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Full Paper

Recreational Water Quality Status of Charty Beach, Jaffna, Sri Lanka

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Abstract

Recreational water quality assessment is an important step to overcoming safety issues for the users and the conservation of the habitat. The present study was conducted for five months from December 2020 to April 2021 to identify the ongoing issues related to the recreational water quality in Charty Beach, Jaffna, Sri Lanka. The water temperature (29.24 °C), pH (8.18), turbidity (8 NTU), and DO (6.71 mg L^{-1}) were all under the marine recreational standards' threshold limits. The total coliform (4.85 MPN 100 mL^{-1}) and *E. coli* count (2.64 MPN 100 mL^{-1}) were both confirmed to be within the international recreational water quality standards. However, measured nitrate (2.66 mg L^{-1}) and phosphate (0.15 mg L^{-1}) levels in the water were found to exceed the threshold limits for marine recreational waters, indicating that the beach has been contaminated with nitrate and phosphate-containing sewage overflow. The higher microbiological indicator values and nitrate content were obtained during the study period in December, which is the year's rainy season. Surface runoff containing feces, and agricultural waste due to rain may be the cause of the highest values. Based on the overall results of the beach water, it can be deemed that Charty Beach is suitable for bathing and recreational activities.

Keywords: fecal pollution, international standards, marine water quality, rainy season, safety issues

Introduction

Coastal areas are great destinations for both leisure and recreational activities [1]. It can be considered a primary asset that attracts millions of people through sun, sand, and sea (3S) tourism. They play a major role in the tourism industry and bring direct and indirect income to the country [2]. The direct economic benefits of tourism include revenue generated by tourist spending on travel, local facilities, leisure activities, and recreation in and around the visiting area, as well as job creation in the larger economy [3].

Marine water pollution causes significant changes in recreational waters, which reduces the demand for recreational activities [1]. The degradation of recreational water quality in the beach areas impacts the aesthetic value of the beach and the safety of the users leading to a loss of income from tourism. Generally, the aesthetic value of recreational water can be expressed in terms of transparency, odor, and color criteria. Here, the clarity or turbidity of the water can lead to safety hazards [4]. At swimming places, swimmers and divers should be able to determine the depth, identify any dangers, and be able to help people who may be in trouble [4].

For these reasons, ensuring the safety of the people involved in recreational activities in the beach area is an important activity. Beach quality assessment mainly depends on the analysis of physicochemical and microbiological parameters and plays an important role in the coastal management process and marine resource conservation [5, 6].

Sri Lanka is an island well known among foreign tourists for its beautiful and mind-blowing beaches. In Sri Lanka, the tourism sector plays a major role in the annual income of the country [6]. According to recent reports, the foreign exchange earnings from tourism in 2019 were Rs. 646,362 million, which covered 13.7 % of the annual GDP of Sri Lanka in 2019 [7]. It makes the tourism industry the third highest GDP earner in Sri Lanka in 2019.

Jaffna peninsula is surrounded by 1000 km^2 of the Indian Ocean and 160 km of shoreline, with all locations being within 10 km of the coast [8]. Casuarina, Kankesanturai, Keerimalai, Charty, and other aesthetically valuable beaches can be found in Jaffna. Due to the civilian conflict, these locations were secluded for more than thirty years, but following the war, they have become popular holiday destinations for both local and international tourists. At the local level, very few studies have been conducted on marine water quality assessment regarding recreational activities [6]. However, no research has been conducted to offer a basis for classifying beaches according to international criteria [6].

Charty Beach is one of the most aesthetically valuable white sandy beaches in the Northern Province of Sri Lanka and is a favorite holiday destination among local and foreign tourists. At Charty Beach, there is no preliminary data recorded, so the current status based on the marine recreational water quality of the beach area is unknown. Quality beaches can have a positive impact on the local economy. So, knowing the desired water quality parameters is an essential task, and an assessment of water quality at the beach will help to identify the ongoing issues and current status. If the water is proven to be of international standards, the beach's reputation will improve, attracting more visitors and helping to protect the local economy. Thus, the study aims to evaluate the physicochemical and microbiological quality of the marine water of Charty Beach, Jaffna, Sri Lanka to determine its present status of focusing recreational activities and compare it with international standards [4] to ensure the safety of the people involved in the recreational activities in that area. It will provide a framework for future research on evaluating Sri Lankan beaches' suitability for recreational activities, which will be valuable to the relevant regional authorities and other interested parties.

Materials and Methods

The study was conducted at Charty Beach, Jaffna district, Northern coast of Sri Lanka (Figure 1). It is located about 20 km away from Jaffna town. The beach is arched and located on Vellanai, a small island in the northern region, which is known as Kayts. For the water quality assessment, five sampling sites along a 135 m stretch of beach were selected. The GPS coordinates were recorded using handheld GPS (Garmin Oregon 750, USA), and the GPS coordinates of the sampling sites are site 1 (A) 9.6330741(N^0) 79.919347(E^0), site 2 (B) 9.6331032(N^0) - 79.9195007(E^0), site 3 (C) 9.6331109(N^0) - 79.9196439(E^0), site 4 (D) 9.6331259(N^0) - 79.9197231(E^0) and site 5 (E) 9.633201(N^0) - 79.9197591(E^0).

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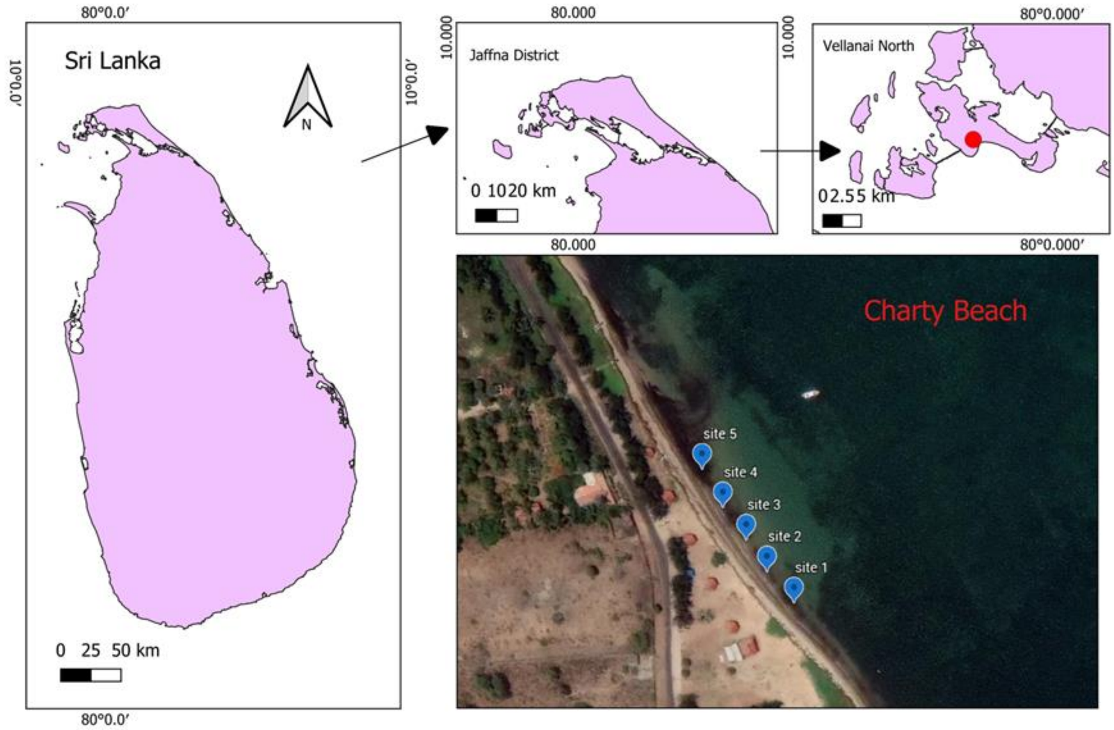

Figure 1. Map showing the study area Charty Beach, Jaffna, Sri Lanka, and the sampling sites along the 135 km stretch in the beach.

These sampling sites were selected using the transect sampling technique. In the horizontal margin along the beach, the difference between the distances of the two sampling locations was 33 m and the vertical margin was 21 m from the shore (Figure 2).

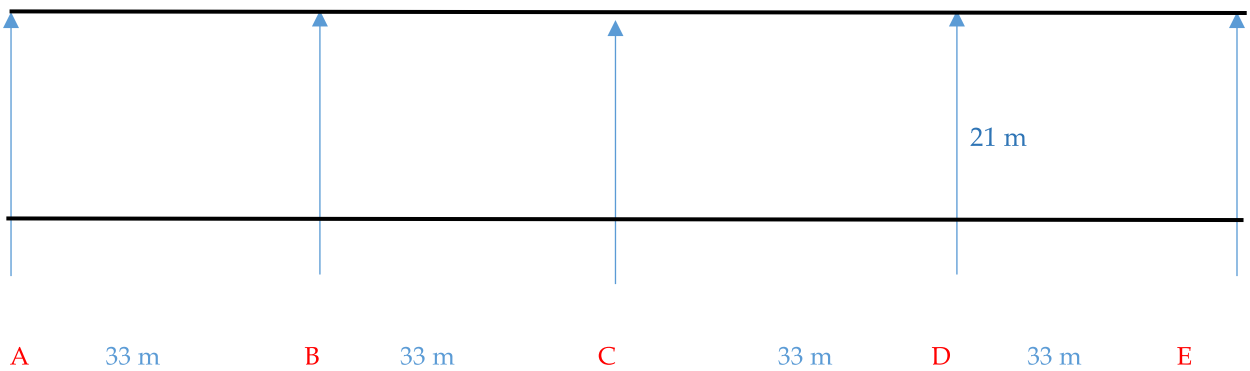

Figure 2. Diagrammatic representation of systematic sampling

Three sampling sites (A, B, and C) were chosen from the five sampling locations for the microbiological study of water (Figure 2). The microbiological samples (Figure 3) were obtained using sterilized glass bottles at a depth of 15 cm below the surface at a place where the water level was approximately 0.5 m [6].

Samples were collected at the same time once a month for a period of five months from December 2020 to April 2021. Sterilized 500 mL glass bottles were used to collect water samples while 100 mL stoppered bottles (dark and light) were used to collect samples for Biological Oxygen Demand (BOD) analysis. The sample bottles used for microbiological analysis were sterilized by autoclave (BKM-

P24(D), China) and the bottles were rinsed thoroughly with seawater before filling the bottle with the sample. During transportation, microbiological sample bottles were covered with aluminum foil and stored in an icebox. The dark stoppered bottles were used for the BOD analysis after five days and the light stoppered bottles after adding the chemicals, the bottle cap was covered with aluminum foil to avoid spillage during transportation.

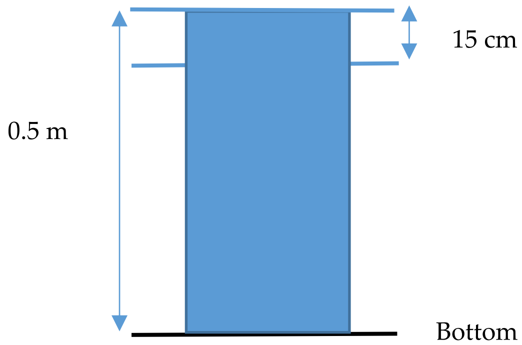

Figure 3. Diagrammatic representation of sampling method in the microbiological

In the laboratory, the microbiological sample bottles were placed in the refrigerator, and before the inoculation, it was allowed some time for the temperature to rise to room temperature. Inoculation was done immediately after coming to the laboratory of the Department of Fisheries, University of Jaffna, Sri Lanka.

The water for the turbidity, nitrate, and phosphate analyses was taken from the sample bottles within 24 hours of sampling. The physical parameters such as air and water temperature, pH, salinity, Total Dissolved Solid (TDS), Electric Conductivity (EC), and Dissolved Oxygen (DO) were measured on-site using the smarTROLL multiparameter (In-situ 458389, USA) [9]. BOD was measured by Winkler's method (APHA, 1998). The nitrate, phosphate, and turbidity of the water were measured using the spectrophotometric (Lovibond XD 7500 US-VIS spectrophotometer, Germany) method. For the enumeration of total coliform count and *E. coli* count, the standard five-tube Most Probable Number (MPN) method was used.

Statistical analysis

In the research, all the physical, chemical, and biological data collected from the water samples were analyzed using Minitab statistical software 2019. It's for the detection of the mean and the standard deviation by descriptive analysis (normal distribution) and two-way ANOVA was used for the detection of significant variations among parameters during the sampling period across the sampling locations and sampling months. Using the same software, the correlation of the parameters was also obtained. Because the total coliform data were discovered to be non-normal, they were statistically analyzed using the nonparametric tests of Minitab software 2019. The Friedman test and Analytical Attribute Analysis tests were used. When finding the mean total coliform count the data from December was removed as an outlier.

Results and Discussion

Due to the lack of ambient water quality standards for a recreational site in Sri Lanka until now, I have used the water quality standards of some countries (Table 1).

Table 1. Recommended marine water quality standard values for the recreational site (Source: [1])

Parameters	India	Malaysia	Japan	Australia
pH	6.5-8.5	-	7.8-8.3	6.5-8.3
Turbidity (NTU)	< 30	-	-	-
DO (mg $L^{-1)}$	≥ 4.0	≥ 5.0	≥7.5	≥ 6.0
TDS (ppt)	-	-	-	-
EC (ÂµS cm^{-1})	-	-	-	-
Salinity (PSU)	-	-	-	-
Temperature (°C)	-	≤2 increase over the maximum ambient temperature	-	16-34
Nitrate (mg L^{-1})	-	0.06	-	-
Phosphate (mg L^{-1})	-	0.075	-	-
Total coliform count (MPN 100 mL^{-1})	-	-	<1000	-
E. coli count (MPN 100 mL^{-1})	<100	<100	-	<150

The mean, minimum, and maximum values of the water quality parameters from the present study are given in Table 2 below.

Table 2. Minimum, maximum, and mean values of the water quality parameters

Parameter	Unit	Minimum	Maximum	Mean	Standard deviation
Temperature	°C	26.73	31.21	29.24	1.40
pH	-	7.53	8.56	8.18	0.24
Salinity	PSU	28	32	29.79	1.39
EC	ÂµScm^{-1}	46355	53732	49463	2666
TDS	ppt	28.425	32.625	30.2	1.46
DO	mg L^{-1}	4.02	11.29	6.71	1.83
BOD	mg L^{-1}	0.40	2	1.24	0.55
Nitrate	mg L^{-1}	1.06	8.2	2.66	2.08
Phosphate	mg L^{-1}	0.06	0.29	0.15	0.06
Turbidity	NTU	7	10	8	0.12
Total coliform count	MPN 100 mL^{-1}	1.80	13	4.85	3.99
E. coli count	MPN 100 mL^{-1}	1.80	6.1	2.64	1.34

Table 2 shows that the measured temperature ranged from 26.73 to 31.21 °C with the mean value (29.24±1.40 °C) falling within the acceptable levels for international recreational standards.

When considering recreational activities, exposure to extreme conditions at low or high values can be problematic for users [4]. People who are inadvertently exposed to extremely cold water (< 15 °C) suffer from cold shock, which can be fatal to the respiratory and cardiovascular systems. Higher temperatures (> 34 °C) can cause heatstroke.

The pH value of the water ranged from 7.53 to 8.56 and the mean value (8.18±0.24) stated that it was within the recommended range for international recreational standards. According to WHO [4], higher and lower pH values in water have a direct impact on recreational users, affecting their skin and eyes. Low and high pH can cause primary irritation of the skin, eyes, and hair [4]. Figures 4a and 4b show the monthly variation of the water temperature and pH.

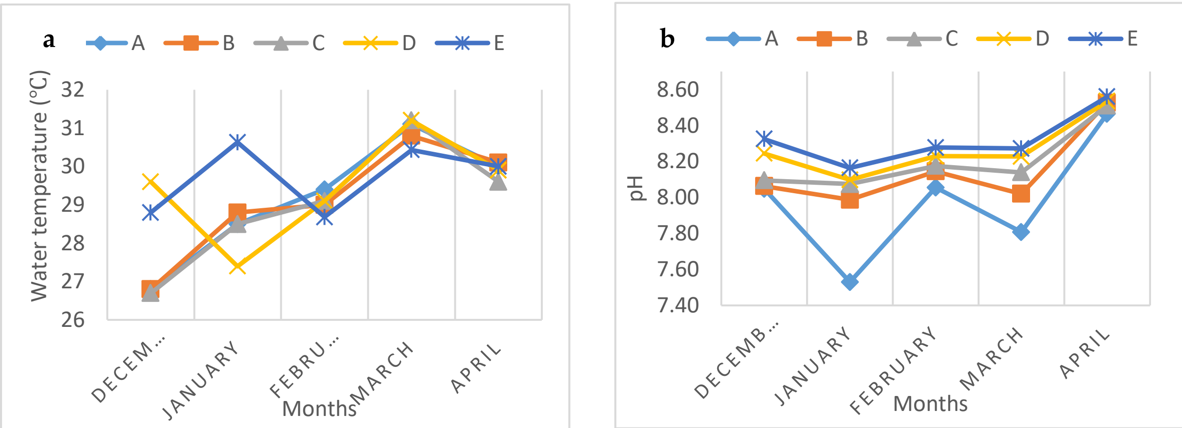

Figure 4. Monthly variation of water temperature (a) and pH (b) at Charty Beach from December 2020 to April 2021

Recorded EC values ranged from 46355.00 to 53732.00 (49463±2666 ÂµS cm^{-1}) (Figure 5a), and it shows a strong correlation with water temperature (r = 0.82) and salinity (r = 0.91). When the salinity of the water increases, the EC of the water increases as well. There is no guideline value to assess the EC of the water, but it is an important parameter that gives information about the industrial sewage contamination of the water. Because the EC value in industrial or domestic sewage and storm water is often high [1].

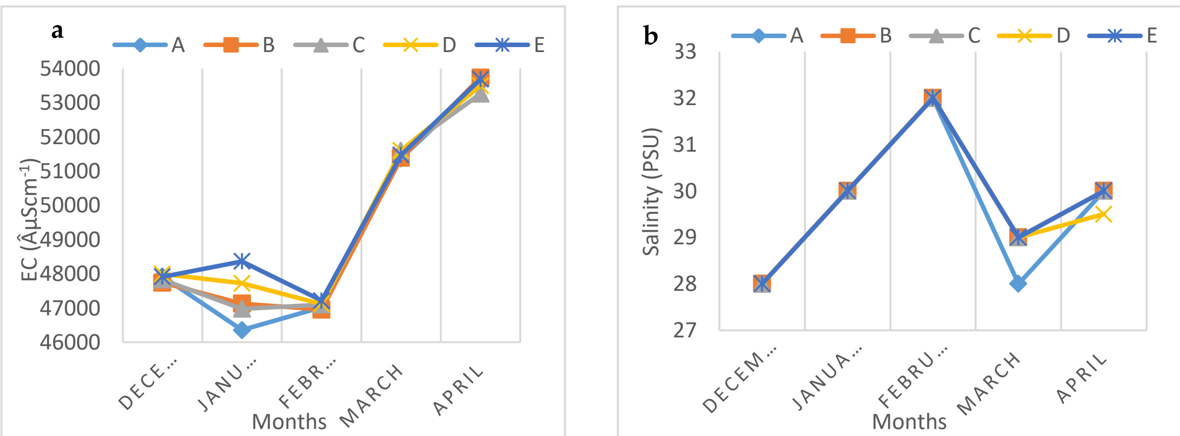

Figure 5. Monthly variation of EC (a) and salinity (b) at Charty Beach from December 2020 to April 2021

Generally, the salinity value of seawater is 35 PSU and salinity indicates the salt concentration in the water body [1]. The present study most importantly does not show the general salinity value of the seawater (35 > 29.79 PSU). This indicates that there may be higher freshwater input to the beach. The salinity of the coastal waters is most often used for the determination of freshwater mixing with seawater. Here, the salinity value of the water ranges (Figure 5b) from 28 to 32 (29.79±1.39 PSU). Salinity helps to trace the sewage outflows in the seawater as well [1]

According to Table 2, the TDS value (Figure 6a) of the water ranged from 28.43 to 32.63 (30.20±1.46 ppt) and turbidity ranged from 7 to 10 (8±0.12 NTU). TDS has a strong influence on the turbidity of the body of water. Although TDS does not have any threshold limits regarding the water quality standards it is a very important parameter to describe the conductivity and salinity variation of the water. In the current study, there was a substantial association between salinity and TDS (r = 0.99) and between conductivity and TDS (r = 0.87). When it comes to recreational activities, the clarity or turbidity of the body of water is important for users to identify submerged obstacles, estimate depth to avoid hazards, and in the emergency case of drowning, lifeguards to rescue the victims [4]. According to Figure 6b, the highest turbidity values were recorded in December. It is the month that shows the highest rainfall causing surface runoff, which is the reason for the highest turbidity.

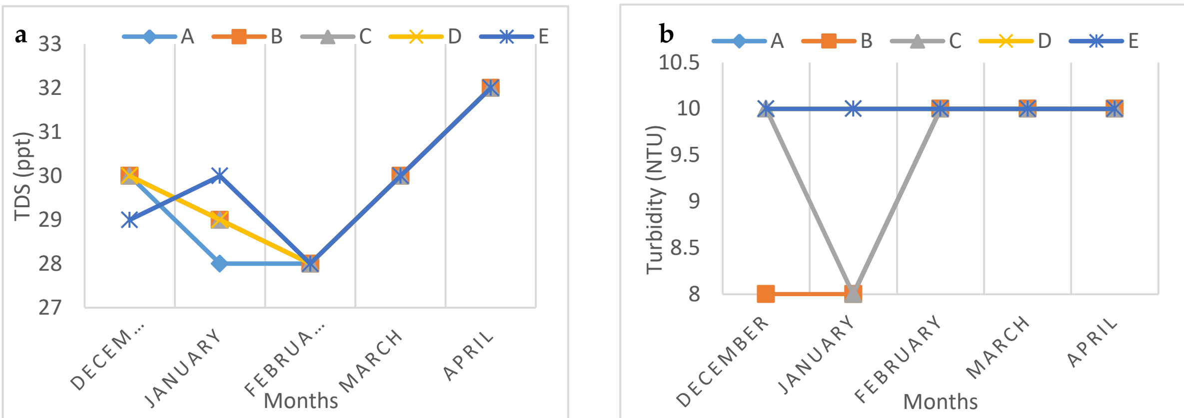

Figure 6. Monthly variation of TDS (a) and turbidity (b) at Charty Beach from December 2020 to April 2021

DO is one of the most important chemical parameters that affect aquatic life. It gives significant information on biotic and abiotic processes. Additionally, DO assesses the degree of contamination by organic matter, the rate at which organic materials decompose, and the water body's ability for self-purification [10]. BOD is an important parameter that measures the quantity of oxygen consumed by microorganisms during the decomposition of organic matter [10]. The presence of high organic matter causes a high BOD level in the water body and reduces the level of DO available for aquatic animals, causing their mortality [11]. BOD values are not used as a parameter for the recreational guidelines. However, BOD is an important indicator for detecting sewage contamination in a body of water [11].

The DO (Figure 7a) recorded at Charty Beach ranged from 4.02 to 11.29 (6.71±1.83 mg L^{-1}) and the BOD from 0.40 to 2.00 (1.24±0.55 mg L^{-1}). The site's overall mean DO value (6.71 mg L^{-1}) is higher than the water quality standards in India, Malaysia, and Australia.

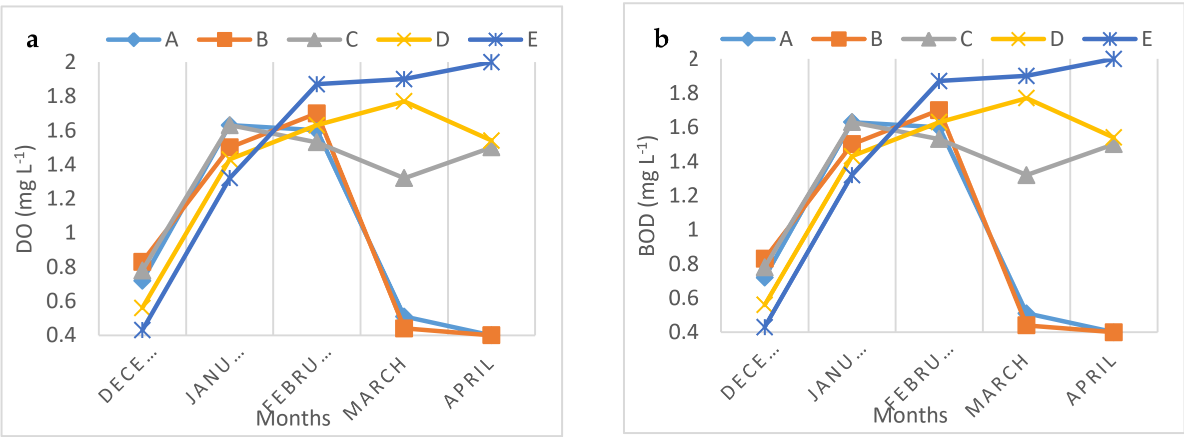

Figure 7. Monthly variation of DO (a) and BOD (b) at Charty Beach from December 2020 to April 2021

The measured nitrate and phosphate contents of the water ranged from 1.06 to 8.20 (2.66±2.08 mg L^{-1}), and from 0.06 to 0.29 (0.15±0.06 mg L^{-1}) respectively. Nitrate content in the water body gives information about whether the water body is contaminated by significant sources of nitrates such as fertilizers, decaying vegetation and animal matter, domestic and industrial effluents, and atmospheric fallout [10].

When excess nitrate is present it can cause eutrophication conditions in the body of water [10]. In the present study, the recorded mean value of nitrate in the water body (2.66 mg L^{-1}) exceeded the Malaysian marine water quality standards (0.06 mg L^{-1}).

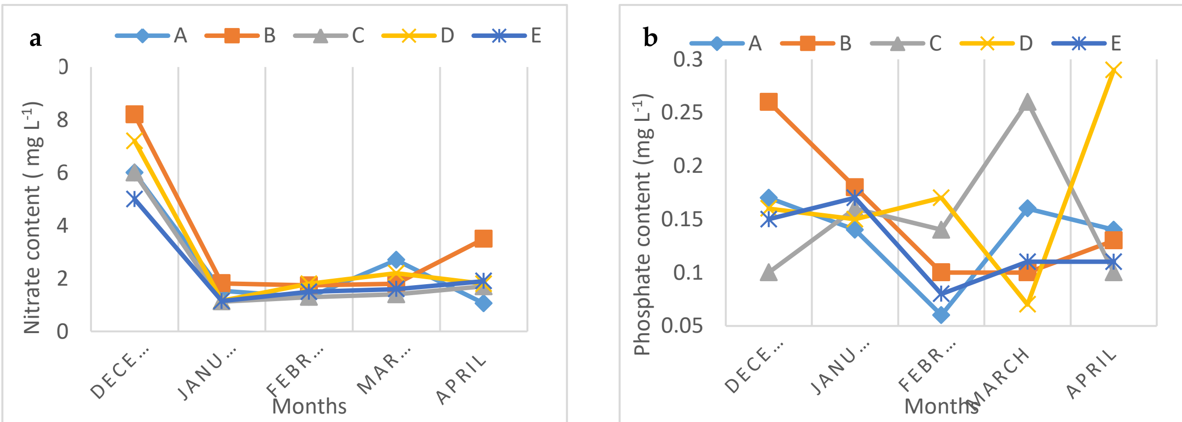

Figure 8. Monthly variation of DO (a) and BOD (b) at Charty Beach from December 2020 to April 2021

Surface runoff carrying nitrogenous fertilizers due to the heavy rain in December can be the reason for the higher values of nitrate in the water [8]. Here the overall mean value of the phosphate (0.15 mg L^{-1}) recorded in the water body exceeds the Malaysian water quality standards (0.075 mg L^{-1}). According to Figure 8a, the highest value of nitrate was observed during December which is in the rainy season.

The mean value of the total coliform count is 4.85±3.99 MPN 100 mL^{-1}. The *E. coli* count ranged from 1.8 to 6.1 MPN 100 mL^{-1} (2.64±1.34 MPN 100 mL^{-1}). Fecal coliform bacteria is an important microbiological indicator because the presence of *E. coli* and thermotolerant coliforms provides evidence of fecal contamination in the water body [6]. Several studies carried out to find out the health effects of exposure to contaminated recreational waters state that the microbial concentration in the water especially the *E. coli* count has a significant relation to the rate of diseases [12]. Here in the present study, the mean total coliform count and the *E. coli* count were 4.85 and 2.64 MPN 100 mL^{-1} respectively. Those were within the Indian, Malaysian, Japanese, and Australian water quality threshold limits for recreational waters.

When analyzing the correlation between the total coliform count and rainfall during the study period, it was found to show a strong correlation between the parameters (r = 0.908). And considering the variation of the *E. coli* count in the water during the study period, it gradually decreased showing a strong correlation (r = 0.888) with rainfall. The highest *E. coli* count was recorded during the month of December, in the rainy season. Because in the rainy season, surface runoff from the catchment areas can contain fecal coliform bacteria which can lead to fecal pollution in a short period. Another important factor that can affect the microbiological indicators in the water is bathing density [1]. Since this research was carried out during the time of the COVID-19 outbreak, and then because of lockdown issues bathing density was found to be very low. This can also have a huge impact on these results. The monthly variation of the two microbiological parameters is given in Figures 9a and 9b.

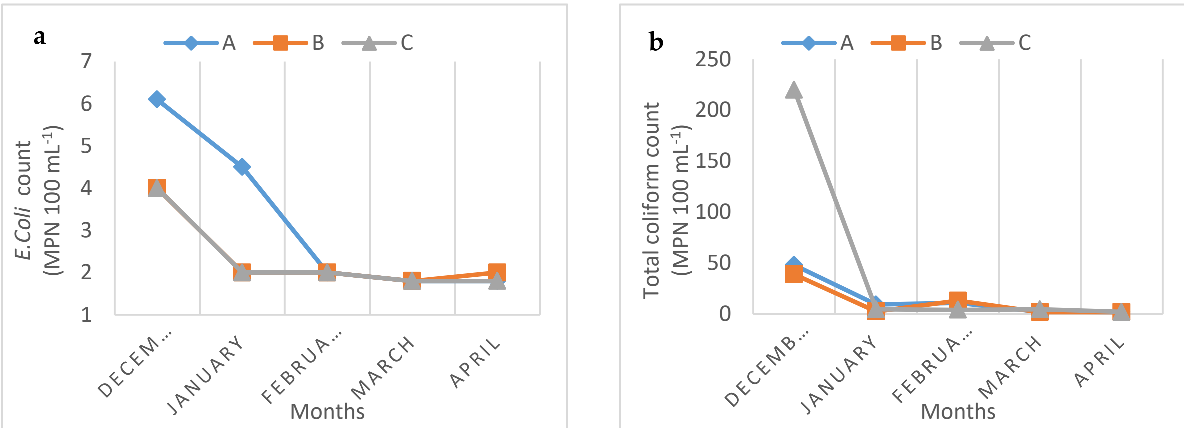

Figure 9. Monthly variation of *E.coli* (a) and total coliform count (b) at Charty Beach from December 2020 to April 2021

The results from the two-way ANOVA showed that these physicochemical and biological factors altogether do not show any variation between sampling locations ($P > 0.05$). This could be related to the fact that the sampling locations are rather close together. When compared to the findings of a recent study of recreational water quality in Arugam Bay Beach [13] and Pasikudah Beach [1], where the water's nitrate and phosphate content exceeded international standards. However other parameters were found to be within the recommended international recreational water quality standards.

Conclusion

Since this is the first study monitoring recreational water quality in Charty Beach and Jaffna, preliminary data was not found to compare the existing recreational situation. Monthly variation of the water quality parameters revealed that the average temperature (29.24 °C), pH (8.18), and turbidity (8 NTU) was within the threshold limits of marine water quality standards for recreational sites. Measured EC, salinity values showed a gradual increase during the study period of December 2020 to April 2021 indicating a strong correlation (r = 0.89). Measured average nitrate and phosphate values, 2.64 and 0.15 mg L^{-1} were found to exceed the maximum values of international marine water quality standards (0.06 mg L^{-1} and 0.075 mg L^{-1}). The highest value of nitrate was recorded during December which is the wet period of the year. This may be due to the surface runoff containing fertilizers and detergent due to the rainfall. DO (6.71 mg L^{-1}) content of the water was within the permissible level of Indian (≥ 4 mg L^{-1}), Malaysian (≥ 5 mg L^{-1}), and Australian (≥ 6 mg L^{-1}) water quality standards but failed in Japanese (≥ 7.5 mg L^{-1}) water quality standards. Total coliform and *E. coli* count results were revealed to be within the threshold limits of International marine water quality standard for recreational sites. However, when considering the highest total coliform count, was recorded during December which was found to have increased the threshold limit of marine water quality standards for recreational sites. The reason for the high number of coliforms in the water may be due to surface runoff from the rain, which causes fecal pollution. The total coliform and *E. coli* count showed a strong correlation with the rainfall data of the study period. Therefore, Charty Beach can be regarded as a beach that is appropriate for recreational activities based on the overall results of the marine water quality indicators. Although the beach water quality is good, it is recommended to have frequent and long-term monitoring of the beach area, with the evaluation of trophic index, water pollution index, and planktonic analysis. Since this research was carried out only for five months and included only one data set for the rainy season doesn't give a proper idea about the beach status throughout the year. So, it is essential to overview the beach status during the warmer season. The variation of water quality can have an impact on the users and the coastal community, it is recommended to have a questionnaire survey or focus group discussion to assess the effect of the variation of water quality on them.

Conflict of interest

The authors declare that they have no conflicts of interest.

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References

[1] K. Sivakumar, Assessment of marine water quality and its suitability for recreational activities in Pasikudah beach, 9th International Symposium 2019 on "Promoting Multidisciplinary Academic Research and Innovation"., Southeastern University of Sri Lanka, University Park, Oluvil, Sri Lanka, 27th - 28th November 2019

[2] A. Yanes, S. Zielinski, M. Diaz Cano, and S. Kim, 'Community-Based Tourism in Developing Countries: A Framework for Policy Evaluation', *Sustainability*, vol. 11, no. 9, p. 2506, Apr. 2019, DOI 10.3390/su11092506.

[3] Papadopoulos, Peter Phillips, Clare Twigger-Rossa, and Sarah Krish, 'The value of bathing waters and the influence of bathing water quality: Literature Review', p. 53, 2018.

[4] WHO, 'Guidelines for safe recreational water environments volume 1 coastal and fresh waters'. 2003.

[5] C. Caladob, 'Microbiology Water Quality of Three Coastal Beaches at Madeira Island, Atlantic Ocean', *Hydrol Current Res*, vol. 05, no. 03, 2014, doi: 10.4172/2157-7587.1000175.

[6] K. Samarasekera, 'Microbiology of Seawater and Sand in a Selected Bathing Site of Sri Lanka – A Study Towards Microbial Quality Assessment', *FEM*, vol. 3, no. 1, p. 9, 2017, doi: 10.11648/j.fem.20170301.12.

[7] 'Annual Statistical Report 2020'. Sri Lanka Tourism Development Authority. [Online]. Available: https://www.sltda.gov.lk/storage/common_media/Annual%20Stastistical%20Report%202021%20-Final%2025.4.20223624932970.pdf

[8] S. S. Sivakumar, 'Reclamation of Land and Improve Water Productivity of Jaffna Peninsula of Northern Sri Lanka by Improving the Water Quality of the Lagoons', vol. 02, no. 08, p. 9, 2013.

[9] P. Shobiya, K. Sivashanthini, S. Sutharshiny, and K. Gunaalan, 'Impacts of the Thondaimanaru Barrage Construction on socio – economic status of fishing communities in Thondaimanaru Lagoon, Jaffna, Sri Lanka', *Vingnanam J Sci*, vol. 14, no. 1, p. 27, Aug. 2019, doi: 10.4038/vingnanam. v14i1.4139.

[10] J. Ma, S. Wu, N. V. R. Shekhar, S. Biswas, and A. K. Sahu, 'Determination of Physicochemical Parameters and Levels of Heavy Metals in Food Waste Water with Environmental Effects', *Bioinorganic Chemistry and Applications*, vol. 2020, pp. 1–9, Aug. 2020, doi: 10.1155/2020/8886093.

[11] Patil, Sawant, and Deshmukh, 'Physico-chemical parameters for testing of water'. International journal of environmental sciences Volume 3, No 3, 2012, 2012.

[12] Annette Priiss, 'Review of epidemiological studies on health effects from exposure to recreational water'. 1998.

[13] K. Sivakumar, Preliminary assessment of marine water quality in bathing, surfing and fishery areas of arugam bay In Proceedings of Fifth Annual Science Research Sessions 2016 on "Enriching the Novel Scientific Research for the Development of the Nation ", pp.17-29, http://ir.lib.seu.ac.lk/handle/123456789/2052