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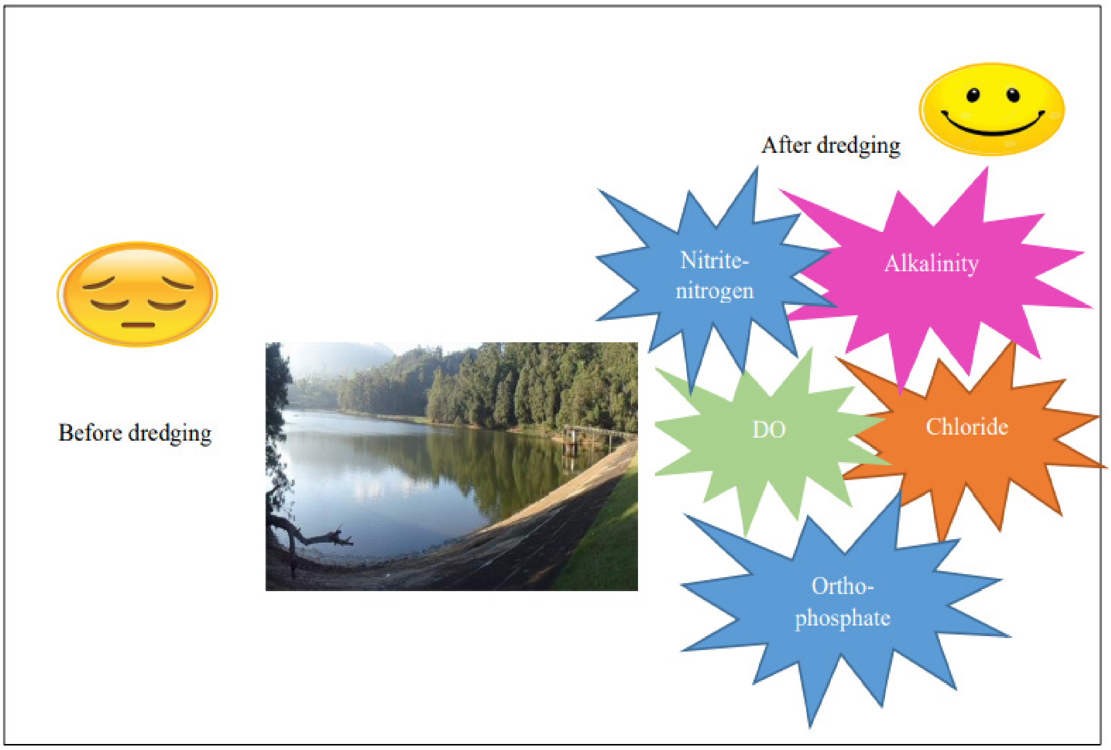

Highlights

- Dredging is critical in order to maintain the original capacity of man-made reservoirs.
- This study explored the impacts of dredging on the water quality of Bomuruwella Reservoir in the Central Province of Sri Lanka
- Dredging has improved chloride, alkalinity, ortho-phosphate, DO and nitrite levels in water.
- All tested water quality parameters were significantly differed following dredging except EC, BOD and nitrite-nitrogen.

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Dredging impact on water quality in Bomuruella Reservoir in Nuwara Eliya, Sri Lanka

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Abstract: The main objective of this study was to assess the difference of water quality of Bomuruwella reservoir before and after the dredging operations of the reservoir, which was carried out between June and September 2014. Water sampling was conducted from February to December 2014 on monthly basis at randomly selected 10 sampling locations. Dissolved oxygen (DO), pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), and salinity were determined *in situ,* and collected water samples were analyzed in accordance with the standard methods. All statistical analyses were performed using MINITAB 14 statistical software. Mean values of EC, DO, Turbidity, TSS, ammoniacal-nitrogen, nitrate-nitrogen, total hardness and Ca hardness, total discharge of nutrients increased while ortho-phosphate, nitrite-nitrogen, alkalinity, and chloride decreased after dredging operation. There were significant differences (p<0.05) between all the mean water quality parameters measured except for EC, BOD, and nitrite-nitrogen following the dredging. Also, the mean total discharge ammoniacal-nitrogen, nitrate-nitrogen, nitrite-nitrogen and orthophosphate before and after dredging period from sluice gate were 4,031.1 m^3/day; 7,986.6 m^3/day, 2,747.4 m^3/day; 208.9 m^3/day and 388,469.4 m^3/day, 309,479.8 m^3/day; 29,324.49 m^3/day, 2,157.67 m^3/day, respectively. In conclusion, dredging operation had impact on the water quality parameters in the reservoir, except chloride, alkalinity, ortho-phosphate, DO and nitrite, where they improved after dredging.

Keywords: Discharge; Dredging; Inland; Sustainable; Water quality.

INTRODUCTION

One of the major environmental concerns at present is the contamination of freshwater bodies' discharge from various point and non-point sources. The characteristics of a stream and river environment can depend upon its geology, substrate, flow rate, volume, water chemistry, mode of primary production, and inhabitants (Hynes, 1970). The environmental gradients and natural disturbance regimes that characterize these open water systems make them complex and diverse systems that are very sensitive to human activities (Bornette *et al*., 1998) whereas excessive connectivity impedes recruitment, and insufficient connectivity causes less competitive species to be eliminated, with no recruitment of new species. As a consequence, very low or very high nutrient levels should decrease species richness by selecting specialized species, whereas intermediate nutrient levels should favour the co-occurrence of species with contrasting nutrient requirements. 2. Among cut-off channels with high sinuosity and which are infrequently flooded by the river (low flood scouring; Ward *et al*., 2002). Rivers, reservoirs, estuaries, and lagoon waters are used extensively for the disposal of various types of waste. Hence, recent studies observed that the water quality in some reservoirs is rapidly deteriorating due to various anthropogenic activities (Kasthuriarachchi *et al*., 2016; Amarathunga and Kazama, 2017; Nandasena *et al*., 2019; Amarathunga *et al*., 2020). In addition, different amounts of pesticides and other pollutants may transport with farm runoff from agrochemicals applied to the farmlands and causing impacts on aquatic fauna (Amarathunga and Fazama, 2014; Sharma *et al*., 2019).

Reservoirs are the most vulnerable water bodies to pollution because of their role in carrying municipal and industrial wastes and run-offs from agricultural lands in their vast drainage basins (Yang *et al*., 2009). In addition, Amarathunga and Kazama (2014) reported that there are high amounts of pollutant adsorbed onto suspended particles, and these pollutants may trap in reservoirs in the river basin. High siltation can be occurred in reservoirs due to high suspended and bed sediment runoff from rivers encompassing different land-use patterns and land-use changes (Amarathunga *et al*., 2014; Ferreira *et al*., 2020). Therefore, timely dredging operations are very important to maintain the water capacity of the reservoirs. Dredging is the removal of sediments and debris from the bottom of water bodies such as lakes, rivers, and harbors. Among the rehabilitation approaches, sediment dredging is commonly used globally in both inland and coastal aquatic habitats. Therefore, sediment dredging has also been used as a thorough and efficient method of removing pollutants worldwide (Gao *et al*., 2019).

The impacts of dredging in some lentic water bodies have been studied in lakes in China (Zhang *et al*., 2010; Yin *et al.,* 2021) and India (Rehman *et al*., 2016). Sri Lanka

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also applies sediment dredging in some inland water bodies for water quality improvement (Perera and De Alwis, 2011). There are various impacts from the dredging activities such as habitat and resource destruction, and eventually the fisheries productivity. The Department of Irrigation in Sri Lanka conducted a dredging program in Bomuruella reservoir in 2014 in order to facilitate sustainable development of its environment. The impacts of dredging on water quality of freshwater bodies in the hill country of Sri Lanka is not previously discussed. Hence, this study aims to determine the effects of dredging on water quality, fishing communities, and aesthetic beauty of the reservoir. This findings of this study will help in recommending suitable measures for sustainable utilization of the reservoir.

METHODOLOGY

The study area

Bomuruella Reservoir is located (Latitude 06°57'N; Longitude 80°48'E) in Nuwara Eliya District in the Central Province of Sri Lanka. Figure 1 illustrates the location of the reservoir and its sampling locations. It was constructed and operated by the Department of Irrigation, which covers more than 30 ha, and remains an important water resource for the area while feeding the Uma Oya, another major tributary of the Mahaweli River in Sri Lanka. This reservoir is also important as an inland fishery site for people in the area, where more than 40 fishermen are utilizing this reservoir as their livelihood (Hettige *et al.*,

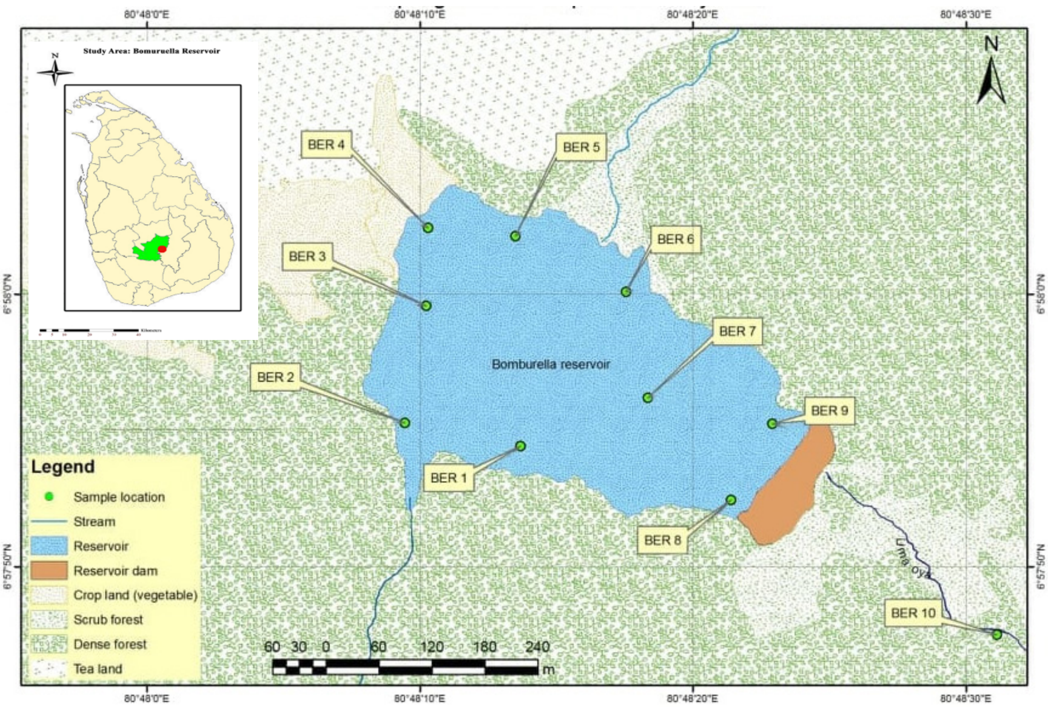

Figure 1: Sampling locations at Bomuruella Reservoir, located in the Central Province of Sri Lanka.

Table 1: GPS positions and other features of sampling Locations at Bomuruella Reservoir, Sri Lanka.

Sampling locations	GPS Position	Environment
BER 01	6°57`54.42"N,80°48`13.67"E	High Aquatic Plant Density
BER 02	6°57`55.28"N,80°48`09.44"E	Sandatenna Ella (The stream comes through the town)
BER 03	6°57`59.56"N,80°48`10.21"E	Buluwela Ella (The stream flows through the village)
BER 04	6°58`02.43"N,80°48`10.29"E	Peedru Watta(The stream flows through the village)
BER 05	6°58`02.13"N,80°48`13.48"E	Galpalama Ella (The stream flows through the forest area)
BER 06	6°58`00.07"N,80°48`17.54"E	Plantation Area
BER 07	6°57`56.20"N,80°48`18.35"E	Middle of the reservoir
BER 08	6°57`52.45"N,81°49`21.39"E	Left bank
BER 09	6°57`55.24"N,80°48`22.91"E	Right bank
BER 10	6°57`47.52"N,80°48`31.13"E	Outlet

2015). Bomuruella reservoir is used for various purposes such as fishing, agricultural activities, drinking, cleaning, and washing purposes by those who live in the surroundings and the downstream area (Hettige *et al*., 2018). Jayasinghe *et al*. (2011) stated that deterioration of this reservoir has taken place due to some anthropogenic activities, such as the release of leachates from the Moon Plains landfill, runoff rich in fertilizers and pesticides from cultivated lands and industrial, hospital, and household wastewater streams.

The Global Positioning System (GPS) coordinates at the different locations and their site descriptions are given in Table 1.

Sampling was performed before (February to May, 2014), during (June to September, 2014), and after the dredging (November to December, 2014) periods.

Analysis of environmental parameters

Water pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, dissolved oxygen (DO), and turbidity were determined *in-situ* using pH meter (Orion 260A), Hanna portable multi-range conductivity meter (HI 8733), portable oxygen meter (Orion 830A), and portable turbidity meter (Hach 2100P), respectively.

Standard Methods for the Examination of Water and Waste Water (American Public Health Association (APHA), 2012) were followed for analyzing total suspended solids (TSS), biochemical oxygen demand (BOD), ammoniacal-N, ortho-phosphate, nitrate-N, nitrite-N, alkalinity, total hardness, Ca-hardness, and chloride. Paired T-test was used to determine significant differences of water quality parameters in selected locations before and after dredging period using MINITAB 14.1 statistical software.

Also, daily rainfall at the weather station, Nuwara Eliya in 2014 was collected from Department of Meteorology to assist interpretation of variations of water quality results. Furthermore, water discharge and water level data were collected from Department of Irrigation, Nuwara Eliya (the water level of the reservoir in February, March, April, May, June, November and December were 22.6, 19.9, 23.6, 17.3, 1.0, 17.6 and 26.0 feet, respectively).

RESULTS AND DISCUSSION

Physiochemical characteristics of water quality before, during, and after-dredging are summarized in Table 2. Moreover, variation of inflow and outflow water quality parameters are included in Tables 3 and 4.

The measured mean pH value (7.76±0.66) before dredging was within the ideal pH range (6-8.5) proposed by the Central Environment Authority (2019). According to the past literature (Jayasinghe *et al*, 2011), the pH levels of all samples were within the standards for both high and low water levels recorded in November 2008 to May 2009. Mean pH in inflow and outflow is comparatively similar before and during dredging (Table 3 and Table 4).

The mean DO values of all the sampling locations were above the recommended level for fish and aquatic life (6 mg/L) during the study period, including both before (6.67±1.40 mg/L) and after (8.70±1.29 mg/L) dredging (Table 2). Usually, the release of organic rich sediments during dredging results in localized depletion of oxygen. Aeration of surface waters and seasonal changes in precipitation also affected the water body leading to the variation of DO concentrations. There was a statistically significant variation of mean DO concentration in selected sampling locations between pre-and post-dredging periods ($p \leq 0.05$). These findings are consistent with the reports by Esguícero and Arcifa (2017) in a study conducted in a Neotropical reservoir, Brazil, where they reported DO values before and after dredging at 4.5 and 6.9 mg/L, respectively. In a study carried out in Lunawa Lagoon, Sri Lanka, the DO was lower after dredging, thus indicating an improvement in water quality (Perera and De Alwis, 2011). The DO is an important parameter to express the amount of oxygen dissolved in water, which is essential for the survival of organisms (Shraddha *et al*., 2011). Hence, it is essential to dredge the aquatic waterbodies when they become unhealthy. Furthermore, when considering the inflow and outflow of variation of DO, inflow DO concentration is comparatively higher than outflow DO concentration before dredging. However, inflow and outflow DO concentration is comparatively similar after dredging (Table 3 and Table 4).

The statistical analysis found that the mean BOD concentration in different sampling locations was not significantly affected before and after dredging periods ($p \geq 0.05$). Mean BOD concentrations before and after dredging were 2.41±1.01 mg/L and 2.70±1.22 mg/L, respectively. Thus, BOD concentration after dredging is slightly higher than after dredging due to the release of organic rich sediment and due to the oxidation of re-suspended organic matter and addition of sewage by river influx (Sangita *et al*., 2014). When considering inflow and outflow variations of BOD, inflow BOD concentration is comparatively similar to that of outflow BOD concentration before, during and after dredging.

The statistical analysis showed that the mean EC in different sampling locations was not significantly vary before and after dredging occurrences ($p \geq 0.05$). Table 2 included the variation in the mean EC and TDS before and after dredging periods. The recorded mean EC was higher after (277.40±83.97 µS/cm) dredging compared to before (241.29±134.25 µS/cm) dredging periods. Similarly, Esguícero and Arcifa (2017) found that conductivity was lower (60.2 µS/cm) after dredging compared to that of before dredging (86.9 µS/cm) based on the study conducted using the Neotropical reservoir in Brazil. The increase in EC was partly due to the increasing NO_3-N concentration as indicated by their significant correlation (Zhang *et al.*, 2010). In addition, the mean TDS in different sampling locations was significantly different between before and after dredging periods ($p \leq 0.05$). Similar findings were observed by Rehman *et al.* (2016) in Dal Lake, Kashmir, India due to dredging activities. The increase in EC and TDS levels also indicate the re-suspension of particulate metals and their release from the sediments to the aqueous phase (Nayar *et al*., 2004). It might be another reason for changes in EC and TDS pre-and post-dredging. When considering

Table 2: Values of water quality before (BD), during (DD) and after dredging (AD) periods (Mean ± SD and Minimum-Maximum).

Parameter	Before Dredging (February to May)	During dredging (June to October)	After Dredging (November to December)
pH	7.76±0.66 6.41-8.74	7.30±0.59 5.02-7.77	-
EC (μS/cm)	241.2967.8-535.0 134.25±	216.60±176.03 100-1100	277.4083.97± 140-409
Salinity (ppt)	0.1±0.1 0.1-0.3	0.1±0.0 0.1-0.2	0.1±0.0 0.1-0.1
TDS (mg/L)	131.47±70.20 79.20-328.00	99.34±11.24 85.10-137.50	202.42±52.74 105.20-275.80
Turbidity (NTU)	7.39±2.82 1.67-13.09	73.23±57.92 1.52±794.00	8.52±1.20 5.35-10.60
DO (mg/L)	6.67±1.40 3.25-9.63	5.53±1.47 1.20-7.31	8.70±1.29 6.10-11.01
BOD (mg/L)	2.41±1.01 0.65-5.35	2.44±1.65 0.00-6.30	2.70±1.22 0.70-4.50
Nitrate - N(mg/L)	0.178±0.091 0.063-0.362	0.66±0.62 0.00-1.81	0.403±0.173 0.201-0.633
Nitrite - N(mg/L)	0.064±0.064 0.006-0.437	0.59±0.67 0.00-1.81	0.044±0.026 0.001-0.086
Ammoniacal-N(mg/L)	0.19±0.23 0.00-1.06	1.02±0.59 0.10-2.65	0.73±0.35 0.06-1.81
Ortho-phosphate (mg/L)	0.006±0.004 0.001-0.018	0.15±0.27 0.00-1.19	0.004±0.002 0.000-0.010
Total Suspended Solids (TSS) (mg/L)	9.01±4.23 2.40-23.60	62.05±148.48 1.20-85.3	11.70±3.37 5.20-16.80
Alkalinity (mg/L)	34.00±7.46 25.00-62.50	44.69±11.71 15.00-70.00	25.88±1.68 22.50-30.00
T-Hardness (mg/L)	33.55±8.24 24.00-70.00	55.28±20.95 32.00-135.00	66.60±8.02 52.00-91.00
Ca-Hardness (mg/L)	7.83±2.08 4.01-12.42	26.31±19.06 10.42-67.36	18.95±7.77 8.42-37.68
Chloride (mg/L)	109.72±113.43 23.04-485.67	63.01±17.66 35.45-120.53	28.36±11.70 10.64-42.54

Table 3: Variation of inflow water quality parameters before, during and after dredging in Bomuruella Reservoir, Sri Lanka.

Sampling Location		EC (µS/cm)	Salinity (ppt)	pH	DO (mg/L)	BOD (mg/L)	Nitrate - N(mg/L)	Nitrite - N(mg/L)	Ammoniacal-N(mg/L)	Ortho-phosphate (mg/L)
BER2	BD	303.95±175.26	0.2±0.1	7.84±0.74	4.75±1.28	2.26±0.55	0.21±0.05	0.0567±0.0336	0.1685±0.1780	0.00±0.00
	DD	208.80±63.02	0.1±0.1	7.50±0.11	5.31±1.81	2.70±1.31	0.56±0.62	0.5361±0.6451	1.2216±0.9936	0.07±0.10
	AD	356.00±2.83	0.1±0.0	-	9.55±2.04	2.90±1.56	0.89±0.26	0.0732±0.182	0.5372±0.3574	0.01±0.00
BER3	BD	169.20±31.57	0.2±0.1	7.81±0.57	4.95±1.20	1.91±0.79	0.19±0.11	0.0517±0.0114	0.1288±0.1304	0.01±0.01
	DD	132.80±0.00	0.1±0.0	6.59±0.08	7.20±0.00	0.77±1.33	1.11±0.00	1.125±0.00	0.1966±0.0000	0.25±0.00
	AD	207.50±0.71	0.1±0.0	-	8.65±0.91	8.65±0.91	1.36±0.71	0.0396±0.0321	0.8886±0.0321	0.00±0.00
BER4	BD	297.45±182.20	0.2±0.1	7.96±0.49	5.35±0.99	3.34±077	0.16±0.04	0.0662±0.0260	0.0662±0.0430	0.01±0.00
	DD	139.35±44.34	0.1±0.0	7.42±0.37	4.54±0.76	1.98±2.47	1.27±0.58	1.2674±0.5803	0.2120±0.1631	0.13±0.15
	AD	222.50±3.54	0.1±0.0	-	9.51±0.86	3.25±1.77	0.86±0.19	0.0353±0.0480	0.6510±0.2201	0.01±0.00
BER5	BD	258.38±170.59	0.2±0.1	7.90±0.63	5.25±0.91	2.24±0.68	0.20±0.08	0.0511±0.007	0.2853±0.2907	0.01±0.00
	DD	204.98±66.96	0.1±0.1	7.39±0.25	4.80±2.80	2.75±2.50	0.89±0.70	0.7459±0.8560	0.8186±0.4959	0.12±0.17
	AD	404.05±6.36	0.1±0.0	-	9.15±0.91	2.85±2.05	0.90±0.22	0.035±0.0464	0.8342±0.2839	0.00±0.00

Note: BD: Before Dredging; DD: During Dredging; AD: After Dredging

Table 4: Variation of outflow water quality parameters before, during and after dredging in Bomuruella Reservoir, Sri Lanka.

Sampling Location		EC (µS/cm)	Salinity (ppt)	pH	DO (mg/L)	BOD (mg/L)	Nitrate - N(mg/L)	Nitrite - N(mg/L)	Ammoniacal- N(mg/L)	Ortho- phosphate (mg/L)
BER1	BD	274.98±164.00	0.2±0.1	7.80±0.66	6.40±0.84	2.13±0.70	0.22±0.10	0.0562±0.0257	0.1013±0.1667	0.00±0.00
	DD	460.00±429.01	0.1±0.1	7.49±0.36	5.48±1.52	2.50±1.33	0.45±0.75	0.4389±0.7508	0.9903±0.5047	0.13±0.23
	AD	393.00±5.66	0.1±0.0	-	9.01±0.43	3.20±1.70	0.90±0.07	0.0444±0.0145	0.5711±0.005	0.00±0.00
BER6	BD	347.10±208.88	0.2±0.1	8.10±0.50	5.90±0.73	2.78±0.78	0.19±0.11	0.0509±0.0133	0.1550±0.2377	0.00±0.00
	DD	211.78±130.72	0.1±0.1	7.50±0.13	5.45±1.57	2.55±0.66	0.75±0.74	1.125±0.00	1.3229±0.6107	0.14±0.26
	AD	315.00±18.38	0.1±0.0	-	8.49±0.55	2.65±1.91	0.97±0.33	0.7300±0.7758	0.8466±0.0322	0.00±0.00
BER7	BD	245.70±108.25	0.2±0.1	7.77±0.07	6.45±0.53	3.42±1.69	0.20±0.10	0.0423±0.0327	0.1090±0.0927	0.01±0.00
	DD	100.00±0.00	0.1±0.1	7.51±0.00	5.00±0.00	2.70±3.82	0.38±0.00	0.0557±0.000	0.6408±0.000	0.13±0.15
	AD	280.00±31.11	0.1±0.0	-	9.51±2.13	2.60±1.56	1.05±0.52	0.0495±0.0192	0.9210±0.1488	0.16±0.31
BER8	BD	183.18±16.91	0.1±0.0	7.53±0.99	5.40±1.87	2.33±0.83	0.21±0.10	0.14761±0.1935	0.1106±0.1018	0.00±0.00
	DD	160.83±45.06	0.1±0.1	7.44±0.30	5.32±0.87	3.13±1.95	0.56±0.70	0.4478±0.7684	1.1234±0.4108	0.01±0.01
	AD	165.00±35.36	0.1±0.0	-	8.36±0.93	2.70±1.56	0.88±0.19	0.0329±0.0139	1.2167±0.8408	0.17±0.31
BER9	BD	177.48±21.18	0.1±0.0	7.76±1.02	6.00±1.82	2.35±1.66	0.20±0.12	0.0514±0.0139	0.1958±0.2047	0.00±0.00
	DD	193.98±85.54	0.1±0.0	6.93±1.29	5.95±1.35	2.65±1.21	0.53±0.67	0.4821±0.6951	1.0389±0.6339	0.01±0.01
	AD	227.00±1.41	0.1±0.0	-	7.71±2.28	2.15±0.21	0.88±0.26	0.042±0.0066	0.6041±0.005	0.31±0.59
BER10	BD	155.50±65.86	0.1±0.0	7.20±0.40	3.25±3.13	1.64±0.88	0.21±0.09	0.0552±0.0354	0.5281±0.4402	0.01±0.01
	DD	164.58±44.93	0.1±0.0	6.93±1.29	4.98±0.99	2.38±1.02	0.52±0.61	0.4278±0.6664	1.3493±0.3054	0.31±0.59
	AD	203.50±3.54	0.1±0.0	-	7.13±1.45	1.50±1.13	1.06±0.03	0.0445±0.0506	0.2623±0.2840	0.00±0.00

Note: BD: Before Dredging; DD: During Dredging; AD: After Dredging mean EC in inflow and outflow is comparatively similar before and after dredging (Table 3 and Table 4).

In the present study, the mean TSS value was relatively high immediately after the dredging compared to before dredging. Likewise, turbidity showed similar variation as TSS in both periods. Resuspension of sediment particles caused by the process of dredging operation has been observed by Rehman *et al*. (2016) in Dal Lake, Kashmir, India. Mean turbidity and TSS values were 7.39±2.82 NTU and 8.52±1.20 NTU before the dredging, whereas the values after dredging were 9.01±4.23 mg/L and 11.70±3.37 mg/L, respectively. The turbidity fluctuated highly in dredge locations owing to disturbed bottom sediments (Wickramarchchi *et al.,* 2010). Both mean TSS and turbidity in the selected 10 sampling locations were found to be statistically different between before and after dredging periods ($p \leq 0.05$). This may due to the effect of dredging on high turbidity levels by disturbing large amounts of settled sediments within a relatively short period. Based on previous literature, dredging contaminated sediments increase particulate-matter-associated contaminants in water next to or near to the dredge, producing deleterious effects on species that occupy those areas (Kjelland *et al.*, 2015).

The variation of mean rainfall before, during, and after dredging months is illustrated in Figure 2. There was a positive but not significant relationship between mean total TSS concentration and mean rainfall ($p \geq 0.05$). As there is an increase in the rainfall after the dredging, more water can be flown in to the reservoir carrying less pollutants. However, large amounts of particulate pollutants carried by runoff are brought into reservoirs due to high rainfall after dredging (Bakar *et al*., 2007)

Furthermore, the mean phosphate concentration was higher pre-dredging than the post-dredging periods in the reservoir (Table 2). These findings were similar to the study conducted by Rehman *et al*. (2016) where alterations in phosphate concentration were attributed to dredging operations in Dal Lake, Kashmir, India. There was a significant decrease in BOD and phosphate levels before and after dredging in Lunawa Lagoon, which could be due to the removal of organic sediments with dredged materials (Perera and De Alwis 2011). According to Pettersson (1998) and Robotham *et al*., (2021), fine-grain sediment consists of high concentrations of soluble nitrogen and phosphorus. Phosphates levels could be increased as a result of excessive fertilization loaded in the reservoir that is discharged to the water body from the agricultural canals. Variation of water discharge before and after dredging mainly explain the differences in the concentrations of phosphates. Due to the suction of sediments from the reservoir, phosphate and other nutrient concentration may be low during post-dredging period. The suction dredging reduced the amount of nutrients released to the water column. Simultaneously, dissolved nutrients such as phosphorous can be adsorbed by suspended solids and deposited into the sediment. The organic matter load, spoiled benthic, and microbial community structure are reduced by dredging while depressing the activities of extracellular enzymes. Therefore, the amount of organic matter mineralization is decreased by post-dredging of water bodies (Zhang *et al.,* 2010; Yin *et al.,* 2021). Moreover, inflow and outflow ortho-phosphate concentrations are comparatively similar after dredging (Table 3 and Table 4). However, when comparing to the mean concentration of ortho-phosphate recorded (Surface: 0.08 ± 0.2; Bottom: 0.12 ± 0.3) in Gregory Lake, Nuwara Eliya in 2015 by Amarathunga *et al*., (2020), mean concentration of ortho-phosphate was comparatively similar to that in the present study. Hence, ortho-phosphate concentration are within the permissible limits for drinking and fish and aquatic life as recommended by Central Environment Authority (2019).

The mean concentration of ammoniacal-N was 0.19±0.23 mg/L and 0.73±0.35 mg/L before and after the dredging operations, respectively. The mean concentration of ammoniacal-N was below the recommended standard level before the dredging period; however, it was above

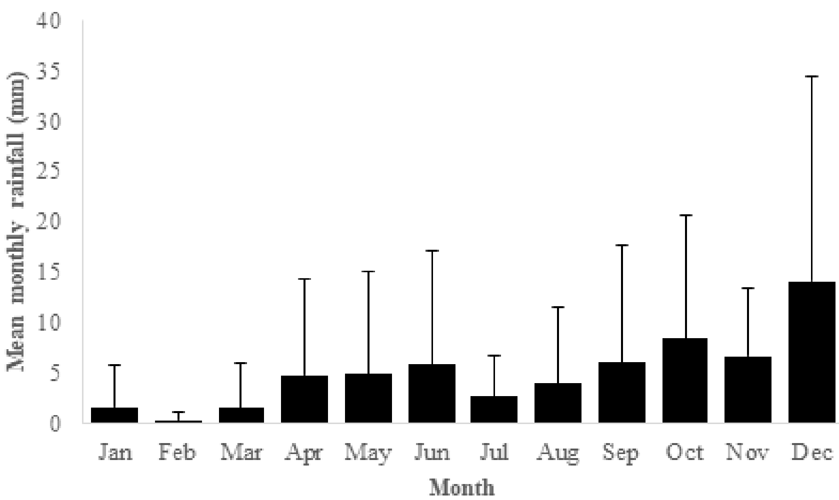

Figure 2: Mean monthly rainfall from Nuwara Eliya Weather Station for the period in 2014. This is the closest weather station to the Bomuruella Reservoir in the Central Province of Sri Lanka.

the recommended level for fish and aquatic life after the dredging period. Higher concentration of ammoniacal-N was observed due to the release of a variety of nitrogen compounds from the sediments after dredging operations. The mean ammoniacal-N was significantly different among the sampling locations before and after the dredging period. Similar results have been established in a previous study conducted in Dongqian Lake, China by Jing *et al.* (2013). They found that dredging could lead to the release of ammonia to the water column in a short term, while the long-term risk of ammonia release was low after dredging. Also, mean concentration of ammoniacal-N in inflow and outflow sites are comparatively similar after dredging (Table 3 and Table 4). However, when comparing to the mean concentration of ammoniacal-N recorded (Surface: 0.17 ± 0.03; Bottom: 0.18 ± 0.04) in Gregory Lake, Nuwara Eliya in 2015 by Amarathunga *et al.*, (2020), mean concentration of ammoniacal-N was comparatively similar in present study. Hence, ammoniacal-N concentration is suitable for drinking and fish and aquatic life recommended by Central Environment Authority (2019).

The mean nitrate level was lower in the pre-dredging (0.178±0.091 mg/L) than the post-dredging (0.403±0.173 mg/L) periods in the reservoir. This could be due to the resuspension of nutrients in the water column (Ryding, 1985). More importantly, the recorded nitrate concentrations before and after dredging periods were below the standard limits of fish and aquatic life (5 mg/L) proposed by Central Environment Authority (2019). Perera and De Alwis (2011) pointed out that there was a significant increase in nitrate levels after dredging in Lunawa Lagoon, which might be explained by the release of trapped nitrogen from the sediments after dredging. The mean nitrate-N in different sampling locations was significantly different between before and after dredging periods. However, there was no significant difference in mean nitrite-N in selected stamping locations between the two periods. Moreover, when considering the inflow and outflow concentration of mean nitrate concentration is comparatively. When considering available water quality data in this reservoir (Jayasinghe *et al.*, 2011), nitrate and nitrite levels were relatively low in the current study, thus making it suitable for drinking and fish and aquatic life as recommended by the Central Environment Authority (2019).

Total discharge of nutrients before the dredging period is presented in Figure 3. The total ammoniacal-N was higher than the total discharge of other nutrients before the dredging period except in February. However, the total discharge of nitrate-N was highest in February compared to other months before the dredging period. The total discharge of ammoniacal-N, nitrate-N, nitrite-N, and ortho-phosphate were 388469.4 m^3/day, 309479.8 m^3/day, 29324.49 m^3/day, and 2157.67 m^3/day, respectively covering the after dredging period. The highest total discharge of nutrients was recorded post-dredging period in December compared to other months before dredging. Excessive loading of nutrients leads to a reduction of clearness in most lakes (Yin and Kong, 2015).

Alkalinity was higher before dredging, with values varying between 25.00 mg/L and 62.50 mg/L (mean value 34.00±7.46 mg/L) while it was after dredging with values between 22.50 mg/L and 30.00 mg/L (mean value 25.88±1.68 mg/L). Similar findings were also observed by Rehman *et al*. (2016) due to the dredging operations in Dal Lake, Kashmir, India, with mean total hardness values at 33.55±8.24 mg/L and 66.60±8.02 mg/L before and after the dredging operations, respectively (Rehman *et al*., 2016). This could be due to the removal of Ca and Mg from sediment particles to the aquatic phase.

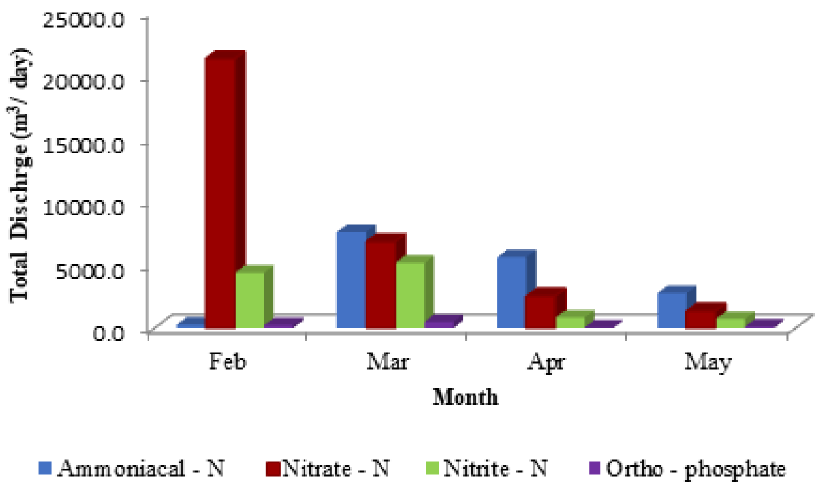

Figure 3: Total discharge of nutrients before dredging at Bomuruella Reservoir, Sri Lanka.

CONCLUSIONS

Except of EC, DO, and nitrite-nitrogen, other water quality parameters were significantly different between before and after dredging operations. The total discharge of nutrients into the reservoir was higher in the post-dredging in comparison to the pre-dredging period. Water quality parameters such as EC, TDS, turbidity, nitrate-nitrogen, ammoniacal-nitrogen, TSS, total hardness, and Ca hardness were all increased after the dredging, while Chloride, alkalinity, orthophosphate, DO and nitrite-nitrogen levels improved after the dredging. The results conclude that dredging operations have imposed notable effects on the water quality in the reservoir.

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STATEMENT OF CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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