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International Journal of KIU

Journal home page : https: //ij.kiu.ac.lk/
DOI: https://doi.org/10.37966/ijkiu2022032034

Original Article

An overview of water quality within the Colombo Municipal Council area; A retrospective report analysis

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Article history:
Received: 13.10.2022
Received in revised form - 23.12.2022
Accepted - 24.12.2022

Cite as: Ayomi A. A., Weerasinghe V. T., Priyadarshani K. S. S., Chulanganie P. A. S., Damayanthi W. L. A., Senarath N. S. A. S. N., Sewwandi K. P. A., Perera A. C. H.(2022) "An overview of water quality within the Colombo Municipal Council area; A retrospective report analysis" International Journal of KIU, 3(2), 143-150. https://doi.org/10.37966/ijkiu2022032034 #Corresponding author: chamilya@kiu.ac.lk

Abstract

Access to safe and quality drinking water is a fundamental requirement and a basic human right. Water quality is determined by its biological, physical, and chemical properties. Colombo Municipal Council (CMC) area consists of the largest population who utilize pipe-borne water supplied by the National Water Supply and Drainage Board (NWS&DB) Sri Lanka. The objective of the study was to assess the water quality of the drinking water under selected parameters within the Colombo Municipal Council area. In this quantitative, retrospective, cross-sectional study, 268 water analysis reports from 1st July to 30th November 2021 were considered with the permission of the Ethics Review Committee of KIU (KIU_ERC_21_194A) and relevant authorities of NWS&DB. Data on selected parameters such as color, turbidity, pH, Total Dissolved Solids (TDS), Free Residual Chlorine (FRC), the total number of coliform bacteria, and the total number of *Escheretia-Coli* (*E-Coli*) were extracted. Data analysis was done using SPSS (Version 25). All values were considered based on reference ranges of Sri Lanka Standards (SLS) guidelines. The study indicated that, among nine water schemes and four water reservoirs, the highest contributions for purification were from the Maligakanda water scheme (15.9% n =56) and Maligakanda water reservoir (51.6%, n=139). All the samples were fully treated water and the mean of the color was 4.03 Hazen Units which was within the permissible level, though (3.7 % n=10) of samples exceeded the range. The mean value of the turbidity was 0.49 Nephelometric Turbidity Unit (NTU) which was within the permissible level and only one sample had deviated from the maximum permissible level. The mean pH value was 7.33 and except for one, all other samples were within the permissible level. The mean value of the TDS was 24.51mg/L and the majority (95.8 %, n= 257) of FRC values varied between 0.6-0.8mg/L which was within the permissible level, while 3.39% (n=10) of samples had 0 mg/L. All samples were free from coliform and *E-Coli*. Most of the samples were within the permissible range of color, pH, turbidity, TDS, FRC, and free from Coliform and *E-Coli* which can be recommended for use.

Keywords*:* Water quality, Safe drinking water, SLS guidelines, Microbial contamination, Hazen Units, Nephelometric Turbidity Unit, pH Value

Introduction

Water is one of the most important substance on earth and consists of hydrogen and oxygen as chemical elements. Water exists in gaseous, liquid, and solid states, and water is essential for living organisms (plants, humans, animals, and microbes) for their survival. If there is no water, there would be no life on earth. It is a magical liquid and the main reason for the existence of living beings on earth. It is one of the most plentiful and essential compounds. Water is a tasteless odorless and colourless liquid at room temperature with the important ability to dissolve many other substances. Water involves in many important functions including regulating body temperature, flushing out waste from the body through perspiration, urination, and defecation, protecting tissues, spinal cord, and joints by lubricating and cushioning, preventing constipation, assisting in digestion, absorption of nutrients, assisting in oxygen circulation via blood (Silver, 2020). Therefore, to regulate bodily functions at an optimum level one needs to have an adequate daily intake of quality water.

Access to safe drinking water is a fundamental requirement for good health, a human right, and a major public concern. Global access to safe drinking water is monitored by the World Health Organization (WHO) and the United Nations International Children's Emergency Fund (UNICEF) (Bain et al., 2014). Water quality is determined by assessing three classes of attributes, namely biological, chemical, and physical. There are standards to assess water quality for each of these three classes, some are considered of primary importance and others are of secondary importance. Primary water standards regulate organic and inorganic chemicals, microbial pathogens, and radioactive elements that may affect the safety and quality of drinking water (Sivaranjani et al., 2015). Poor water quality can cause health risks for people and risks for ecosystems. In addition, the need for sustainable urban water supplies requires that the quality of existing available water resources as well as their watersheds need to be under continuous monitoring. Besides, the level of treatment required for human consumption, agriculture, animal husbandry, and industry necessitates an understanding of the quality of source waters. In this way, at the beginning of the twentieth century, the importance of water quality has to be considered and the concentration of chemicals in sewage and industrial discharges in waterbodies needs to be controlled (Gholizadeh et al., 2016).

According to the estimation of WHO, almost 10% of the population around the world does not have proper access to quality drinking water. Therefore, WHO has included water quality as one of the sustainable development goals of the United Nations (UN) to ensure universal access to water and sanitation by 2030 (WHO, 2008). Therefore, interventions to improve the quality of drinking water provide significant health benefits by improving awareness and access to safe drinking water (Aryal et al., 2012). Therefore every effort should be made to achieve drinking water quality as safe as practicable.

Obtaining safe drinking water is one of the major issues among individuals who are living in South Asian countries as well as contamination of drinking water is considered a major burden on human health. Diarrheal diseases due to the consumption of micro bacterial contaminated drinking water and Chronic Kidney Diseases (CKD) due to the consumption of drinking water contaminated by Arsenic (As) are the major problems in the Sri Lankan population (Jayasumana et al., 2013). Those at great risk of water-borne diseases are infants, young children, people who are living under poor sanitary conditions, and elderly people (Ellawala & Priyankara, 2016).

Parameters of drinking water quality mainly included color, turbidity, pH value, TDS, FRC, the total number of coliform bacteria, and the total number of E-Coli. Deviation of each parameter of water quality adversely affects all living organisms.

The Color of the drinking water is determined by the Platinum-Cobalt Scale (also known as a Pt/Co scale or an Apha-Hazen Scale) ranging from 0 to 500 with the lowest value at "0" referring to water as white or "distilled". It measures "yellowness" in liquid based on dilutions of 500 parts per million (ppm) platinum cobalt solution. This color index is a method for evaluating pollution levels in water or wastewater along with determining product quality and impurities. A 500 value on the scale means the water is distinctly yellow (Spartan, 2022). The drinking water samples which exceed 15 Hazen Units in color are not recommended for utilization according to the SLS guidelines (SLS, 2013).

Turbidity is not a major health concern. However high turbidity can interfere with the disinfection, water treatment process, and contamination. Normal pH values of the drinking water lie within the range of 6.5 – 8.5. It is not recommended to drink acidic water, as its high acidity and concentration of heavy metals could have several negative health consequences including poisoning or toxicity. Additionally, the acidity of the water can erode tooth enamel, and cause itchy skin or irritability in the gastrointestinal tract. Alkaline water doesn't pose any serious health risks. However high pH could make skin dry and itchy or cause damage to the lining of the stomach (WHO, 2007).

Total Dissolved Solids (TDS) is a measurement of the number of dissolved ions in water. It predominantly comprises inorganic salts. However, elevated levels of specific ions included in the TDS measurement such as nitrate, arsenic, aluminum, copper, or lead could produce health risks (WHO, 2007).

Although chlorine reduces the infectious risk, recent studies show that chlorine in treated water is dangerous to human health due to the possibility of developing allergic symptoms ranging from skin rash to intestinal symptoms, and arthritis and destroying protective lactic acid bacteria in the colon, which strengthens the mucosal immune response against foreign pathogens in the intestine (Sheikhi et al., 2014).

According to the WHO, the mortality of water-associated diseases exceeds 5 million people per year. In general terms, the greatest microbial risks are associated with the ingestion of water that is contaminated with human or animal feces. Wastewater discharges in fresh water and coastal seawater are the major sources of fecal microorganisms, including pathogens. Acute microbial diarrheal diseases are a major public health problem in developing countries (Cabral, 2010). The Total Coliforms (TCs) and *Escherichia coli* are used as indicators to detect the fecal contamination of drinking water (Aryal et al., 2012). According to a report on drinking water by WHO, water for human consumption should be free from any disease-causing microorganisms per 100 mL of water (Osiemo et al., 2019).

The government of every country is primarily responsible for providing clean and safe drinking water to people. In the Sri Lankan context, National Water Supply & Drainage Board (NWS&DB) is the main government organization responsible to provide safe piped-borne water in Sri Lanka. The NWS&DB supplies water to 34% of the country's population, while local authorities and community water supply schemes account for another 10%. Most of the cities and their suburbs are supplied with treated water by NWS&DB. People who are living in rural areas use their own water supplies, most frequently sourced from groundwater such as shallow wells and deep wells. People who are living in the dry zone of Sri Lanka, use water in irrigation tanks for bathing and household consumption (Ellawala & Priyankara, 2016).

It is essential to assess the quality of drinking water regularly according to the recommended guidelines. When assessing the water quality, there are recommended guidelines by WHO and Sri Lanka Standard Institute (SLS) guidelines (SLS, 2013) that are suitable for the Sri Lankan setting. NWS&DB of Sri Lanka follows the SLS guidelines when checking the quality of drinking water (NWSDB, 2020)

Colombo Municipal Council (CMC) area consists of 592,872 population and 47 administrative districts (Department of Census and Statistics, 2020). When considering this population 99% of them utilize pipe-borne water which is supplied by NWS&DB (NWSDB, 2020).

Based on these concerns, it is important to assess the quality of drinking water in the CMC area because it is one of the largest populations that utilize pipe-borne water which is supplied by the National Water Supply and Drainage Board (NWS&DB) Sri Lanka. Ambathale water treatment plant is one of the main center where the water treatment takes place in Sri Lanka and it is the water resource center for the CMC which is supplied by the Kelani River. The major reservoir tanks which are located in Maligakanda, ElliHouse, Dehiwala, and Jubilie are supplied by Ambathale treatment plant and distribute purified water around the CMC area (NWSDB, 2020)

Before providing water to the CMC, water quality parameters are detected at several pre-determined end-points located in Thimbirigasyaya, Pamankada, Hultsdrop, Mattakkuliya, Borella, Slave Island, Maligakanda, Kotahena, and Maligawatta. However it may be contaminated through various means when reaching the endpoint consumption hence, the current study was conducted to assess the water quality under selected parameters within Colombo municipal council area.

Methodology

A descriptive, retrospective, cross-sectional study was carried out using the secondary data extracted from 268 water analysis reports which were obtained from the Central laboratory of the National Water Supply & Drainage Board Rathmalana from the 1st of July to the 30th of November 2021, representing all 47 administrative districts of the CMC area of Western Province, Sri Lanka. The initial calculated sample size using the Daniel Formula was 385. However, researchers could not have direct access to the water schemes, since this research was done during the Covid-19 pandemic. Therefore, 268 water analysis reports which were obtained from the Central Laboratory in Rathmalana were considered secondary data of the current study.

All water samples (100%) that were used in this study were analyzed by NWS&DB and were fully treated water. The data were collected using a data extraction sheet which was developed by researchers referring to scientific literature. The data were analyzed using Microsoft Excel and SPSS version 25. Data are presented as descriptive statistics, such as frequencies, means, and standard deviations.

Ethical clearance was obtained from the Ethics Review Committee of KIU (ERC number KIU/ERC/21/194_A) and special approval and consideration have been obtained from the chief chemist of NWS&DB Maligakanda. The confidentiality of the data was maintained during the research process.

Results

The majority of water samples were collected from Maligakanda schemes15.9% n=56) followed by Thimbirigasyaya (14.2%, n=50,) Slave Island (9.9%,n=35,) and Pamankada (9.4% n=33) respectively. The rest of the samples are tabulated in Table 01. The majority of samples were distributed by the Maligakanda reservoir within the CMC area, of which 51.6% (n=139) and 24.2% (n=65) were distributed by the ElliHouse reservoir (Table 2).

Table 01: Frequency of samples based on water schemes

Scheme	Frequency	Percentage (%)
Thimbirigasyaya	50	14.2
Pamankada	33	9.4
Hultsdrop	25	7.1
Mattakkuliya	11	3.1
Borella	31	8.8
Slave Island	35	9.9
Maligakanda	56	15.9
Kotahena	11	3.1
Maligawatta	17	4.8

Table 02: Frequency of samples based on water reservoir

Reservoir	Frequency	Percentage
Jubilie	28	10.4%
Dehiwala	37	13.8%
Maligakanda	139	51.6%
ElliHouse	65	24.2%

Color

The mean value for color was 4.03 (± 4.55) Hazen Units. The majority (96.18% n=258) of samples were within permissible levels of SLS guidelines, while 27.9% (n= 75) samples indicated 0 Hazen Units referring to water as distilled. Ten samples that were collected from Maligakanda, Thimbirigasyaya, Slave Island, and Borella schemes exceeded the maximum permissible level of 15 Hazen Units within the data collection period.

Turbidity

The mean value for the turbidity was 0.49 (±1.48) NTU. The majority of samples (98.8% n=265) were within the maximum permissible level of 2 NTU according to the SLS guidelines. Only one sample which was collected from the Maligakanda scheme deviated from the permissible level and was 23.6 NTU. Another two samples which were collected from Thimbirigasyaya and Borella schemes slightly exceeded the permissible level.

pH

The mean value for the pH was 7.33 (±0.97). Except for one sample, other samples (99.6% n=267) were within the permissible level of 6.5 to 8.5 according to the SLS guidelines.

Total Dissolved Solids (TDS)

The mean value of the TDS was 24.51 (±4.12) mg/L. All the samples (100% n= 268) were within the permissible level of 500mg/L according to the SLS guidelines and the majority of samples were within 23 to 24.4mg/L.

Free Residual Chlorine (FRC)

The majority of samples (95.8% n=257) were within 0.6 to 0.8 mg/L for FRC. The maximum acceptable FRC level according to the SLS guidelines is 1mg/L. Eleven samples collected from Borella, Slave Island, Pamankada, Thimbirigasyaya, Maligakanda, and Hulstdrop had 0 mg/L for FRC. Only one sample indicated FRC as 0.1mg/L which was below the minimum recommended level of 0.2mg/L for treated drinking water by WHO.

Total coliform and E-Coli

All the samples were free from total Coliform bacteria and *E-Coli*. SLS guidelines describe that *E-Coli* or thermotolerant coliform bacteria shall not be detectable in any 100ml of the water samples and further total coliform bacteria shall not exceed 03 in any 100ml of the water sample.

Discussion

The study considered 268 water analysis reports regarding characteristics such as color, turbidity, pH, Total Dissolved Solids (TDS), Free Residual Chlorine (FRC), the total number of coliform bacteria, and the total number of E-Coli. In the current study, the mean value of the color of water samples was 4.03 Hazen Units which was within the permissible level of WHO specification (5-50 Hazen Units). Ten samples exceeded the permissible level which was not preferred for drinking purposes. A similar study was done in the Kalatuwawa water treatment plant and after the treatment process, the average color was indicated as 0 Pt/Co (similar to the Hazen unit) Units which was within the WHO limits (Premaratne & Senarathne, 2017). Both studies indicate similar results on the color of the water after the treatment showing that the treatment process in Sri Lanka conforms to recommended levels. Another Australian study also indicated the same finding as their results were also within the permissible level as recommended by WHO (Senevirathna et al., 2019) showing that the methods used in treating water in Sri Lanka are adequate. However alarmingly in the current study ten samples (3.7%) exceeded the permissible level which cannot be recommended for usage. This observation was not detected in previous studies locally and internationally. This highlights the need to evaluate the treatment procedure in the Sri Lankan context as previous studies done in Sri Lanka have conformed to the standard. The recommended turbidity levels were seen in the current study and previous studies done locally and in the Australian study, This finding is a positive factor for the treatment process storage and delivery of drinking water in Sri Lanka.

In the current study, the mean value of pH was 7.33 and was within the permissible level of the SLS specification of 6.5-8.5. Only one sample was 6.45 which exceeded the permissible level. In a similar study in 2014 done in the Kelani River basin, the pH values varied between 4.36 and 8.98 which exceeded the SLS and WHO guidelines and indicated a significant difference in pH variant compared to the current study (Mahagamage, & Manage, 2014). A pH variation is due to chemicals minerals pollutants soil mixing etc and it can be inferred that in the 2014 study the variation in pH could have been due to contamination. However, in the current study contamination seems to be minimal.

In keeping with the results of this study, another study conducted in selected water resources in Giradurukotte indicated the same results as the current study where the pH of groundwater and surface water varied between 6.56-7.72 and 6.88-7.51 respectively according to the SLS guidelines which are suitable for drinking (Kumari et al., 2016).

When comparing the Giradurukotte study with the current study Total Dissolved Solids (TDS) value varied between 0 mg/L to 41.7 mg/L and 65.9 mg/l to 311 mg/l and 40.2 mg/l to 141.53 mg/l respectively for the shallow wells and surface water bodies. Both values did not exceed the maximum permissible level of SLS specification of 500mg/L, even though the Giradurukotte study indicated a slightly higher amount than the current study (Kumari et al., 2016). Another study conducted in India also showed that values are within the recommended range of WHO (Sharma & Rout, 2011).

In the current study, the majority of the samples did not exceed the maximum permissible level for FRC according to the SLS specification of 1mg/L through 11 samples had 0 mg/L which gave rise to the risk of contamination by coliform bacteria. A similar study was done in the Riyadh region in Saudi Arabia, which recorded an FRC between 0.2 and 0.5mg/L which was a permissible level according to the Saudi Arabian Standards and had very lesser risk compared to the current study findings (Al-Omran et al., 2015)

In the current study, all samples were free from Coliform bacteria according to the SLS guidelines as 0cfu/100ml for the desired level and 03cfu/100ml for the permissible level at 37^0C (SLS, 2013). A similar study conducted in western Nepal indicated the presence of total coliform in 86.90% of the total samples which were taken from a natural source, reservoir, and tap water which shows a significant difference between the current study (Aryal et al., 2012). In the current study, all samples were free from E-Coli according to the SLS guidelines as 0cfu/100ml for the desirable and permissible level at 44^0C (Sri Lanka Standard 614:2013, 2013). Further similar results were shown by another study conducted in Australia on the presence of E.coli and coliforms (Seneviratne et al., 2012).

Conclusion

Pipe-borne treated water in Sri Lanka is suitable for human consumption

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