the case of, water supply management cannot be isolated from other concerns. So, a clear understanding of the social, cultural and economic characteristics of the community is essential to build up successful management capabilities (Lammerink et al., 1999). But a lot of issues are occurred due to less community involvement in developing such an approach in developing countries such as Sri Lanka. Because majority of the rural communities have the dependency culture. This is the foremost issue experienced by the government and other parties when implementing these community participatory approaches. Due to paternalism between the government and rural people, it is hard to penetrate the idea that communities need to take on responsibilities. Under these circumstances, communities do not accept the community managed water supply with an open mind. To overcome this issue government and other organizations must be creative at the beginning and throughout the project (Harvey and Reed, 2006). However, continued support of the government is needed to sustain these projects in developing countries.

The development of the community can be hindered by the National Water Policies. Ineffective design of systems could lead to inequality in water distribution. Because of that, community managed water supply schemes are not possible to commence due to difficulties in finding a common denominator (Calzada et al., 2017). Also, low capital investments are the main limitation in these kinds of projects.

2.7 Advantages and disadvantages of CMWSS

Community Managed Water Supply Schemes are designed using the demand-driven approach with a clear understanding of the demand of the community and available resources etc. In case, these water supply schemes ensured the long-term sustainability and effectiveness of the projects. The provincial council is selected the Grama Niladhari Divisions which have real water demand for safe water. Therefore, CWMSS provides benefits for the people having true demand for safe water (Mimrose et al., 2011).

The Sri Lankan government was commenced the project of Community Water Supply and Sanitation with the collaboration of the World Bank and Japanese Bank for International Corporation. The objectives of the project are to ensure safe drinking water, sanitation, environmental programs, education of hygiene and diversifying community activities. Under this participatory development approach, the community is involved in cost-sharing and decision- making. These water supply schemes help to build capacity and strengthen the community (Kwena and Moronge, 2016). Some of the indirect advantages are empowering women in decision-making, developing infrastructure, and ultimately enhancing the economy of the country.

According to Antonio (2005), community managed water supply and sanitation projects do not provide long-term social befits to society in developing countries. The fundamental cause of this failure is a lack of knowledge of the topic of sustainability. The projects' long-term viability is largely dependent on maintaining a satisfactory level of service during the life of the community-managed water delivery system. The community takes over project administration and ownership after the projects are completed. Although conceptually sound the water supply project then after depends on the capacity of the community. Therefore, identifying the root cause of performance differences in community managed water supply projects is important for the sustainable management of existing projects and to implement new projects (Antonio, 2005).

In some cases, provinces like southern water quality parameters are not maintained according to the standard levels in community managed water supply schemes. So that, health risks are great due to bacterial contamination, rich in fluoride and hardness and the presence of heavy metals like cadmium, lead, etc (Mimrose et al., 2011).

2.8 Water Sources for CMWSS

Water sources for community managed water supply schemes are varied. Drinking water is mainly derived from groundwater or surface water. Some of them are wells, hand pump tube wells, dug wells, springs, rivers, reservoirs and water board. The critical problem related to water sources is contaminants. However, many people use this water without prior treatments. Because of that access to unsafe drinking water sources may increase the prevalence of water-borne infections in the future (Asarudeen et al., 2021).

2.9 Factors affecting water quality

Water quality is influenced by natural factors and anthropogenic activities. A range of variables that limit water consumption is defined as water quality (Foster and Gomes, 1989). In water supply systems microbiological and chemical stability of the water is mainly dependent on the quality of raw water. The reliability of the treatment process also affects the quality of water in the distribution process (Jachimowski, 2016). Water is chemically stable. But when there is the precipitation of deposits occurred for example calcium carbonate stability of water is changed (Bilozor et al. 2010).

In coastal areas, the quality and quantity of water are mainly affected by seawater intrusion. Groundwater can be reduced due to the over extraction of groundwater near the coastal areas. This may cause an influx of saline water (Mingyuan, 2015). Therefore, in the southern province water quality of water supply systems is badly affected by this issue.

Further, both ground and surface water resources are also contaminated with natural disasters as well as human activities which will be aggravated by rapid population growth and in line with that increase of industrialization and urbanization, poor waste management practices especially due to open dumping of waste materials and lack of using proper sanitation practices.

In water supply schemes quality of water is dependent mainly on water supply sources, the efficiency of water treatment method, method of water intake and distribution (Radzka and Jankowska, 2015). Therefore, water supply systems in rural areas should be connected with the protection of quantity and quality of water resources. Biological progress, agricultural activities, land use and wastewater management should be monitored when considering the quality of water in water supply schemes. Consequently, frequent assessment of water is needed through the lifetime of water supply schemes.

2.10 Reasons for Poor Consumer Satisfaction

According to Oliver (1997), consumer satisfaction can be defined as a consumer's response about the state of fulfillment and judgment of the fulfilled state. The expectation of consumer acts as a yardstick on which consumers evaluate the quality of service (Ojo, 2011). If the supply is not continued, the water quality may deteriorate. Although the number of water connections is increased due to population growth and rapid urbanization, treatment plant capacities are not increased. Therefore, water shortage or intermittent water supply can occur. In case water quality can deteriorate. Due to the dissatisfaction with service water quality issues can be occurred. If the CMWSS incapable to cater qualitatively and quantitatively sufficient service, that is the fact of losing satisfaction of consumer (Global Scientific Journal,2018).

2.11 Contaminants in drinking water and related diseases

A proper supply of safe drinking water is one of the most important criteria for a healthy life, but water-borne infections remain the leading cause of death in developing countries. National standards or international guidelines form the basis for assessing the safety of drinking water. The most important of these are the WHO guidelines for drinking water quality. The health risks that may be associated with the quality of drinking water vary worldwide (Fawell and Chipman, 2000). Contaminated water sources in rural areas have led to infectious and parasitic diseases among people.

So that major contaminants in drinking water can be categorized into microbial contaminants and chemical contaminants. Drinking water can be contained bacteria, parasites, and viruses as pathogenic agents. Contamination of drinking water with pathogens that cause diarrheal disease. This problem occurs as a result of drinking water pollution by fecal substances especially by human feces. Therefore, *Escherichia coli* and *streptococcus* feces are used as indicators of fecal contamination in drinking water. Cholera is a water-borne disease that continues to plague developing countries. Enteric infections are most frequently associated with water (Mead et al., 1999).

There are different sources of chemical contaminants. The most important pollutants from a health perspective are the naturally occurring chemicals normally found in groundwater. Arsenic, fluoride, selenium, uranium, iron, agricultural chemicals, urban pollution and by-products of water treatment are the main chemical contaminants in drinking water. Arsenic can be entered into drinking water sources by natural deposits in the earth. In many cases, it may cause abnormal pregnancy outcomes, childhood cancers and mortality among young adults (Smith et al., 2006).

Sri Lanka is an agricultural country. Nitrate is the most important agricultural contaminant which causes blue baby syndrome or methemoglobinemia (Fan, 1996). Heavy metals are contained in industry waste which causes severe health issues to humans. Overall, the provision and maintenance of safe drinking water still appear to be an essential requirement for public health in Sri Lanka.

Diseases and problems caused by contaminants in drinking water is depicted in Table 2.1

Table 2. 1: Diseases and problems caused by contaminants in drinking water

Causative item	**Disease and problems**
Bacteria	Typhoid, gastroenteritis, bacterial dysentery, cholera and tuberculosis
Virus	Poliomyelitis, meningitis, infectious hepatitis, respiratory diseases, diarrhea and enteritis
Protozoa	Amoebic dysentery, diarrhea and amoebic meningo encephalitis
Helminthes	Hook, round, and thread worm infections
Fungi/algae	Color, turbidity, taste, odor and toxins
Cadmium	Decalcification of the bones, protein and sugar in urine and kidney damage
Lead	Muscular paralysis, damage to nervous system, liver and Kidney, lowered IQ, anemia
Fluoride	Mottling of teeth (dental fluorosis), cracking of teeth and Osteofluorosis
Nitrate	Methanomoglobinaemia
Sulphate	Diarrhea
Hydrogen sulphide	Taste and odor problems
Iron	Yellow color, unpleasant taste and odor
Zinc	Unpleasant taste
Manganese	Unpleasant taste
Mercury	Affects kidney, nervous system, and causes brain damage
Chromium (hexavalent)	Kidney problem, lung cancer and skin diseases
Arsenic	Skin, bladder and lung cancer
Aluminium	Alzheimer (memory loss)
Pesticide	Kidney disease, reduced vision, joint pains and memory loss
Dissolved salts	Unpalatable if greater than 1200 mg/L

Source: (Amarasiri, 2008)

2.12 Water quality parameters

Since potable water is considered as the most significant fluids for human consumption that must be free of any kind of microbial, inorganic and organic contaminants. That should be safe to drink and proper for domestic activities. The quality of water is evaluated under various parameters on the base of laboratory analysis and these estimations provide essential information on the quality of water. Therefore, analytical examination of quality of the drinking water can be divided in to three main categories. Such as Physical, chemical and biological characteristics. (Mamta and Tomar, 1999)

2.12.1 Physical characteristics of water

The physical characteristics of drinking water is defined as the appearance of the water. For a drinking water it should be esthetically palatability pleasing to consumer, and its appearance must be clear. These qualities respond to the taste, smell, sense of sight or touch and they are related with the physical state of water. Physical parameters are given below;

- Temperature
- Colour
- Odor
- Taste
- Turbidity
- Total Suspended Solids
- Total Dissolved Solids

2.12.2 Chemical characteristics of water

Water is a universal solvent; it can dissolve naturally occurring substances and substances those created by human activities. Concentration of these substances in water depending on their solubility, quantity and physiochemical quality. Following chemical parameters use for analyzing quality of water for drinking

- pH
- Conductivity

- Total Alkalinity (as $CaCO_3$)
- Total Hardness (as $CaCO_3$)
- Dissolved Oxygen (DO)
- Chloride (as Cl)
- Ammonia
- Nitrate (as NO3), Nitrite (as NO2)
- Fluoride (as F)
- Phosphates (as PO4)
- Iron (as Fe)
- Sulphate (as SO4)
- Metals
- Manganese
- Residual chlorine

2.12.3 Biological characteristics of water

The most important contaminant of untreated drinking water is microbial contamination. Therefore, it is essential to examine biological characteristics of potable water in regular basis. Biological parameters are given below.

- E.-coli Bacteria
- Total coliforms bacteria
- Faecal coliforms bacteria
- Trichoptera
- Ephemeroptera
- Plecoptera
- Mollusca
- BOD

The suitability of water for human consumption is measured based on the drinking water standards established by government and international organizations and institutions, such as Sri Lanka Standards Institute (SLSI), WHO Geneva, Environmental Protection Agency (EPA) USA, Drinking Water Quality Standards in Middle East etc. Table 2.2 indicates the drinking water requirements according to the SLS 614:2013. CMWSS should maintain proper monitoring system for assisting and observing its hygienic quality.

Table 2. 2: Sri Lanka standards for potable water SLS 614:2013 first revision

Parameter	Unit	Requirement (Max)
Physical-Organoleptic requirements		
Colour	Hazen	15
Odour		Unobjectionable
Taste		Unobjectionable
Turbidity	(NTU)	2
pH at 25^0 C $\pm 2^0$ C		6.5 -8.5
Chemical requirements		
Aluminium (as Al)	mg/l	0.2
Ammonia; Free ammonia (as NH_3) Albuminoid ammonia	mg/l mg/l	0.06 0.15
Anionic detergent (as Methylene blue active substances	mg/l	0.2
Calsium (as Ca)	mg/l	100
Chloride (as Cl^-)	mg/l	250
Conductivity	µc/cm	
Chemical Oxygen Demand (COD)	mg/l	10
Copper (as Cu)	mg/l	1.0
Fluoride (as F^-)	mg/l	1.0
Free Residual Chlorine	mg/l	1
Iron (as Fe)	mg/l	0.3
Manganese (as Mn)	mg/l	0.1
Magnesium (as Mg)	mg/l	30
Nitrate (as NO_3^-)	mg/l	50
Nitrite (as NO_2)	mg/l	3
Nickel (as Ni)	mg/l	0.02
Oil and grease	mg/l	0.2

Phenolic compounds (as C_6H_5OH)	mg/l	0.001
Sodium (as Na)	mg/l	200
Sulphate (as SO_4^{-2})	mg/l	250
Total alkalinity (as $CaCO_3$)	mg/l	200
Total dissolved solids	mg/l	500
Total hardness (as $CaCO_3$)	mg/l	250
Total Phosphates (as PO_4^{-3})	mg/l	2.0
Zinc (as Zn)	mg/l	3.0
Arsenic (as As)	mg/l	0.01
Cadmium (as Cd)	mg/l	0.003
Chromium (as Cr)	mg/l	0.05
Cyanide (as CN)	mg/l	0.05
Lead (as Pb)	mg/l	0.01
Mercury (as Hg)	mg/l	0.001
Selenium (as Se)	mg/l	0.01
Bacteriological requirements		
(a)Treatment works and piped distribution system		
E-coli	No/100 ml	0
Total Coliforms	No/100 ml	3
(b) Large water supplies		
E-coli	No/100 ml	0
Total Coliforms	No/100 ml	Shall not be present in 95% of samples in a year In remaining 5% samples shall not exceed 10
(c) Individual or small community supplies (include wells, bore holes and springs)		
E-coli	No/100 ml	0
Total Coliforms	No/100 ml	10

Source: (Sri Lanka Standards Institute, 2013)

2.13 Monitoring of the water quality

A programmed procedure of water sampling, measurement and evaluation of different water characteristics aimed to assess the conformity of specific objectives. Water quality monitoring is used to warn of ongoing and emerging issues, determine compliance with drinking water quality, and protect other beneficial water uses. The effectiveness of water quality monitoring systems leads to ensuring safe water to the community (Levesque and Oberg, 2012). Physical parameters such as temperature, pH value, color, odors and turbidity do not play a decisive role in human health. However, they can be indicators of acceptance and other impurities that consumers deserve to develop their desire to drink. When considering chemical parameters, total hardness, chloride, nitrate, total phosphate, fluoride and heavy metals play a major role in affecting human health. The limits for these harmful parameters are set at the national level or the international level (WHO, EPA,) by various laws, ordinances, and standards.

Traditional water quality assessment methods rely on comparing experimentally measured parameter values to established criteria. This methodology can be used to properly identify the source of pollution and can be essential to verify compliance. But it does not provide a general overview of the spatial and temporal trends of total water quality in catchment areas (Debels et al., 2005). To overcome this problem scientist designed the concept water quality index to obtain overall water quality in the watershed.

2.14 Water quality index

Physical, chemical and biological parameters are used to assess the water quality in drinking water. Different standards and limits for human health are established at the national and international levels. The most convenient method is Water Quality Index (WQI). Any result of water quality quantities can be used as a water quality indicator. Water quality indices are a quick and easy way to assess the quality of drinking water. National and international organizations have developed a variety of water quality indexes. WQI shows the yearly cycle, regional and temporal fluctuations, and trends in water quality at low concentrations by representing most of the information in a single value and presenting the data in a simplified logical manner. (Shweta et al, 2013). WQI is useful in comparative purposes, to address general problems to communicate with large public (Hallock, 2002). WQI is less useful in site-specific decision-making (Yogendra and Puttaiah, 2008). WQI has three main factors. They are parameter selection, determination of quality curve for each parameter (sub-indices) and sub-indices aggregation with mathematical expression.

At the global level, there is no single index that can represent the total water quality of each water body. However, global water quality indices are also required to measure changes in water quality over time and space, as well as to assess the success or failure of international water treaties. Therefore, many countries have begun developing composite water quality indices to explain their water quality status.

The Universal Water Quality Index, National Sanitation Foundation Water Quality Index, Canadian Council of Ministers of the Environment Water Quality Index, Weight Arithmetic Water Quality Index, and Oregon Water Quality Index, among others, are some of the water quality indices. Water quality indexes (WQIs) were used to evaluate water quality in specific locations. Furthermore, when compared to their respective requirements for a given location, these indicators are frequently dependent on the amount of water quality metrics and types of water quality measurements. (Chowdhury et al., 2012).

2.14.1 Universal Water Quality Index (UWQI)

Universal Water Quality Index (UWQI) was designed to provide an easier way to represent the quality of surface water used as drinking water. UWQI is superior to the existing index in that it reflects the suitability of water for a particular application. UWQI is used for drinking water rather than the general water supply. UWQI can be applied for universal purposes while other indices are developed by different nations with their quality standards. UWQI is developed using European Communities legislations, Turkish water pollution control regulations and other reported scientific information (Nagels et al., 2001).

2.14.2 National Sanitation Foundation Water Quality Index (NSFWQI)

National Sanitation Foundation Water Quality Index (NSFWQI) was developed by Brown et al. (1972) using the Delphi method. They selected parameters rigorously. After that, they developed a common scale and assigned weights to the parameters. National Sanitation foundation gave their support to develop this index. On the basis of nine factors, the NSFWQI is used to compare the water quality of various water sources. pH, turbidity, dissolved oxygen, temperature, fecal coliform, biochemical oxygen demand (BOD), total nitrates and phosphates, and total solids are the variables to consider. (Kumar, and Alappat, 2009). The numerical value is obtained using the transformation of recorded data into a weighting curve chart. This WQI can be used to calculate water quality in critically polluted water bodies. The mathematical equation for NSF WQI is expressed by,

$$WQI = \sum_{i=1}^{n} QiWi$$

Where, Qi = sub-index for i^{th} water quality parameter,

Wi = weight associated with i^{th} water quality parameter,

N = number of water quality parameters

2.14.3 Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI)

This water quality index was formulated by the Canadian Council of Ministers of the Environment. This WQI was developed to assess surface waters for the protection of the aquatic environment according to specific guidelines. CCME WQI is a useful tool that enables professionals to translate to large amount of water quality monitoring details into simple overall value. The parameters related to different measurements may differ from one location to another location. The sampling protocol needs at least 4 parameters and samples at least 4 times (Khan et al., 2005). The advantage of CCME WQI is that it displays measurements of different variables in one number and combines different measurements with different measurements into one metric. Loss of information owing to the combining of several variables into a single index value, loss of interaction between variables, and lack of index transferability to various ecosystem types are all CCME WQI drawbacks. This is not an alternative to detailed variable analysis but is designed as a tool to help water managers communicate overall water quality more consistently and continuously (Zandbergen and Hall, 1988).

Water quality guidelines are numerical values of the chemical, physical, biological or radioactive properties of water, indicating that exceeding them can have adverse effects. The water quality guidelines used in the calculations are defined to protect aquatic life. These include national guidelines developed by Canadian Council of Ministers of the Environment and state-specific and site-specific guidelines developed by federal, state, and territory partners. Exceeding the guideline values at a given location is more likely to adversely affect aquatic life at that location. CCME WQI associates water quality data with many useful uses of water by using different water quality guidelines as a standard. Each index is computed for a single measurement point over the reference period specified. Various water quality metrics are assessed on water samples obtained during this time. The results are compared to the applicable water quality criteria for each metric. These are referred to as tests. The three elements used to construct the index specify parameters and test percentages that do not meet the rules, as well as deviations from the standard guidelines for tests that do not meet the standard norms. Scope (F1), frequency (F2), and amplitude (F3) are the three variables. The index is a number that ranges from 0 to 100. (Khan et al., 2005).

2.14.4 Weight Arithmetic Water Quality Index (WAWQI)

This index is used to classify water quality according to the level of purity. This WQI plays a significant role in the evaluation and management of water quality. This is useful to communicate overall water quality data to policy makers and citizens. Multiple water quality parameters are incorporated in a mathematical equation to scale up the condition of the water source with the number. But this is not given enough details about the water quality situation (Akoteyon et al., 2011). The mathematical equation for WA WQI is expressed by,

$$WQI = \sum Qi \sum Wi / \sum Wi$$

The quality rating scale (Qi) for each parameter is calculated by using this expression,

$$Qi = 100[Vi - Vo/ Si - Vo]$$

Where,

Vi = estimated concentration of ith parameter in the analyzed water
Vo = the ideal value of this parameter in pure water
Si = recommended standard value of i^{th} parameter

2.14.5 Oregon Water Quality Index (OWQI)

The Oregon water quality index (OWQI) developed a score to evaluate the overall quality of water from a stream in Oregon and adapted it to other geographic locations, combining eight water factors into a single number. The criteria employed in this water quality index include temperature, biochemical oxygen demand, dissolved oxygen, pH, total solids, total phosphorus, fecal coliform, ammonia, and nitrate nitrogen. The original OWQI was modeled after the NSFWQI, which employed the Delphi approach to choose variables. The index employs the notion of harmonic averaging and has no parameter weighting. (Dunnette, 1979). OWQI can be used to represent status and trends of water quality for legal water quality measurements. The calculation of OWQI is made by using the equation given by

$$\text{WQI} = \sqrt{\frac{n}{\sum_{i=1}^{n} \frac{1}{SI_i^2}}}$$

Where ,

n = number of subindices

SI= subindex of ith parameter.

Advantages and disadvantages of selected water quality indices is depicted in Table 2.3.

Table 2. 3: Merits and demerits of selected water quality indices

Advantages	**Disadvantages**
National Sanitation Foundation (NSF) WQI	
1. The data in a single index value is summarized in an objective, rapid and reproducible manner. 2. Assession between areas and identifying changes in water quality. 3. Index value relate to a potential water use. 4. Facilitates communication with lay person.	1. The general water quality is represented and the specific use of the water is not represented. 2. Data loss during handling. 3. Lack of dealing with uncertainty and subjectivity present in complex environmental issues
Canadian Council of Ministers of the Environment (CCME) WQI	
1. Represent measurements of multiple variables in a single number. 2. Flexibility in determining of input parameters and goals. 3. Adaptability to various legal requirements and different water uses. 4. Statistical simplification of complex multivariate data. 5. Clear and understandable diagnostic for managers and the general public. 6. Appropriate tool for water quality assession in a specific location. 7. Easy to calculate. 8. Tolerance to missing data. 9. Suitable for data analysis from automated sampling 10. Combine multiple measurements in a variety of different measurement units in a single metric.	1. Loss of information on single variables. 2. Loss of information about the objectives specific to each location and particular water use. 3. Sensitivity of the results to the formulation of the index. 4. Information loss on interactions between variables. 5. Lack of portability of the index to different ecosystem types. 6. Easy to manipulate (biased). 7. The same importance is given to all variables. 8. No combination with other indicators or biological data. 9. The water quality diagnostic is partial. 10. F1 not working appropriately when too few variables are considered or when too much covariance exists among them.

Oregon WQI	
1. Un-weighted harmonic square mean formula used to combine sub-indices allows the most impacted parameter to impart the greatest influence on the water quality index. 2. Method acknowledges that different water quality parameters will pose differing significance to overall water quality at different times and locations. 3. Formula is sensitive to changing conditions and to significant impacts on water quality.	1. Does not consider changes in toxics concentrations, habitat or biology. 2. To make inferences of water quality conditions outside of the actual ambient network site locations is not possible. 3. Cannot determine the water quality for specific uses nor can it be used to provide definitive information about water quality without considering all appropriate physical, chemical and biological data. 4. Cannot evaluate all health hazards (toxics, bacteria, metals, etc.).
Weight Arithmetic WQI	
1. Incorporate data from multiple water quality parameters into a mathematical equation that rates the health of water body with number. 2. Less number of parameters required in comparison to all water quality parameters for particular use. 3. Useful for communication of overall water quality information to the concerned citizens and policy makers. 4. Reflects the composite influence of different parameter , i.e. important for the assessment and management of water quality. 5. Describes the suitability of both surface and groundwater sources for human consumption.	1. WQI may not carry enough information about the real quality situation of the water. 2. Many uses of water quality data cannot be met with an index. 3. The eclipsing or over-emphasizing of a single bad parameter value 4. A single number cannot tell the whole story of water quality; there are many other water quality parameters that are not included in the index. 5. WQI based on some very important parameters can provide a simple indicator of water quality.

Source: (Shweta et al., 2013)

Classification of water sources depend on the marks that received. Different water quality indices have different marking schemes. Table 2.4 shows marking scheme of recommended indices in the world.

Table 2. 4: Marking scheme of each recommended indices in the world

National Sanitation Foundation Water Quality Index (NSFWQI)	
WQI Value	**Rating of Water Quality**
91-100	Excellent water quality
71-90	Good water quality
51-70	Medium water quality
26-50	Bad water quality
0-25	Very bad water quality
Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI)	
91-100	Excellent water quality
75-90	Good water quality
51-74	Fair water quality
26-51	Marginal water quality
0-25	Poor water quality
Oregon Water Quality Index (OWQI)	
90-100	Excellent water quality
85-89	Good water quality
80-84	Fair water quality
60-79	Poor water quality
0-59	Very poor water quality
Weight Arithmetic Water Quality Index (WAWQI)	
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
Above 100	Unsuitable for drinking purpose

Source: (Shweta et al., 2013)

3. METHODOLOGY

Figure 3.1 depicts the summarized procedure of this research

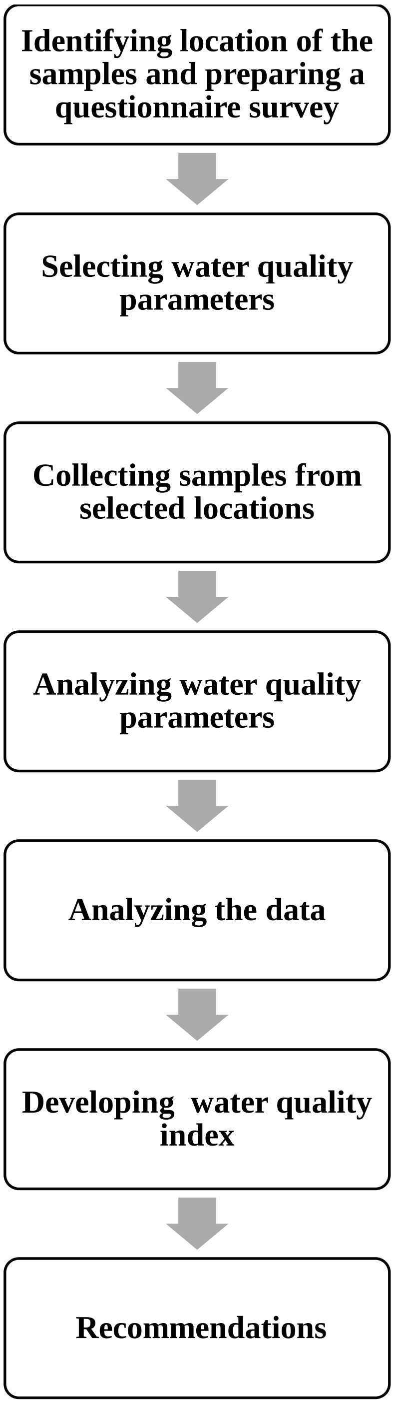

Figure 3.1: Summarized overall procedure of the study

3.1 Study area

The research study and the questionnaire survey was conducted with the chosen CMWSS in southern province. In Galle there are 172 CMWSS. Among 19 DS, CMWSS are present in 12 DS. There are 333 CMWSS in Matara, among 16 DS, CMWSS are present under 15 DS, while Hambanthota there are 182 CMWSS, and these CMWSS are present in 11 DS among 12. Figure 3.2, Figure 3.3, and Figure 3.4 illustrate the study areas of Galle, Matara and Hambanthota.

Figure 3.2: Study area Galle district

Figure 3.3: Study area Matara district

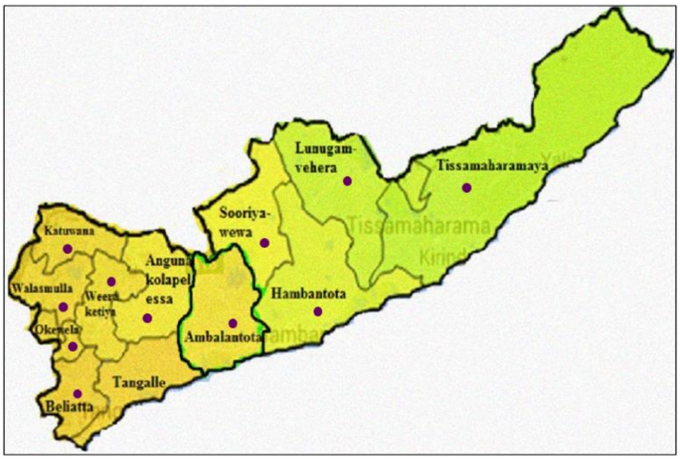

Figure 3.4: Study area Hambanthota district

Source: (Sri Lanka - Maps - ecoi.net)

3.2 Questionnaire survey

In order to get the public perception for water quality of the southern province, it is decided to conduct a questionnaire survey. Further to this, for evaluating the reliability of numerical results, consumer perception and satisfaction, questionnaire survey was carried out using 517 households in the study area. The sample was selected using proportionate stratified random sampling method where districts were considered as strata. The designed questionnaire has been attached in the Appendix A.

Respondents were the direct users of water in the Southern province. Because of that the answers or the responds were important for this research.

3.3 Selecting water quality parameters

The parameters were limited due to the lack of lab facilities, as well as a lack of time and money to conduct experiments and variations of the results of few parameters (Residual Chlorine, Dissolved Oxygen etc.) due to distance between the sample collecting location and lab. Therefore, fourteen physical, chemical and biological parameters were measured for each sample. The parameters measured in each sample were Temperature, Turbidity, pH, Electrical Conductivity (EC), Total Hardness (as

$CaCO_3$), Nitrate (as NO3), Fluoride (as F), Iron (as Fe,) Manganese (Mn), Arsenic (As), Cadmium (Cd), Lead (Pb), *E-coli* Bacteria and Total Coliforms (T-coli).

3.4 Collecting samples from selected locations

Out of 687 CMWSS (Galle 172, Matara 333 and Hambanthota 182) in the southern province rural water supply, 488 (Galle 172, Matara 172, Hambanthota 144) water samples were collected from various sources including tube wells, dug (open) wells, streams (streams, springs, rivers, tanks) and water board bulk supply. Sampling can't be done by the researcher due to limited time and distance. Therefore, sampling locations were decided by the CMWSS's officer and the samples were brought to the Environmental engineering laboratory of Department of Civil and Environmental Engineering, Faculty of Engineering, University of Ruhuna by them with corresponding GPS points for analysis. Number of samples collected from different DS with water sources of Galle, Matara and Hambanthota are depicted in Table 3.1, 3.2, and 3.3 respectively.

Table 3.1: Number of samples collected from different DS in Galle district

Divisional Secretariat (DS)	No. of dug well schemes	No. of tube well schemes	No. of surface water schemes	Total number of CMWSS
Akmeemana	4	0	0	04
Ambalangoda	4	0	0	04
Baddegama	4	2	7	13
Balapitiya	6	0	0	06
Benthota	5	0	0	05
Elpitiya	4	0	10	14
Imaduwa	7	1	0	08
Nagoda	11	0	13	24
Neluwa	0	2	34	36
Niyagama	8	0	9	17
Thawalama	0	0	34	34
Yakkalamulla	3	0	4	07
Total	**56**	**5**	**111**	**172**

Table 3. 2:Number of samples collected from different DS in Matara district

Divisional Secretariat (DS)	No. of dug well schemes	No. of tube well	No. of surface water schemes	Total number of
Welipitiya	13	3	1	17
Malimbada	9	0	0	9
Akuressa	10	0	3	13
Athuraliya	4	0	4	8
Pitabeddara	0	0	9	9
Pasgoda	2	0	21	23
Kotapola	0	0	30	30
Hakmana	22	0	0	22
Kamburupitiya	5	0	2	7
K. Puhulwella	8	0	1	9
Mulatiyana	4	0	8	12
Dikwella	8	0	0	8
Devinuwara	3	0	0	3
Thihathgoda	1	0	0	1
Matara	1	0	0	1
Total	**90**	**3**	**79**	**172**

Table 3. 3: Number of samples collected from different DS in Hambanthota district

Divisional Secretariat (DS)	No. of dug well schemes	No. of tube well schemes	No. of surface water schemes	NWS&DB (Water board	Total number of
Angunakolapelas	6	3	3	1	13
Ambalanthota	6	3	3	0	12
Beliatta	10	9	2	0	21
Hambanthota	1	0	1	2	4
Katuwana	18	1	1	0	20
Lunugamwehera	0	0	1	0	1
Okewela	7	2	0	1	10
Sooriyawewa	2	0	4	0	6
Thissamaharamay	0	2	5	0	7
Walasmulla	20	4	6	0	30
Weeraketiya	13	4	3	0	20
Total	**83**	**28**	**29**	**4**	**144**

3.5 Analysis methods for conducting experiment

Table 3.4. provides a summary of the analysis techniques related to the water quality parameters.

Table 3. 4: Time duration, preservative and test method for conducting experiment

Parameter	Holding time	Preservative method	Method of Analysis
Temperature	On site	-	Thermometer
pH	On site 2 hours	-	pH meter
Turbidity	48 hours	Cool, 4^0C	Turbidity meter
Conductivity (us/cm)	28 days	Cool, 4^0C	EC meter
Total Hardness (as $CaCO_3$)	6 months	Cool, 4^0C	EDTA Titration method
Nitrate (as $NO3^-$)	48 hours	Cool, 4^0C	UV Visible Spectro photo metric method
Fluoride (as F)	28 days	None required	SPANDS method
Iron (as Fe)	24 hours	Cool, 4^0C	UV Visible Spectro photo metric method
Manganese (Mn)	6 months	Add HNO3 to pH<2 Cool, 4^0C	Atomic absorption Spectro photometric graphite method
Arsenic (as As)			
Cadmium (Cd)			
Lead (as Pb)			
Total Coliform bacteria	24 hours	Cool, 4^0C	Membrane filter method
E-coli Bacteria			

Source: (American Public Health Association – APHA)

3.5.1 Analysis of water quality parameters

APHA Standard Methods of the Examination of Water and Wastewater (1998) was used to analyze the samples. Temperature, Turbidity, EC, Total Hardness, were measured according to the APHA standard, part 2000. pH, Nitrate (as NO_3^-), were measured according to the APHA standard, part 4000. Metals were measured according to APHA Standard, part 3000 and E-coli and T coliform were measured according to the APHA standard, part 9000.

3.5.1.1 Determination of Temperature, pH, EC, Turbidity

Temperature, pH, EC, and Turbidity were measured using pH/Conductivity combined meter (multiparameter meter) and Turbidity meter respectively as shown in Figure 3.5,3.6. Before taking readings, meters were calibrated using pH, conductivity and turbi dity standard calibration solutions.

Figure 3.5: pH/ Conductivity (HQ 40d Multi) meter

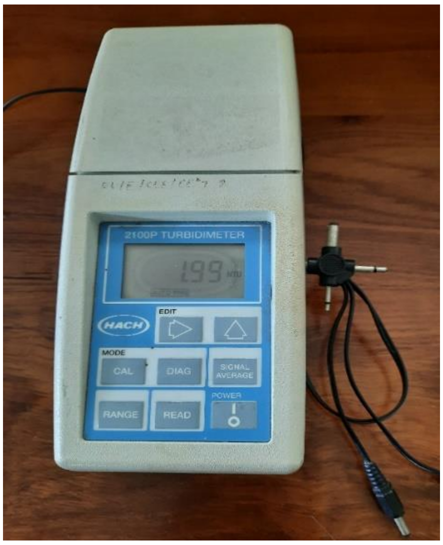

Figure 3.6: Turbidity meter (2100P)

3.5.1.2 Determination of Fluoride

Fluoride concentration was determined using the SPAND method. It was measured with a fluoride meter. 2 ml of SPANDS reagent was added to 10 ml of deionized water to set the zero. The sample was then treated with 2 ml of SPADNS reagent and fluoride was measured using the meter. Figure 3.7 shows the SPANDS Reagent and Fluoride meter.

Figure 3.7: SPANDS Reagent and Fluoride meter (DR1900)

3.5.1.3 Analysis of Total Hardness

The total hardness of each sample was determined by titrating with 0.01M EDTA (Ethylene Diamine Tetra Acetic acid). 50 ml of sample was poured in to the 250 ml conical flask. Then 1 ml of hardness buffer solution and 0.1g of total hardness indicator were added to the sample. If the sample solution turns to blue colour there is no hardness and sample turns to purple, it was titrated with 0.01M EDTA to the end point where colour change occurred from purple to blue. Figure 3.8 shows titrating the sample with 0.01M EDTA. Total hardness was calculated based on the equation below.

$$\text{Total Hardness (as } CaCO_3) = \frac{\text{Volume of 0.01M EDTA used, ml}}{\text{Volume of the sample (50ml)}} \times 1000$$

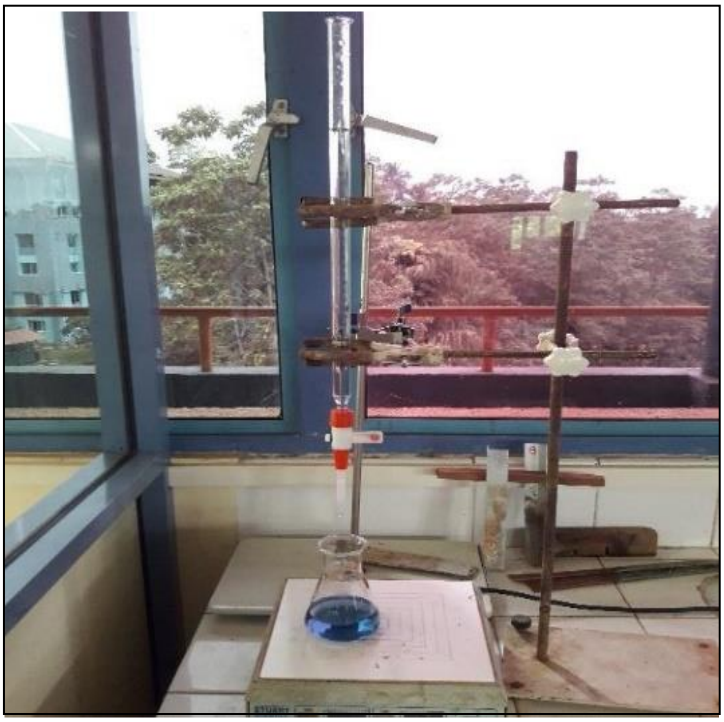

Figure 3.8: Titrating the sample with 0.01M EDTA

3.5.1.4 Determination of Nitrate (NO_3^-)

Preparation of calibration standards

UV visible spectrophotometer was used for analyze the NO_3^- , hence, standard calibration curve was required. Therefore, standard solutions were prepared using the 100ppm NO_3^- and 38% HCl according to the Table 3.5. Figure 3.9 shows spectrophotometer.

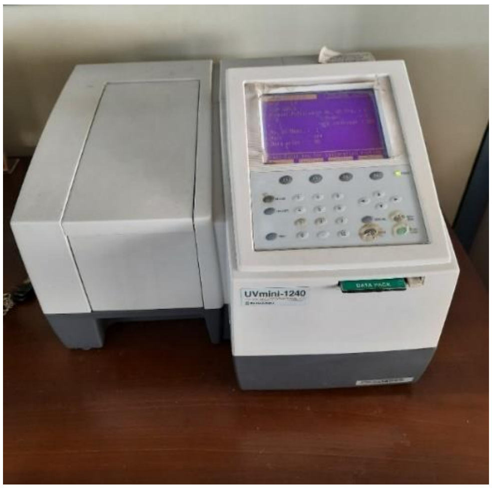

Figure 3.9: Spectrophotometer (UVmini-1240)

Table 3. 5: Calibration standards

100 ppm NO_3^- (ml)	**No. of drops of 38% HCl**	**Final Volume (ml)**	**NO_3^- concentration (ppm)**
1	10	100	1.0
1	5	50	2.0
2	5	50	4.0
4	5	50	8.0
8	5	50	16.0

Preparation of unknown samples

Volume of 20 ml was measured from filtered samples and 2 drops of 38% HCL were added to each sample. Then they were mixed well.

Measure absorbance values of standards and unknown

1. Initially, wave length was adjusted to 220nm and 275 nm respectively.
2. Then, one cuvet was filled with blank and the instrument was set to ‘0’ absorbance by auto zeroing.
3. After that absorbance value at 220nm and 275nm of each prepared standard solution and unknown samples were recorded against blank reagent
4. Then the corrected absorbance was calculated according to the equation below.

$$\text{Corrected absorbance} = \text{Abs}_{220nm} - 2 \times \text{Abs}_{275nm}$$

Where,

Abs 220: Absorbance for wave length of 220nm

Abs 275: Absorbance for wave length of 275nm

5. Finally, NO_3^- concentrations of the unknown samples were determined from the standard calibration curve of corrected absorbance vs NO_3^- concentration (ppm).

Table 3.6 represents the corrected absorbance values obtained for the standard solutions. Figure 3.10 depicts the standard calibration curve of corrected absorbance vs NO_3^- concentration.

Table 3. 6: Corrected absorbance and standard concentration of nitrate

NO_3^- concentration (ppm)	**Abs $_{220\ nm}$**	**Abs $_{275\ nm}$**	**Corrected Abs.**
1.0	0.084	0.002	0.080
2.0	0.149	0.008	0.133
4.0	0.266	0.004	0.258
8.0	0.523	0.006	0.511
16.0	1.016	0.007	1.002

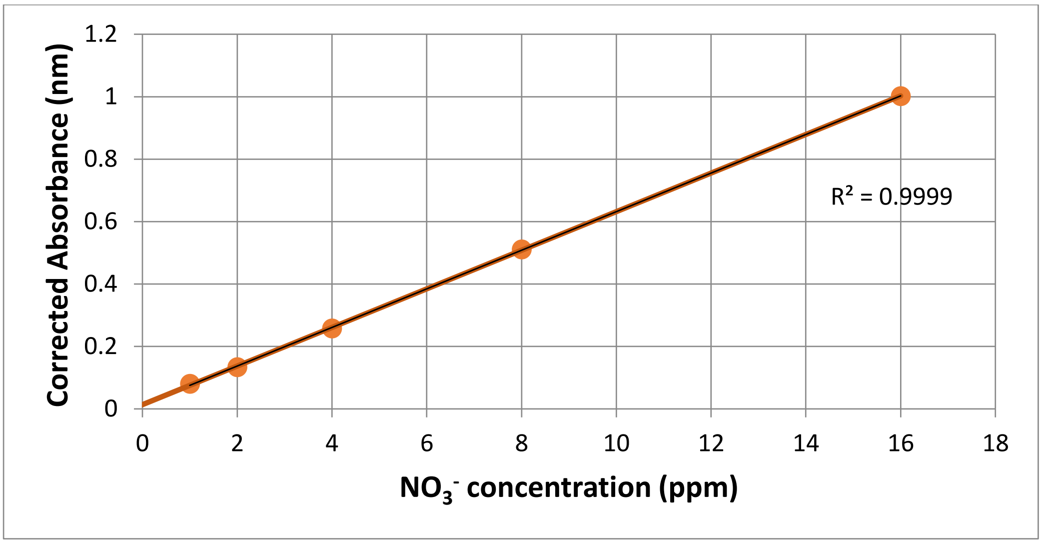

Figure 3.10: Calibration curve of corrected absorbance vs NO_3^- concentration

3.5.1.5 Determination of Iron (Fe)

Iron concentration was determined by using UV Spectrophotometer. Therefore, Fe standard solutions were prepared to form the calibration curve. Figure 3.11 shows the Fe2+ stock solution and standard solutions.

Preparation of standards

1. 0.7022g of ferrous ammonium sulfate hexahydrate was dissolved in DI water. This solution was diluted to 1L. This solution was 100 mg/L Fe^{2+} (same as 100 ppm). Sodium acetate was used as buffer to maintain a constant pH, in order to prevent Fe^{2+} being oxidized to Fe^{3+}.

2. Standard solutions of 0.0, 2.0, 4.0, 6.0 and 8.0 ppm were prepared by diluting 0.0, 2.0, 4.0, 6.0 and 8.0 ml respectively of the 100ppm stock solution into five separate volumetric flasks of 100 ml. 5 ml of a 0.25% ortho-phenanthroline solution was added to each flask. Then Deionized (DI) water was added up to the mark 100ml of the flask and it was mixed well.

Figure 3.11: Fe2+ stock solution and standard solutions

Preparation of unknown samples

1. 5 ml of the 0.25% ortho-phenanthroline solution was added to a volumetric flask of 100 ml.
2. Then the unknown sample was added up to the mark of 100ml and mixed well.

Creating standard calibration curve

1. Initially, wave length was adjusted to 510nm.
2. Then, one cuvet was filled with blank and the instrument was set to '0' absorbance by auto zeroing.
3. After that each prepared standard solution and samples were measured with their absorbance values at the wave length 510nm.
4. Then Fe concentrations of the unknown samples were determined from the standard calibration curve of absorbance vs concentration (ppm).

Table 3.7 represents the absorbance values obtained for the standard solutions. Figure 3.12 depicts the calibration curve for Fe.

Table 3. 7: Absorbance and Standard concentration of Fe

Standard Concentration (mg/L)	**Absorbance (nm)**
0	0.002
2	0.375
4	0.768
6	1.178
8	1.541

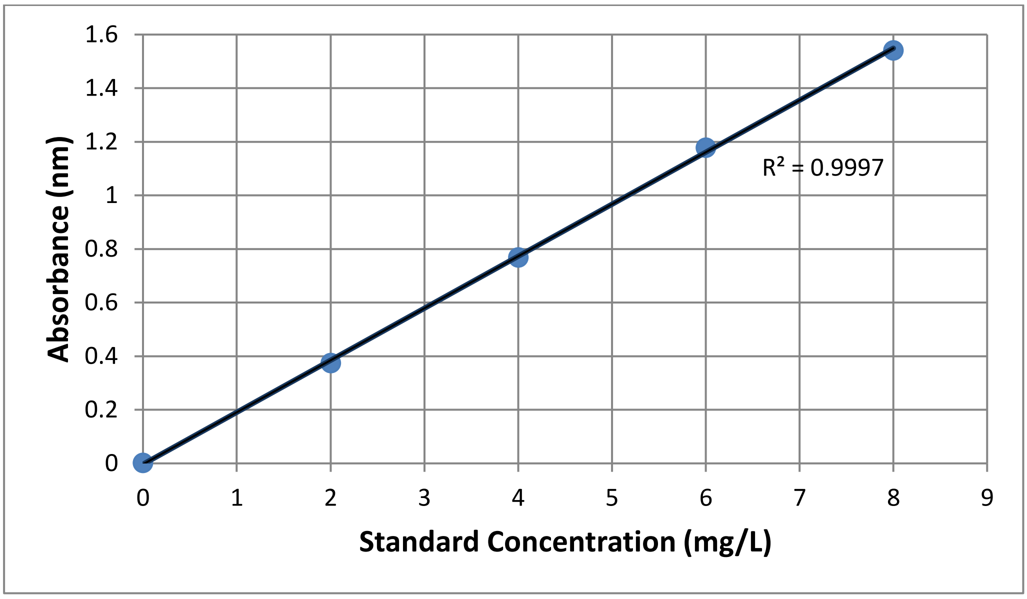

Figure 3.12: Standard calibration curve for Fe

3.5.1.6 Analysis of Heavy Metals

Atomic absorption spectrophotometer: TRACE AI1200 which is shown in Figure 3.13 was used to determine the heavy metal concentration. Graphite furnace method was selected to measure heavy metals such as Cd, As, Mn and Pb due to their concentration in ppb level in drinking water.

Figure 3.13: Atomic absorption spectrophotometer (TRACE AI1200)

Standard solutions were prepared for each heavy metal using corresponding standard stock solutions to develop the calibration curve relevant each heavy metal. Then absorbance of standard solutions and unknown samples were measured. After that concentration of heavy metals for the samples were determined from the standard calibration curve.

3.5.1.7 Determination of E-coli and Total Coliform bacteria

E-coli and Total coliform bacteria was determined using the membrane filtration method. Before initiating the experiment, all the glassware, forceps and filter funnel were sterilized using autoclave and they were kept in Bio safety cabinet after wrapping with aluminum foil paper. Chromocult®Coliform Agar ES was used for prepare culture media. 34.5 g of Chromocult®Coliform Agar was added to a 1000ml conical flask then distilled water was added up to the mark and it was heated with frequent stirring using magnetic stirrer until get a clear solution. The solution was poured in to the petri dishes under the sterilized condition in bio safety cabinet when it reached to 40^oC to 45^oC. 100 ml water sample was taken in to the measuring cylinder and it was filtered using the filter paper having properties of 0.45 μm pore size and 47 mm diameter and vacuum filtration apparatus.

After filtration, the membrane filter paper was placed on the culture media in the petri dish. After that, the lid was sealed without letting any air into the petri dish. After 24 hours of incubation at $37^{0}C$, colonies were counted using a colony counter. Blue colour colonies were represented the *E-coli* and pink colour was represented other coliforms. Summation of both *E-coli* and other coliforms give the count of total coliforms. Figures 3.14, and 3.15, depict membrane filter set up, E-coli and other coliforms.

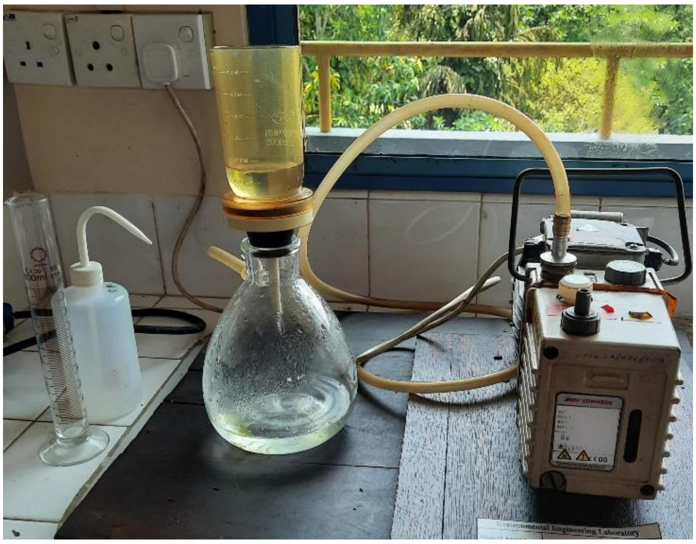

Figure 3.14: Membrane filter set up

Figure 3.15: E-coli and other coliforms

3.6 Analyzing the data

In this research, there were two different data sets were used for analyzing. One was from questionnaire survey which is to evaluate the reliability of the research and through that to understand the public perception and satisfaction over CMWSS.

The second data set was received through analyzing 14 water quality parameters for 488 water samples from different CMWSS operating in the southern province.

All the data were statistically analyzed using appropriate statistical techniques.

3.7 Developing WQI

In this research one of the major objectives is develop the water quality index for each scheme. Hence, among water quality indices most suitable one, Canadian Council of Ministers of the Environment (CCME) was used to calculate Water Quality Index (WQI). The measured values of each parameter of the sample comparison with the Sri Lankan standard (SLS 614:2013) values. These were referred as tests. Three factors were used to calculate the WQI such as scope (F_1), frequency (F_2) and amplitude (F_3). The index produces a number between 0 and 100. Better water quality is indicated by a higher WQI value. Table 3.8 shows water quality rating for different water quality index.

Table 3. 8: water quality rating for different WQI

CCME WQI	
WQI Value	**Water Quality Rating**
91-100	Excellent
75-90	Good
51-74	Medium
26-50	Bad
0-25	Very bad

WQI was calculated based on the equation below.

$$WQI = 100 - \left[\frac{\sqrt{(F1^2 + F2^2 + F3^2)}}{1.732}\right]$$

Where,

Scope (F_1): The scope element shows the percentage of all failed parameters that did not meet the standard levels at any time during the reference period (Boyacıoğlu, and Gündogdu, 2013).

$$F1 = \left(\frac{\text{Number of failed parameters}}{\text{Total Number of parameters}}\right) X\ 100$$

Frequency (F_2): The percentage of individual tests that don't meet the guidelines for water quality is shown by the frequency factor

$$F2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}}\right) X\ 100$$

Number of failed tests represents the number of failed parameters in the sample among the evaluated 14 parameters.

Amplitude (F_3): The amplitude factor represents the average deviation of failed test values from the standard values. An excursion is the relative deviation of a failed test from the guideline.

When the test value must not exceed the standard value,

$$\text{excursion} = \left(\frac{\text{Failed Test Value}}{\text{Standard Value}}\right) - 1$$

When the test value must not be lower than the standard value,

$$\text{excursion} = \left(\frac{\text{Standard Value}}{\text{Failed Test Value}}\right) - 1$$

The normalized sum of the excursions (nse) was calculated by for failed parameters of the sample as follows,

$$\text{nse} = \frac{\sum \text{excursion}}{\text{number of tests}}$$

Then, F_3 was determined by using a formula that scales the nse to yield a range between 0 and 100.

$$F_3 = \left(\frac{\text{nse}}{0.01\text{nse} + 0.01}\right)$$

3.8 Limitation on the research

I. Samples are collected by the technical officers and civilians of relevant community managed organization due to the lack of time and facility of reaching to each CMWSS.

II. Microbiological parameters should be checked for rural water supply systems at least three times each year (pre-monsoon, during monsoon and post-monsoon) (National Drinking Water Quality Standards and Directives 2005). But due to limited time, facilities and money it is difficult to impose such testing procedure.

III. Some water quality parameters are avoided in this research such as residual chlorine, dissolved oxygen because they should be measured on site and some are avoided due to the lack of facilities, exceeding the allocated budget and high time consumption such as Alkalinity, Phosphorus etc.

4. RESULTS AND DISCUSSION

Questionnaire survey was carried out using 517 number of households from the study area. According to the Questionnaire survey the highest percentage of water sources managed by CMWSS was shallow wells (49.7%) followed by streams (29.1%) and tube wells (14.9%) respectively. Figure 4.1 shows water sources managed by CMWSS according to the survey.

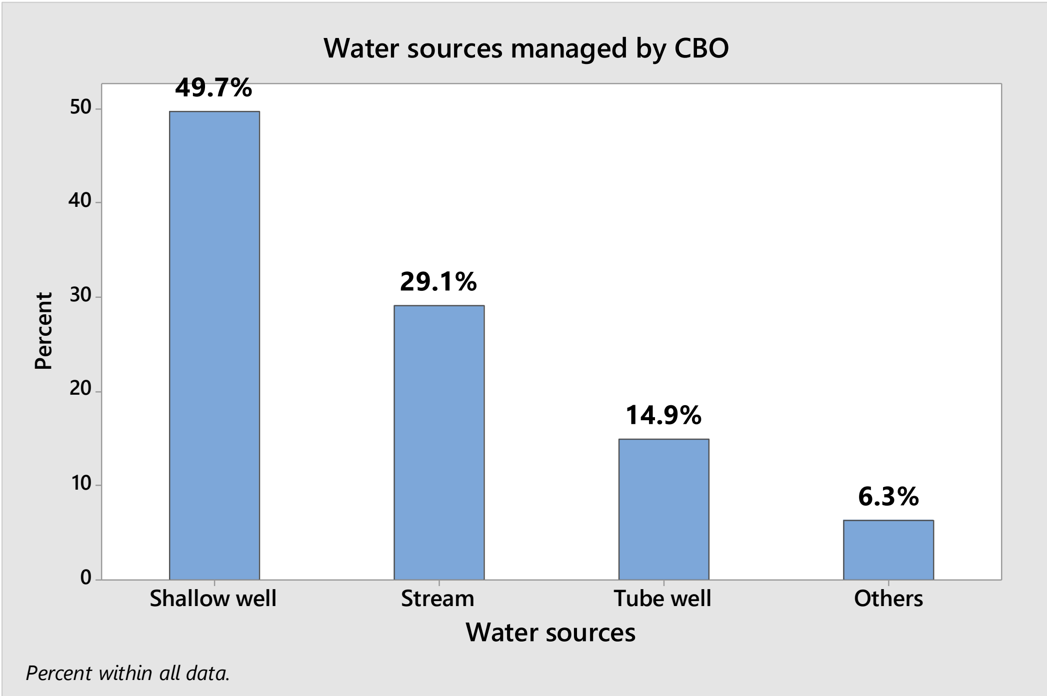

Figure 4.1: Water sources managed by CMWSS (according to survey)

Only 70.3% of households were satisfied about the water supplied by the water sources managed by the CMWSS. According to the Figure 4.2 some steps should be taken to increase the satisfaction of consumers as almost 30% of consumers were not satisfied about the quality of the water due to hardness, colour and smell.

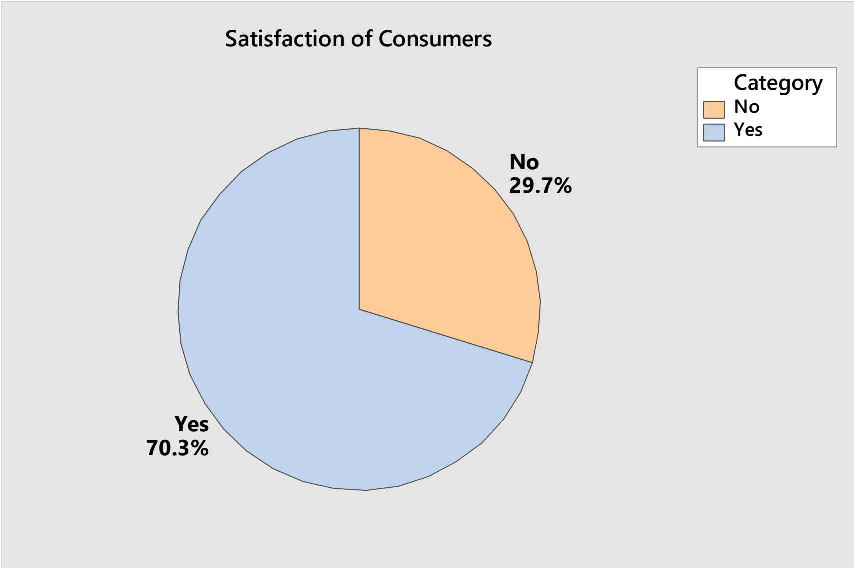

Figure 4.2: Status of Consumer satisfaction

Almost 51% of the households in the province used 251 to 500*l* of water per day, followed by 27% of households who used more than 500 l/day. Figure 4.3 depicts water requirement per day.

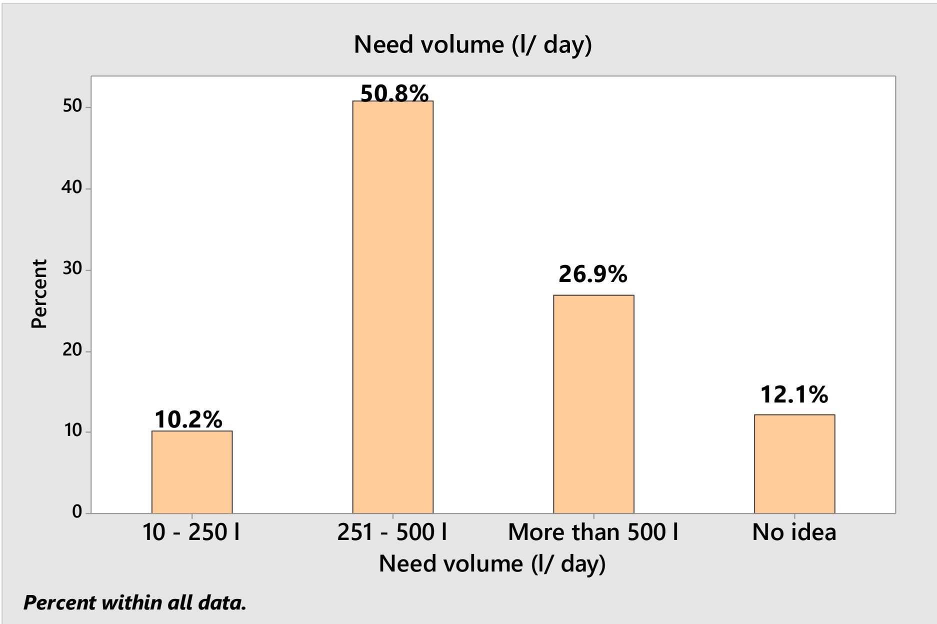

Figure 4.3: Need volume per day

Water Quality parameters were measured using the selected sample of 488 CMWSS operated water sources which included 172 water sources from Galle, 172 from Matara and 144 from Hambanthota district. In addition, the sample included various types of water sources such as ground water (dug wells and tube wells), surface water (stream, spring, tank, river, lake) (Sahoo and Khaoash, 2020) and water board bulk supply.

4.1 Water Sources managed by the Community Managed Water Supply Schemes in Southern Province

Ground water source (dug wells and tube wells), which represented 54.3% of the water sources managed by CMWSS in the province, while surface water (lakes, rivers, springs and streams) represented 44.9%. Figure 4.4 shows water sources managed by CMWSS.

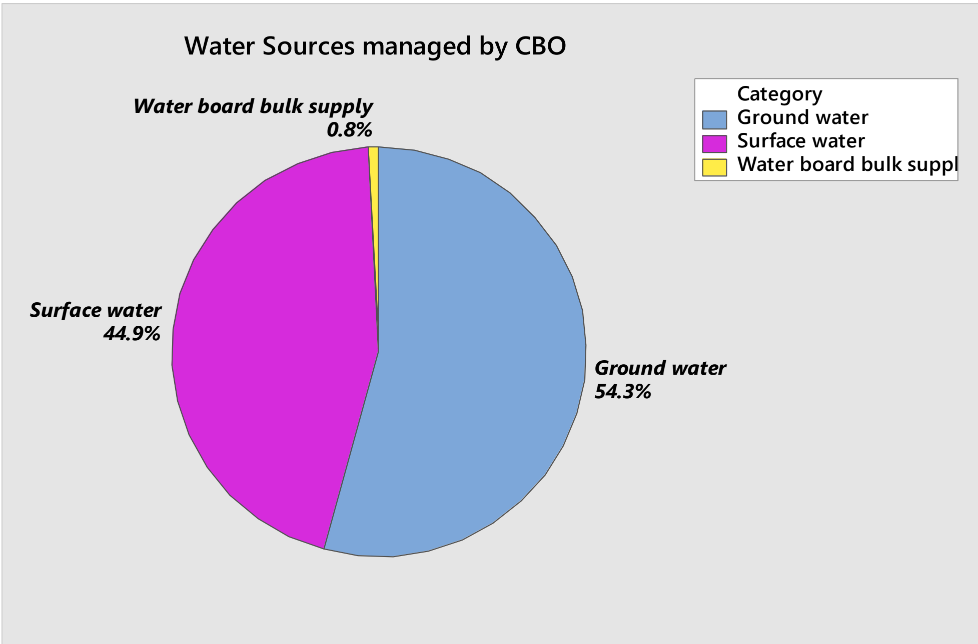

Figure 4.4: Water sources managed by CMWSS

Majority of water sources maintained by CMWSS was Dug wells (46.9%) followed by the streams which represented 41.8% while the least was the rivers (0.2%). Detailed classification of water sources is shown in Figure 4.5.

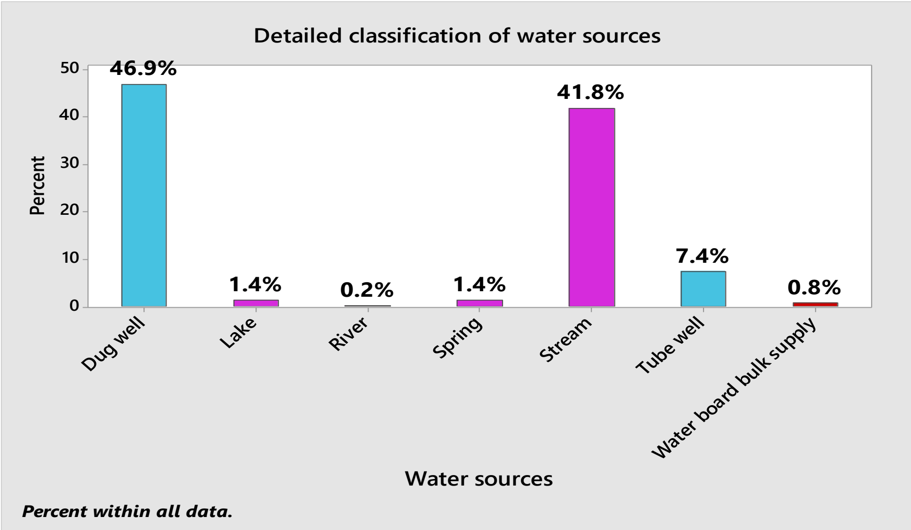

Figure 4.5: Detailed classification of water sources managed by CMWSS

4.2 Water Quality Parameters

4.2.1 Physical parameters

Under Physical parameters it was measured Temperature and Turbidity.

4.2.1.1 Temperature

Temperature is extremely useful in understanding the physical, chemical and biological activities that are accelerated or slowed by temperature changes. (Lewoyehu, 2021). Sri Lankan Standards do not contain a standard value for temperature (SLS 614 2013). Water temperature range of all tested schemes in southern province was recorded between 24.4°C and 32.5°C.

4.2.1.2 Turbidity

Turbidity is measured using NTU and is caused by particles suspended or dissolved in water that scatter light, making the water appear cloudy or murky. Sediment - especially clay and silt, fine organic and inorganic matter, soluble colored organic compounds, algae, and other microscopic organisms are examples of particulate matter. Table 4.1 depicts descriptive statistics of the turbidity in the southern province and its' districts.

Descriptive statistics of turbidity in Southern province and its' districts

Table 4. 1: Descriptive statistics of the turbidity (NTU) in Southern province and its' districts

Province/ District	Mean	Standard Deviation	Q1	Q2 (Median)	Q3	Min	Max
Southern province	5.1	0.72	1.2	2.0	3.8	0.3	305.0
Galle District	3.0	0.37	1.3	1.9	2.9	0.5	53.8
Hambanthota District	5.2	0.95	1.0	1.6	3.8	0.3	106.0
Matara District	7.1	1.84	1.6	2.4	5.1	0.7	305.0

Galle district had a significantly lower mean turbidity value (3 NTU) with compared to that of Matara and Hambanthota districts ($p<0.05$). But mean turbidity of Matara and Hambanthota were not significantly different.

Descriptive statistics of turbidity of different water sources

Descriptive statistics of turbidity of different types of sources is shown in Table 4.2.

Table 4. 2: Descriptive statistics of turbidity of different types of water sources

Water source	Mean	Standard Deviation	Q1	Q2	Q3	Min	Max
Ground water (All)	6.6	1.28	1.2	2.3	5.0	0.3	305.0
Dug well	7.1	1.48	1.3	3.2	14.9	0.3	33.5
Tube well	3.9	0.88	0.9	1.6	3.8	0.3	19.0
Surface water (All)	3.3	0.39	1.3	1.8	2.7	0.5	52.2
Lake	3.1	1.51	0.6	0.8	5.4	0.5	9.8
River	0.9	-	-	0.9	-	0.9	0.9
Spring	9.2	7.19	1.1	1.6	5.0	0.9	52.2
Stream	3.1	0.34	1.3	1.8	2.7	0.5	38.1
Water board bulk supply (NWS&DB)	5.5	3.63	1.2	2.4	12.9	0.8	16.3

Mean turbidity levels of all the other water sources except the river, were higher than the standard level of SLS 614 2013. Mean turbidity levels of ground water, surface water and water board bulk supply were not significantly different. No significant difference was observed between turbidity levels of dug wells and tube wells. Turbidity of spring water was significantly higher than that of stream water ($p<0.5$).

Status of turbidity level of water sources in Southern province and its' districts

Almost half of the water sources (50.8%) in the province had allowable level of turbidity i.e., maximum is 2 NTU (SLS 614 2013). A detailed classification of water sources managed by CMWSS is shown in Figure 4.6.

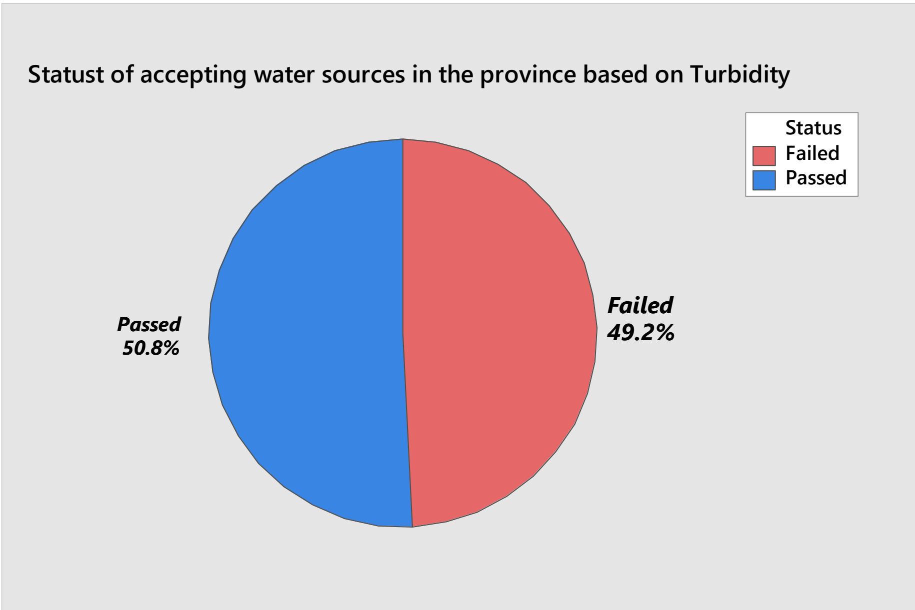

Figure 4.6: Detailed classification of water sources managed by CMWSS

In Matara district, 57.6% of the water sources did not have allowable level of turbidity while in Galle and Hambanthota districts those percentages were 44.2% and 45.1% respectively. Figure 4.7 depicts the status of water sources of each district based on turbidity.

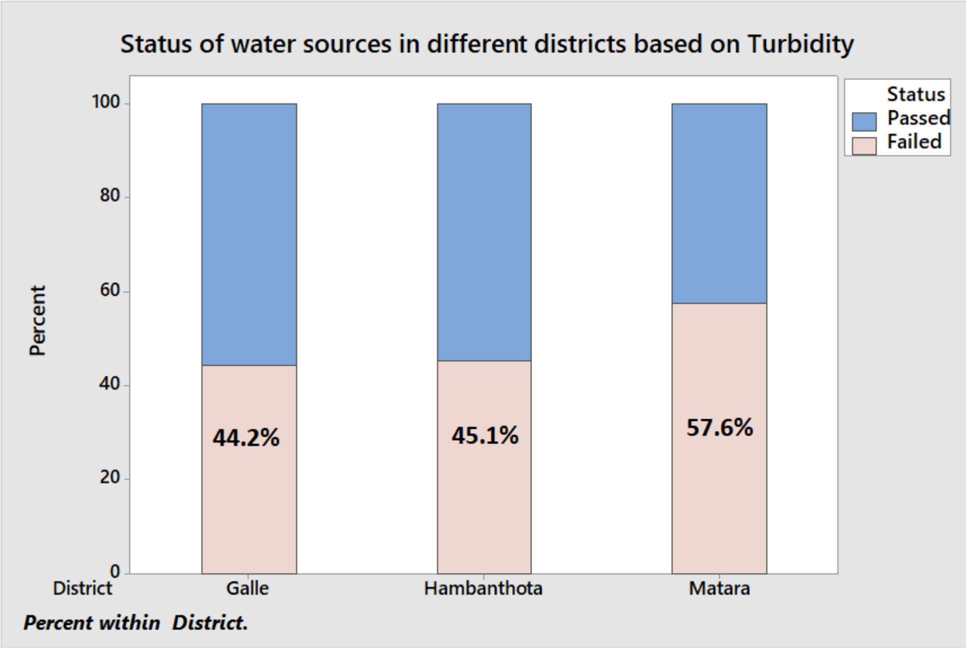

Figure 4.7: Status of water sources of each district based on turbidity

Status of water sources under different types based on turbidity

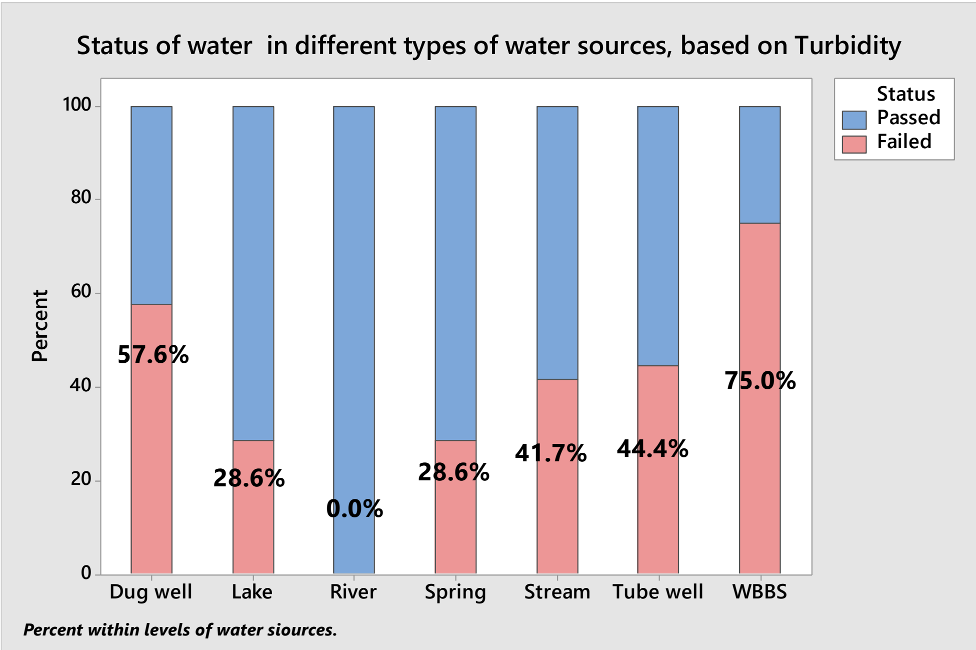

Figure 4.8: Status of water sources under different types based on turbidity

More than 40.0% of water sources of the type dug well, tube well, stream as seen in Figure 4.8 and WBBS had the turbidity level more than 2 NTU and hence the water of these sources should be treated for drinking and food processing. This will increase the cost of water treatment. Additionally, turbidity greater than 2NTU can be harmful to fish and other aquatic life by reducing food supplies, degrading spawning grounds, and interfering with gill function.

4.2.2 Chemical parameters

4.2.2.1 pH value

pH is defined as the amount of hydrogen ions in a solution. Acidic solutions have a lower pH value than alkaline solutions. Very acidic water produces sour taste and very alkaline water produces alkaline taste. The germicidal potential of chlorine is reduced at higher pH levels (Damo and Icka, 2013).

Descriptive statistics of pH values in Southern province and its' districts

Table 4.3 shows descriptive statistics of the pH in Southern province and its' districts. Mean pH value of Hambanthota district was higher ($p = 0.00$) than the mean pH values of Galle and Matara districts.

Table 4. 3: Descriptive statistics of the pH in Southern province and its' districts

Province/ District	Mean	Standard Deviation	Q1	Q2 (Median)	Q3	Min	Max
Southern province	6.3	0.04	5.7	6.3	7.0	4.3	10.0
Galle District	5.9	0.05	5.6	6.0	6.4	4.3	8.8
Hambanthota District	7.0	0.06	6.6	7.2	7.5	4.9	8.3
Matara District	6.1	0.07	5.5	6.0	6.7	4.4	10.0

Descriptive statistics of pH level in different types of water sources in Southern province

The mean pH values of ground water, surface water and water board bulk supply did not significantly differ. The descriptive statistics of pH of different types of water sources in the province is given in Table 4.4. But mean pH value of dug wells (6.2) was significantly different from that of tube wells which was 7.3 (p = 0.00). Further, Streams' mean pH value was significantly lower compared with mean pH values of lakes and springs (p = 0.00).

Table 4. 4: Descriptive statistics of pH of different types of water sources in the province

Water source	Mean	Standard Deviation	Q1	Q2	Q3	Min	Max
Ground water (All)	6.4	0.06	5.6	6.3	7.2	4.4	8.3
Dug well	6.2	0.06	5.6	6.2	7.0	4.4	7.9
Tube well	7.3	0.11	7.1	7.5	7.7	4.9	8.3
Surface water (All)	6.2	0.05	5.7	6.3	6.7	4.3	10.0
Lake	7.4	0.07	7.3	7.4	7.6	7.1	7.6
River	7.6	-	-	7.6	-	7.6	7.6
Spring	7.3	0.12	7.1	7.4	7.6	6.7	7.7
Stream	6.2	0.05	5.7	6.2	6.6	4.3	10.0
Water board bulk supply (NWS&DB)	7.1	0.06	7.0	7.1	7.3	7.0	7.3

Status of pH level of different water sources in Southern province

Majority of water sources managed by CMWSS in the province did not have the accepted level of pH values for drinking water. Almost all failed-water sources had their pH value less than 6.5 (Table 4.5).

Table 4. 5: Percentage of water sources in each pH category under different districts

Province/ District	**Percentage of water sources**			
Southern province	**pH< 6.5**	**Accepted pH level (6.5 - 8.5)**	**pH>8.5**	**Total**
Galle District	59.6	40.0	0.4	100
Hambanthota District	80.8	18.6	0.6	100
Matara District	22.2	77.8	0.0	100
	69.8	29.6	0.6	100

It was observed that the pH value of almost 81.0% of the water sources in Galle district was not in the accepted range.

4.2.2.2 Electrical Conductivity (EC)

The Electrical conductivity of water increased due to high ion concentration. The EC value indicates the amounts of soluble salts present in the water (Koç, 2017). A high dissolved solids concentration significantly impacts the taste of the drinking water (Damo and Icka, 2013).

Descriptive statistics of conductivity (µS/cm) of water sources in the province and its districts

There was a huge variation in mean conductivity values among districts within the province. The Conductivity of three districts differs significantly from one another ($p=0.00$). The descriptive statistics of conductivity of water in the province and its districts is depicted in Table 4.6.

Table 4. 6: Descriptive statistics of conductivity of water in the province and its districts

Province/ District	Mean	Standard Deviation	Q1	Q2 (Median)	Q3	Min	Max
Southern province	213.7	13.2	41.1	81.5	303.8	0.01	2059.0
Galle District	72.3	6.3	28.4	49.6	79.4	0.01	546.0
Hambanthota District	442.7	27.9	158.2	392,5	594.5	25.8	1826.0
Matara District	163.3	20.9	39.5	70.8	190.9	17.5	2059.0

Descriptive statistics of conductivity of different water sources

As shown in Table 4.7 and Figure 4.9 the ranges of conductivity values were quite high in ground water sources (dug wells and tube wells) when compared to those values of the other sources because ground water contains higher concentrations of ions and minerals than surface water (Sahoo and Khaoash, 2020).

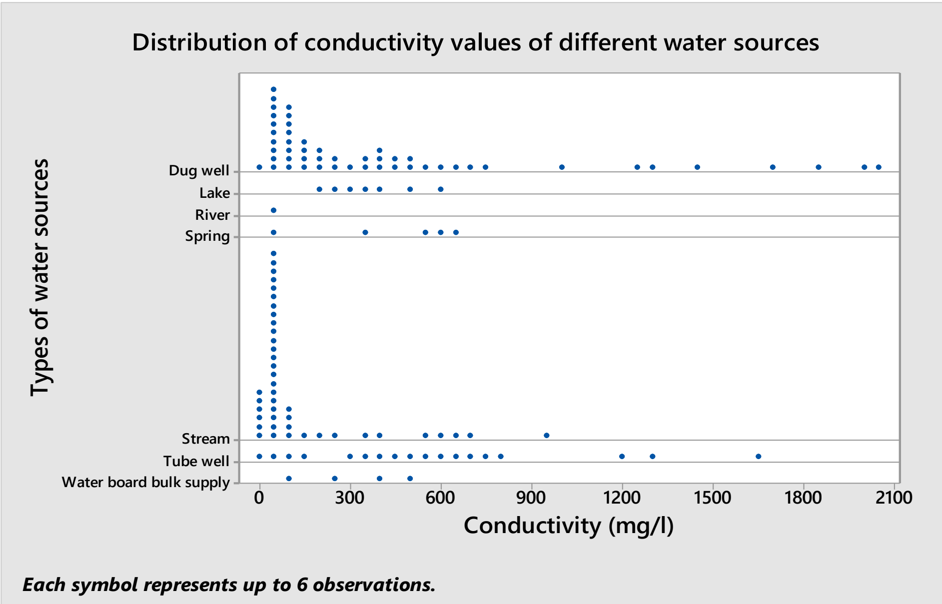

Figure 4.9: Distribution of conductivity values of different water sources

Table 4. 7: Descriptive statistics of conductivity of different types of water sources in the province

Water source	Mean	Standard deviation	Q1	Q2	Q3	Min	Max
Ground water (All)	309.6	21.0	77.2	170.0	438.5	1.3	2059.0
Dug well	272.9	21.8	72.9	147.7	385.5	1.3	2059.0
Tube well	543.0	55.0.	369.8	519.0	650.8	10.1	1656.0
Surface water (All)	95.9	10.2	29.9	41.3	73.4	0.01	973.0
Lake	362.1	54.7	258.0	331.0	493.0	182.4	600.0
River	72.3	-	-	72.3	-	72.3	72.3
Spring	454.7	86.4	343.0	558.0	626.0	29.9	670.0
Stream	74.6	8.5	29.4	40.2	66.9	0.01	973.0
Water board bulk supply (NWS&DB)	306.8	81.2	142.0	324.0	454.3	103.0	476.0

Status of water sources in the province and districts, based on conductivity

Figure 4.10 shows Status water sources in the province based on conductivity, and Figure 4.11 clearly shows that almost 92% of the water sources in Hambanthota district did not have the allowable conductivity level.

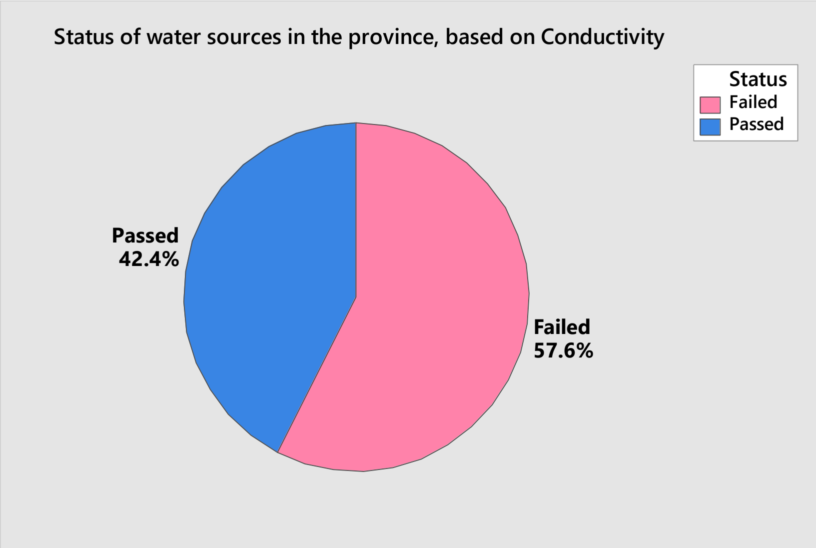

Figure 4.10: Status water sources in the province based on conductivity

Figure 4.11 depicts status of water sources in districts based on conductivity. It is vital to give consideration to water board bulk supply because all those water sources did not have the allowable conductivity level. Similar results were observed with lakes and river water (see Figure 4.12).

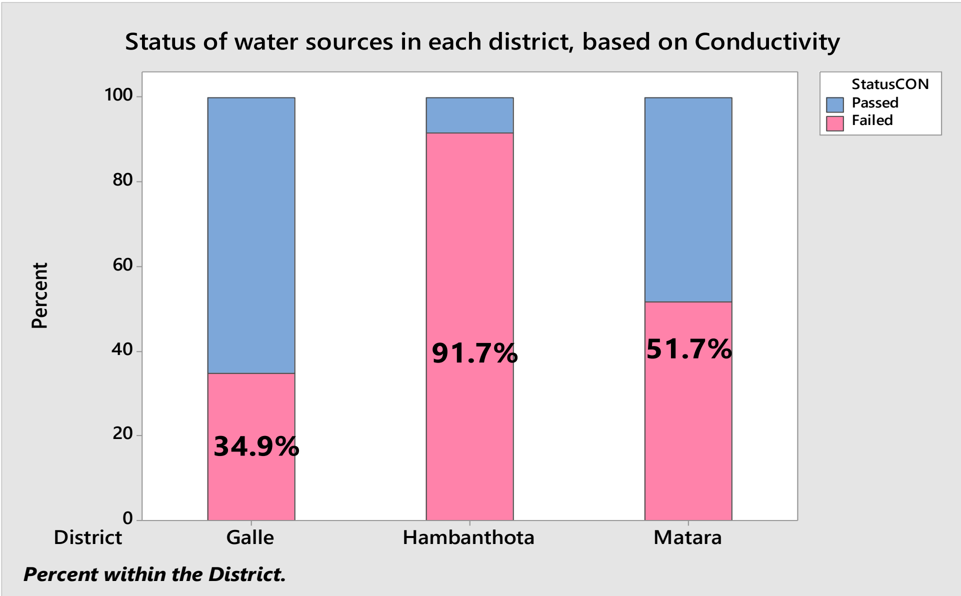

Figure 4.11: Status of water sources in districts based on conductivity

Status of water sources under different types based on conductivity

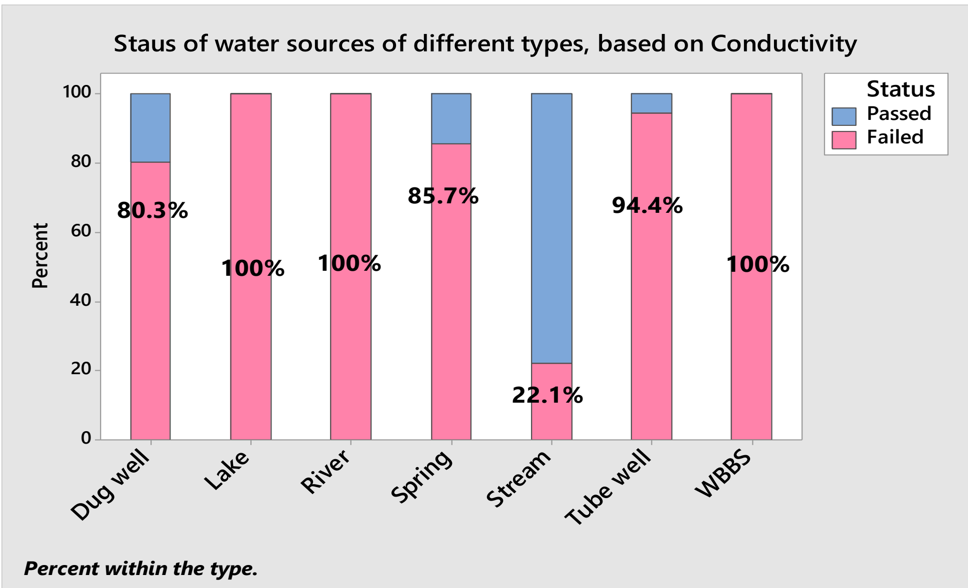

Figure 4.12: Status of water sources of different types based on conductivity

4.2.2.3 Total hardness (as $CaCO_3$)

Hardness is divided into two categories; carbonate hardness (temporary hardness) occurs due to presence of calcium and magnesium bicarbonates in water and non-carbonate hardness occurs due to dissolve of calcium and magnesium salts (chlorides, sulphates and nitrates) in water. Hardness causes scaling on cooking utensils such as electric kettles, water heaters and boilers which reducing the heating efficiency. Scale can clog pipes which reducing the water pressure (Amarasiri, 2015). Because of the bitterness of magnesium hardness causes bad taste (Ayala et al., 2017).

Descriptive statistics of Total hardness (mg/l) of water sources in the province and its districts

Total hardness of the water in southern province varied from 0.0 (mg/l) to 492 (mg/l) with a mean value of 42.0 mg/l. Water sources in Hambanthota had significantly higher mean total hardness than those in Matara and Galle (p=0.00). Similar findings have been reported by (Ayala et al., 2017). Hambanthota district in Sri Lanka recorded the highest hardness value. Table 4.8 shows Descriptive statistics of Total hardness (mg/l) of water sources in the province and its districts

Table 4. 8: Descriptive statistics of Total hardness (mg/l) of water sources in the province and its districts

Province/ District	Mean	Standard Deviation	Q1	Q2 (Median)	Q3	Min	Max
Southern province	42.0	3.8	0.0	0.0	32.0	0.0	492.0
Galle District	2.5	0.67	0.0	0.0	0.0	0.0	70.5
Hambanthota District	129.2	9.3	14.0	114.0	211.0	0.0	492.0
Matara District	8.6	2.3	0.0	0.0	0.0	0.0	200.0

Descriptive statistics of Total hardness (mg/l) of different types of water sources in the province

Mean total hardness of tube well (150.3 mg/l) was significantly higher than that of dug wells (42.8 mg/l) (p=0.00). In addition, 50% of dug wells in the province had 0.0 mg/l total hardness. Table 4.9 depicts Descriptive statistics of Total hardness (mg/l) of different types of water sources in the province. Apart from that, ground water sources had a significantly higher mean total hardness than the surface water sources (p=0.0). Similar result has been reported by (Ayala et al., 2017). Generally, the ground water in Sri Lanka is extremely hard. Within the surface water sources, streams had a significantly lower mean total hardness compared with lakes and springs (p=0.00). Further, river water had the lowest mean hardness value (0.0 mg/l) and spring water had the highest mean value as 174.6 mg/l.

Table 4. 9: Descriptive statistics of Total hardness (mg/l) of different types of water sources in the province

Water source	Mean	Standard deviation	Q1	Q2	Q3	Min	Max
Ground water (All)	57.4	5.91	0.0	0.0	91.0	0.0	492.0
Dug well	42.8	5.7	0.0	0.0	34.8	0.0	492.0
Tube well	150.3	17.0	76.5	135.0	223.5	0.0	458.0
Surface water (All)	22.2	4.26	0.0	0.0	0.0	0.0	356.0
Lake	113.1	15.5	86.0	98.0	148.0	58.0	170.0
River	0.0	-	-	0.0	-	0.0	0.0
Spring	174.6	38.8	104.0	172.0	260.0	0.0	302.0
Stream	13.9	3.7	0.0	0.0	0.0	0.0	356.0
Water board bulk supply (NWS&DB)	108.5	41.4	25.5	115.0	185.0	6.0	198.0

Status of water sources in the province and districts based on Total hardness

Almost 96.0% of the water sources in the province had the allowable level (≤ 250 mg/l) of total hardness (SLS 614 2013). Figure 4.13 shows Status of water sources in the province based on total hardness, and Figure 4.14 shows Status of water sources in different districts, based on total hardness. All the water sources in Galle and Matara districts had allowable level of total hardness.13.2% of water sources in Hambanthota district were exceeded the standard level.

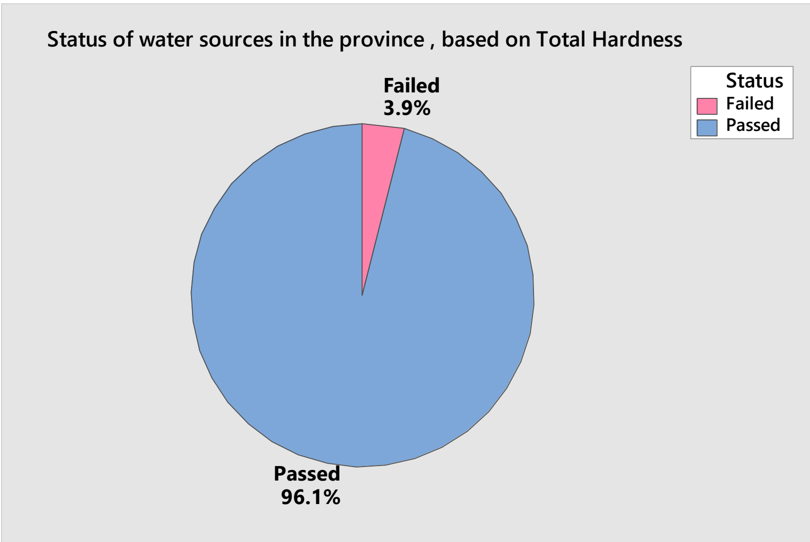

Figure 4.13: Status of water sources in the province based on total hardness

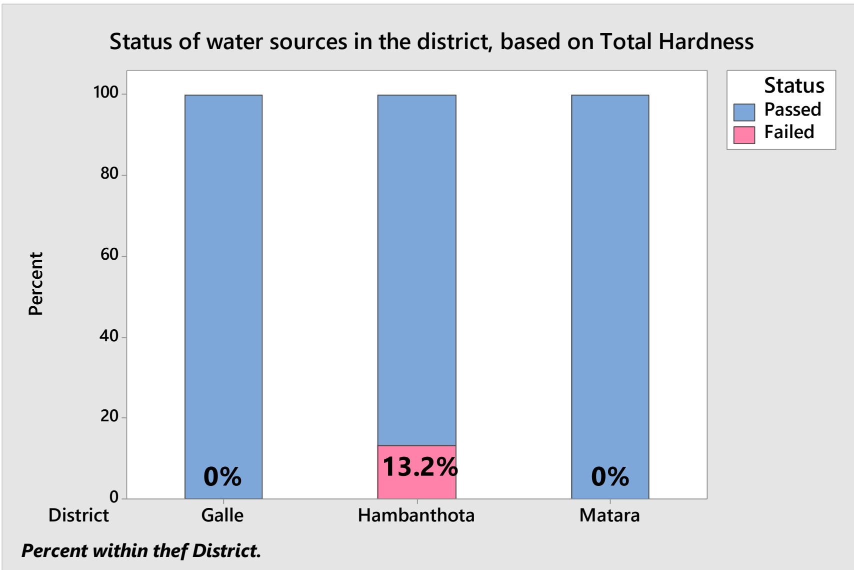

Figure 4.14: Status of water sources in different districts, based on total hardness

Status of water from different types of water sources in relation to Total hardness

All the water sources under lakes, rivers and water board bulk supply had allowable level of total hardness. Figure 4.15 shows the status of water sources of different types, based on Total hardness.

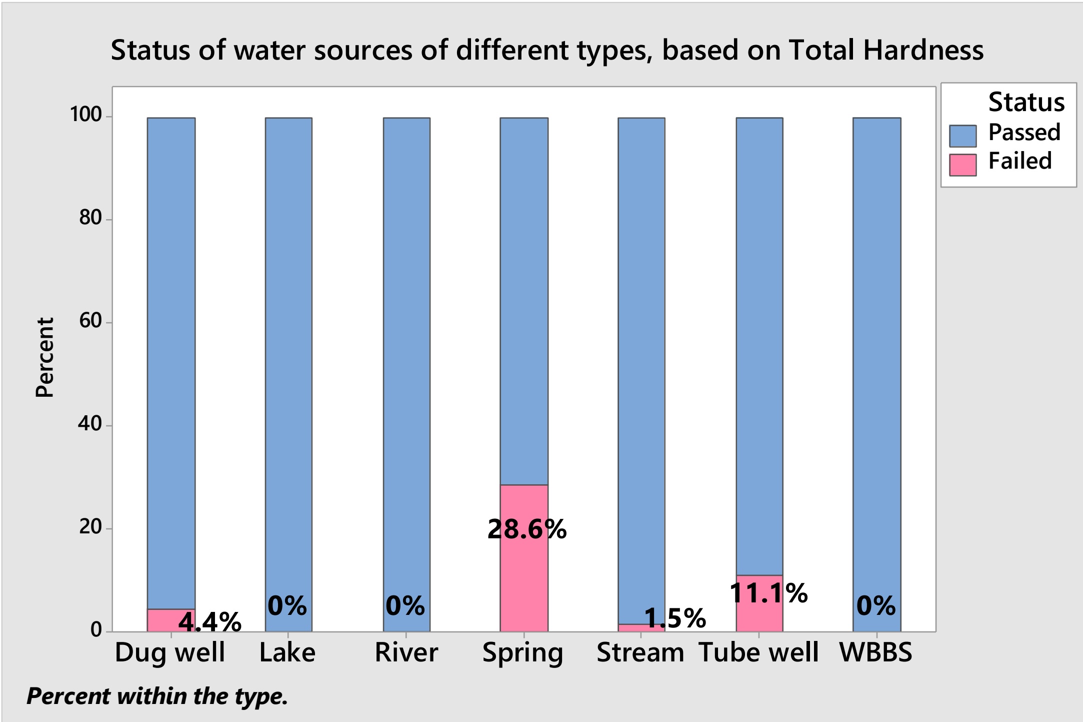

Figure 4.15: Status of water sources of different types, based on Total hardness

4.2.2.4 Nitrate level (as NO_3)

Nitrate is the most important agricultural contaminant (Fan, 1996). Industrial waste, chemicals, and human and animal waste are some additional sources of nitrate in water. Nitrate in drinkable water is 50mg/L according to WHO recommendations (WHO, 2011), and Sri Lankan requirements are also 50mg/L. (SLSI,614: 2013). Nitrate levels in drinking water that are over 50 mg/L cause serious illnesses like methemoglobinemia (Ugbaja et al.,2012) or "blue baby syndrome" in newborn babies (Gupta et al., 2009)

Descriptive statistics of NO_3 level (mg/l) of water sources in the province and its districts

Table 4.10 shows the descriptive statistics of NO_3 level (mg/l) of water sources in the province and its districts

Table 4. 10: Descriptive statistics of NO3 level (mg/l) of water sources in the province and its districts

Province/ District	Mean	Standard deviation	Q1	Median	Q3	Min	Max
Southern province	2.2	0.17	0.1	0.6	2.6	0.0	31,4
Galle District	4.0	0.39	0.2	1.5	5.9	0.01	31.4
Hambanthota District	1.1	0.11	0.24	0.7	1.5	0.02	8.4
Matara District	1.4	0.23	0.0	0.1	1.5	0.0	20.3

Descriptive statistics of NO_3 level (mg/l) of different types of water sources in the province

Mean nitrate level was not significantly different among ground water, surface water and water board bulk supply. There was no statistically significant difference in mean nitrate levels between dug and tube wells. (p=0.051). But mean nitrate level of spring water (0.42 mg/l) was significantly lower than that of stream water (2.5 mg/l) (p=0.00). Descriptive statistics of NO3 level (mg/l) of different types of water sources in the province is given in Table 4.11.

Table 4. 11: Descriptive statistics of NO3 level (mg/l) of different types of water sources in the province

Water source	**Mean**	**Standard deviation**	**Q1**	**Q2**	**Q3**	**Min**	**Max**
Ground water (All)	2.2	0.25	0.02	0.5	2.5	0.0	31.4
Dug well	2.3	0.3	0.02	0.5	2.7	0.0	31.4
Tube well	1.4	0.4	0.2	0.5	1.1	0.01	11.2
Surface water (All)	2.3	0.25	0.1	0.7	2.7	0.0	19.3
Lake	0.8	0.2	0.4	0.7	1.3	0.2	1.5
River	1.4	-	-	1.4	-	1.4	1.4
Spring	0.4	0.2	0.02	0.1	0.6	0.02	1.6
Stream	2.5	0.3	0.1	0.8	2.9	0.0	19.3
Water board bulk supply (NWS&DB)	0.6	0.6	0.3	0.5	0.9	0.2	1.1

Status of water sources in the province and its districts, based on NO_3 level (mg/l)

Status of sources in the province, based on NO_3 level is depicted in Figure 4.16.

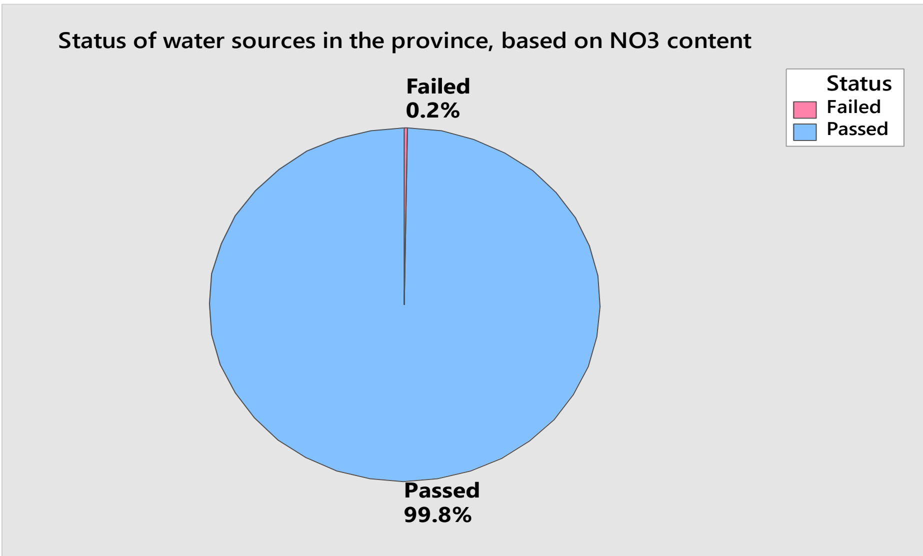

Figure 4.16: Status of water sources in the province, based on NO_3 level

Almost all the water sources (99.8%) in the province had the NO_3 content less than the maximum allowable level i.e. 50 mg/l (SLS 614 2013). All the water sources in Galle, Matara and Hambanthota districts had allowable level of NO_3. Figure 4.17 shows the status of water sources in each district, based on NO_3 level.

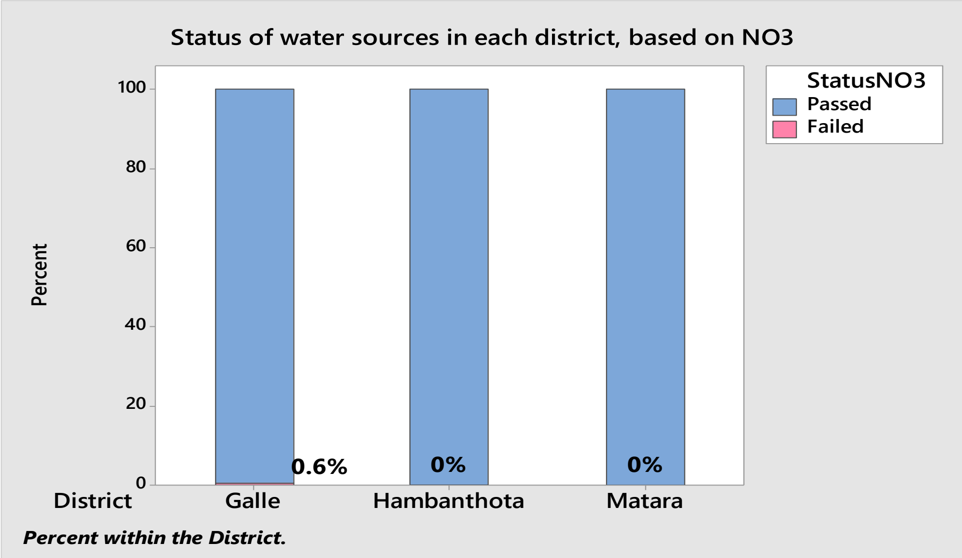

Figure 4.17: Status of water sources in each district, based on NO_3 level

Status of water sources of different types based on NO_3 level

All the water sources (dug well, lakes, rivers, springs, streams, tube wells and water board bulk supply) had allowable level of NO_3. Status of water sources of different types, based on NO3 level is as in Figure 4.18.

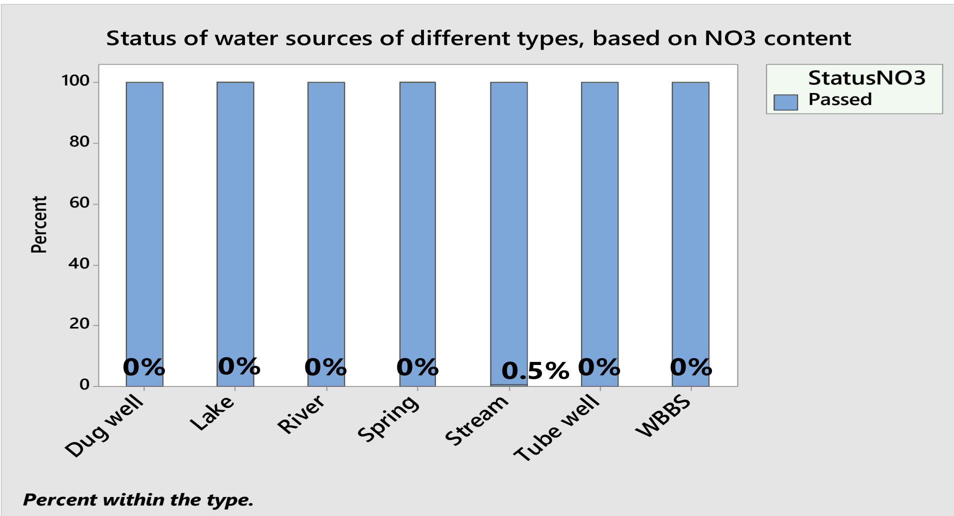

Figure 4.18: Status of water sources of different types, based on NO_3 level

4.2.2.5 Iron (as Fe) content

During the cycle of water movement, many solid and gaseous components were dissolved in water especially many and varied constituents are added to the water from dissolution of rocks and minerals (Hickey, H., 2008).

With at least 5% of the earth's crust made of iron, it is one of the planet's most abundant resources. The iron in the earth's surface dissolves when it rains, causing it to enter almost every natural water source, including well water. Ferrous iron dissolves completely in water, and making it clear and colorless. When insoluble iron is present in water, the water becomes cloudy and develops a reddish-brown substance.

Iron is a secondary or aesthetic contaminant even though it is not harmful to health and is necessary for good health. Iron aids in the transportation of oxygen in the blood. Water has an unappealing metallic taste from dissolved ferrous iron. When iron reacts with tea, coffee, and other beverages, it creates an inky, black appearance as well as a harsh, unpleasant taste. Vegetables cooked in high-iron water turn dark and unappealing. It also causes discoloration and turbidity in water. The present standard level for iron in water is 0.3 mg/l (SLS 614 2013), which is based on taste and appearance rather than any negative health effects.

Descriptive statistics of iron content of water sources in the province and its districts

Mean iron (as Fe) content of the water sources in Galle district was significantly higher than the allowable level ($p = 0.00$) as shown in Table 4.12.

Table 4. 12: Descriptive statistics of iron content of water sources in the province and its districts

Province/ District	Mean	Standard deviation	Q1	Q2 (Median)	Q3	Min	Max
Southern province	5.60	1.30	0.03	0.06	0.20	0.01	416.0
Galle District	15.70	3.50	0.10	0.19	0.43	0.01	416.0
Hambanthota District	0.10	0.01	0.03	0.05	0.11	0.02	2.1
Matara District	0.06	0.01	0.03	0.04	0.05	0.02	0.7

Descriptive statistics of iron content (mg/l) of different types of water sources in the province

Fe content varied significantly between surface water (7.9 mg/1) and WBBS (0.1mg/l) ($p=0.00$). while no significant difference was observed between ground water sources and surface water sources. Table 4.13 depicts the descriptive statistics of iron content of water sources of different types.

Table 4. 13: Descriptive statistics of iron content of water sources of different types

Water source	Mean	Standard	Q1	Q2	Q3	Min	Max
Ground water (All)	3.8	1.17	0.04	0.06	0.1	0.02	149.0
Dug well	4.3	1.35	0.03	0.06	0.2	0.02	149.0
Tube well	0.4	0.23	0.04	0.09	0.1	0.12	10.1
Surface water (All)	7.9	2.42	0.03	0.06	0.2	0.01	416.0
Lake	0.03	0.00	0.02	0.03	0.03	0.02	0.03
River	0.02	-	-	0.02	-	0.02	0.02
Spring	0.1	0.02	0.02	0.04	0.1	0.02	0.2
Stream	8.4	2.59	0.03	0.07	0.2	0.01	416.0
Water board bulk supply (NWS&DB)	0.1	0.02	0.02	0.06	0.1	0.02	0.12

Status of water sources in the province and districts based on Fe content

Most of the water sources (89.1%) in the province had not exceeded the allowable level of Fe content in portable water (0.3 mg/l), (SLS 614 2013). Comparatively a higher percentage of water sources in Galle district (compared with Matara and Hambanthota) had more than 0.3mg/l Fe content. Figure 4.19 and 4.20 show the status of water sources in province and each district based on Fe content respectively.

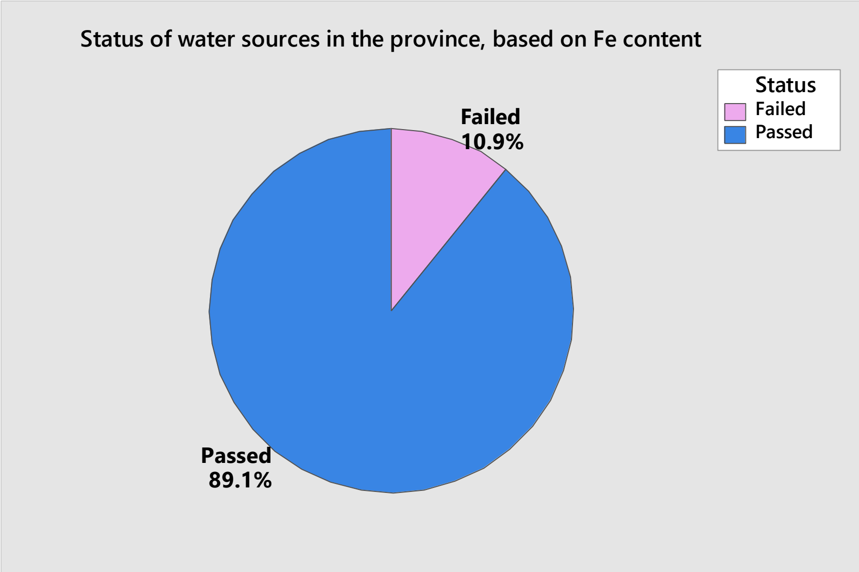

Figure 4.19: Status of water sources in the province based on Fe content

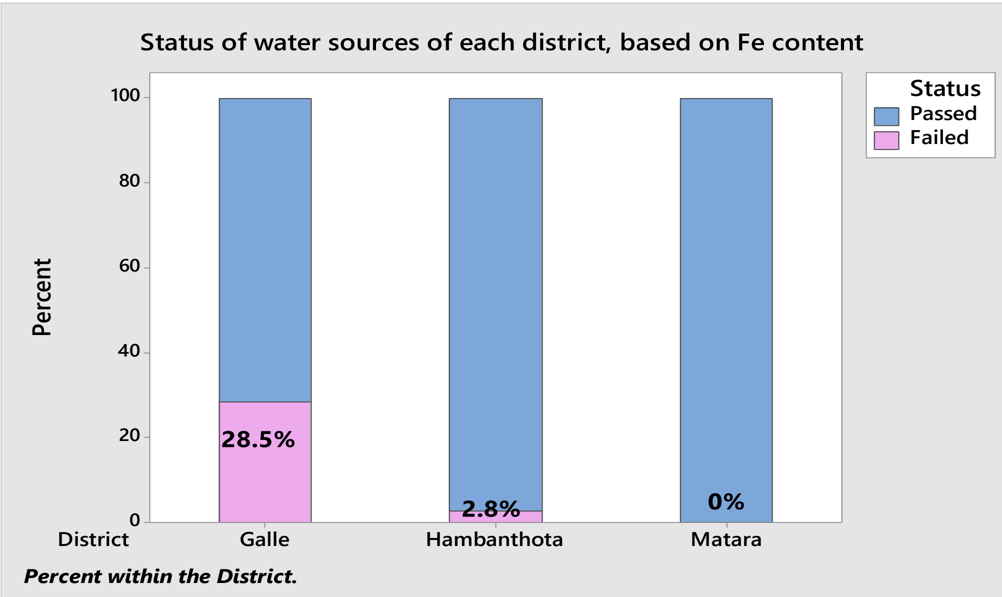

Figure 4.20: Status of water sources in each district based on Fe content

Status of water sources of different types, based on Fe content

Except dug well, tube well (ground water) and streams, all the other types (lakes, spring and WBBS) had Fe content less than 0.3 mg/l the accepted level set by SLS 614 2013. Status of water sources of different types, based on Fe content is shown in Figure 4.21.

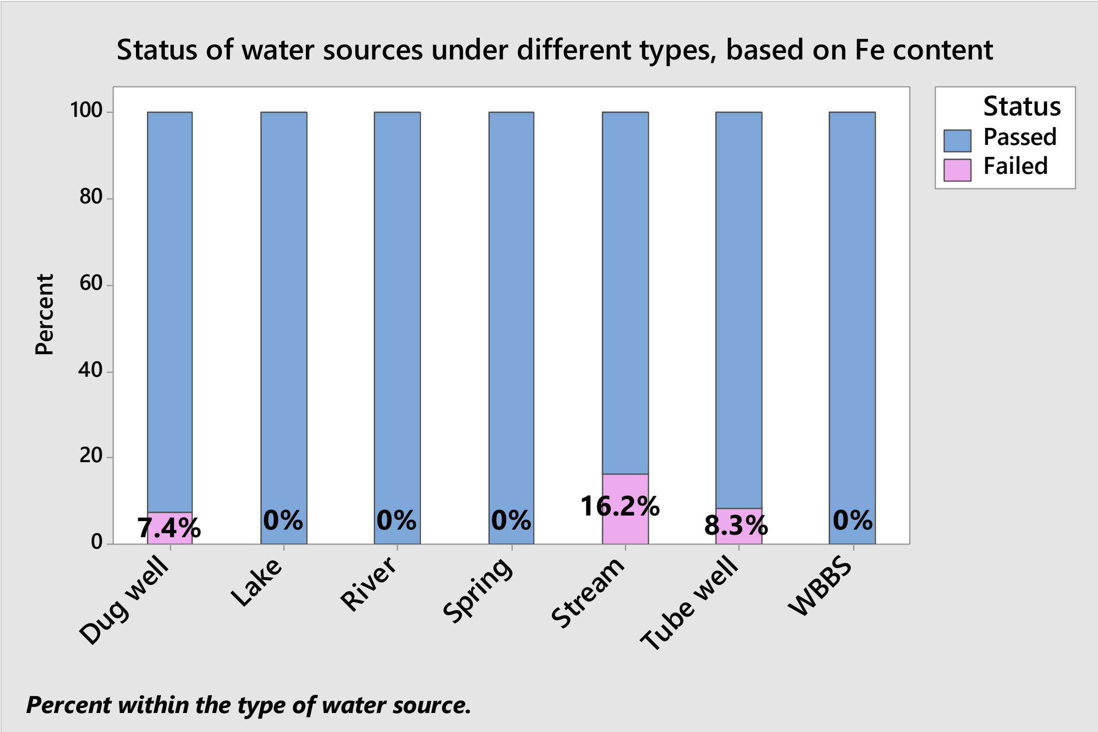

Figure 4.21: Status of water sources of different types, based on Fe content

4.2.2.6 Fluoride (as F) content

Fluoride is a common constituent of groundwater. Fluoride naturally occurs in public water systems as a result of runoff from fluoride-containing rocks and soils weathering and leaching from soils into groundwater. High fluoride concentrations in groundwater are also caused by volcanic activity, agricultural fertilizer use, and industrial activities (clays used in ceramic industries or coal combustion). Fluoride is essential for the development of human bones and teeth. However, excessive fluoride in drinking water harms human health by causing dental fluorosis and skeleton fluorosis (Yadav et al., 2006). Fluoride levels in drinking water should be less than 1.5 mg/L, according to

WHO guidelines (WHO, 2011). The maximum amount allowed in public water systems is 1.0mg/l, also known as the Maximum Contaminant Level (MCL), as prescribed by SLS 614 2013.

Descriptive statistics of Fluoride content of water sources in the province and its districts

Water sources' mean fluoride levels varied significantly between districts (p =0.00) showing that Hambanthota had the highest fluoride content (0.33 mg/l). But mean fluoride content of any district did not exceed the permissible level 1.0 mg/l set by SLS 614 2013.Similar outcomes were reported by (Ayala et al., 2017). The high value of fluoride content recorded in dry zone of Sri Lanka. Table 4.14 depicts the descriptive statistics of Fluoride content (mg/l) of water sources in the province and its districts.

Table 4. 14: Descriptive statistics of Fluoride content (mg/l) of water sources in the province and its districts

Province/ District	**Mean**	**Standard deviation**	**Q1**	**Q2 (Median)**	**Q3**	**Min**	**Max**
Southern province	0.22	0.01	0.11	0.19	0.28	0.0	1.25
Galle District	0.16	0.01	0.10	0.16	0.21	0.0	0.57
Hambanthota District	0.33	0.02	0.15	0.34	0.44	0.01	1.25
Matara District	0.19	0.01	0.10	0.18	0.26	0.0	1.05

Descriptive statistics of Fluoride content of water sources of different types in the province

Mean Fluoride level of ground water and surface water were equal amount (0.2mg/l).

There was a significant difference in fluoride content of dug wells and tube wells (p = 0.00). Table 4.15 depicts the descriptive statistics of Fluoride content of water sources of different types.

Table 4. 15: Descriptive statistics of Fluoride content of water sources of different types

Water source	**Mean**	**Standard deviation**	**Q1**	**Q2**	**Q3**	**Min**	**Max**
Ground water (All)	0.2	0.01	0.10	02	0.4	0.0	1.3
Dug well	0.2	0.01	0.09	0.2	0.3	0.0	1.2
Tube well	0.4	0.04	0.24	0.4	0.5	0.1	1.3
Surface water (All)	0.2	0.01	0.12	0.2	0.3	0.0	0.6
Lake	0.3	0.04	0.21	0.3	0.4	0.1	0.5
River	0.4	-	-	0.4	-	0.4	0.4
Spring	0.2	0.05	0.15	0.2	0.4	0.04	0.4
Stream	0.2	0.01	0.12	0.2	0.2	0.0	0.6
Water board bulk supply (NWS&DB)	0.3	0.09	0.13	0.3	0.5	0.1	0.5

Status of water sources in the province and districts based on Fluoride content

Figure 4.22 clearly depicted that 99.0% of the water sources in the province had less fluoride content than the permissible level prescribed by SLS 614 2013 (1.0 mg/l).

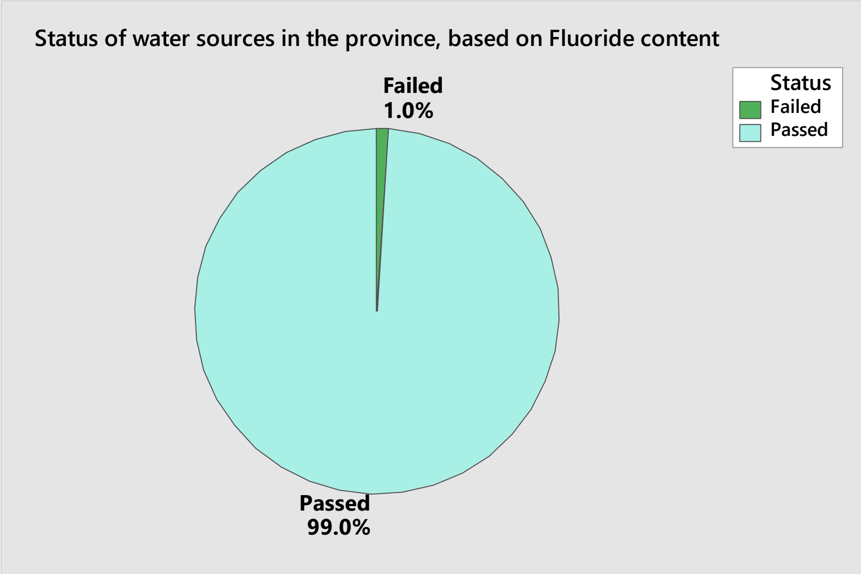

Figure 4.22: Status of water sources in the province based on fluoride content

All districts showed almost more than 98% of water sources in each district had permissible level of Fluoride content which 1 mg/l (SLS 614 2013). Status of water sources in each district, based on Fluoride content is given in Figure 4.23.

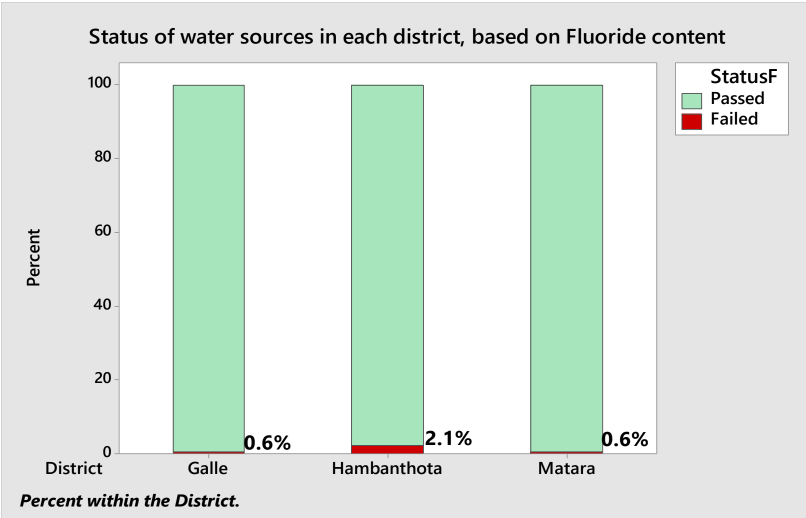

Figure 4.23: Status of water sources in each district, based on Fluoride content.

Status of water sources of different types, based on Fluoride content

Except for dug wells, tube wells, and streams, the fluoride content of all other types was less than 1.0 mg/l (614:2013 SLS). Groundwater has a higher fluoride content than surface water.Figure 4.24 shows the status of water sources of different type based on Fluoride content.

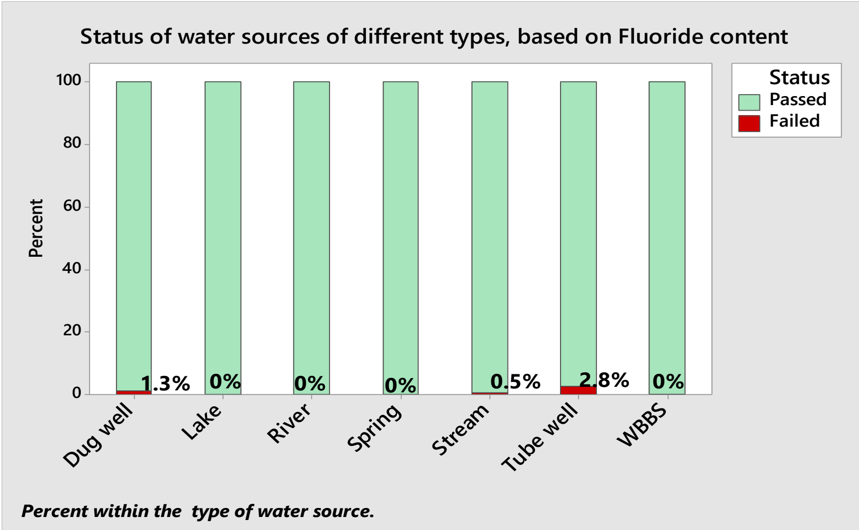

Figure 4.24: Status of water sources of different types, based on Fluoride content

4.2.2.7 Heavy Metals

Though only a few heavy metals are required for human health, an excessive amount can have negative effects (USEPA, 2015). Both natural processes and human activities cause the release of heavy metals into the environment (Chowdhury et al.,2016). As, Cd, Pb, and Mn were analyzed under heavy metals. According to Sri Lankan Standard 614 2013, limits of As, Cd, Pb, and Mn are respectively 0.01mg/l, 0.003mg/l, 0.01mg/l and 0.1mg/l. An excess amount of As, can cause skin, bladder and lung cancer. Due to excess amount of Cd in water causes human health such as Decalcification of the bones, protein and sugar in urine and kidney damage. An excessive Pb in water causes muscular paralysis, damage to nervous system, liver and kidney, lowered IQ, anemia. Unpleasant taste of water occurs due to excess amount of Mn. According to analysis heavy metals in water samples of the province were below the detection level.

4.2.3 Biological parameters

At the source, during collection, distribution, or transportation, as well as during use and storage, water can become contaminated with microorganisms. (Damo and Icka, 2013).

4.2.3.1 *E. coli* bacteria count

E. coli bacteria count should be 0/100 ml for drinking water (SLS 614 2013).

Descriptive statistics of *E. coli* bacteria count of water in the province and its' districts

Mean *E. coli* count/100 ml water was not significantly different among districts. But mean *E. coli* count of each district was significantly higher than the accepted level (p= 0.00). Table 4.16 depicts the descriptive statistics of *E. coli* bacteria level of water in the province and its' districts.

Table 4. 16: Descriptive statistics of *E. coli* bacteria level of water in the province and its' districts

Province/ District	Mean	Standard deviation	Q1	Q2 (Median)	Q3	Min	Max
Southern province	37.5	4.5	1.0	5.0	28.0	0.0	736.0
Galle District	31.7	6.9	1.0	5.0	19.0	0.0	736.0
Hambanthota District	33.1	9.3	0.0	1.0	15.0	0.0	704.0
Matara District	47.0	7.2	1.3	12.0	51.0	0.0	684.0

Descriptive statistics of *E. coli* bacteria count of various water sources in the province

Tube wells had significantly lower *E. coli* count than the dug wells while streams had lower *E. coli* count than the springs (p =0.00). Except lakes all the other water sources had their *E. coli* count significantly higher than the accepted level which is 0/100ml of water (p =0.00). Table 4.17 depicts descriptive statistics of *E. coli* bacteria count of various water sources in the province.

Table 4. 17: Descriptive statistics of *E. coli* bacteria count of different water sources in the province

Water source	Mean	Standard deviation	Q1	Q2	Q3	Min	Max
Ground water (All)	29.9	5.4	0.0	2.0	16.0	0.0	704.0
Dug well	33.1	6.4	0.0	3.0	17.0	0.0	304.0
Tube well	9.2	3.2	0.0	0.0	8.0	0.0	89.0
Surface water (All)	45.0	7.0	2.0	12.0	43.0	0.0	736.0
Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0
River	10.0	-	-	10.0	0.0	10.0	10.0
Spring	117.1	93.0	3.0	15.0	73.0	1.0	672.0
Stream	44.3	6.8	3.0	13.0	43.0	0.0	736.0
Water board bulk supply (NWS&DB)	132.0	142.0	0.0	1.0	396.0	0,0	528.0

Status of water sources in the province and districts based on *E. coli* count

Majority of water sources (66.0%) in the province had exceeded the accepted level of *E. coli* count**.** 0/100 ml of water (SLS 614 2013). Figure 4.25 shows the status of water sources in the province based on *E. coli* count.

In all districts more than 55.0% of water sources had *E. coli* count higher than the accepted amount (0/100 ml) of E coli (SLS 614 2013). Figure 4.26 shows the status of water sources in districts based on E. coli count

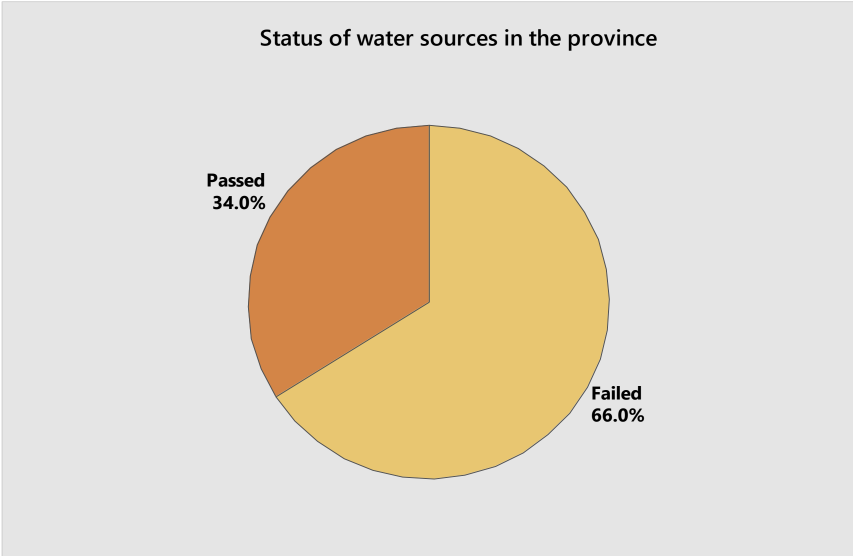

Figure 4.25: Status of water sources in the province based on *E. coli* count

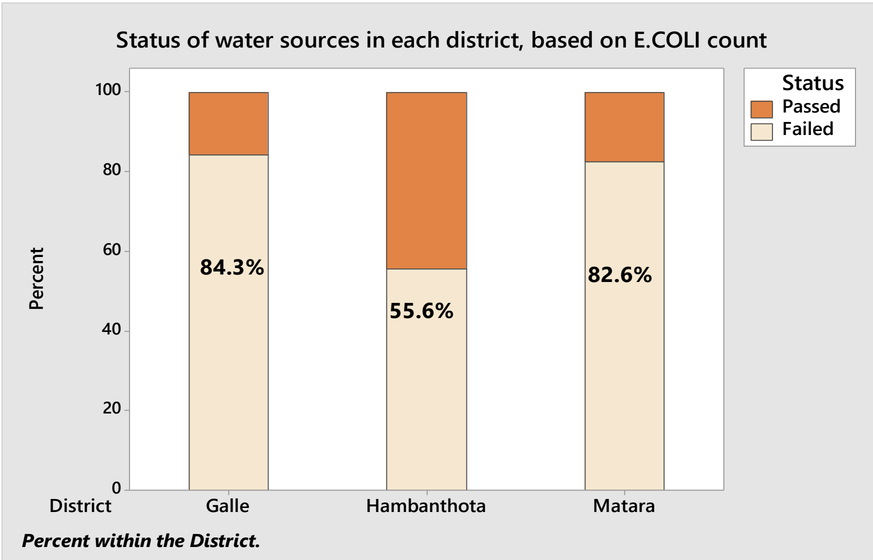

Figure 4.26: Status of water sources in districts based on E. coli count

Status of water sources which are under different types, based on *E. coli* count.

More than or equal to 44 % of water sources in all types had unaccepted count of *E. coli* i.e., 0 count in 100 ml water (SLS 614 2013). Figure 4.47 depicts Status of water sources belong to different types, based on E. coli count.

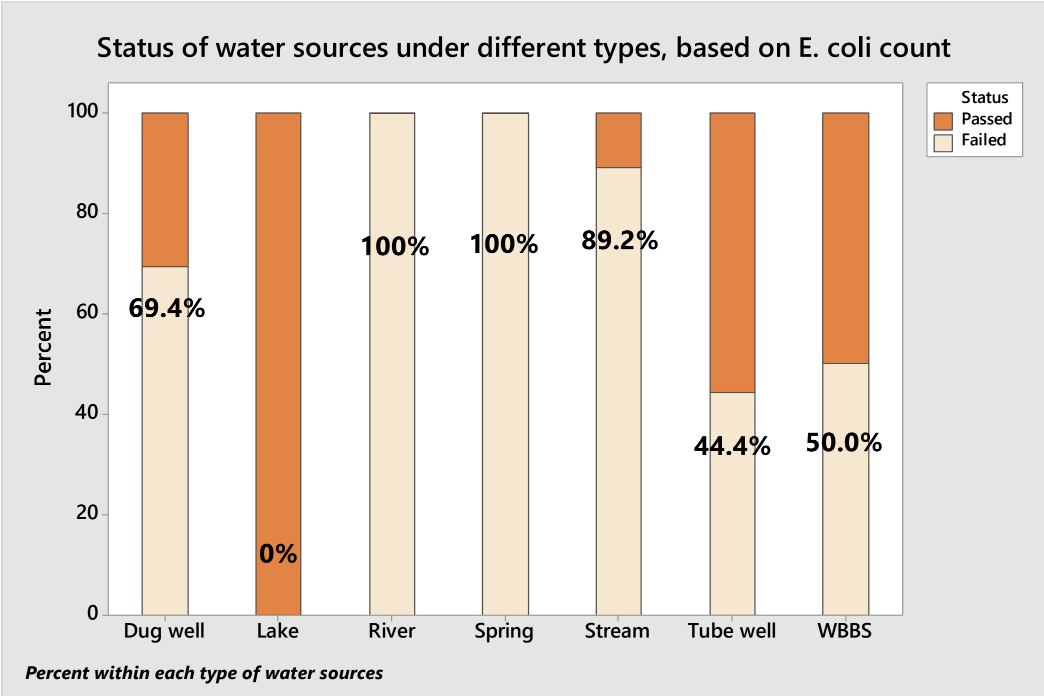

Figure 4.27: Status of water sources belong to different types, based on E. coli count.

4.2.3.2 Total coliform bacteria count

Microbial contamination (bacteria or viruses) of drinking water is a life threating issue and proper process of prevention is vital across the world no matter it is developed or developing country (Fawell et al. 2003). The total coliform count in drinking water should not exceed 10/100 ml water (SLS 614 2013).

Descriptive statistics of total coliform bacteria count of water in the province and its' districts

Mean total coliform count/100 ml water was significantly higher in Matara districts compared with Galle district. Moreover, mean total coliform count of each district was significantly higher than the allowable level (10/100ml, SLS614 2013) Table 4.18 depicts the descriptive statistics of total coliform bacteria level of water in the province and its' districts.

Table 4. 18: Descriptive statistics of total coliform bacteria level of water in the province and its' districts

Province/	Mean	Standard	Q1	Q2	Q3	Min	Max
Southern province	80.3	7.22	4.0	29.0	96.0	0.0	1514.0
Galle District	57.2	9.25	4.0	15.0	58.5	0.0	1175.0
Hambanthota District	83.3	17.9	1.0	22.0	68.3	0.0	1514.0
Matara District	101.1	10.3	9.3	62.0	131.5	0.0	840.0

Descriptive statistics of total coliform bacteria count of different water sources in the province

Dug wells had a significantly higher total coliform count when compared with that of tube wells ($p = 0.00$) while both were significantly higher than the standard accepted level. Similarly total coliform count of streams, dug wells, and tube wells in the province except the lakes had exceeded the accepted level ($p = 0.00$). Table 4.19 depicts the descriptive statistics of total coliform bacteria count of different water sources in the province.

Table 4. 19: Descriptive statistics of total coliform bacteria count of different water sources in the province

Water source	Mean	Standard deviation	Q1	Q2	Q3	Min	Max
Ground water (All)	71.8	9.6	2.0	17.0	78.0	0.0	1514.0
Dug well	79.0	11.0	2.0	18.0	87.0	0.0	1514.0
Tube well	26.0	5.9	0.0	11.0	40.0	0.0	133.0
Surface water (All)	89.0	10.8	10.0	44.0	104.0	0.0	1352.0
Lake	4.0	2.7	0.0	1.0	6.0	0.0	19.0
River	14.0	-	-	14.0	-	14.0	14.0
Spring	194.0	137.0	20.0	51.0	117.0	16.0	1008.0
Stream	89.0	10.6	11.0	50.0	110.0	0.0	1352.0
Water board bulk supply (NWS&DB)	173.0	149.0	3.0	173.0	475.0	0.0	618.0

Status of water sources in the province and districts based on total coliform count

The majority of the province's water sources (65.0%) had exceeded total coliform count than the accepted count by SLS 614 2013, i.e., 10/100 ml of water. Figure 4.28 depicts the status of water sources in the province based on total coliform count.

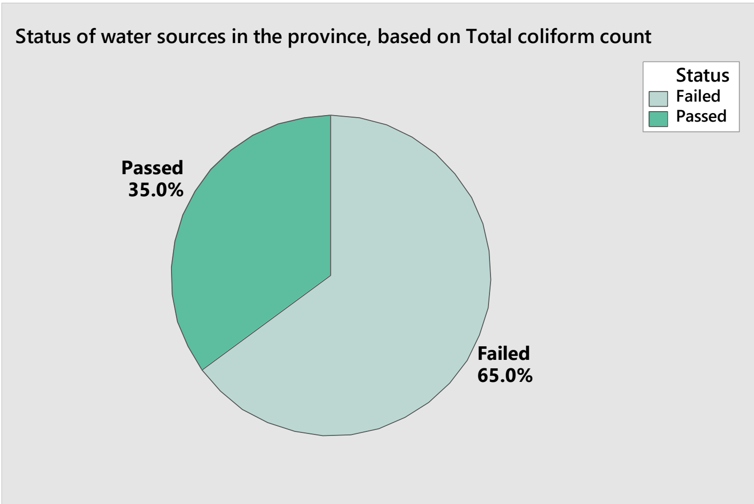

Figure 4.28: Status of water sources in the province based on total coliform count

In all districts, more than 56.0% of the water sources had the higher total coliform count than the allowable count. Figure 4.29 shows the Status of water sources in each district based on total coliform count.

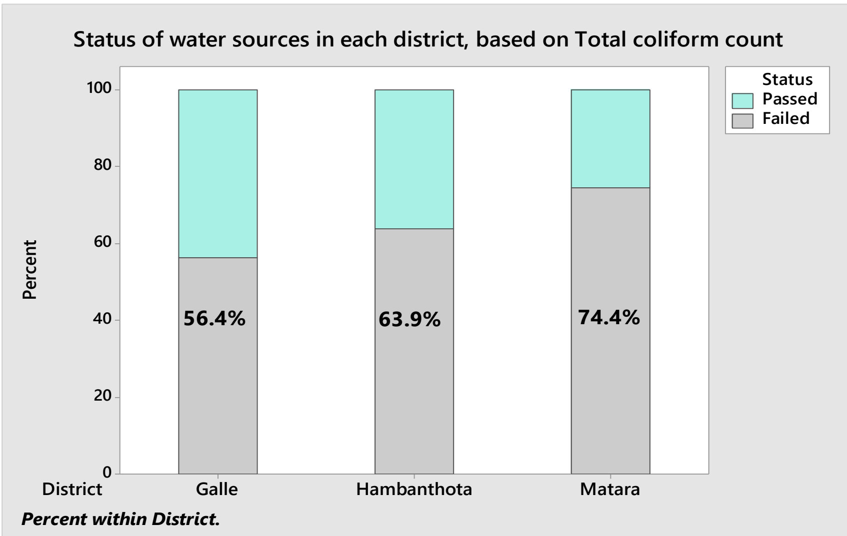

Figure 4.29: Status of water sources in each district based on total coliform count

Status of various kind of water sources in relation to total coliform count/100 ml of water

All the sources had higher total coliform count than the allowable level. The lowest percentage depicted in lakes (14.3%). Figure 4.30 shows the Status of different types of water sources in relation to total coliform count/100 ml of water.

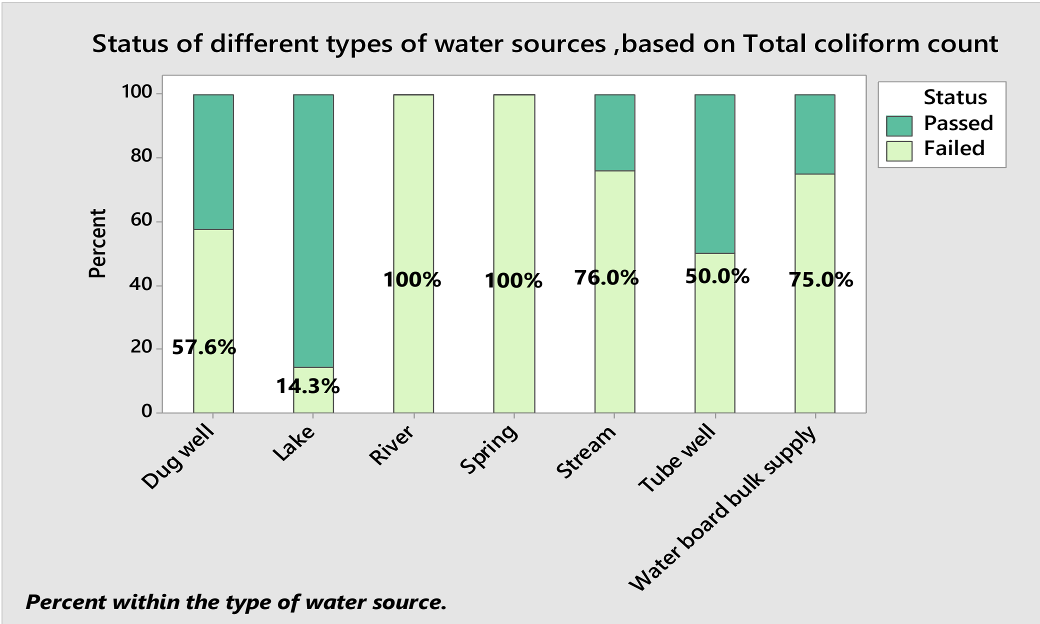

Figure 4.30: Status of different types of water sources in relation to total coliform count/100 ml of water

4.3 Seasonal Impact

Descriptive statistics of water quality parameters with the season in the Southern province

Mean Turbidity, pH value, E-coli count, and Total Coliform count were not significantly different between wet and dry seasons. There was a significant difference between the mean Conductivity values and mean Total hardness values of wet and dry seasons (p=0.00). The dry season showed a higher value. Nitrate content and Iron content in the wet season were significantly higher than that of the dry season (p=0.00). Fluoride content in the dry season was significantly higher when compared with the wet season (p=0.00). Descriptive statistics of water quality parameters with the season in the Southern province is depicted in Table 4.20

Table 4.20: Descriptive statistics of water quality parameters with the season in the province

Province	**Parameter**	**Season**	**Mean**	**Q1**	**Q2**	**Q3**	**Mini.**	**Max.**
Southern	Turbidity	Dry	5.41	0.84	1.56	5.13	0.53	52.20
		Wet	5.08	1.27	2.00	3.57	0.27	305.00
	pH	Dry	6.96	6.70	7.15	7.31	5.37	7.82
		Wet	6.23	5.63	6.20	6.76	4.32	10.04
	Conductivity	Dry	403.3	235.3	387.5	560.8	25.8	1177.0
		Wet	188.1	3805	72.3	194.6	0.00	2059.0
	Total hardness	Dry	148.9	76.0	146.0	213.5	0.00	356.0
		Wet	27.62	0.00	0.00	0.00	0.00	492.0
	Nitrate	Dry	1.276	0.324	0.992	1.900	0.016	8.448
		Wet	2.372	0.077	0.544	2.901	0.000	31.410
	Iron	Dry	0.057	0.023	0.034	0.069	0.018	0.445
		Wet	6.300	0.020	0.050	0.180	0.010	416.00
	Fluoride	Dry	0.328	0.160	0.340	0.455	0.010	1.230
		Wet	0.205	0.110	0.180	0.260	0.000	1.250
	E-coli	Dry	65.60	0.00	1.00	15.50	0.00	704.00
		Wet	33.71	1.00	5.50	28.25	0.00	736.00
	Total coliform	Dry	147.9	0.00	16.00	102.8	0.00	1514.0
		Wet	71.18	5.75	31.00	95.00	0.00	1175.0

4.4 WQI value

The Water Quality Index (WQI) is a useful tool for providing a single term of the overall water quality status when choosing an appropriate treatment method to raise the water quality to a drinkable level (Shweta et al., 2013). Table 4.21 shows water quality rating for different WQI with treatment technique.

Table 4. 21: Water quality rating for different WQI with treatment method

WQI Value	Rating Water Quality	Type of Treatment
91 – 100	Excellent	no
75 - 90	Good	Preliminary
51 – 74	Medium	primary
26 – 50	Bad	Secondary
0 - 25	Very bad	Secondary/Advanced

4.4.1 Descriptive statistics of WQI values of the province and its' districts

It was observed that none of the water sources sampled in the province had its' WQI value less than 29.3. Mean WQI of Galle district was considerably higher than those of Hambanthota and Matara districts ($p=0.00$) while mean WQI of Hambanthota and Matara districts were not significantly different from each other. Comparing to Matara and Galle districts, 50% of water sources in Hambanthota district had WQI value less than or equal 39.7. Table 4.22 depicts the descriptive statistics of WQI values of the province and its' districts

Table 4. 22: Descriptive statistics of WQI values of the province and its' districts

Province/ District	Mean	Standard deviation	Q1	Q2 (Median)	Q3	Min	Max
Southern province	59.8	0.82	41.1	59.4	76.0	29.3	95.0
Galle District	65.9	1.24	54.3	68.0	78.8	34.0	95.0
Hambanthota District	55.1	1.70	37.7	39.7	76.5	29.3	94.1
Matara District	57.6	1.23	43.9	54.5	68.5	33.4	94.2

4.4.2 Classification of water sources in relation to WQI value

Comparatively the highest percentage (39.1%) of water sources had the WQI in between 26 to 50 which is rated as bad followed by the medium group (33.8%) WQI (51-74). 24.8% of water sources belonged to the category 'good' (75-90) WQI. Only 2.3% of water sources belonged to the 'excellent' (91 -100) WQI group while none of the water sources belonged to category of 'very bad' (0 – 25). Figure 4.31 depicts Classification of water sources in Southern province considering their WQI value.

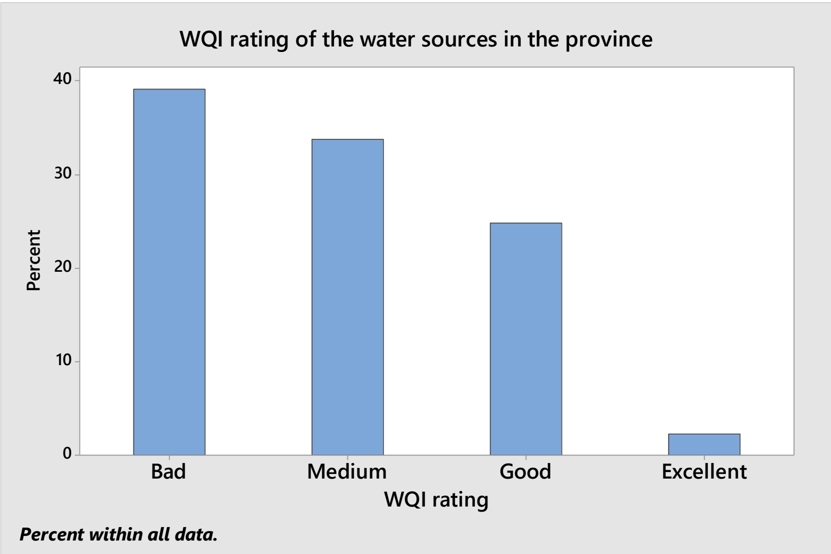

Figure 4.31: Classification of water sources in Southern province considering their WQI value

4.4.3 Classification of water sources within districts using their WQI values

When considering the water sources having the lowest WQI values (26 to 50) which is rated as 'bad' , the highest percentage of water sources (56.3%) in Hambanthota district was in 'bad' category, followed by Matara district (44.8%) and Galle district as 19.2%. Only equal or less than 3.0% of the water sources in each district had the WQI value equal or higher than 91 is rated as 'excellent'. Classification of water sources of each district, based on WQI value is depicted in Figure 4.32

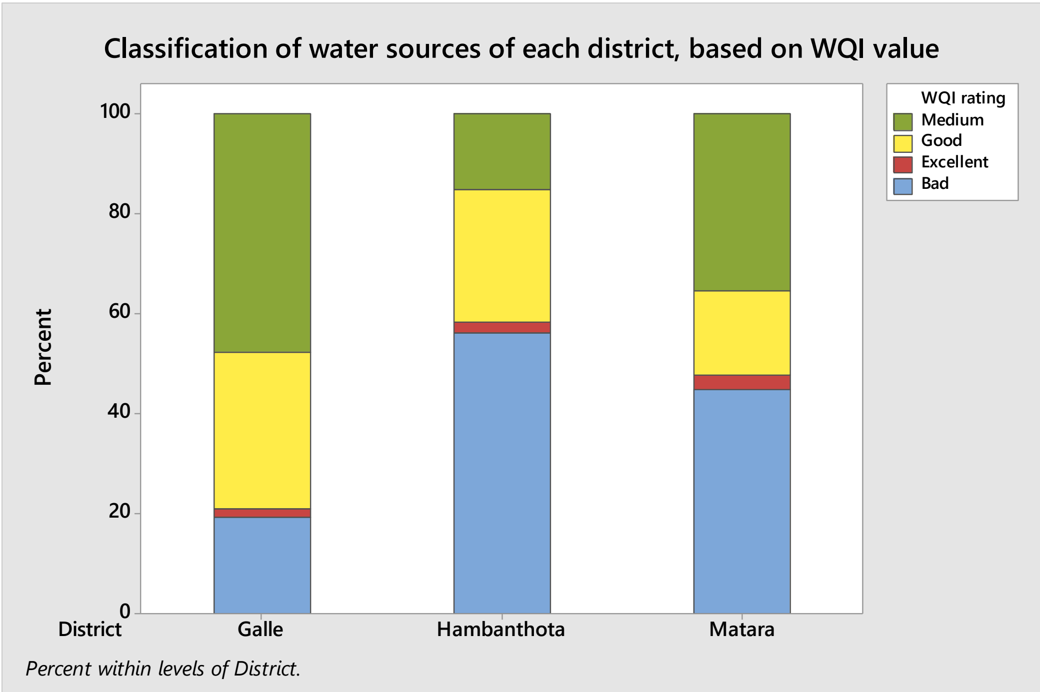

Figure 4.32: Classification of water sources within districts using their WQI values

4.4.4 WQI values with regards to water sources

It was observed that all the water sources except springs had mean WQI value equal or higher than 59.0. Further, 50% of each kind of water sources except springs had WQI value equal or higher than 56.0. WQI values of ground water (60.0), surface water (59.6) and water board bulk supply (59.4), were not significantly different from each other. But spring water showed significantly lower mean WQI value (38.2) in comparison to that of stream and lake water. Table 4.23 depicts the descriptive statistics of WQI with regards to water sources.

Table 4. 23: Descriptive statistics of WQI with regards to water sources

Water source	**Mean**	**Standard deviation**	**Q1**	**Q2**	**Q3**	**Min**	**Max**
Ground water (All)	60.0	1.18	39.7	61.0	77.9	29.3	95.0
Dug well	59.7	1.28	39.7	60.9	77.9	29.3	95.0
Tube well	61.3	3.13	39.7	67.4	78.2	37.7	94.1
Surface water (All)	59.6	1.12	45.8	56.0	73.0	34.0	94.1
Lake	80.4	1.27	77.0	79.7	5.4	76.5	9.8
River	70.9	-	-	70.9	-	70.9	0.9
Spring	38.2	0.61	37.7	37.7	39.7	35.3	39.7
Stream	59.6	1.14	46.0	56.0	71.8	34.0	94.2
Water board bulk supply (NWS&DB)	59.4	12.1	38.2	57.6	82.3	37.7	84.6

5. CONCLUSION

This study analysed the physical, chemical, and biological water quality parameters and created a Water Quality Index (WQI) to assess the water quality of CMWSS in the southern province. Altogether, 488 (71% out of total schemes) of water samples from CMWSS from different water sources in three districts in Southern province (172 schemes in Galle,172 in Matara, and 144 schemes in Hambanthota) were analysed. The water quality of the schemes was classified as Excellent (91-100), Good (75-90), Medium (51-74), Bad (26-50), and Very Bad (0-25) according to the Canadian WQI value. Based on the findings of the study following conclusions were made.

According to the analysis Temperature, Nitrate, and Heavy metals were not exceeding the Sri Lankan Standards (SLS 614-2013). The mean value of nitrate level in the province was 2.2 mg/L and almost all the water sources (99.8%) in the province had the NO_3 content less than the maximum allowable level i.e., 50 mg/l (SLS 614 2013). However, CMWSS in southern province were contaminated with Fluoride, Hardness, Electric Conductivity (EC), Iron, pH, Turbidity, *E-coli* and Total Coliforms. Around 2.1% of CMWSS in the Hambanthota district had fluoride concentrations higher than the 1.0 mg/l (SLS 614-2013) and 13.2% of water sources in Hambanthota district had high hardness (> 250 mg/l; SLS 614 2013). The mean total hardness of the tube wells (150 mg/l) was significantly higher than that of dug wells (43 mg/l). Groundwater sources had a significantly higher mean total hardness than that of the surface water sources. More than 92% of CMWSS in the Hambanthota district had higher EC values than that in Galle and Matara. In the southern province, 11% of the CMWSS exceeded the iron concentration 0.3 mg/l, SLS 614-2013. Comparatively a higher percentage of water sources in Galle district (compared that with Matara and Hambanthota) had higher Fe content. The mean value of the pH of water sources in the southern province was 6.3. pH value of almost 81 % of the water sources in Galle district was not in the accepted range (6.5-8.5) of SLS 614-2013. More than 49 % of CMWSS in the province had a turbidity value of more than 2 NTU exceeding the SLS 614-2013. In addition, CMWSS of the southern province were highly contaminated with *E. coli* and total coliform bacteria. In all districts more than 55 % of CMWSS had high *E. coli* count and total coliform count exceeding the accepted limits (0/100 ml of *E. coli* and 3/100 ml of total coliform) in SLS 614-2013). Surface water sources of CMWSS had a higher mean *E-coli* count (45 / 100 ml) than that of groundwater (30 / 100 ml). In all districts, more than 56 % of the CMWSS had a higher total coliform count than the allowable limit in SLS 614-2013. Surface water sources of CMWSS had a higher mean total coliform count (89 / 100 ml) than that of groundwater (72 / 100 ml).

Developed WQI revealed that none of the CMWSS in the southern province categorized as “Very Bad” quality (0-25). Among 488 schemes in the province, only (2.3%) 11 schemes belonged to the “Excellent” category (91-100) based on this WQI. Majority of the schemes (39.1%) had the WQI between 26-50 and rated as “Bad” and need to have secondary treatment. There were 33.8% of CMWSS that belonged to the “Medium” category (51-74) of WQI and 24.8% in the “Good” category (75-90) which were not suitable for drinking without preliminary treatment. More than half (56.3%) of CMWSS in Hambanthota district were in the ‘Bad’ category. Therefore, Hambanthota district CMWSS were highly contaminated than those in Galle and Matara districts.

A questionnaire survey was conducted with 517 households in the study area to determine consumer perceptions of water quality of CMWSS. The survey revealed that more than 62 % of respondents received a monthly income of less than Rs.25,000. More than 62 % of respondents used water without being treated at home (boiling, filtration, etc), and 70 % of consumers were satisfied with water supplied by the CMWSS in the Southern Province. Around 51% of the households in the province used 251 to 500 L of water per day. It was noted that 77% of consumers used water from CMWSS for other purposes in addition to drinking, and 80% of consumers mentioned that the water supplied for them had a good quality. However, raw water of (97.7%) 477 CMWSS in the southern province need to be further treated for *E. coli*, total coliforms, conductivity, hardness, iron, fluoride, pH, and turbidity before used as potable water.

6. RECOMMENDATIONS

According to the above conclusions following recommendations are suggested to enhance the water quality of CMWSS in the southern province.

Among 14 parameters only 3 parameters are in acceptable level and out of 488 water schemes only 11 schemes in southern province rated as ‘excellent quality. It is not necessary to undergo any treatment. However, 477 schemes in the province getting contaminated chemically, physically or biologically. Therefore, prior treatment techniques should be used in every scheme to improve the quality of potable water as shown in Table 6.1. For the ‘good’ category it should be undergone disinfection (boiling or chlorination). For ‘medium’ category should be followed slow sand filtration and chlorination and for the ‘bad’ category should be undergone aeration, coagulation &Flocculation, sedimentation, rapid sand filtration and chlorination.

Table 6. 1: Treatment recommendations for drinking water quality

WQI (Water Quality Index)	Aeration (A)	Coagulation & Flocculation (B)	Sedimentation (C)	Rapid sand filtration (D)	Slow sand filtration (E)	Disinfection (F)	No Treatment (G)
Excellent Scheme							**11 CMWSS**
Good Scheme						**122 CMWSS**	
Medium Schemes					**166 CMWSS**		
Bad Schemes		**191 CMWSS**					

According to Table 6.1 proposed treatment methods for relevant CMWSS with Grama Niladari (GN) divisions in Galle, Matara and Hambanthota districts have been attached in Appendix B.

- According to the result of the public survey it is clear that most of people (77%) in rural area of southern province use potable water for all other purposes, though they have limited amount of pure water. They are not aware how to use water for various purposes considering their water quality. As a result, community organisations have to expend money to treat water for drinking purposes. Therefore, it should be recommended to conduct awareness programme for them about the water reuse and reclamation.

- People assume that as long as the water is clear, it is safe to drink, so they don't bother to treat it. According to the survey, 62.6% consumers used water without any treatment. As a remedy people to be educated on the dangerous of consuming untreated water and basic household treatment systems so that they treat the water prior to consumption. It is required to introduce more cost-effective treatment procedures for the consumers as the majority of the household in the southern province monthly income is less than Rs.25,000.

- Regular assessments of water quality in CMWSS in the southern province are required to reduce the impact of water pollution. Maintenance of the water supply schemes also should be done regular basis.

- All policymakers and staff at the Department of National Community Water Supply should work together to develop these schemes to the expected standards.

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APPENDICES

Appendix- A: The Questionnaire

දකුණු පලාතේ ප්‍රජා ජල සැපයුම් සංවිධානයන්හි

ජලයෙහි තත්වය පරීක්ෂා කිරිම.

ප්‍රතිලාභීන්ගේ ජලය පිළිබඳ සංජානය අධ්‍යනය සඳහා ප්‍රශ්නාවලිය

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වැදගත් : කරුණාකර අදාල කොටුව තුළ ඔබේ කැමැත්ත පරිදි හරි ලකුණ (√) යොදන්න.

නිවසේ ලිපිනය :-

අදාල ප්‍රජා සංවිධානයේ නම :-

ලිපිනය :-

ප්‍රාදේශිය ලේකම් කොට්ඨාශය :-

<u>ප්‍රතිලාභියාගේ සමාජීය හා ආර්ථික තොරතුරු</u>

I. ස්ත්‍රී/පුරුෂ භාවය — පුරුෂ ☐ ස්ත්‍රී ☐

II. වයස
- 18ට අඩු ☐
- 18-34 ☐
- 35-49 ☐
- 50 හෝ ඊට වැඩි ☐

III. අධ්‍යාපන තත්වය
- අපොස සා.පෙ දක්වා ☐
- අපොස උ.පෙ දක්වා ☐
- විශ්ව විද්‍යාලය අධ්‍යාපන ☐

IV. උපන්දා සිට (ගාල්ල/මාතර/හම්බන්තොට) ප්‍රදේශයේ වෙසෙන්නේ ද? ඔව් ☐ නැත ☐

V. රැකියාවක නිරතවේ ද? ඔව් ☐ නැත ☐

VI. රැකියාවක නිරතවේ නම් මාසික ආදායම්
රු. 10000 අඩු ☐
රු. 10000 – 25000 අතර ☐
රු. 25000– 40000 අතර ☐
රු. 40000 හෝ ඊට වැඩි ☐

අනෙකුත් සාමාන්‍ය තොරතුරු

VII. නිවසේ සාමාජිකයන් සංඛ්‍යාව දරුවන් ගණන ....
වැඩිහිටියන් ගණන ....‥

VIII. ප්‍රජා සංවිධානයේ ජල මූලික ප්‍රභවය
නොගැඹුරු ළිඳ ☐
නල ළිං ☐
දිය දහර ☐
වෙනත් ☐

IX. නල ජලය බීමට පමණක් ගන්නවා ද? ඔව් ☐ නැත ☐

X. (a)දවසකට ජල අවශ්‍යතාවය .... ලිටර් (ඔබ දන්නවානම්)

(b)මාසිකව ගෙවන මුදල ....

XI. ප්‍රතිලාභියාගේ ජලය පිළිබඳව ඇති සංජානය

(a) ලැබෙන ජලය පිළිබඳව තෘප්තිමත් ද? ඔව් ☐ නැත ☐
(b) ලැබෙන ජලයෙ කිවුල ජලය ද? ඔව් ☐ නැත ☐
(c) ලැබෙන ජලයෙ සුවදක් ඇත් ද? ඔව් ☐ නැත ☐
(d) ලැබෙන ජලයෙ අවර්ණ ද? ඔව් ☐ නැත ☐

පිළිතුර නැති නම් වර්ණය සඳහන් කරන්න ....

XII. ඔබට ලැබෙන ජලයෙහි තත්වය බීමට සුදුසුයි.

තදින් පිලිගනී ☐ පිලිගනි ☐ පිලිනොගනි ☐ තදින් පිලි නොගනී ☐

XIII. ජලයට ක්ලෝරින් දැමීම

තදින් පිලිගනී ☐ පිලිගනි ☐ පිලිනොගනි ☐ තදින් පිලි නොගනී ☐

XIV. නිවසෙහි

I. එම ලැබෙන ජලය බීමට ගනී. ☐

II. උණු කර බීමට ගනී. ☐

III. වෙනත් ක්‍රම භාවිතා කරයි. ☐

XV. ජලයෙහි තත්වය පරික්‍ෂා කිරිම සඳහා ප්‍රජා සංවිධානය වැයමක් දරයි ද? ඔව් ☐ නැත ☐

XVI. ජලය ප්‍රයෝජනය ගැනිමෙන් කිසියම් ආසාත්මිකතාවයට ගොදුරු වී තිබේ ද? ඔව් ☐ නැත ☐

'ඔව්' නම් එම ආසාත්මිකතාවය ....

Appendix- B: Analyzed Questionnaire Survey

Demographic characteristics of households' owners in the study

Gender

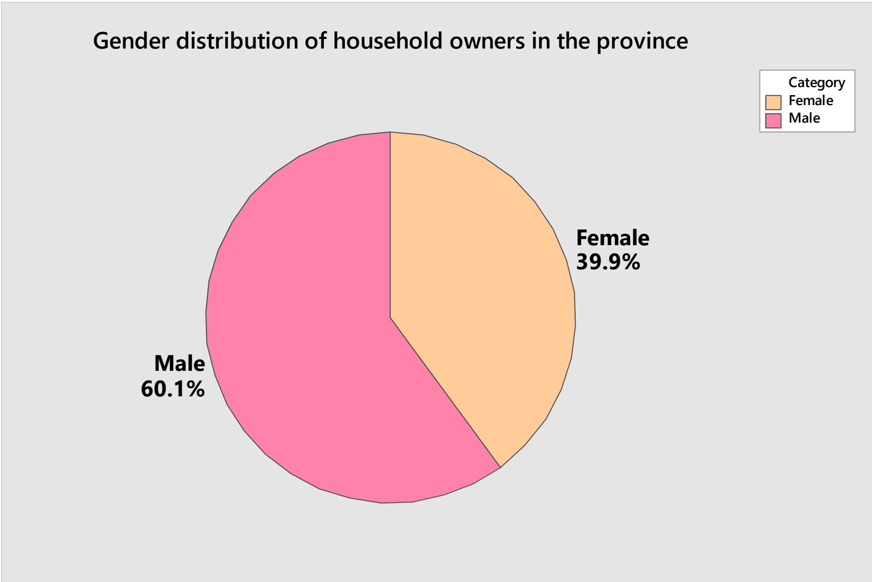

Figure B-1: Gender distribution of heads of households in the province

Almost 60.0% of the heads of households were males.

Age

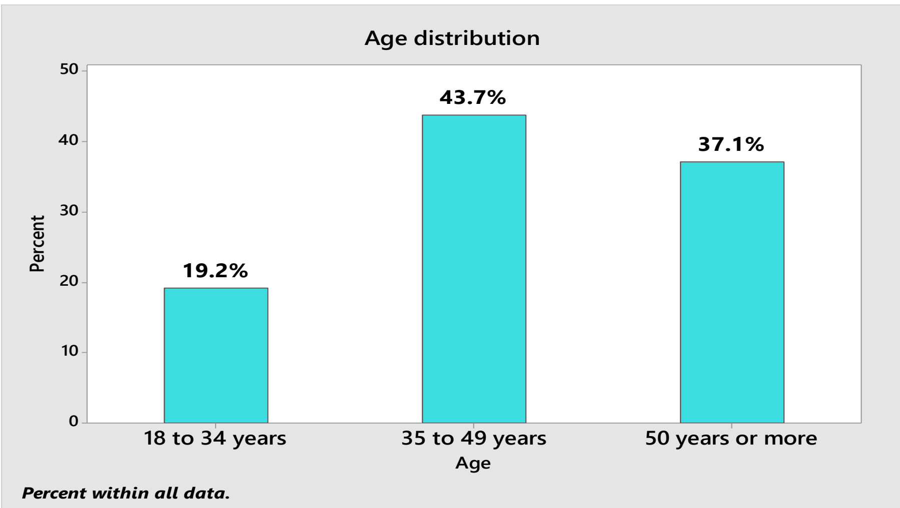

Figure B-2: Age distribution of the household heads of the study sample

Education level

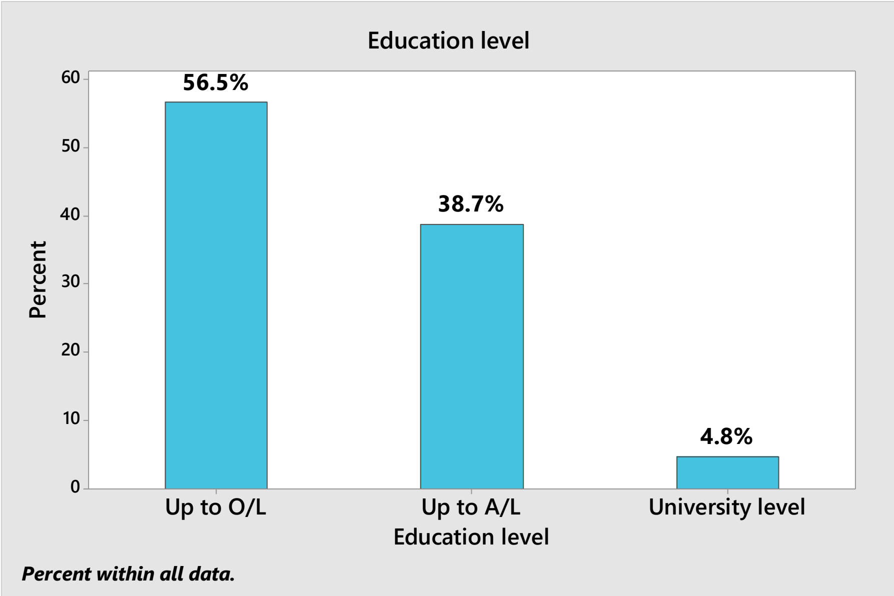

Figure B-3: Education levels of the household heads of the study sample

More than half of the heads of household (56.5%) had their education up to O/L. Only around 5% had the university level education.

Live in the area from birth

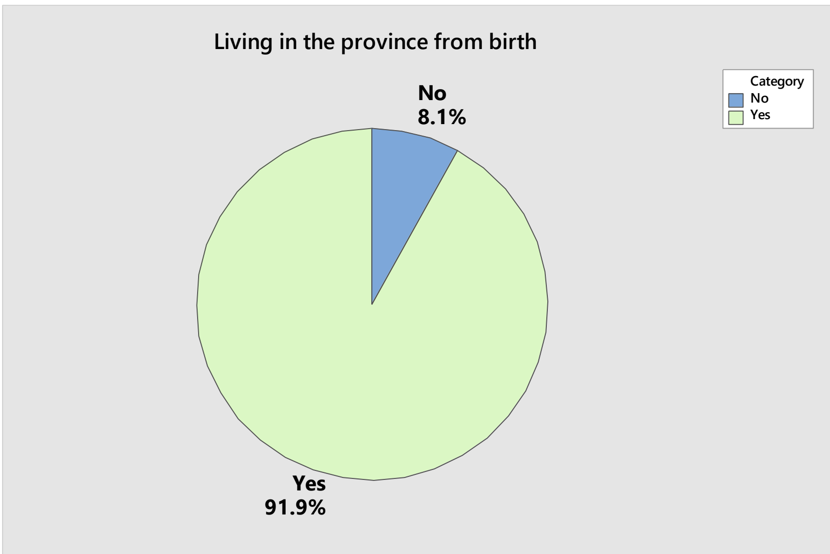

Figure B-4: Status of living from the birth of heads of households in the study

Almost 92% of the heads of households has been living in the province from their birth. This situation would be beneficial for managing water sources in the province as these people have more experience and proper knowledge about the water sources in their area.

Employment

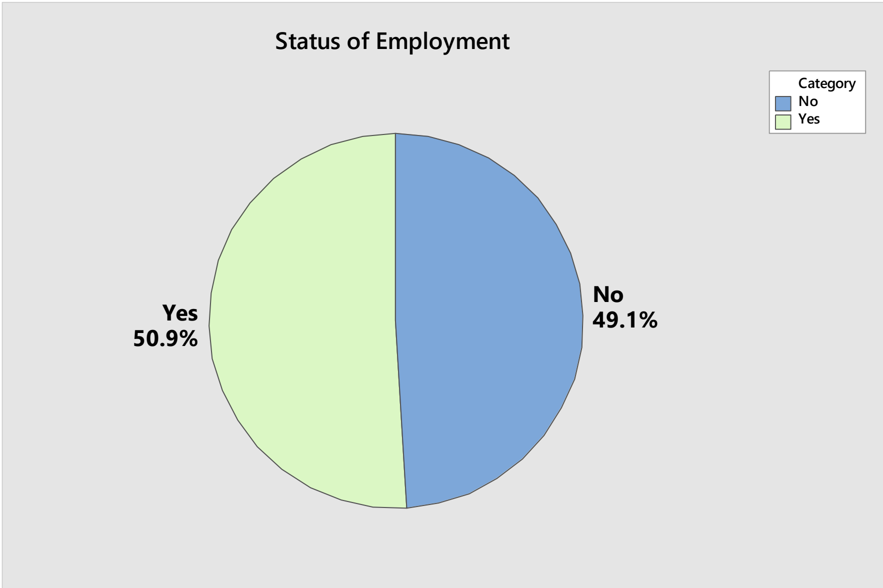

Figure B-5: Status of Employment of heads of households in the study sample

51% of the heads of households was employed while 49% was not.

Monthly income

Table: B-1: Income distributions among heads of households

Income category (Rs/month)	**Percentage of households**
<10000	19.7
10000 - <25000	42.8
25000 - 40000	32.1
>40000	5.4

Majority of heads of households (42.8%) received 10000 -<25000 Rs/ month while 5.4% received more than 40000 Rs/month. Around 62.5% of the heads of households received less than 25000 Rs./month. Therefore, establishing CMWSS and proper maintenance of them are vital to provide portable water with good quality for these people.

Family members

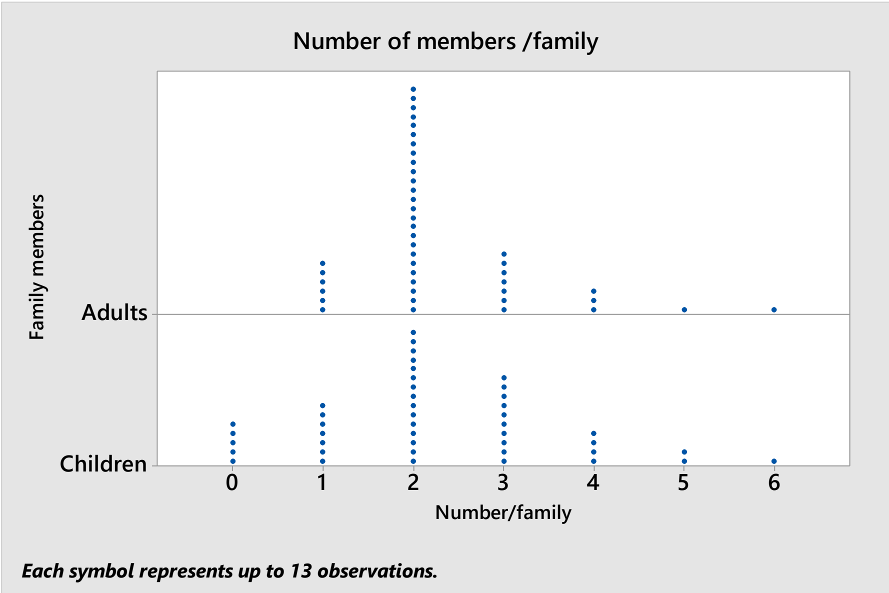

Figure B-6: Number of children and adults per family

Table: B-2: Percentage of households with respect to number of members /family

Family members	**Number / family**							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Adults	0.2	13.5	61.4	15.5	6.8	2.3	0.4	100
Children	10.2	16.8	36.6	23.0	9.1	3.1	1.2	100

Highest percentage of households had 2 adults (61.4%). Similarly, when considering number of children, the highest percentage (36.6%) was recorded for the category of 2 children/household.

Water sources managed by CMWSS

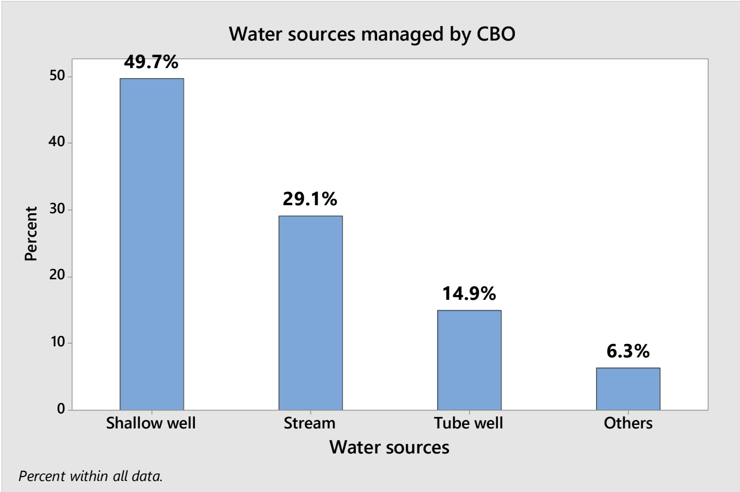

Figure B-7: Water sources managed by CMWSS

The highest percentage of water sources managed by CMWSS was shallow wells (49.7%) followed by streams (29.1%) and tube wells (14.9%) respectively (p=0.00).

Piped water is used only for drinking

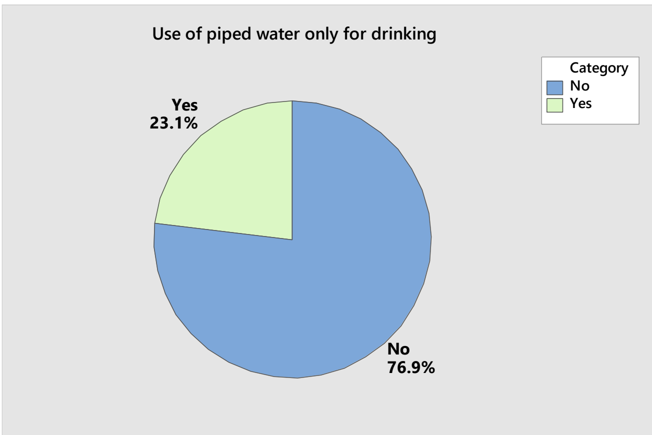

Figure B-8: Status of using piped water only for drinking

About 23% of households used piped water only for drinking (p=0.00). A significant percentage of households (77%) used potable water for other purposes in addition to drinking, this may cause to increase the required volume of portable water and thereby the cost for the water treatment.

Need volume per day

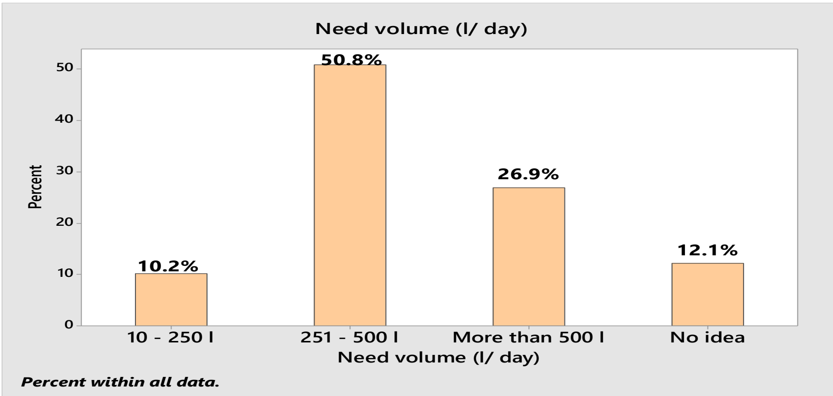

Figure B-9: Need volume per day

Almost 51% of the households in the province used 25*1* t0 500 *l* of water per day, followed by 27% of households who used more than 500 l/day.

Consumer perception

Consumer Satisfaction

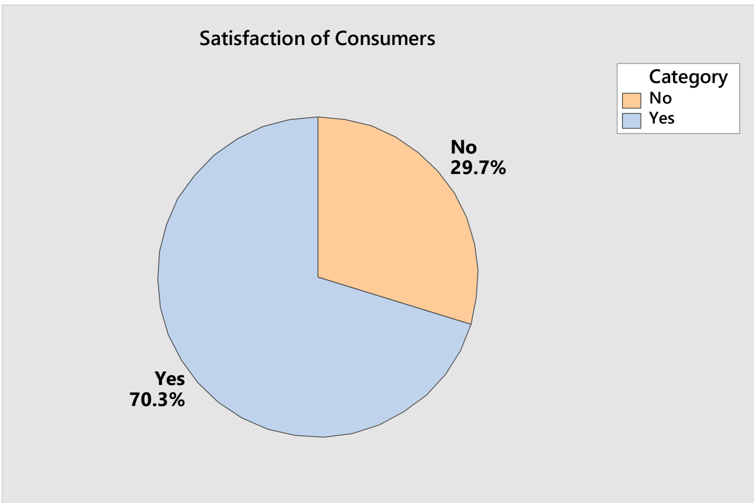

Figure B-10: Status of Consumer satisfaction

Only 70.3% of households were satisfied about the water supplied by the water sources managed by the CMWSS (p=0.00). The above results suggest that some steps should be taken to increase the satisfaction of consumers as almost 30% of consumers were not satisfied about the quality of the water, they received even though this percentage is significantly low.

Hardness

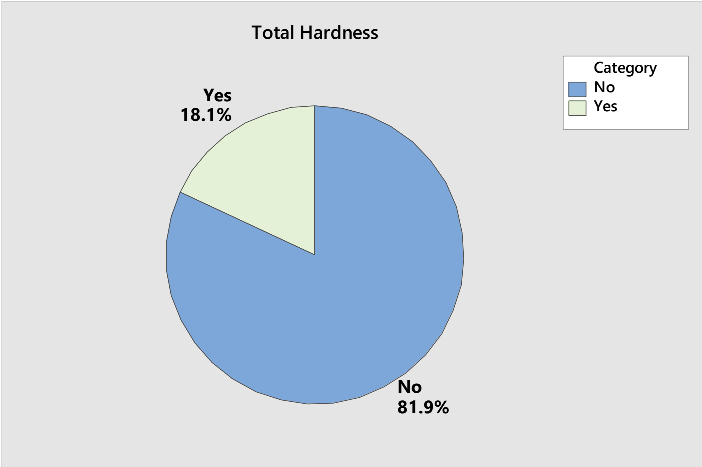

Figure B-11: Hardness of the water

Majority of the consumers (82%) confirmed that the water they received from water sources did not have hardness. (p=0.00).

Smell

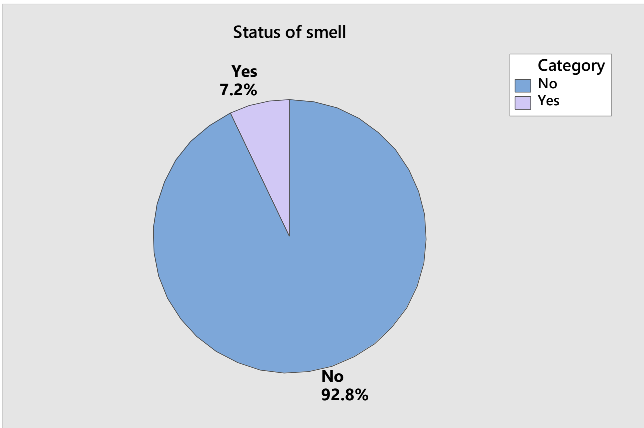

Figure B-12: Smell of the water

Majority of people (93%) mentioned that the water they received were not smelly (p=00).

Colour of water

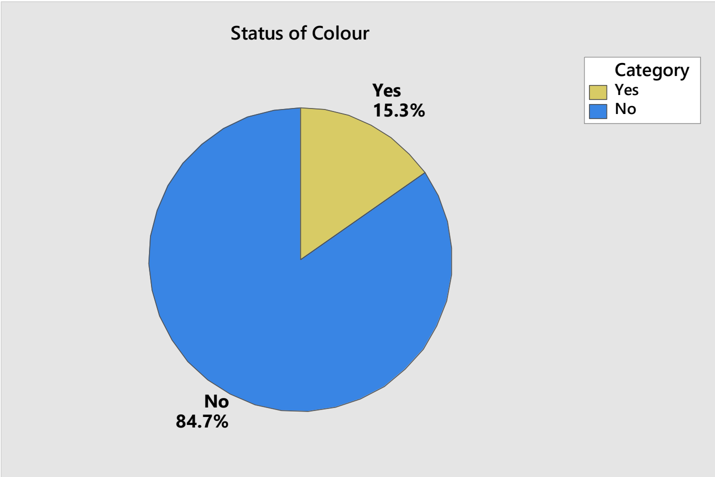

Figure B-13: Colour of water

Almost 85% of the households stated that water supplied by CMWSS was colourless (p=0.00).

Suitability of received water for drinking

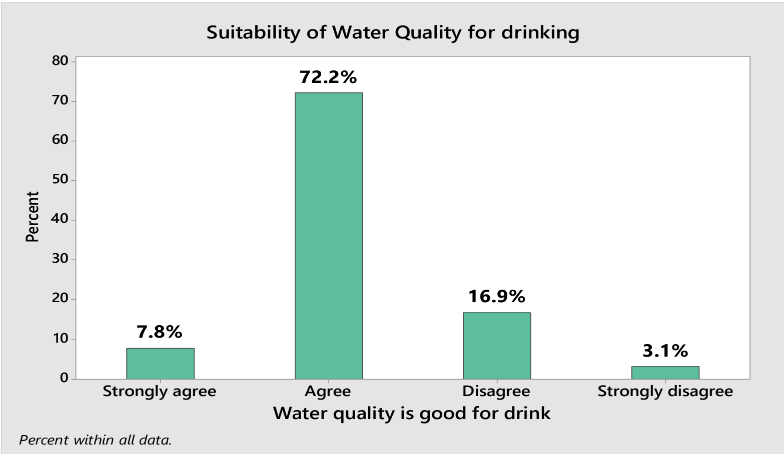

Figure B-14: Suitability of water quality for drinking

Around 80% of consumers mentioned that the water supplied for them had a good quality and therefore could be used for drinking (p=000).

Consumers' response for adding Cl

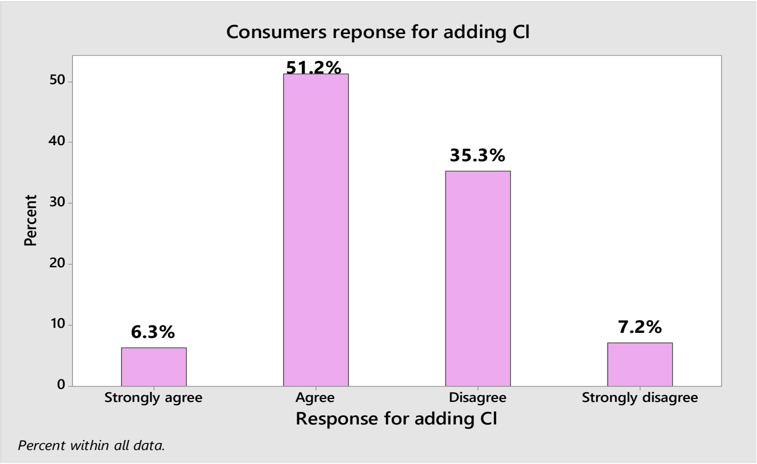

Figure B-15: Consumer response for adding Cl to treat water

Almost 57.5% of the consumers expressed their preference for adding Cl as a water treatment (p=0.00) in contrast to 42,5% of consumers who did not prefer for adding Cl.

Water purification at home

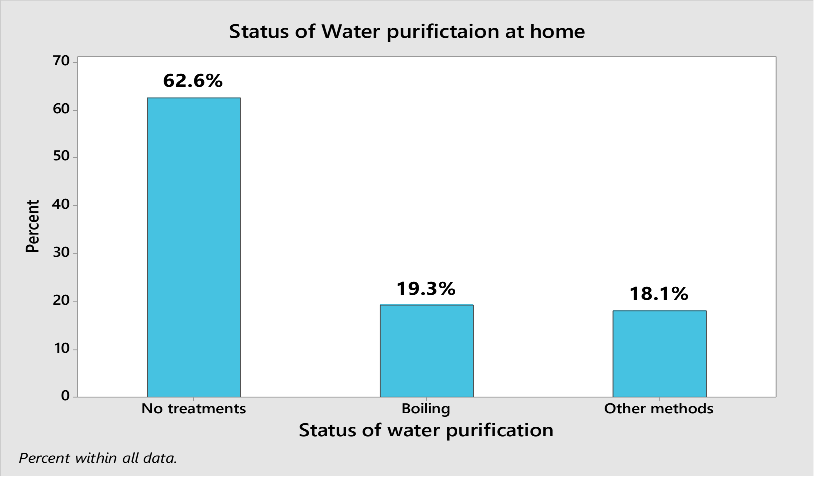

Figure B-16: Whether water is purified at home before using

Only 37.4% of households used some methods to purify water at home before using while 62.6% used as received (p=0.00).

The effort made by CMWSS to test the water quality

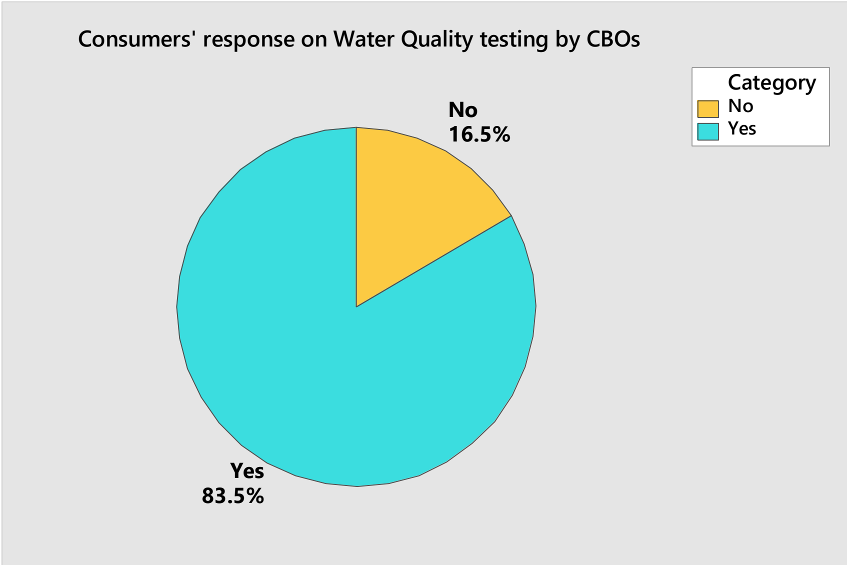

Figure B-17: Whether CMWSS made some efforts to test water quality

The above figure shows that 83,5% of households have stated that CMWSS try their best to do water quality testing (p=0.00).

Allergic conditions

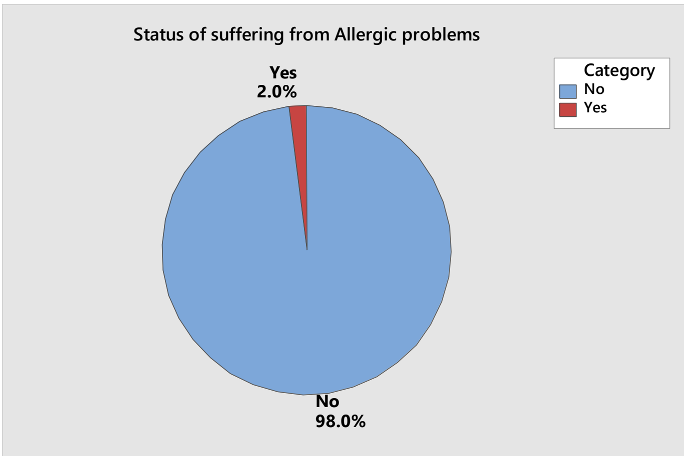

Figure B-18: Status of getting allergic conditions after using water

Significantly very low percent of consumers (2%) complained that they had suffered from allergic conditions (p=0.00). Hence, the above results indicate that the quality of the portable water provided by CMWSS was good.

Considering all variables analyzed previously, it can be concluded that the most of the consumers were satisfied with the portable water supplied by CMWSS in the province.

Appendix- C: Collection of Water Samples

Appendix- D: Treatment Recommendations

Table- D.1: Treatment Recommendations for Galle District

No	Sample No	Divisional Secretariat Division	Grama Niladari Division	CMWSS Name	WQI	Treatment Recomandation
1	GL 1	Nagoda	Aluth Ethala (Mapalagama)	Gamidiriya Samagama	**88**	F
2	GL 2	Nagoda	Parana Thanayamgoda Middle	Mihikatha	**67**	E, F
3	GL 3	Nagoda	Parana Thanayamgoda Down	Piyasen	**85**	F
4	GL 4	Nagoda	Yatalamaththa	70 kanda	**95**	G
5	GL 5	Nagoda	Yatalamaththa East	Rukmalgoda kanda	**95**	G
6	GL 6	Nagoda	Yatalamaththa West	Kandauda waththa	**89**	F
7	GL 7	Nagoda	Urala Down	Kandauda waththa	**71**	E, F
8	GL 8	Baddegama	Halpathota North	Berillawaththa	**72**	E, F
9	GL 9	Baddegama	Babarawana Kanda	Pragathi	**89**	F
10	GL 10	Baddegama	Ganegama South	Paramitha	**55**	E, F
11	GL 11	Neluwa	Danawala	Danawala Eksath Jala Paribogika samithiya	**71**	E, F
12	GL 12	Neluwa	Ebalegedara North	Suduwellewa	**37**	A, B, C, D, F
13	GL 13	Neluwa	Ebalegedara North	Somasarama watha	**55**	E, F
14	GL 14	Neluwa	Ebalegedara North	Udumulla	**53**	E, F

15	GL 15	Neluwa	Gigummaduwa Down	Diyananawala	**55**	E, F
16	GL 16	Neluwa	Gigummaduwa Up	Ransilu	**46**	A, B, C, D, F
17	GL 17	Neluwa	Gigummaduwa Up	Godayamulla	**50**	A, B, C, D, F
18	GL 18	Neluwa	Gigummaduwa Down	Suduwellewa	**72**	E, F
19	GL 19	Neluwa	Koswatta	Sarvodaya	**71**	E, F
20	GL 20	Neluwa	Batuwangala	Sisilasa Jala paribogika samithiya	**73**	E, F
21	GL 21	Thawalama	Eppala	Swashakthi	**40**	A, B, C, D, F
22	GL 22	Nagoda	Udugama South	Gallandala Pansal kanda	**36**	A, B, C, D, F
23	GL 23	Nagoda	Udugama South	Ketagoda Pradeshiya Sabha	**36**	A, B, C, D, F
24	GL 24	Nagoda	Gallandala	Gallandala	**40**	A, B, C, D, F
25	GL 25	Nagoda	Kondagala/ Udugama North	Kondagalapara	**35**	A, B, C, D, F
26	GL 26	Nagoda	Homadola	Homadola	**34**	A, B, C, D, F
27	GL 27	Nagoda	Gammedagoda South	Annasigalahen a	**40**	A, B, C, D, F
28	GL 28	Nagoda	196 Udawelivitiya	Kurudukanda Janapadaya	**44**	A, B, C, D, F
29	GL 29	Nagoda	194B Udawelivitiya West	Nildiyawara	**34**	A, B, C, D, F
30	GL 30	Nagoda	194B Udawelivitiya West	Ekamuthu	**37**	A, B, C, D, F
31	GL 31	Imaduwa	Kabaragala	Eththagalgoda waththa	**52**	E, F
32	GL 32	Imaduwa	Kabaragala	Batapiyassa kanda	**95**	G
33	GL 33	Imaduwa	Hawpe	Saviya	**90**	F
34	GL 34	Imaduwa	Hawpe	Samagi	**39**	A, B, C, D, F

35	GL 35	Imaduwa	Wathawana	Sancity	**69**	E, F
36	GL 36	Imaduwa	Hawpe	Diyadotha	**72**	E, F
37	GL 37	Imaduwa	Thiththagalla East	Diyatha	**83**	F
38	GL 38	Imaduwa	Imaduwa	Niwcity	**89**	F
39	GL 39	Yakkalamulla	Welendawa	Welendawa	**78**	F
40	GL 40	Yakkalamulla	Karagoda	Kithulange waththa	**89**	F
41	GL 41	Yakkalamulla	Gahalakoladeniya	Guruwalkanda	**77**	F
42	GL 42	Yakkalamulla	Gahalakoladeniya	Galedanda kanda	**78**	F
43	GL 43	Yakkalamulla	Wathogala	Randiyadahara	**84**	F
44	GL 44	Yakkalamulla	Nakiyadeniya Up	Ulpatha	**81**	F
45	GL 45	Yakkalamulla	Udumalagala	Udumalagala	**71**	E, F
46	GL 46	Thawalama	Kudugalpala	Shakthi mithuru	**56**	E, F
47	GL 47	Thawalama	230C Kubukgoda	Sahana	**59**	E, F
48	GL 48	Thawalama	Thawalama North	Rukaththana Ella	**58**	E, F
49	GL 49	Thawalama	Malgalla	Malgalla	**64**	E, F
50	GL 50	Thawalama	227 B Thawalama South	Samagi	**53**	E, F
51	GL 51	Thawalama	Malgalla	Samagi	**40**	A, B, C, D, F
52	GL 52	Thawalama	Halvitigala Janapadaya 1Step	Halvitigala Jala Paribogika Samithiya	**60**	E, F
53	GL 53	Thawalama	Halvitigala Janapadaya	Ekamuthu	**79**	F
54	GL 54	Thawalama	228 F Thalangalla East	Kubuksewana	**84**	F
55	GL 55	Thawalama	229 Opatha	Dilenatharu Sarvodaya	**82**	F
56	GL 56	Thawalama	Opatha East	Ulpatha	**65**	E, F
57	GL 57	Thawalama	Thawalama	Opatha Nagarika	**70**	E, F

58	GL 58	Thawalama	229 B Weerapana	Sahana	**57**	E, F
59	GL 59	Thawalama	230 B Weerapana West	Ekamuthu	**51**	E, F
60	GL 60	Thawalama	Weerapana North	Diriya	**88**	F
61	GL 61	Nagoda	Keppitiyagoda North	Keppitiyagoda	**47**	A, B, C, D, F
62	GL 62	Nagoda	Thalgaswala Estate	Sisilasa	**65**	E, F
63	GL 63	Nagoda	Thalgaswala	New Town Thalgaswala Jala Paribogika Samithiya	**89**	F
64	GL 64	Niyagama	38 Niyagama	Shakthi mithuru	**85**	F
65	GL 65	Niyagama	34 Maththaka	Perakum	**67**	E, F
66	GL 66	Niyagama	34 A Babarawana	Medagoda	**62**	E, F
67	GL 67	Niyagama	34 A Usbim Janapadaya	Samurdhi Balakaya	**70**	E, F
68	GL 68	Niyagama	33A Godamuna South	Samurdhi Mahasen	**88**	F
69	GL 69	Niyagama	33A Godamuna South	Shakthi Grameeya	**71**	E, F
70	GL 70	Niyagama	Godamuna North	Gemidiriya Samagama	**89**	F
71	GL 71	Niyagama	33C Godamuna North	Pepala kanda	**87**	F
72	GL 72	Niyagama	33D Bangamukanda	Bangamu kanda grameeya Sanvidanaya	**88**	F
73	GL 73	Welivitiya Divithura	Kuttiyawaththa	Gampubudu	**85**	F
74	GL 74	Welivitiya Divithura	Thanabaddegama	Diyadotha	**74**	E, F

75	GL 75	Welivitiya Divithura	Ampegama	Beptis	**37**	A, B, C, D, F
76	GL 76	Elpitiya	94C Wathuravila	Morankanda	**75**	F
77	GL 77	Elpitiya	94 L Ambana North	Diyadotha	**47**	A, B, C, D, F
78	GL 78	Elpitiya	25 D Batuwanhena	Janasaviya	**77**	F
79	GL 79	Elpitiya	27 A Wallabagala	Kottagalkanda	**46**	A, B, C, D, F
80	GL 80	Elpitiya	27 A Wallabagala	Sujatha	**43**	A, B, C, D, F
81	GL 81	Elpitiya	27 A Wallabagala	Udahawaththa	**69**	E, F
82	GL 82	Elpitiya	27 A Wallabagala	Okanda	**87**	F
83	GL 83	Elpitiya	28 G Katandola	Pubudu	**89**	F
84	GL 84	Elpitiya	28 G Katandola	Isuru	**63**	E, F
85	GL 85	Elpitiya	28 G Katandola	Sanhidiya	**76**	F
86	GL 86	Elpitiya	28 G Katandola	Chinthana	**69**	E, F
87	GL 87	Elpitiya	31 Amugoda	Halwalagoda	**74**	E, F
88	GL 88	Elpitiya	30C Delpona	Randiya Jala Paribogika Samithiya	**72**	E, F
89	GL 89	Elpitiya	30C Delpona	Maharappal waththa	**80**	F
90	GL 90	Niyagama	33 E Uhanovita	Haththaka Uhanovita	**87**	F
91	GL 91	Thawalama	Koralegama	Wekil Ela	**53**	A, C, E
92	GL 92	Thawalama	Panangala East	Pokuna Ehala	**41**	A, B, C, D, F
93	GL 93	Thawalama	224 Eppala	Eppala Eksath	**42**	A, B, C, D, F
94	GL 94	Thawalama	224 Eppala	Samurdhi	**36**	A, B, C, D, F
95	GL 95	Thawalama	Panangala East	Daluggala	**72**	E, F
96	GL 96	Thawalama	Panangala East	Oruhena	**56**	E, F
97	GL 97	Thawalama	Hiniduma North	Uragal Lella	**57**	E, F
98	GL 98	Thawalama	Hiniduma West	Yaddehikanda	**71**	E, F
99	GL 99	Thawalama	Hiniduma West	Manakanda	**38**	A, B, C, D, F
100	GL 100	Thawalama	Hiniduma North	Mayithri	**76**	F
101	GL 101	Thawalama	Batahena	Mahamederiya	**74**	E, F

102	GL 102	Thawalama	Thudagalpala	Thudugalpala	**44**	A, B, C, D, F
103	GL 103	Thawalama	Panagala East	Ekamuthu	**69**	E, F
104	GL 104	Thawalama	Koralegama	Kanneliya	**57**	E, F
105	GL 105	Thawalama	225 B Gallandala	Mayura	**63**	E, F
106	GL 106	Neluwa	Thabalegama	Thabalagama	**65**	E, F
107	GL 107	Neluwa	Madugeta	Ginnadi Jala Paribogika sanwardana Samithiya	**90**	F
108	GL 108	Neluwa	Warukandeniya	Paragahadola	**85**	F
109	GL 109	Neluwa	Warukandeniya	Warukandeniya	**86**	F
110	GL 110	Neluwa	Millawa Down	Meeruppakand a	**90**	F
111	GL 111	Neluwa	Dellawa	Kaluwalahena	**55**	E, F
112	GL 112	Neluwa	Dellawa	Thennahena	**41**	A, B, C, D, F
113	GL 113	Neluwa	Dellawa	kudagalahena	**87**	F
114	GL 114	Neluwa	Miyanawathura	Kekunagahawa tta	**83**	F
115	GL 115	Neluwa	Pannimulla	Nimnadi	**59**	E, F
116	GL 116	Neluwa	Miyenawathura	Apallabedda	**78**	F
117	GL 117	Neluwa	Panagoda	Apeksha	**81**	F
118	GL 118	Neluwa	Panagoda	Sawashakthi Jala ha Welfare Socity	**55**	E, F
119	GL 119	Neluwa	Pannimulla	Wadimulla	**69**	E, F
120	GL 120	Neluwa	Ehalapitiya	Ehalapitiya Jala Paribogika Samithiya	**60**	E, F
121	GL 121	Balapitiya	21 B Heenatiya Northa	Heenatiya Jala Paribogika Samithiya	**70**	E, F
122	GL 122	Balapitiya	16 D Nanathota	Menikagama Development Society	**67**	E, F

123	GL 123	Balapitiya	17 D Nanathota	Rathukurusa Niwasa Sankeerna Samithiya	**56**	E, F
124	GL 124	Balapitiya	18 D Nanathota	Erora	**55**	F
125	GL 125	Benthota	12 Thunduwa East	Ekamuthu	**67**	E, F
126	GL 126	Benthota	12 Thunduwa West	Janashakthi	**72**	E, F
127	GL 127	Benthota	10 Kahawagammedda	Nelum	**78**	F
128	GL 128	Benthota	10 Kahawagammedda	Pubudu	**74**	E, F
129	GL 129	Benthota	14 E Ethungagoda	Munsinha Janapada	**54**	E, F
130	GL 130	Balapitiya	16 Palagaspalatha	Ekamuthu	**50**	A, B, C, D, F
131	GL 131	Balapitiya	Maduwa	Maduwa	**70**	E, F
132	GL 132	Ambalangoda	75 J Thanipolgaha	Waraniyakele Paneeya Jala Project	**80**	F
133	GL 133	Ambalangoda	75 Batapola West	Manamgoda Jala Paribogika Society	**62**	E, F
134	GL 134	Gonapinuwala	16 E Eriyagahamulla	Methiwarana Sanwathsara	**77**	F
135	GL 135	Gonapinuwala	Mahagangoda	Angankanda	**70**	E, F
136	GL 136	Akmeemana	Halgasmulla	Halgasmulla	**75**	F
137	GL 137	Akmeemana	Weliketiya	Weliketiya	**81**	F
138	GL 138	Akmeemana	Keranvila	Keranvila Janapada Water	**68**	E, F
139	GL 139	Akmeemana	Niyagama	Niyagama	**84**	F
140	GL 140	Baddegama	Baddegama	Pradeshiya Sabha	**56**	E, F
141	GL 141	Baddegama	Weyihena	Wahugala kanda	**65**	E, F
142	GL 142	Nagoda	Bovitiyamulla	Bovitiyamulla	**75**	F

143	GL 143	Nagoda	Udawelivitiya West	Udawelivitiya Paneeya Jala Yojana Kramaya	**68**	E, F
144	GL 144	Nagoda	Malamura	Dingi Dola	**63**	E, F
145	GL 145	Nagoda		Ukovita	**81**	F
146	GL 146	Niyagama	Marakgoda	Mahadeniya	**64**	E, F
147	GL 147	Niyagama	Batahena	Babarawana Grameeya Sanvidanaya	**90**	F
148	GL 148	Niyagama	Usbim Janapadaya	Udahena	**90**	F
149	GL 149	Niyagama	Usbim Janapadaya	Mederihena	**90**	F
150	GL 150	Neluwa	Ihala Lelwala	Kabaragalagam a	**56**	E, F
151	GL 151	Neluwa	Ihala Lelwala	Ihala lelwala	**50**	A, B, C, D, F
152	GL 152	Neluwa	Ihala Gigummaduwa	Suhada	**54**	E, F
153	GL 153	Neluwa	Pahala Lelwala	Kabaragala watta (Tube well)	**58**	E, F
154	GL 154	Neluwa	Pahala Lelwala	Kabaragala watta	**78**	F
155	GL 155	Neluwa	Medagama	Sarvodaya	**64**	E, F
156	GL 156	Neluwa	Medagama	Sarvodaya (Tube well)	**42**	A, B, C, D, F
157	GL 157	Neluwa	Mavita	Degallakanda	**51**	E, F
158	GL 158	Neluwa	Batuwangala	Kuruduwatta Batuwangala Eksath Jala Paribogika	**56**	E, F
159	GL 159	Neluwa	Mawanana	Geegana Gedara	**54**	E, F
160	GL 160	Neluwa	Ihala Gigummaduwa	Kenda Ketiya	**39**	A, B, C, D, F

161	GL 161	Thawalama	Koralegama	Jayamaga	**59**	E, F
162	GL 162	Thawalama	Panangala North	Hagaran Ela	**49**	A, B, C, D, F
163	GL 163	Thawalama	Kudugalpala	Halla kanda	**57**	E, F
164	GL 164	Nagoda	Udaweliwitiya	kurudujanapad aya	**53**	E, F
165	GL 165	Baddegama	Baddegama East	Suduwelipatha	**82**	F
166	GL 166	Baddegama	Manampita	Sri Sudarshi	**55**	E, F
167	GL 167	Gonapinuwala	Manampita	Sri Priyadarshi	**68**	E, F
168	GL 168	Gonapinuwala	Thilakagama	Thilakagama	**76**	F
169	GL 169	Gonapinuwala	66C Woodlenwatta	Samagi	**60**	E, F
170	GL 170	Baddegama	206 D Gonapura	Gonapura New Water Project	**61**	E, F
171	GL 171	Neluwa	-	Ginganga	**50**	A, B, C, D, F
172	GL 172	Baddegama	Warakapitikanda	Pahala Keebhiya New Water Project	**46**	A, B, C, D, F

Table -D.2: Treatment Recommendation for Matara District

No	Sample No	D.S Division	G.N Division	CMWSS Name	WQI	Treatment Recommendation
1	3	Welipitiya	Palalla	Randiyamuthu	**78**	F
2	4	Welipitiya	Udukawa South	Udara	**87**	F
3	7	Welipitiya	Wilegoda	Sramashakthi	**38**	A, B, C, D, F
4	12	Welipitiya	Poraba kananke South	Prathiba	**71**	E, F
5	15	Welipitiya	Padili Kokmaduwa	Shakthi	**81**	F
6	16	Welipitiya	PadiliKokmaduwa	Shakthi Polawaththa part	**56**	E, F
7	18	Welipitiya	Hallala	Wiskam	**82**	F
8	19	Welipitiya	Borala	Gammaddasawiya	**81**	F
9	20	Welipitiya	Pallala-Kohunugamuwa	Randiyamuthu	**41**	A, B, C, D, F
10	21	Welipitiya	Bathalahena	Diriya	**39**	A, B, C, D, F
11	22	Welipitiya	Beralaliya	Diriya Shakthi	**88**	F
12	23	Welipitiya	Beralaliya	Nawadiriya Shakthi	**69**	E, F
13	24	Welipitiya	Jamburegoda West	Arunalu	**39**	A, B, C, D, F
14	25	Welipitiya	Hallala	Shakthi	**61**	E, F
15	26	Welipitiya	Moonamalpa	Gamishakthi	**50**	E, F
16	27	Welipitiya	Puhuluhena	Gamunusawiya	**74**	F
17	29	Welipitiya	Kokmaduwa North	Mahengoda	**76**	F

18	30	Welipitiya	Wahala Kananke South	Neethra	**42**	A, B, C, D, F
19	31	Malimbada	Pahala Kiyaduwa (Vikumgama)	Gamisumituro mithuru Samajaya	**87**	F
20	32	Malimbada	Akuragoda North	Prabudda	**43**	A, B, C, D, F
21	35	Malimbada	Algiriya	Ekamuthu	**43**	A, B, C, D, F
22	36	Malimbada	Paraduwa-East Algiriya	Ekamuthu II	**88**	F
23	39	Malimbada	Horagoda West	Suhada	**40**	A, B, C, D, F
24	40	Malimbada	Horagoda South	Samagi	**74**	E, F
25	44	Malimbada	Horagoda East	Abimana	**34**	A, B, C, D, F
26	45	Malimbada	Maragahahena	Sirasa	**43**	A, B, C, D, F
27	48	Akuressa	Illuppalla	Digilinadee	**63**	E, F
28	50	Akuressa	Peddapitiya North	Pragathi	**46**	A, B, C, D, F
29	51	Akuressa	Hikgoda Midellaketiya	Nildiya	**48**	A, B, C, D, F
30	52	Akuressa	Godapitithanna	Nildiya	**88**	F
31	56	Akuressa	Ahalape	Digili	**86**	F
32	57	Akuressa	Diyalape	Nildiyadahara	**61**	E, F
33	60	Akuressa	Ganhala	Gannadee	**82**	F
34	61	Akuressa	Yakabedda	Dilenatharu	**67**	E, F
35	63	Akuressa	Peddapitiya South	Ekamuthu	**88**	F
36	64	Akuressa	Lenama North	Halla alla	**79**	F
37	65	Akuressa	Maliduwa down	Digili Nadee	**86**	F

38	66	Akuressa	Maramba North	Nildiyakadura	**66**	E, F
39	67	Akuressa	Maliduwa up	Pinidiyakawaya	**93**	F
40	68	Athuraliya	Balakawala	Pragathi	**80**	F
41	70	Athuraliya	Dematapassa	Wijaya	**66**	E, F
42	71	Athuraliya	Wilpita East II	Wilpita Nilwala grameeya	**35**	A, B, C, D, F
43	72	Athuraliya	Kehelwala	Sri Dilenatharu	**80**	F
44	78	Athuraliya	Welihena	Diriya I	**39**	A, B, C, D, F
45	80	Athuraliya	Welihena	Diriya II	**63**	E, F
46	82	Athuraliya	Urumuththa	Samagi	**60**	E, F
47	85	Athuraliya	Urumuththa	Swashakthi	**46**	A, B, C, D, F
48	86	Pitabeddara	Diyadawa	Dundiya	**55**	E, F
49	87	Pitabeddara	Darangala I	Wijaya	**93**	F
50	88	Pitabeddara	Kudagalahena	Parakum	**75**	F
51	90	Pitabeddara	Gorakawela	Sirimadura	**46**	A, B, C, D, F
52	91	Pitabeddara	Thannahena	Janashakthi	**94**	G
53	92	Pitabeddara	Kosnilgoda	Nildiya	**56**	E, F
54	93	Pitabeddara	Kudagalahena	Ekamuthu	**48**	A, B, C, D, F
55	94	Pitabeddara	Kiriwelkale South	Ranga	**62**	E, F
56	96	Pitabeddara	Siyambalagoda West	Nildiyawara	**42**	A, B, C, D, F
57	98	Kotapola	Beliattakubura	Surath I	**52**	E, F
58	99	Kotapola	Beliattakubura	Surath II	**47**	A, B, C, D, F
59	100	Kotapola	Pussewela	Himakadura	**41**	A, B, C, D, F

60	101	Kotapola	Mederipitiya	Ginnadee	**61**	E, F
61	102	Kotapola	Pallegama North	Babaragoda	**59**	E, F
62	104	Kotapola	Kolawenigama	Randiya	**57**	E, F
63	105	Kotapola	Kiriweldola	Sihasa	**46**	A, B, C, D, F
64	107	Kotapola	Kiriwalagama	Seetakadu	**46**	A, B, C, D, F
65	108	Kotapola	Bateyaya	Thusara	**53**	E, F
66	109	Kotapola	kalugalahena	Diriya	**94**	G
67	110	Kotapola	Kalugalahena-Thanipita	Pragathi	**48**	A, B, C, D, F
68	111	Kotapola	kalugalahena	Eksath Sramashakthi	**46**	A, B, C, D, F
69	112	Kotapola	Thanipita	Sunila	**41**	A, B, C, D, F
70	113	Kotapola	Kalugalahena	Yatulla	**67**	E, F
71	114	Kotapola	kiriwalagama	Sirasa	**49**	A, B, C, D, F
72	115	Kotapola	Thenipita	Nildiya	**40**	A, B, C, D, F
73	116	Kotapola	Adaradeniya	Sisila	**45**	A, B, C, D, F
74	117	Kotapola	Usamalagoda	Bodeniya	**50**	E, F
75	118	Kotapola	Morawaka	Sugathi I	**46**	A, B, C, D, F
76	120	Kotapola	Morawaka	Sugathi II	**49**	A, B, C, D, F
77	121	Kotapola	Nawalahena	Pubudu	**70**	E, F
78	122	Kotapola	Paragala	Ekamuthu Sarwodaya	**40**	A, B, C, D, F
79	123	Kotapola	Lidagawahena	Amunugammulla Horagala	**49**	A, B, C, D, F

80	124	Kotapola	Kotapola North	Gami Sumithuro Mithru Samajaya	**44**	A, B, C, D, F
81	125	Kotapola	Kudaludeniya	Gami Sumithuro Mithuru Samajaya	**58**	E, F
82	126	Kotapola	Horagala East	Ekamuthu	**39**	A, B, C, D, F
83	127	Kotapola	Usamalagoda	Nilwala	**41**	A, B, C, D, F
84	128	Kotapola	Kotapola North	Nildiyadahara	**64**	E, F
85	129	Kotapola	Lidagawahena	Janashakthi	**45**	A, B, C, D, F
86	129	Kotapola	Wiharahena	Rohana	**42**	A, B, C, D, F
87	131	Pasgoda	Btandura South	Jana Navoda	**46**	A, B, C, D, F
88	132	Pasgoda	kirilipana	Dimuthu	**81**	F
89	133	Pasgoda	kekundeniya	Neelamba	**55**	E, F
90	134	Pasgoda	Ginneliya East	Praja Sagari	**43**	A, B, C, D, F
91	136	Pasgoda	Ginneliya North	Ginneliya North Rantharu Praja Hawla	**54**	E, F
92	140	Pasgoda	Beralapanathara North	Dimuthu	**42**	A, B, C, D, F
93	141	Pasgoda	Katawala	Thurushakthi Suwasetha	**94**	G
94	142	Pasgoda	Pattigala	Pivithuru	**48**	A, B, C, D, F
95	143	Pasgoda	Napath ella	Ranmal	**56**	E, F
96	144	Pasgoda	Pasgoda	Janashakthi I	**58**	E, F
97	145	Pasgoda	Pasgoda	Janashakthi II	**50**	A, B, C, D, F
98	146	Pasgoda	Pasgoda	Janashakthi III	**71**	E, F

99	147	Pasgoda	Pasgoda	Janashakthi IV	**43**	A, B, C, D, F
100	148	Pasgoda	Bengamuwa East	Swashakthi	**81**	F
101	149	Pasgoda	Denkandaliya	Samagi	**50**	E, F
102	150	Pasgoda	Rotumba West	Thalgasthanna	**43**	A, B, C, D, F
103	151	Pasgoda	Puwakgahahena	Ekamuthu Suwashakthi	**53**	E, F
104	152	Pasgoda	Mawarala	Pinimuthu	**45**	A, B, C, D, F
105	153	Pasgoda	Mawarala	Mihiwara	**54**	E, F
106	154	Pasgoda	Gomila	Janahitha	**59**	E, F
107	155	Pasgoda	Adaluwa	Mihikatha	**45**	A, B, C, D, F
108	157	Pasgoda	Pathawita	Samagi	**45**	A, B, C, D, F
109	161	Pasgoda	Molokgama North	Walagamba	**62**	E, F
110	162	Mulaityana	Mulatiyana	Thushara	**48**	A, B, C, D, F
111	163	Mulaityana	Mulatiyana	Nildiya	**62**	E, F
112	164	Mulaityana	Deiyandara	Sisila	**79**	F
113	165	Mulaityana	Gombeddala South	Piyagatapela	**47**	A, B, C, D, F
114	166	Mulaityana	Bergama North	Sisila	**59**	E, F
115	167	Mulaityana	Baragama East	Sampath	**50**	
116	169	Mulaityana	Rathkekulawa	Wikashitha	**67**	E, F
117	170	Mulaityana	Horapavita South	Isuru	**55**	E, F
118	171	Mulaityana	Mudaligedara	Nildiyadahara	**45**	A, B, C, D, F
119	172	Mulatiyana	Rathkekulawa	Wikasitha I	**65**	E, F
120	173	Mulaityana	Rathkekulawa	Wkasitha II	**55**	E, F
121	174	Mulaityana	Pitawalgama	Swashakthi	**42**	A, B, C, D, F

122	175	Hakmana	Kongala Middle	Suhada Sahana sewa Padanama	**59**	E, F
123	176	Hakmana	Allewela West	Kongahapitiya Drinking water Project	**76**	F
124	177	Hakmana	Udupillagoda West	Janatha Dewelopment Centre	**83**	F
125	178	Hakmana	Pananwela East	Praja Sanwardana padanama II	**58**	E, F
126	179	Hakmana	Pananwela East	Praja Sanwardana padanama I	**48**	A, B, C, D, F
127	180	Hakmana	Denagama East	Thilina	**66**	E, F
128	181	Hakmana	Narawelpita South	Janasarana Ekabadda	**39**	A, B, C, D, F
129	182	Hakmana	Denagama East	Thilina I	**57**	E, F
130	183	Hakmana	Denagama East	Thilina II	**60**	E, F
131	184	Hakmana	Udupillegoda East	Janatha Udupillagoda /East Gamidiriya Samagama	**36**	A, B, C, D, F
132	187	Hakmana	Muruthamuraya West	Thilina	**39**	A, B, C, D, F
133	189	Hakmana	Gangodagama	Uyanweta	**81**	F
134	190	Hakmana	Lalpe	Isuru Janatha Lalpe Gamidiriya Samagama	**83**	F
135	191	Hakmana	Kabiyapola South	Pinimuthu	**69**	E, F

136	192	Hakmana	Lalpe	Sinhabala	**80**	F
137	193	Hakmana	Kandegoda	Kandegoda Ltd Janatha Gamidiriya	**80**	F
138	194	Hakmana	Kongala West	Sinha Samagi	**43**	A, B, C, D, F
139	195	Hakmana	Narawelpita East	Randiya	**73**	E, F
140	196	Hakmana	Kohuliyadda	Minijaladahara	**36**	A, B, C, D, F
141	197	Hakmana	Kongala East	Ekamuthu	**70**	E, F
142	198	Hakmana	KongalaWest	Kongalawest grameeya organization	**44**	A, B, C, D, F
143	199	Hakmana	Kohuliyadda	Salila Dahara	**37**	A, B, C, D, F
144	201	Kamburupitiya	Kahagala South	Samagi	**40**	A, B, C, D, F
145	202	Kamburupitiya	Karaputugala North	Pavara	**40**	A, B, C, D, F
146	203	Kamburupitiya	Kahagala	Isiwara	**43**	A, B, C, D, F
147	205	Kamburupitiya	Mapalana Magin Ihala	Navoda	**79**	F
148	206	Kamburupitiya	Ihalavitiyala East	Suhada	**69**	E, F
149	103-i	Kamburupitiya	Ihalavitiyala East	Pubudu	**45**	A, B, C, D, F
150	103-ii	Kamburupitiya	Palolpitiya	Janatha sanwardena padanama	**41**	A, B, C, D, F
151	106-i	Kirinda Puhulwella	Ovitigamuwa South	Randiya	**47**	A, B, C, D, F
152	106-ii	Kirinda Puhulwella	Watukolakanda	Ekamuthu	**60**	E, F

153	130-i	Kirinda Puhulwella	Hettiyawala North	Hettiyawala North	**61**	E, F
154	130-ii	Kirinda Puhulwella	Boraluketiya	Boraluketiya	**53**	E, F
155	137-i	Kirinda Puhulwella	Hettiyawala North	Bagya	**64**	E, F
156	137-ii	Kirinda Puhulwella	Walakanda West	Randiya	**59**	E, F
157	138-i	Kirinda Puhulwella	Walakanda South	Nilnadee	**35**	A, B, C, D, F
158	138-ii	Kirinda Puhulwella	Kirinda phulwella	Krinda Phulwella Praja Sanwardana padanama	**67**	E, F
159	138-iii	Kirinda Puhulwella	Walaknda East	Suhada Shakthi	**88**	F
160	188-1	Devinuwara	Walbulugahahena	Samagi I	**45**	A, B, C, D, F
161	188-2	Devinuwara	Walbulugahahena	Samagi II	**43**	A, B, C, D, F
162	1-i	Devinuwara	Aparekka North	Diyawara Aruna	**36**	A, B, C, D, F
163	1-ii	Dickwella	Walasgala East	Sahana	**54**	E, F
164	28-i	Dickwella	Urugamuwa middle	Shakthi	**37**	A, B, C, D, F
165	28-ii	Dickwella	Urugamuwa North	Navodya	**57**	E, F
166	58-i	Dickwella	Dandeniya South	Sithumina I	**66**	E, F
167	58-ii	Dickwella	Dandeniya South	Sithmina II	**33**	A, B, C, D, F
168	58-iii	Dickwella	Urugamuwa West	Sampatha I	**58**	E, F
169	5-iv	Dickwella	Urugamuwa West	Sampatha II	**53**	E, F
170	85-i	Dickwella	Urugamuwa West	Sampatha III	**47**	A, B, C, D, F

171	85-ii	Thihagoda	Batuwita 1	Samagi	**43**	A, B, C, D, F
172	9-ii	Matara	Deeyagaha East	Randiyawara	**52**	E, F

Table--D.3: Treatment Recommendation for Hambanthota District

No	Sample No	D.S Division	G.N. Division	CMWSS Name	WQI	Treatment Recommendations
1	H 1	Beliatta	Beligalla North	Nildiya	**61**	E, F
2	H 2	Beliatta	Beligalla West	Apeksha	**38**	A, B, C, D, F
3	H 3	Beliatta	Nugewela	Nugashakthi	**70**	E, F
4	H 4	Beliatta	Wadiya East	Dedunu	**64**	E, F
5	H 5	Beliatta	Pallanthra East	Shakthi	**40**	A, B, C, D, F
6	H 6	Beliatta	Beligalla East	Janapubudu	**55**	E, F
7	H 7	Beliatta	Wadiya	Sisildiya	**43**	A, B, C, D, F
8	H 8	Beliatta	Maha Heella East	Parakum	**74**	E, F
9	H 9	Beliatta	Abagasdeniya East	Ranthilina	**38**	A, B, C, D, F
10	H 10	Beliatta	Gatamanna East	Minikirana	**78**	F
11	H 11	Beliatta	Oivilana	Diriya	**40**	A, B, C, D, F
12	H 12	Beliatta	Mirtiswatta East	Arunodaya	**40**	A, B, C, D, F
13	H 13	Beliatta	Kuda Heella East	Nawoda	**38**	A, B, C, D, F
14	H 14	Beliatta	Dedduwawala East	Pragathi	**40**	A, B, C, D, F
15	H 15	Beliatta	Dedduwawala	Ekamuthu	**38**	A, B, C, D, F
16	H 16	Beliatta	Galagama East	Janadeepa	**40**	A, B, C, D, F
17	H 40	Beliatta	Udahalmotagama	Sawiya	**40**	A, B, C, D, F
18	H 127	Beliatta	Gatamanna East	Thilina	**35**	A, B, C, D, F

19	H 128	Beliatta	325 Maligathanna	Nagena Tharu	**35**	A, B, C, D, F
20	H 129	Beliatta	326 Idikatigoda	Wijaya	**35**	A, B, C, D, F
21	H 130	Beliatta	344 Maha Heella West	Isuru	**38**	A, B, C, D, F
22	H 17	Walasmulla	Uda Julampitiya	Isuru	**40**	A, B, C, D, F
23	H 18	Walasmulla	Bowala South	Srama Udana	**88**	F
24	H 19	Walasmulla	Bowala /North/West	Bowala Ekabadda	**68**	E, F
25	H 20	Walasmulla	Widikanda	Sampatha	**80**	F
26	H 21	Walasmulla	Udahagoda	Shakthi	**38**	A, B, C, D, F
27	H 22	Walasmulla	Namaneliya	Praja Shakthi	**85**	F
28	H 23	Walasmulla	Mapitakanda	Gamunu	**66**	E, F
29	H 24	Walasmulla	Hagithakanda North	Randiyawara	**82**	F
30	H 25	Walasmulla	Agalabada	Janasetha	**38**	A, B, C, D, F
31	H 26	Walasmulla	Akpitiya	Grameeya	**85**	F
32	H 27	Walasmulla	Madagamgoda	Srama Shakthi	**74**	E, F
33	H 28	Walasmulla	Pissubedda	Pubudu	**41**	A, B, C, D, F
34	H 29	Walasmulla	Kebellaketiya	Samagi	**94**	G
35	H 30	Walasmulla	Kakiriobada	Randiya	**38**	A, B, C, D, F
36	H 31	Walasmulla	Batagassa	Udahiru	**51**	E, F
37	H 32	Walasmulla	Egodabedda	Arunalu	**88**	F
38	H 33	Walasmulla	Pahalawatta	Grameeya	**94**	G
39	H 34	Walasmulla	Kurudeniya	Ranmal	**38**	A, B, C, D, F
40	H 35	Walasmulla	Nangikakanda North	Randiya	**35**	A, B, C, D, F

41	H 36	Walasmulla	kornkarahena	Nawodana	**41**	A, B, C, D, F
42	H 37	Walasmulla	Kurudeniya	Dakma	**40**	A, B, C, D, F
43	H 38	Walasmulla	Warapitiya	Pivithuru	**40**	A, B, C, D, F
44	H 39	Walasmulla	Rabanwala North/South	Srama UdanaII	**71**	E, F
45	H 68	Walasmulla	Radaniara	Sinha	**68**	E, F
46	H 135	Walasmulla	Horewela	Sihapan	**35**	A, B, C, D, F
47	H 136	Walasmulla	Yahalmulla	Dinula	**35**	A, B, C, D, F
48	H 137	Walasmulla	Widikanda	Amarahiru	**35**	A, B, C, D, F
49	H 138	Walasmulla	wividapola	Sudira diya	**40**	A, B, C, D, F
50	H 139	Walasmulla	wattehengoda	Sanhida	**68**	E, F
51	H 140	Walasmulla	Hadugala	Sadundiya	**35**	A, B, C, D, F
52	H 41	Okewela	Udadeniya	Sasajana	**40**	A, B, C, D, F
53	H 42	Okewela	Wawwa	Idula	**40**	A, B, C, D, F
54	H 43	Okewela	Kadigamuwa West	Janajaya	**76**	F
55	H 44	Okewela	Thalahaganwaduwa Up	Sri Lack	**35**	A, B, C, D, F
56	H 45	Okewela	Rajapuragoda	Nawodya	**38**	A, B, C, D, F
57	H 46	Okewela	Udadeniya	Dinujaya	**87**	F
58	H 47	Okewela	Suminiridugama	Sisila	**75**	F
59	H 142	Okewela	Nathuwala	Gamidiriya	**38**	A, B, C, D, F
60	H 143	Okewela	Rajapuragoda	Nildiya	**29**	A, B, C, D, F
61	H 144	Okewela	Kandebedda	Suhada	**35**	A, B, C, D, F

62	H 48	Weeraketiya	Ambakolawewa South	Surathura	**78**	F
63	H 49	Weeraketiya	Ambakolawewa North	Abayashakthi	**64**	E, F
64	H 50	Weeraketiya	Morayaya North	Praja Shakthi	**38**	A, B, C, D, F
65	H 51	Weeraketiya	Gonadeniya Down	Diriyamaga	**40**	A, B, C, D, F
66	H 52	Weeraketiya	Gonadeniya Down	Diriyamaga II	**35**	A, B, C, D, F
67	H 53	Weeraketiya	Wekadawala North	Ehkabadda Shakthi	**86**	F
68	H 54	Weeraketiya	Debokkawa East	Jaya Maga	**38**	A, B, C, D, F
69	H 55	Weeraketiya	Kaluwagahayaya	Water Consumers Society	**38**	A, B, C, D, F
70	H 56	Weeraketiya	Kudabibula North	Ekamuthu	**38**	A, B, C, D, F
71	H 57	Weeraketiya	Kinchigune East	Gami Shakthi	**88**	F
72	H 58	Weeraketiya	Julampitiya	Ehkabadda	**40**	A, B, C, D, F
73	H 59	Weeraketiya	Kadamadiththa	Grameeya	**38**	A, B, C, D, F
74	H 60	Weeraketiya	Okandayaya North	Sithumina	**40**	A, B, C, D, F
75	H 61	Weeraketiya	Meegasara	Migara nadee	**38**	A, B, C, D, F
76	H 62	Weeraketiya	Eththademaliya	Nildiya Dahara	**40**	A, B, C, D, F
77	H 63	Weeraketiya	Mulkirigala North	Jala Dahara	**40**	A, B, C, D, F
78	H 64	Weeraketiya	Mulkirigala West	Gami Shakthi	**38**	A, B, C, D, F
79	H 65	Weeraketiya	Kudabedigama	Kudabedigama Grameeya	**40**	A, B, C, D, F
80	H 66	Weeraketiya	Bedigama south	Ekamuthu	**38**	A, B, C, D, F

81	H 67	Weeraketiya	Bedigama	Nil Diya	**73**	E, F
82	H 69	Katuwana	Walgammulla	Swa Shakthi	**38**	A, B, C, D, F
83	H 70	Katuwana	Walgammulla	Swa Shakthi	**38**	A, B, C, D, F
84	H 71	Katuwana	Bintrhanna	Eksath	**82**	F
85	H 72	Katuwana	Karametiya	Niwahal	**40**	A, B C, D, F
86	H 73	Katuwana	Ambagahahena	Ambagahahena	**38**	A, B, C, D, F
87	H 74	Katuwana	Ranasinghagoda	Ittakurugoda	**75**	F
88	H 75	Katuwana	Obadagahadeniya	Randiya Dahara	**40**	A, B, C, D, F
89	H 76	Katuwana	Ranasinghagoda	Ranahansa	**38**	A, B, C, D, F
90	H 77	Katuwana	Siyabalamuraya	Janamuthu	**38**	A, B, C, D, F
91	H 88	Katuwana	Hellala	Pubudu	**40**	A, B, C, D, F
92	H 89	Katuwana	Mallaketigoda	Ehkabadda	**38**	A, B, C, D, F
93	H 90	Katuwana	Ulahitiyawa West	Nawodya	**74**	E, F
94	H 91	Katuwana	Ulahitiyawa East	Randiya	**82**	F
95	H 92	Katuwana	Meemanakoladeniya	Nildiya	**82**	F
96	H 93	Katuwana	Siyarapitiya	Maithri	**35**	A, B, C, D, F
97	H 94	Katuwana	Gomadiya	Sanhida	**35**	A, B, C, D, F
98	H 95	Katuwana	Rukmalpitiya	Apeksha	**94**	G
99	H 96	Katuwana	Gallidamulla	Samagi	**40**	A, B, C, D, F
100	H 97	Katuwana	Puwakgasara	Puwakgasara	**40**	A, B, C, D, F
101	H 141	Katuwana	Weerakkuttigoda	Nildiyawara	**35**	A, B, C, D, F
102	H 78	Agunakolapelassa	Kankanumgama	Arunalu	**85**	F
103	H 79	Agunakolapelassa	Binkama	Harasara	**78**	F

104	H 80	Agunakolapelassa	Kalawelwala	Kalawelwala	**38**	A, B, C, D, F
105	H 81	Agunakolapelassa	Dikwewa	Janasetha	**60**	E, F
106	H 82	Agunakolapelassa	Uswewa	Randiya Samagi	**79**	F
107	H 83	Agunakolapelassa	Amarathunga Gama	Lahiru	**82**	F
108	H 84	Agunakolapelassa	Kohombagaswewa	Randiriya	**70**	E, F
109	H 85	Agunakolapelassa	Thalawa	Mahasen	**80**	F
110	H 86	Agunakolapelassa	Guruwala	Nil Nadee	**35**	A, B, C, D, F
111	H 87	Agunakolapelassa	Dandenigama	Sampath	**40**	A, B, C, D, F
112	H 98	Agunakolapelassa	Mahajadura	Pubudu	**40**	A, B, C, D, F
113	H 107	Agunakolapelassa	Julammala	Jala Sarana	**40**	A, B, C, D, F
114	H 108	Agunakolapelassa	Rathmalwala	Pubudu	**38**	A, B, C, D, F
115	H 99	Ambalanthota	Murawasihena	Dahamidiriya	**38**	A, B, C, D, F
116	H 100	Ambalanthota	Murawasihena	Sathira	**38**	A, B, C, D, F
117	H 101	Ambalanthota	Murawasihena	Janahitha	**75**	F
118	H 102	Ambalanthota	Barawakubuka	Ruhunu Divi Sarana	**38**	A, B, C, D, F
119	H 103	Ambalanthota	Rote (184)	Minimuthu	**74**	E, F
120	H 104	Ambalanthota	Hadawinna	Siyath	**67**	E, F
121	H 105	Ambalanthota	Mamadala North	Shakthi	**80**	F
122	H 106	Ambalanthota	Athbatuwa	Shakthi	**41**	A, B, C, D, F
123	H 116	Ambalanthota	Galwewa	Paspume	**85**	F
124	H 117	Ambalanthota	Walawawatta West	Walawa Nadee	**78**	F
125	H 118	Ambalanthota	Athbatuwa	Srama Shakthi	**84**	F

126	H 119	Ambalanthota	Hadurakatuwa	Ranmuthuduwa	**86**	F
127	H 109	Thissamaharamaya	Gonagamuwa	Shakthi	**61**	E, F
128	H 110	Thissamaharamaya	Nedigamwila	Nawoda	**79**	F
129	H 111	Thissamaharamaya	Halmillawa	Janasuwa	**38**	A, B, C, D, F
130	H 112	Thissamaharamaya	Raththalumiwalayaya	Rathnelum	**38**	A, B, C, D, F
131	H 113	Thissamaharamaya	Ekamuthugama	Samagi	**38**	A, B, C, D, F
132	H 114	Thissamaharamaya	Wijithapura	Nawoda	**73**	E, F
133	H 115	Thissamaharamaya	Allagala	Praja Rashmi	**71**	E, F
134	H 120	Sooriyawewa	Hathporuwa	Randiya Dahara	**76**	F
135	H 122	Sooriyawewa	Ranmuduwewa	Randiya	**81**	F
136	H 123	Sooriyawewa	Mahagalwewa	Suhada	**77**	F
137	H 124	Sooriyawewa	Andarawewa	Dharmadutha	**87**	F
138	H 125	Sooriyawewa	Hathporuwa	Sri Jaya	**82**	F
139	H 126	Sooriyawewa	Viharagala	Walawe Nadee	**79**	F
140	H 131	Hambanthota	Arawanamulla	Pubudu	**40**	A, B, C, D, F
141	H 132	Hambanthota	Liyangasthota	Dimuthumuthu	**85**	F
142	H 133	Hambanthota	Hadilla	Divisuru	**81**	F
143	H 134	Hambanthota	Badagiriya	Community Development	**38**	A, B, C, D, F
144	H 121	Lunugamwehera	Aluthgamara	Achala	**79**	F