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Freshwater biodiversity in the littoral Zone of a Sri Lankan Tank ecosystem with its water quality parameters

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ABSTRACT

Nikiniyawa wewa is one of the tanks situated within the Anuradhapura district, North Central province in the dry zone of Sri Lanka. This tank is surrounded by urban and suburban areas. Both biological and physico-chemical data were collected according to the standard methods. During the survey a total of 21 aquatic plant species belong to 18 families were recorded. This includes 8 submerged, 6 emergent, 3 free floating species and 4 plants which are attached to the substratum and have floating leaves. The highest plant diversity was recorded in non polluted area (H'=2.87) while the lowest recorded in polluted site (H'=2.71). The identified faunal composition was 38 bird species belonged to 22 families consist of 36 breeding residents, 2 winter visitors and 1 endemic species; 11 fish species belonged to 7 families included 10 indigenous species and 1 exotic species; 12 dragonfly species belonged to 3 families included 11 residents and 1 endemic species; 3 amphibian species; 2 reptile species and 1 mammal species. The highest fish faunal diversity was recorded in non-polluted (H'=2.14) site while the lowest in polluted site (H'=0.60). It is observed that although most of the water quality parameters have values within the permissible limits of National Water Supply and Drainage Board (NWSDB) and water of the polluted site had high phosphate level. The fauna and flora species distribution has determined by one or more physico-chemical parameters. The biodiversity of aquatic plants and fishes were influenced by water quality parameters such as BOD, colour, electrical conductivity, pH and chloride content and not influenced by temperature, DO and phosphate content.

Keywords: Nikiniyawa wewa, littoral zone, physico-chemical parameters, species diversity, aquatic fauna and aquatic flora.

1. Introduction

Sri Lanka possesses three hectares of island lentic water for every square kilometer of land. This is one of the highest densities of the island, tanks (wewa), ponds, man-made canals and other still water in the world (Baldwin, 1991). Fresh water resources in Sri Lanka can be classified as tanks, reservoirs, rivers, streams and wetlands (Nathanael and Silva, 1993). Among them, tanks are one of the important ecosystems in Sri Lanka. There are about 12,000 man-made tanks located in the dry zone of Sri Lanka which cover an area of approximately 170,000 hectares and these tanks can be divided into two categories, namely, perennial and shallow seasonal tanks (Nathanael and Silva, 1993). Anuradhapura is an ancient city of Sri Lanka comprising of both seasonal and perennial tanks representing the cascade systems

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(Panabokke, 1999). The first tank was constructed around the 5^{th} and 6^{th} centuries BC (Paranavitana, 1961).

Lakes consist of 4 zones, defined by depth and distance from shore, namely, benthic zone, profundal zone, limnetic zone and littoral zone. (1) Benthic zone is the bottom of the lake and inhabited by organisms that can tolerate cool temperatures and low oxygen levels (Largen, 2004). (2) Profundal zone consists of deep, aphotic regions and this region is too dark for photosynthesis. Oxygen levels are low in the profundal zone. This zone is inhabited by fish adapted to cool dark waters. (3) Limnetic zone is well-lit, open surface water, farther from shore, extending to depth penetrated by light. It is occupied by phytoplankton, zooplankton and higher animals. This zone produces food and oxygen that supports most of the lake's consumers. (4) Littoral zone of lentic water bodies such as reservoir, ponds, lakes etc. is a shallow water area near the shoreline. It includes rooted vegetation and has a maximum light penetration through water. The width, length and depth of the littoral zone vary with the seasons such as dry and wet seasons. Wide range of aquatic fauna spread in the littoral zone of perennial tanks. Some species of aquatic fauna spend their whole life cycle, part of the life cycle or adult stage of the life cycle in fresh water. Most of young stages of aquatic fauna are found in the littoral zone of perennial tanks (Fernando and Weerawardhena, 2002).

Most of the freshwater animals breed in the littoral zone during or after the monsoonal floods, when plenty of water is available for young to spread over a wide area where crowding is less and with a plenty of food supply in the form of minute plants and animals (Fernando and Weerawardhena, 2002). As the littoral zone also consists of aquatic hydrophytes, terrestrial trees where the roots are partially submerged in the water, it provides great protection, shelter, breeding grounds and feeding grounds for aquatic fauna. Hence, any adverse effects such as toxins, pollution in the littoral zone will affect the biodiversity of the lake. The solid wastes, industrial effluents, storm water, soap and detergent, faecal matter and cow dung are very frequently mixed with the water of the littoral zone before entering into the limnetic and profundal zones in the perennial tanks, that are located in the urban area. Therefore, it could be considered that the most susceptible area of the perennial tank for pollution is the littoral zone.

Kekirawa is an ancient city of Anuradhapura district comprising of both seasonal and perennial tanks. Most of the tanks in the Kekirawa are heavily infested with aquatic plants, and the factors for massive production of aquatic macrophytes in these tanks have not been investigated. Nikiniyawa wewa is one of the tanks situated within Kekirawa and there are no studies have been conducted to investigate the sustainable use of this natural resource by people living closer to the tank. Therefore, the objective of this study was focused on documenting the diversity and abundance of freshwater macro fauna and flora in the littoral zone of Nikiniyawa wewa with special reference to its water quality parameters, in order to provide the baseline data for further research and recommendations for the sustainable use of Nikiniyawa wewa.

2. Study area

Nikiniyawa wewa (lat. 8.03° N and long. 80.58° E) is situated at Kekirawa in the Anuradhapura District of North-central Province, Sri Lanka. Since it is located in the dry zone, it receives an annual rainfall between 1,000-1,500 mm/year from the northeast monsoon and inters monsoons. The temperature ranges between 19 - 35 °C. February to April is the warmer season and August is considered as the warmest month of the year.

Study sites were identified based on the preliminary studies and water quality parameters. The three sampling sites at Nikiniyawa wewa, (1) a highly polluted site near hotel adjacent to Kekirawa-Thalawa road (3.01 mg/L), (2) a moderately polluted site near a bathing place (1.97 mg/L) and (3) a non polluted site totally covered with aquatic vegetation (1.63 mg/L) were selected considering their Biochemical Oxygen Demand (BOD) values (Figure 1).

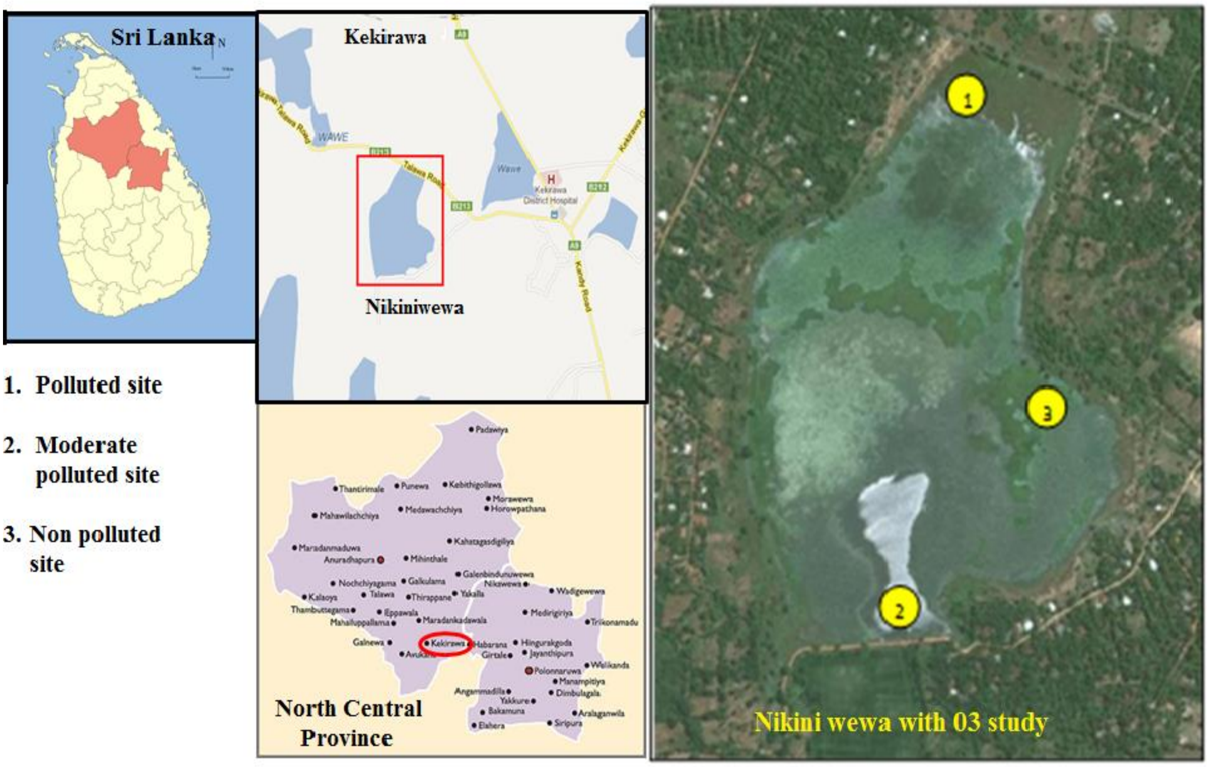

Figure 1: Map of the study area Nikiniyawa wewa in Sri Lanka and the sampling locations at Nikiniyawa wewa, (1) polluted site, (2) moderately polluted site and (3) non polluted site

3. Methodology

3.1 Sampling

Sampling was done between 6.00 h & 8.00 h and 16.00 h & 18.00 h for fauna & flora, once a week and twice a month, respectively from June to November 2012 from main 3 sites representing all possible habitats of Nikiniyawa wewa.

3.1.1 Vegetation

Visual estimation was done for vegetation using a quadrant on the water surface and the proportion of space covered (% cover) by each species. The plants were categorized with special reference to their habit, namely free floating plants, submerged plants, emergent plants and plant attached to the substrate and have floating leaves. Plant identification was done using the photographic guide of aquatic plants prepared by the National Aquaculture Development Authority (NAQDA) and the Flora of Ceylon (Dassanayake and Fosberg, 1980-1991; Dassanayake, *et al.*, 1994-1995 and Dassanayake and Clayton, 1996-2000). Unknown species were identified by preparing herbarium specimens at the National Herbarium, Peradeniya, Sri Lanka.

3.1.2 Fauna

Aquatic macro fauna and amphibian species and their distribution were recorded. The relative abundance of fish was calculated as the number of fish caught per unit operation of the dragnet and the species diversity of fish was calculated as the number of species per site. The visual encounter survey was done for identification and counting of the visible fauna such as birds, dragonflies, mammals and reptiles in the littoral zone. A pair of binoculars (Bushnell 13-1056C) was used to identify the species at a distance. Aquatic fauna were identified using "A Guide to the Freshwater Fauna of Ceylon (Sri Lanka)" (Fernando and Weerawardhena, 2002), "Freshwater Fishes of Sri Lanka" (Pethiyagoda, 1991) and "Dragonflies of Sri Lanka" (Bedjanič *et al.,* 2006-2007). Water related reptiles were identified using "A Photographic Guide to Snakes and Other Reptiles of Sri Lanka" (Das and de Silva, 2011). Bird identification and nomenclature was based on Kotagama and Fernando (1994).

3.1.3 Water quality parameters

The physico-chemical parameters which included, colour, temperature, pH, turbidity, conductivity, hardness, inorganic matter, BOD and the flow velocity of surface water were measured in the field and sampling was carried out in triplicate from 5 locations (A, B, C, D and E) (Figure 2) at each three sites in 2 L pre-cleaned polythene jars once a month from June to November 2012 according to the specified Standard Methods for Examination of Water and Wastewater (APHA, 2001). The water quality data for the selected sites were collected from the National Water Supply and Drainage Board (NWSDB), Sri Lanka.

The pH, turbidity and conductivity of the water were measured using portable Hach digital pH meter, turbidity meter and conductivity meter, respectively. The colour of the water was determined using HAZAN method. The amount of dissolved ions and oxygen was measured titrimetrically or turbidimetrically using the water samples brought to the laboratory. Dissolved Oxygen (DO) and BOD were measured by the Winkler method. The total hardness (Ca^{2+} and Mg^{2+}) and alkalinity of water were determined titrimetrically. Concentrations of nitrate (NO_3^-), nitrite (NO_2^-) and phosphate (PO_4^{3-}) were measured by the colorimetric method (APHA, 2001). The rainfall data were obtained from the Meteorological Department of Sri Lanka.

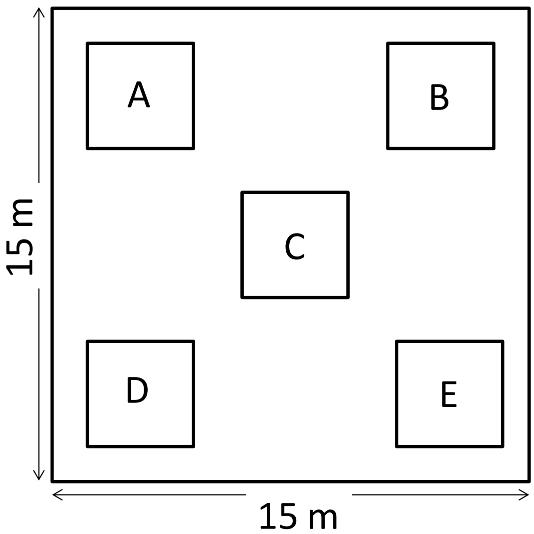

Figure 2: Diagram displays five water sampling locations (A, B, C, D, and E) at each three sample sites (1), (2) and (3)

3.2 Data Analysis

3.2.1 Diversity indices

Relative abundance of bird species was determined by the Shannon diversity Index (Magurran, 1988).

$$H' = -\sum_{i=1}^{s} P_i \ln P_i \qquad\qquad H' = -\sum_{i=1}^{s} \left(\frac{n_i}{N}\right) \ln \frac{n_i}{N}$$

Where, s = the number of species recorded in each habitat
N = the number of individuals in a sample of the community
n_i = the number of individuals of species 'i' in a sample of the community
P_i = population of individuals found in the 'i^{th}' species

Simpson's Index (Magurran, 1988) was used weighted towards the abundance of the dominant species in each habitat.

$$D = \sum_{i=1}^{s} \frac{n_i(n-1)}{N(N-1)} \qquad\qquad D_s = {}^{1}/_{D}$$

Where, s = The number of species recorded in each habitat
n_i = Total number of individuals present in each species
N = Total number of individuals in all species
D = Simpson's index
Ds = Simpson's diversity index

3.2.2 Statistical analysis

One-way ANOVA was performed to determine the significant differences of testing physico-chemical parameters of water and performed MINITAB Version 14.0 software to determine the influence of water quality on the diversity of aquatic plant and fishes.

4. Results and discussion

4.1 Vegetation - Species richness and diversity

A total of 21 aquatic plant species belonging to 18 families were recorded during the survey. This includes 8 submerged species, 6 emergent species, 3 free floating species and 4 plants which are attached to the substratum and have floating leaves. The total number of plant species observed in non-polluted site, moderately polluted site and polluted site were 21, 18 and 14, respectively. *Utricularia* sp., *Ottelia alismoides, Neptunia oleracea* were observed only in the non-polluted site and they may prefer non polluted water for their growth. *Cyperus iria, Cyperus procerus, Bacopa monnieri* and *Jussiaea repens* were comparatively high in the polluted site compared to the other two sites. These plant species show significantly high abundance (85 %) on the polluted site than the non-polluted site (24 %). Therefore, these two sets of plants can be taken as the indicator species for water quality of Nikiniyawa tank.

Table 1: Diversity indices for aquatic plant species sampled at Nikiniyawa wewa

Diversity Index	Non-polluted	Mod-polluted	Polluted
H'	2.86	2.71	2.31
D	0.06	0.07	0.12
H' - Shannon-Wiener Diversity Index		D - Simpson's	

Non polluted site (*H*'=2.86) has the highest plant species diversity and it may be due to the undisturbed habitat characteristics, that favours the growth of diverse aquatic flora. Although the abundance of dominant species in the polluted site (*D*=0.12) is high compared to the other two sites, the species diversity (*H*'=2.31) is low (Table 1). The habitat condition of polluted and moderately polluted site was altered due to anthropogenic activities such as, dumping garbage, use of detergents and agrochemicals and subsequently, this may have led to low plant diversity in these two sites.

4.2 Faunal composition - species richness and diversity

Thirty-eight bird species, eleven fish species, three amphibian species, two reptile species, one mammal species and twelve dragonfly species were recorded during the survey (Table 2).

Table 2: Faunal species richness at the Nikiniyawa wewa

Faunal Species	Number of Species				Families
	Non-polluted	Mod-polluted	Polluted	Total	
Birds	36	16	25	38	22
Fishes	11	05	02	11	07
Amphibians	03	01	02	03	-
Reptiles	02	-	01	02	-
Mammals	01	-	-	01	-
Dragonflies	12	08	04	12	03
Total	65	30	34		

A total of 38 bird species belonging to 22 families and this includes 36 breeding residents, 2 winter visitors and 1 endemic species. 11 fish species belong to 7 families and this includes 10 indigenous species and 1 exotic species. *Channa striatus, Etroplus suratensis, Oreochromis mossambicus*, *Lepidocephalichthys thermalis* were only observed at the non polluted site. Therefore, they may require high water quality for their survival. 12 dragonfly species belonging to 3 families include 11 residents and 1 endemic species. Non polluted site has the highest species diversity (Table 3). The reason for high diversity could be due to the undisturbed habitat characteristics, availability of food resources and good water quality in the non polluted site compared to the other two sites. The habitat of polluted and moderately polluted site was altered due to anthropogenic activities such as, dumping garbage, use of detergents and agrochemicals, which may have led to low species diversity. Abundance of dominant species in the polluted site is comparatively high for many species (birds-*D*=0.09, fishes-*D*=0.52 and dragonflies-*D*=0.10).

Table 3: Species diversity at the Nikiniyawa wewa

	Non-polluted		Mod-polluted		Polluted	
	H'	*D*	*H*'	*D*	*H*'	*D*
Birds	3.35	0.04	2.80	0.06	2.76	0.09
Fishes	2.14	0.10	1.07	0.31	0.60	0.52
Amphibians	1.08	0.24	0.00	1.00	0.69	0.33
Reptiles	0.64	0.33	-	-	0.00	0.00
Mammals	0.00	1.00	-	-	-	-
Dragonflies	2.41	0.06	2.01	0.08	1.33	0.10
H' - Shannon-Wiener Diversity Index			*D* - Simpson's Index			

The species diversity of birds, amphibian and dragonfly in the polluted habitat is high compared to moderately polluted site. As moderately polluted site is a bathing place and it is often occupied by people. Many bird species do not prefer disturbances; therefore, it may be the reason for the low bird diversity at the moderately polluted site. Bird species like *Phaenicophaeus viridirostris*, *Himantopus himantopus* are confined to polluted area and can be considered as edge preferring species. Species living in disturbed habitats should be able to tolerate all the disturbances including pollution.

Dragonflies are often addressed as "guardian of the watershed". In nature dragonflies appear in two levels, they are the subjects of conservation concerns as endangered species and as indicators of wetland habitat quality. In different stages of their lives, dragonflies occur both in terrestrial and freshwater habitats and are sensitive to disturbances in both. The habitat selections of adult insects strongly depend on vegetation structure, while water quality and aquatic habitat structure are critical for the development of their larval stages. Therefore, along with birds and amphibians, dragonflies can serve as one of the key bio-indicator groups (Bedjanič *et al*., 2007).

4.3 Physico-chemical parameters of water

The colour of water in the 3 selected sites shows a significant difference ($p < 0.05$). The colour of water in the polluted site exceeds the maximum permissible level (30 Hazen units) of the National Water Supply and Drainage Board (NWSDB). Impurities dissolved or suspended in water and the presence of planktons may give a higher permissible level in water. Therefore, plankton density and dissolved materials are high in the polluted site.

Although the turbidity levels of 3 sites are within the permissible levels (2-8 FTU) of NWSDB, it is comparatively higher in the polluted site than the other two sites. Mendis (1965) stated that most of the lowland lakes have low turbidity and colour values than lakes having connections to rivers that receive large quantities of suspended material, with the subsequent heavy growth of plankton. Nikiniyawa wewa has no any connection with a river. Therefore, the amount of dissolved substances or organic matter should be high in the polluted site.

The water temperature of 3 sites ranges from 29-31 °C. In the wetland site report for Anuradhapura tanks, the water temperature range between 28-31.5 °C (Anon, 1994) and it has stated that the water temperature of most of the dry zone stagnant water bodies ranges between 29-33 °C (Silva, 2003). The present study also confirmed the temperature recorded during previous studies.

pH values of the study sites are within the prescribed limit of NWSDB (6.5-9) and WHO (6.5-8.5) (WHO, 2008). The pH of natural waters is between 6.0 and 8.5 and high pH levels can occur in eutrophic waters (Chapman and Kimstash, 1992). Therefore, eutrophication has not occurred in the Nikniyawa wewa.

Electrical conductivity of the 3 selected sites ranged between 350-560 μS/cm. According to Silva (2003), electrical conductivity of the Nuwara wewa ranged between 290 and 840 μS/cm and Anuradhapura tanks at the wetland site reported range is 340-945 μS/cm and the present study confirm those values. These changes may be due to the differences in the presence of inorganic anions (Cl^-, NO_2^-, NO_3^-, SO_4^{2-} and PO_4^{3-}) and cations (Na^+, Mg^{2+}, Ca^{2+}, Fe^{2+}/Fe^{3+}

and Al^{3+}), as a consequence of degree of addition of various pollutants such as sewage, pesticides and other runoffs, which cause the increment of total dissolved solids in the system.

The range of total hardness (concentration of Ca^{2+} and Mg^{2+}) and alkalinity obtained are 80-152 mg/L and 100-180 mg/L, respectively. These values are well within the acceptable range of NWSDB (total hardness - 250-600 mg/L and alkalinity - 200-400 mg/L), although there are large variations in 3 sties. In the wetland site report (Anon, 1994) the total hardness was reported to be between 71 and 114 mg/L for Anuradhapura tanks. According to Singha (1988), hardness of water less than 50-150 mg/L is considered as moderately hard, 150-300 mg/L is hard and over 3000 mg/L is very hard. According to this scale, water in the non-polluted site and the moderately polluted site are moderately hard and water in the polluted site is hard. Higher concentration of Ca^{2+} and Mg^{2+} affects the acidity as well as the ionic balance of water.

In the study area, the minimum and maximum values of chloride obtained were 52.5 mg/L (non-polluted) and 68.6 mg/L (polluted), respectively. Since the most important source of chlorides in water is the discharge of domestic sewage, including human and animal excreta, the sampling sources might have received some input of sewage. However, the values do not exceed the WHO limit for drinking water (250 mg/L) (WHO, 2008).

The nitrate and nitrite lie below detectable level 0.2-0.3 mg/L and 0.002 mg/L, respectively. The values are much less than the prescribed maximum of NWSDB (nitrate-10 mg/L and nitrite-0.01 mg/L). Nitrate is found in nature in very small amounts, because of the ongoing growth and decaying process. When plants and animals die and decompose, ammonia is produced. Bacteria usually turn the ammonia into NO_3^-. Pollutants such as sewage or manure, however, contain much higher levels of nitrates.

Phosphate content was found in the range 0.19-0.52 mg/L and the values do not exceed the NWSDB limit for tank water (2 mg/L). According to Chapman and Kimstash (1992) the level of phosphate in natural freshwater ranges from 0.005-0.02 mg/L, therefore, the study sites have higher phosphate content.

Mean fluoride content was found within below detectable level (BDL) 0.19-0.39 mg/L. In all the sampling stations, the fluoride content in drinking water was less than the NWSDB permissible limits (0.6 mg/L). Fluoride levels higher than 1 mg/L in water may cause dental fluorosis, therefore, there is no threat of dental fluorosis to the people who use water from Nikiniyawa wewa as recorded fluoride levels are lower than 0.6 mg/L. Sulphate was found only in the polluted site (4.0 mg/L) and lies BDL of NWSDB (400 mg/L).

Mean iron concentration of the sampling stations were between 0.20-0.27 mg/L and it is lower than the NWSDB (1.0 mg/L) and WHO (0.3 mg/L) (WHO, 2008) standards. Iron in excess of 0.3 mg/L causes staining of clothes and utensils, and is also not suitable for processing of food, beverage, ice, dyeing, bleaching and many other activities. Iron in higher concentrations may lead to unpleasant taste, odour and also cause vomiting.

Dissolved oxygen contents of 3 sites ranges from 2.53-3.77 mg/L. According to Central Environmental Authority the proposed Water Quality Standards/CLASS II Water CATEGORY 04 for Fish & Aquatic Life DO should be higher than 3 mg/L. Low levels of pollutants and high density of submerged aquatic vegetation may result in high DO (3.77

mg/L) content in non polluted site, while the high level of pollutants and decaying matter may result in lower DO content in the polluted site.

In the selected sites, sampled BOD ranged from 1.62-3.02 mg/L. The highest BOD value (3.02 mg/L) was recorded from polluted site, where to a greater extent human interference had been taken place and as a consequence high abundance of decomposing organic matter in this site compared to the other sites. According to UN Department of Technical Cooperation for Development the maximum permitted BOD level is < 100 to 300 mg/L. It is important to note that low BOD content is an indicator of good quality water, while a high BOD indicates polluted water. It indicates the amount of putrescible organic matter present in water. BOD directly affects the amount of DO in rivers and streams. The greater the BOD, more rapidly oxygen is depleted in the water. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low DO: aquatic organisms become stressed, suffocate, and die (Lokhande *et al*. 2011).

Table 4: Physico-chemical parameters of water of Nikiniyawa wewa

Parameter		Non polluted	Moderately polluted	Polluted
		Mean ± SD	Mean ± SD	Mean ± SD
Water temperature	[°C]	29.93 ± 0.70	30.67 ± 0.72	30.67 ± 0.72
Colour	[HAZEN]	25.87 ± 1.46	28.93 ± 0.70	39.33 ± 1.11
Turbidity	[FTU]	2.56 ± 0.01	3.17 ± 3.16	7.17 ± 0.06
Electrical conductivity	[µS/cm]	344.53 ± 3.72	369.67 ± 0.82	559.67 ± 1.05
pH		7.53 ± 0.01	7.45 ± 0.01	8.25 ± 0.08
Chloride/Cl^-	[mg/L]	51.73 ± 0.80	39.73 ± 0.70	67.67 ± 0.90
Total Alkalinity (as $CaCO_3$)	[mg/L]	142.87 ± 0.64	100.13 ± 0.74	180.00 ± 0.53
Total Hardness (as $CaCO_3$)	[mg/L]	136.07 ± 0.96	80.33 ± 0.90	151.67 ± 0.90
Nitrate/NO_3^- (as N)	[mg/L]	0.20 ± 0.00	0.10 ± 0.00	0.29 ± 0.03
Nitrite/NO_2^- (as N)	[mg/L]	0.002 ± 0.00	0.002 ± 0.00	0.002 ± 0.00
Sulphate/SO_4^{2-}	[mg/L]	0.00 ± 0.00	0.00 ± 0.00	3.93 ± 0.26
Fluoride/F^-	[mg/L]	0.37 ± 0.00	0.19 ± 0.00	0.39 ± 0.03
Phosphate/PO_4^{3-}	[mg/L]	0.19 ± 0.00	0.52 ± 0.00	0.32 ± 0.00
Total Iron	[mg/L]	0.20 ± 0.00	0.25 ± 0.00	0.27 ± 0.00
DO	[mg/L]	3.77 ± 0.13	3.20 ± 0.08	2.53 ± 0.01
BOD	[mg/L]	1.62 ± 0.02	1.97 ± 0.01	3.02 ± 0.01

Note: Measurements are taken at 25 °C.

4.4 Relationship between water quality parameters and biodiversity

According to the Pearson correlation the biodiversity of aquatic plants and fishes were influenced by water quality parameters such as BOD, colour, electrical conductivity, pH and chloride content and not influenced by temperature, DO and phosphate content (Table 5).

5. Conclusion and Recommendations

The present study reveals that the Nikiniyawa wewa supports high freshwater biodiversity which is located in the dry zone of the Anuradhapura district. The fauna and flora species distribution has determined by one or more physico-chemical parameters. It is observed that although most of the water quality parameters have values within the WSDB permissible limits and water of the polluted site had high phosphate level. Several pollutants were mixed frequently to the littoral zone of Nikiniyawa wewa and amount of pollutants varied between 3 sites. Factors like absence of scientific drainage, poor sanitation, presence of stagnant water, unhygienic conditions, etc., are causing water quality degradation.

Table 5: Correlation between biodiversity and physico-chemical parameters of water in Nikiniyawa wewa

Variable	Aquatic plant diversity & physico-chemical parameters		Fish diversity & physico-chemical parameters	
	Pearson correlation	*p* value	Pearson correlation	*p* value
Temperature	0.317	0.034	0.305	0.219
DO	-0.304	0.220	-0.701	0.001
BOD	0.520	0.027	0.854	0.000
PO_4^{3-}	-1.45	0.343	-0.412	0.090
Colour	0.518	0.023	0.844	0.000
Electrical conductivity	0.637	0.005	0.920	0.000
Cl^-	0.948	0.000	0.985	0.000
pH	0.755	0.000	0.835	0.000

Though the Nikiniyawa wewa is one of the water sources in the Kekirawa urban area developing and practising, it is recommended that some measures should be taken to control the pollution; novel methods of utilization of aquatic weeds will be greatly helpful in controlling aquatic weeds in a nonpolluting manner and restoring water bodies to their intended uses and also conservation measures should be launched to conserve the biodiversity of Nikiniyawa wewa.

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6. References

1. Anon, (1994), Wetland site report and conservation management plan: Tanks in the Anuradhapura district. Central Environmental Authority, Sri Lanka, pp 13.

2. APHA, (2001), Standard Methods for the Examination of Water and Wastewater. 20th edition, American Public Health Association/AWWA/Water Environment Federation, Washington, DC, USA.

3. Baldwin, M.F., (1991), Natural resources of Sri Lanka: Condition and trends. Natural Resources Energy and Science Authority (NARESA), Colombo, Sri Lanka, pp 280.

4. Bedjanič, M., Conniff, K. and de Silva Wijeyeratne, G., (2006), Gehan's photo booklet: Dragonflies of Sri Lanka and Southern India. Jetwing Eco Holidays, Colombo, Sri Lanka.

5. Bedjanič, M., Conniff, K. and de Silva Wijeyeratne, G., (2007), Gehan's photo guide: Dragonflies of Sri Lanka. Jetwing Eco Holidays, Colombo, Sri Lanka.

6. Chapman, D. and Kimstash, V., (1992). The selection of water quality variable. In: D. Chapman, ed. Water quality assessments. A guide to the use of biota, sediments and water in environmental monitoring. Chapman and Hill Ltd., London, pp 51-120.

7. Das, I. and de Silva, A., (2011), A photographic guide to snakes and other reptiles of Sri Lanka. 2nd edition, New Holland Publishers, London.

8. Dassanayake, M.D., and Fosberg, F.R., (1980-1991). A revised handbook to the flora of Ceylon. Vol. I–VII, Amerind Publishing Co. Pvt. Ltd. , New Delhi, India.

9. Dassanayake, M.D., Fosberg, F.R. and Clayton, W.D., (1994-1995). A revised handbook to the flora of Ceylon. Vol. VIII–IX, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India.

10. Dassanayake, M.D., and Clayton, W.D., (1996-2000), A revised handbook to the flora of Ceylon. Vol. X–XII, Amerind Publishing Co. Pvt. Ltd., New Delhi, India.

11. Fernando, C.H. and Weerawardhena, S.R., (2002), A guide to the freshwater fauna of Ceylon (Sri Lanka). A reprint of A.S. Mendis and C.H. Fernando (1962) with a forward, a check list of amphibians of Sri Lanka and selected references on freshwater fauna. pp 173.

12. Kotagama, S. and Fernando, P., (1994), A field guide to the birds of Sri Lanka. The Wildlife Heritage Trust of Sri Lanka, Colombo, Sri Lanka.

13. Largen, (2004), Aquatic biomes, EVPP 111 lecture. (mason.gmu.edu)

14. Lokhande, R.S., Singare, P.U. and Pimple, D.S., (2011), Study on physico-chemical parameters of wastewater effluents from Taloja industrial area of Mumbai. India International Journal of Ecosystem, 1(1), pp 1-9.

15. Magurran, A.E., (1988), Ecological diversity and its measurements. Chapman and Hall, London, pp 192.

16. Mendis, A.S., (1965), A preliminary survey of 21 Ceylon lakes-2. Limnology and fish production potential. Bulletin of the Fisheries Research Station, Ceylon, 18(1), pp 7-16.

17. Nathanael, S. and Silva, E.I.L., (1993), The future trend of fresh water resources in Sri Lanka - an urgent need for long-term research. Sri Lankan Journal of Agricultural Sciences, 30(1), pp 74-85.

18. Panabokke, C.R., (1999), The small tank cascade systems of the Rajarata, their settings, distribution patterns and hydrography. IIMI-MASL, pp 39.

19. Paranavitana, S., (1961), Civilization of the early Anuradhapura period. In: C.W. Nicholas, ed. A concise history of Ceylon. Colombo. Ceylon University Press, chapter 6, pp 95-121.

20. Pethiyagoda, R., (1991), Freshwater fishes of Sri Lanka. Colombo: Wildlife Heritage Trust, Sri Lanka.

21. Silva, E.I.L., (2003), Quality of irrigation water in Sri Lanka status and trends. Institute of Fundamental Studies, Kandy, pp 1-12.

22. Singha, M.P., (1988), Effect of waste disposal on water quality of river Damodar in Bihar: Physico-chemical characteristic. In: Trivedy, R.K., ed. Ecology and pollution of Indian rivers, Ashish Publication House, New Delhi, (1), pp 219-246.

23. WHO Guidelines for Drinking-water Quality (GDWQ), (2008), 3rd edition.