Soil and water quality in Thalangama Tank, wetlands and paddy fields in Thalangama, Katuwana GN, Kiriwaththuduwa GN and Walpitayaya

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Thalangama Tank Sampling	Paddy field - Water Sampling
	
Water quality measurement at the site it-self	Soil and Water sampling
	
Paddy field Soil Sampling	Thalangama Tank outlet

1.0 Introduction

1.1 Wetland

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by water. According to the general classification, there are five major types of wetland namely; marine (coastal wetlands including coastal lagoons, rocky shores, and coral reefs), estuarine (including deltas, tidal marshes, and mangrove swamps), lacustrine (wetlands associated with lakes), riverine (wetlands along rivers and streams), Palustrine (meaning "marshy" - marshes, swamps and bogs). In Sri Lanka all types of the wetland are disperse in all over the country with zone specific and providing suitable habitats for wildlife and buffering zone for pollutant remediation. Further, wetlands are among the world's most productive environments which play vital role in the hydrological cycle and recharging of ground water. However, the exact role of wetlands is depending on a wide range site-specific features, including the type and the location of the wetlands.

Wetlands should be studied as part of wider hydrological system, basins, and catchment characteristic and anthropological activities. The water and sediment in the wetland mainly influenced by the activities in the upstream, it's directly effect on the downstream in the wetlands. Therefore, proper management of wetlands are important to be considered. Further, wetlands are globally support significant in agriculture and human activities. Even small wetlands play a significant role in reducing poverty and supporting both livelihoods and biodiversity.

1.2 Wetland agriculture

All most all the type of wetlands highly suitable for agriculture purposes. They provide a ready supply of water, are usually found in flat areas, and the regular input of sediment and plant material means that many are naturally fertile. Wetlands are playing an increasingly significant role in the agricultural output of many developing countries; 48% and 66% of Ramsar-designated wetlands in Asia and Africa respectively are used for agriculture (McCartney et al., 2005).

2.0 Methodology

2.1 Study Area

Thalangama tank, Averihena tank (Podi wewa) and adjacent paddy fields were selected to collected water and soil samples for the present study. In addition, other abundant paddy field and lands which are being cultivated under the project also was selected to collect water and soil samples. Sampling locations mark in red circle (Fig. 1, 2, 3) and the relevant GPS points for each location is given in table 1 to 3)

Thalangama tank and paddy field

Thalangama tank was built during the era of King Parakramabahu VI (1551-1547 AD) for paddy cultivation and is situated close to the ancient city of Kotte. The areas between Akurugoda and Thalangama north use the runoff water for paddy cultivation. The tank is an important habitat for water birds, functioning as an urban biodiversity refuge, and it is surrounded by densely populated human settlements of the Colombo District. The site is situated in the Madiwela catchment area within the Kelani river basin, which includes the Colombo flood detention area. The tank is situated within the Madiwela catchment area, which is influenced by 3 hydrological zones and is an important component for water drainage in the city of Colombo. The total catchment area is 33.34 sq. miles, and the upper reaches extend up to Pannipitiya and Kottawa. The gross capacity of the tank is 50 Ac. ft., and its surrounding habitats serve as an important flood retention area.

Major habitat types associated with the tank include seasonally flooded grassland/paddy fields freshwater swamp forests, aquatic macrophytic vegetation. A study conducted by the CEA and IUCN reported that forty-one plant species in the area with 90 bird species (13 are migrants), 12 species of reptiles, 10 species of mammals and 15 freshwater fish species.

Further the report emphasis that the tank comprises of a mix of exotic and indigenous freshwater fish species where native fish, *Puntius singhala, Etroplus maculates* and *Esomus thermoicos* also were recorded. Locally declining aquatic birds include *Pelecanus philippensis* and *Rostratula benghalensis* were reported and noteworthy reptiles such as *Lissemys punctata*, and *Xenochrophis piscator,* endemic primate of *Trachypithecus vetulus,* and rare mammals such as *Prionailurus viverrinus* and *Lutra lutra* have been recorded around the tank (Rathnayake and Kotagama, 2002). The floating aquatic plants such as *Nelumbium* spp. and *Nymphaea* spp. form a prominent component of the aquatic plants in the tank.

During the study is was observed that the surroundings of the tank is used for human settlements, home gardens, paddy cultivation, and for livestock rearing while the wetland is used for small-scale fisheries and recreational activities. Further it was noticed that the area is used by visitors for bird watching and relaxation.

Services of the Thalangama Tank

The Thalangama tank and its surrounding paddy fields are important for flood detention in the Greater Colombo area and providing service for hydrological and biophysical value**s.** The Thalangama tank is a unique remnant of the historic past. The tank has been used for paddy cultivation for a long time, and historic evidence indicates that the surrounding area had been continuously and extensively cultivated. The northern boundary of the tank lies along the bund, which serves as a connecting road between Thalangama and Akurugoda.

Due to rapid urbanization of the area, the land value has increased significantly leading to excessive land filling and the reclamation of paddy lands for housing, despite the fact that this activity is illegal. The highly concentrated human population in the Jayawadanagama housing scheme has resulted in dumping of garbage and other solid waste within the tank environs and the release of wastewater into the tank. Waste from a nearby poultry farm is also released to the tank causing deterioration in water quality and spreading invasive aquatic plants such as such *Annona glabra, Eichhornia crassipes* and *Salvinia molesta* on the tank was the identified disturbances and threats to wards the Thalangama tank.

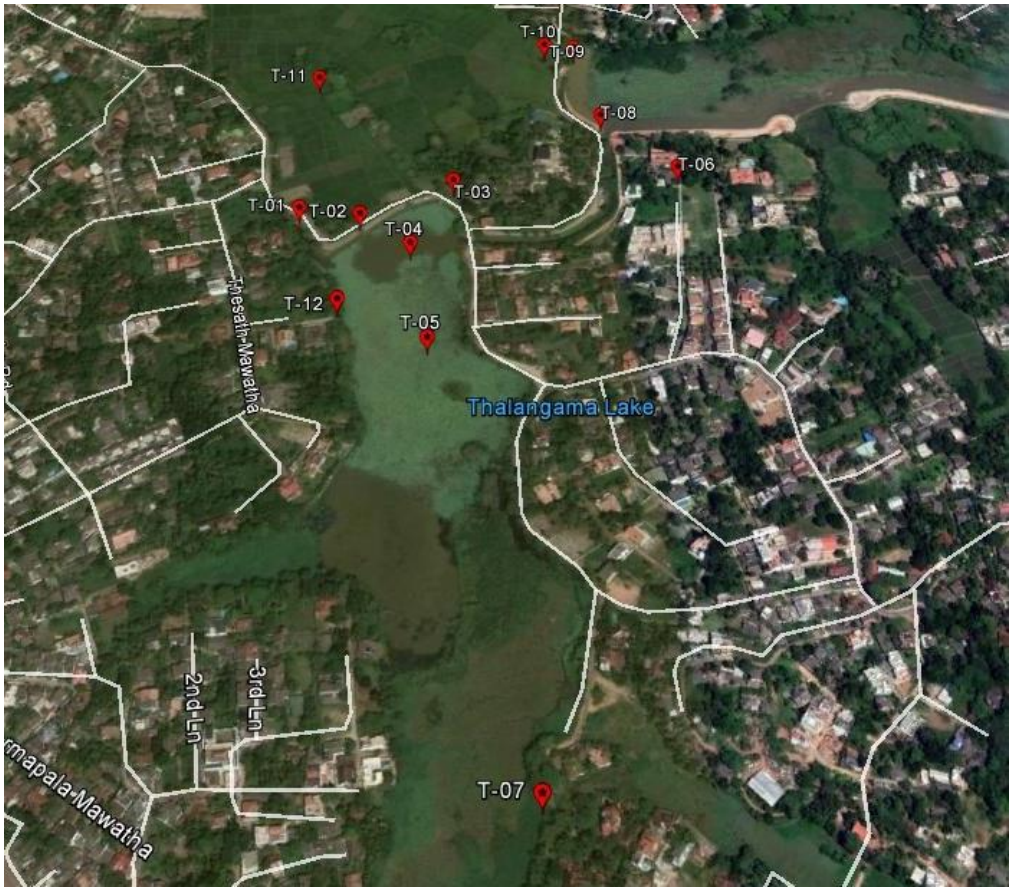

Figure 1: Water and soil sampling locations in Thalangama tank, Averihena tank (Podi wewa) and adjacent paddy field (T-01 to T-12)

Table 1: GPS points of the water and soil sampling locations in Thalangama tank, Averihena tank (Podi wewa) and adjacent paddy field (T-01 to T-12)

Thalangama Sampling Location	Location		Collected Sample	
	Latitude	Longitude	Water	Soil
T-01	6°53'20.63"N	79°56'46.18"E	√	√
T-02	6°53'20.22"N	79°56'48.27"E	√	
T-03	6°53'21.46"N	79°56'51.63"E	√	
T-04	6°53'18.82"N	79°56'49.94"E	√	√
T-05	6°53'14.91"N	79°56'50.25"E	√	√
T-06	6°53'21.48"N	79°56'59.58"E	√	
T-07	6°52'59.68"N	79°56'52.39"E	√	
T-08	6°53'24.09"N	79°56'57.17"E	√	√
T-09	6°53'27.52"N	79°56'56.59"E	√	√
T-10	6°53'27.72"N	79°56'55.52"E	√	
T-11	6°53'26.69"N	79°56'47.07"E	√	
T-12	6°53'16.66"N	79°56'47.35"E	√	√

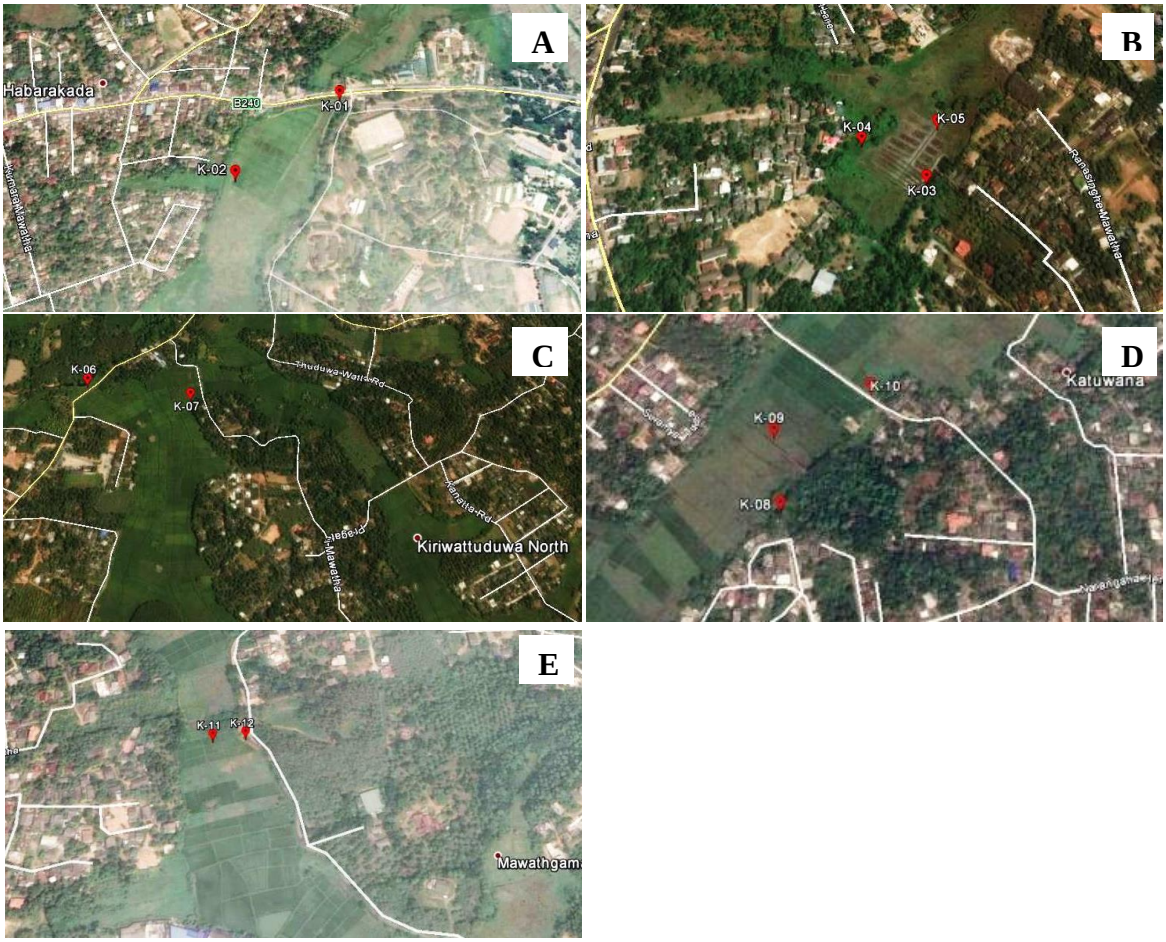

Figure 2: Water and soil sampling locations in Katuwana GN and Kiriwaththuduwa GN paddy fields (A: Habarakada, B: Hiripitiya, C: Jampugasmulla, D: Katuwana, E: Mawathagama) (K-01 to K-12).

Table 2: GPS points of the water and soil sampling locations in Katuwana GN and Kiriwaththuduwa GN paddy field.

Katuwana GN and Kiriwaththuduwa GN Sampling Location			Location		Collected Sample	
			Latitude	Longitude	Water	Soil
K-01	**1**	Habarakada	6°51'56.28"N	80° 1'1.15"E	√	√
K-02			6°51'51.03"N	80° 0'54.95"E	√	
K-03	**2**	Hiripitiya, Pannipitiya	6°49'51.25"N	79°58'6.53"E	√	√
K-04			6°49'52.92"N	79°58'3.93"E	√	
K-05			6°49'53.73"N	79°58'7.00"E	√	√
K-06	**3**	Jampugasmulla, Homagama	6°47'48.96"N	79°59'54.10"E	√	√
K-07			6°47'47.31"N	80° 0'3.23"E	√	
K-08	**4**	Katuwana, Homagama	6°49'55.43"N	79°59'43.66"E	√	√
K-09			6°50'14.06"N	80° 0'32.12"E	√	√
K-10			6°49'58.83"N	79°59'43.07"E	√	
K-11	**5**	Mawathagama, Homagama	6°50'14.09"N	80° 0'30.74"E	√	
K-12			6°50'14.06"N	80° 0'32.12"E	√	√

Figure 3: Water and soil sampling locations in Walpitayaya paddy field (W-01 to W-12)

Table 3: GPS points of the water and soil sampling locations in Walpitayaya paddy field.

Walpitayaya Sampling Locations	Location		Collected Sample	
	Latitude	Longitude	Water	Soil
W-01	6°53'12.62"N	80° 2'26.50"E	√	√
W-02	6°53'14.89"N	80° 2'26.06"E	√	√
W-03	6°53'17.37"N	80° 2'26.06"E	√	√
W-04	6°53'19.12"N	80° 2'25.71"E	√	
W-05	6°53'19.26"N	80° 2'27.31"E	√	√
W-06	6°53'18.06"N	80° 2'30.90"E	√	√
W-07	6°53'20.62"N	80° 2'31.80"E	√	
W-08	6°53'19.00"N	80° 2'34.06"E	√	√
W-09	6°53'22.26"N	80° 2'34.17"E	√	
W-10	6°53'19.45"N	80° 2'28.92"E	√	√
W-11	6°53'21.19"N	80° 2'27.92"E	√	
W-12	6°53'19.27"N	80° 2'31.91"E	√	√

2.2 Collection of soil and water samples

At the first sampling occasion water and soil samples were collected from Thalangama (Thalangama Tank), Katuwana GN, Kiriwaththuduwa GN and Walpitayaya wetlands paddy fields in 16th and 24th February 2019 where the second sampling was conducted 27th September and 20th October 2019 for Katuwana GN, Kiriwaththuduwa GN and Walpitayaya wetlands paddy fields and Thalangama Tank repetitively. Thrid sampling was carried June 7th and 12th 2020. In each location twelve water samples and six or more soil samples were collected. All the soil and water sampling points were geo-referenced using GPS receiver, Garmin etrex-3 GPS at the site.

Water samples were collected into pre-cleaned polystyrene bottles for chemical analysis and sterile amber colour glass bottles were used to collect samples for total and feacal coliform analysis. Water pH, temperature, and Dissolved Oxygen (DO) were measured using HACH portable multi meters (HACH - HQ 40D) where Electrical Conductivity (EC) was measured using the portable conductivity meter (HACH - Sension EC5) and turbidity was measured by portable turbidity meter (Milwaukee Mi-415) at the site itself (APHA, 1995). Collected water samples were kept in ice box (4^0C) during the transportation and microbial analysis was done within 24 hours.

Soil samples were collected using a hand-held soil auger (0-30cm) as a composite sample at each location and were subjected to air dry, crushed and sieved using 2 mm sieve and stored in sealed polythene bags under dark condition and preserved in labeled plastic bags until analysis (EPA, 1993).

2.3 Water quality analysis

2.3.1 General water quality analysis

Chemical Oxygen Demand (COD) was measured by standard dichromate oxidation, titrimetric method where Total Hardness (TH) and Total Alkalinity (TA) were measured using titrimetric method. Biological Oxygen Demand (BOD) was obtained using Winkler method. N- NO_3^-, N-NO_2^-, N-NH_3 and Total Phosphate (TP) concentrations were measured using standard spectrophotometric methods. Fluoride (as F^-) concentration was measured using SPANDS colorimetric method (HACH photometer -DR2700). Total Iron (as Fe) were measured using colorimetric method (HACH photometer -DR2700) (Table 4) (APHA, 1995).

2.3.2 Trace metal analysis in water samples

Trace metal analysis in water samples were performed by filtering a portion of water sample threw 0.45µm filter disk and then the samples were acidified with a drop of ultra-pure conc. HNO_3 in order to maintain the pH < 2.0. Cadmium (as Cd), Aluminum (as Al), Chromium (as Cr) and Manganese (as Mn) were measured by using the Graphite Furnace - Atomic Absorption Spectrophotometry (GF-AAS) (APHA, 1995).

2.3.3 Total Coliform (TC) and Feacal Coliform (FC) analysis

Total Coliform (TC) and Feacal Coliform (FC) bacteria count were obtained by standard Membrane Filtration method. Membrane Lactose Glucuronide Agar (MLGA) plates were used to determine the TC and FC count in 100mL of water samples (CFU/100mL) (The Environment Agency, 2002).

2.4 Soil quality analysis

2.4.1 General soil quality parameters

2.4.1.a Moisture of soil

Aliquot approximately 25.0 g of moist soil was put into petri dish and dried at 105 ^oC in the oven until get constant weight. The soil moisture content was calculated using following equation (EPA, 1993).

$$\text{Moisture content (\%)} = \frac{\text{Weight of the moist soil (W1) - Weight of the dry soil (W2)}}{\text{Weight of the dry soil (W2)}}$$

2.4.1.b Organic content of soil

Soil sample was dried at 450 ^oC in the oven for 2 hours. The organic content of soil was calculated using following equation (EPA, 1993).

$$\text{Organic content (\%)} = \frac{\text{Weight of the dried soil at 105 } ^oC \text{ (W2) - Weight of the dried soil at 450(W4)}}{\text{Weight of the dried soil at 450 } ^oC \text{ (W3)}}$$

2.4.2.c Inorganic content of soil

Soil sample was dried at 1050 ^{o}C in the muffle furnace for 1 hour and the inorganic content of soil was calculated using following equation (EPA, 1993).

$$\text{Inorganic content (\%)} = \frac{\text{Weight of the dried soil at 450 } ^{o}\text{C (W3) - Weight of the dried soil at 1050 } ^{o}\text{C (W4)}}{\text{Weight of the dried soil at 1050 } ^{o}\text{C (W4)}}$$

2.4.2 Soil Nitrate and Phosphate analysis

2.4.2 a Extraction

50 g of soil sample was transferred to 250 ml stopper conical flask and shaken with 50 ml of distilled water (1:1 ratio). After shaking, the equilibration was taken place by leaving the samples for 30 minutes. The samples were filtered into Buchner funnels by using filter papers Whatman no. 42. In the case of turbid of the filtrates, centrifuge was carried out using 3000 rpm for 5 minute (EPA, 1993).

2.4.2 b Determination of Nitrate

First, the concentration of the chloride in the sample was determined using titrimetric method with silver nitrate and amount of silver sulfate equivalent to the amount of chloride was added. Next 2-5 ml of the sample was taken from above sample to the centrifuge test tube and the volume was topped up to 10 ml with distilled water. The tube was centrifuged for 10 min until solution was clear. 5 ml of the clear solution was taken in glass evaporating dish, put on water bath, evaporated to dryness and it was cooled. 1 ml of phenoldisulphonic acid was added after 10 min. then 10 ml of water was added and transferred to 100 ml volumetric flask and made alkaline by the addition of conc. NH_4OH. The absorbance at 410 nm was measured by using UV/ Visible Spectrophotometer (EPA, 1993).

2.4.2 c Determination of Phosphate

10 ml of extracted sample was placed in a 50 ml measuring flask and added 10 ml of distilled water adding 2-3 drops of Ascorbic acid following stirred and stand for 15 min and reading was taken at 880 nm by using UV/ Visible Spectrophotometer (EPA, 1993).

2.4.3 Trace metal analysis in soil

Total trace metal concentrations were determined as the method described by Spositoet *et al.*(1983), where 2g of air dried soil sample was digested with 20 ml of 4 M HNO_3 in a water bath at 80 ^{o}C for 4 hours. The extracted soil samples filtered and total concentrations of Cadmium (as Cd), Aluminum (as Al), Chromium (as Cr) and Manganese (as Mn) and total iron (as Fe) were measured using the Graphite Furnace - Atomic Absorption Spectrophotometry (GF-AAS) (Spositoet *et al.*, 1983).

2.4.4 Analysis of Total Coliform (TC) and Feacal Coliform (FC) in Soil samples

Total Coliform (TC) and Feacal Coliform (FC) count were obtained by standard filtration method. Membrane Lactose Glucuronide Agar (MLGA) plates were used to determine the CFU of TC and FC in 10g of soil samples (The Environment Agency, 2002).

Table 4: Water and soil quality parameter and tested methods

Parameter	Recording Unit	Method of testing
Water quality parameters		
Temperature (TE)	**^{0}C**	Thermometry
pH		Multi-parameter - (Model - HACH-HQ 40D)
Electric Conductivity (EC)	**µs/cm**	Portable conductivity meter (Model - HACH - Session EC5)
Total Dissolved Solid (TDS)	**mg/L**	Portable conductivity meter (Model - HACH - Session EC5)
Turbidity (TB)	**NTU**	Turbidity meter
Dissolved Oxygen (DO)	**mg/L**	Multi-parameter - (Model - HACH-HQ 40D)
N- NO_3	**mg/L**	Spectrophotometric
N-NO_2	**mg/L**	Spectrophotometric
N- NH_3	**mg/L**	Spectrophotometric
Total Phosphorus (TP)	**mg/L**	Spectrophotometric
Total Alkalinity (TA) (as CaCO3)	**mg/L**	Titrimetry
Total Hardness (TH) (as CaCO3)	**mg/L**	Titrimetry
Fluoride (as F^-)	**mg/L**	Spectrophotometric
Biological Oxygen Demand (BOD)	**mg/L**	Winkler method
Chemical Oxygen Demand (COD)	**mg/L**	Dichromate oxidation Titrimetry
Total Iron (as Fe)	**mg/L**	colorimetric
Cadmium (as Cd)	**mg/L**	Graphite Furnace - Atomic Absorption Spectrophotometry (GF-AAS)
Aluminum (as Al)	**mg/L**	
Chromium (as Cr)	**mg/L**	
Manganese (as Mn)	**mg/L**	
Total coliform (TC)	**CFU/100 mL**	Membrane filtration method
Feacal coliform (FC)	**CFU/ 100mL**	
Soil quality parameters		
Moisture content	**%**	Gravimetric method
Organic content	**%**	Gravimetric method
Inorganic Content	**%**	Gravimetric method
Nitrate	**mg/L**	Spectrophotometric
Phosphate	**mg/L**	Spectrophotometric
Total Iron (as Fe)	**mg/L**	Graphite Furnace - Atomic Absorption Spectrophotometry (GF-AAS)
Cadmium (as Cd)	**mg/L**	
Aluminum (as Al)	**mg/L**	
Chromium (as Cr)	**mg/L**	
Manganese (as Mn)	**mg/L**	
Total coliform (TC)	**CFU**	Filtration method
Feacal coliform (FC)	**CFU**	

3.0 Results

3.1 Surface water quality in Thalangama tank, Averihena tank and adjacent paddy fields

The results of the study showed that pH in surface water collected from Thalangama tank, Averihena tank (Podi Wewa) and adjacent paddy fields ranged from 6.9 to 8.2 where pH in water samples collected from paddy fields pH remained range between 6.37 to 8.3 during the February 2019 to June 2020. Electric Conductivity (EC), Total Dissolved Solid (TDS), Turbidity and Dissolved Oxygen (DO) were ranged from 65.8 to 284.2 µs/cm, 80.3to 122.9 mg/L, 1.7 to 10.4 NTU, and 2.6 to 7.4 mg/L respectively. Compared to the first (February 2019) and second (October 2019) sampling times the highest EC (220.4-284.2 µs/cm), TDS (89.6-122.9 mg/L) and turbidity (4.3-10.4 NTU) ranges were recorded in third sampling time (June 2020). $N\text{-}NO_3^-$, $N\text{-}NO_2^-$, $N\text{-}NH_3$, Total Phosphate (TP), Total Hardness (TH), Total Alkalinity (TA) and fluoride in water samples were within the CEA irrigation and agricultural water standard (Annex- I). Moderately high BOD was detected in all the sampling location where sampling location T-07 showed the highest BOD (5.8 mg/L) (February 2019), 6.7 mg/L (October 2019) and the value exceeded the irrigation and agricultural water standard given by the CEA. Water quality results of the study indicated that the upper catchment of the tank was polluted having high COD values (Table 5). Sampling locations showed COD value variations in vast range in first and second sampling times (1.3-70.2) where low COD values (0.15-18.25 mg/L) were recorded in third field visit (June 2020) Total iron and trace metal (Fe, Cd, Al, Cr, Mn) were within the irrigation and agricultural water standard where Al concentration was recorded moderately high in the location of T-10 in Averihena tank during first and second sampling occasions (February 2019-October 2019). All the sampling locations were found to be contaminated with Total Coliform (TC) and Feacal Coliform (FC) (Table. 5).

Table 5a: Surface water quality in Thalangama tank, Averihena tank and adjacent paddy fields (First filed visit from 16th to 24th February 2019) *wetlands paddy fields and Thalangama Tank repetitively.*

Water quality parameters	Sampling Locations in Thalangama tank and paddy field												Range		Mean	CEA (2001) CL-II (06)
	T-01	T-02	T-03	T-04	T-05	T-06	T-07	T-08	T-09	T-10	T-11	T-12	Min	Max		
T (^{0}C)	29.9	31.0	29.7	28.0	31.1	32.8	32.8	32.2	32.5	31.4	31.5	31.4	28.0	32.8	31.2	_
pH	8.2	7.6	7.3	6.9	7.6	7.5	7.1	7.2	7.4	7.1	7.6	7.4	6.9	8.2	7.4	**6.0 - 8.5**
EC (µs/cm)	164.0	148.1	160.8	135.6	155.7	155.2	137.1	154.0	167.8	162.5	157.6	167.8	135.6	167.8	155.5	**700**
TDS (mg/L)	109.9	99.2	107.7	90.9	104.3	104.0	91.9	103.2	112.4	108.9	105.6	112.4	90.9	112.4	104.2	**500**
TB (NTU)	2.3	4.5	2.3	1.8	1.7	2.4	2.9	3.4	2.7	2.4	2.8	2.7	1.7	4.5	2.7	_
DO (mg/L)	6.8	6.8	5.9	5.9	6.2	6.4	4.7	6.9	7.4	3.7	3.9	4.3	3.7	7.4	5.7	**3.0 (min)**
N- NO_3 (mg/L)	ND	0.05	ND	0.12	0.12	ND	0.03	ND	0.03	2.28	ND	0.92	0.03	2.28	0.51	**5.0**
N-NO_2 (mg/L)	ND	ND	ND	0.002	0.001	ND	ND	ND	ND	ND	0.001	ND	0.001	0.002	0.001	_
N- NH_3 (mg/L)	ND	ND	ND	0.004	0.006	ND	ND	ND	0.005	ND	ND	0.003	0.003	0.006	0.005	_
TP (mg/L)	0.69	0.72	0.47	0.37	0.26	0.69	1.86	0.05	0.26	0.76	1.11	0.69	0.0	1.9	0.7	**2.0**
TA (mg/L)	52	42	32	28	36	26	24	28	48	26	22	28	22.0	52.0	32.7	**200**
TH (mg/L)	84	72	78	38	58	56	38	54	52	58	54	56	38.0	84.0	58.2	**250**
F (mg/L)	0.12	0.09	0.03	0.03	0.12	0.08	0.14	0.15	0.09	0.07	0.14	0.16	0.0	0.2	0.1	**1.5**
BOD (mg/L)	4.2	3.2	3.6	3.4	3.4	3.2	5.8	3.2	3.4	3.8	2.2	2.4	2.2	5.8	3.5	**5.0**
COD (mg/L)	47.2	58.7	35.8	35.8	24.3	24.3	35.8	35.8	1.3	58.7	47.2	70.2	1.3	70.2	39.6	**40.0**
Fe (mg/L)	0.14	0.19	0.15	0.05	0.06	0.74	0.42	0.43	0.14	0.74	0.23	0.43	0.1	0.7	0.3	**1**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.0018**
Al (mg/L)	0.002	0.004	0.004	ND	ND	0.010	ND	ND	0.001	0.040	ND	0.014	0.001	0.040	0.011	**0.005**
Cr (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.05**
Mn (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**1.0**
TC (CFU/100 mL)	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200	200	200	**100**
FC (CFU/100 mL)	121	184	45	48	78	48	145	124	84	15	74	78	15	184	87	**ND**

T : Temperature EC: Electric Conductivity TDS: Total Dissolved Solid TB: Turbidity DO: Dissolved Oxygen TP: Total Phosphorus TA: Total Alkalinity
TH: Total Hardness F: Fluoride BOD: Biological Oxygen Demand COD: Chemical Oxygen Demand TC: Total Coliform FC: Feacal Coliform ND: Not Detected
CEA: Central Environmental Authority Proposed ambient water quality standards for inland waters Sri Lanka (2001) - CLASS II - Irrigation and agriculture (6)

Table 5 b: Surface water quality in Thalangama tank, Averihena tank and adjacent paddy fields (Second field visit from 7th September and 20th October 2019)

Water quality parameters	Sampling Locations in Thalangama tank and paddy field												Range		Mean	CEA (2001) CL-II (06)
	T-01	T-02	T-03	T-04	T-05	T-06	T-07	T-08	T-09	T-10	T-11	T-12	Min	Max		
T (^{0}C)	25	27.2	25	26	28	7.45	27.8	27.9	28.4	32.9	36.3	35.5	7.45	36.3	27.3	-
pH	7.32	7.21	7.49	7.62	7.6	8.3	7.15	6.9	7.5	6.37	6.79	6.66	6.37	8.30	7.24	**6.0 - 8.5**
EC (µs/cm)	159.8	201.0	112.0	65.8	80.6	80.7	155.0	102.5	89.7	93.1	205.0	156.0	65.8	159.8	125	**700**
TDS (mg/L)	103.9	95.2	112.9	80.3	96.7	109.5	89.2	106.2	99.4	106.4	102.3	108.1	80.3	112.9	101.3	**500**
TB (NTU)	1.7	5.4	2.8	1.7	2.3	2.5	3.4	2.8	2.3	2.8	3.8	2.9	1.7	5.4	2.9	-
DO (mg/L)	7.3	6.8	4.5	6.1	6.5	6.8	4.7	4.6	3.2	2.6	3.9	4.3	2.6	7.3	5.1	**3.0 (min)**
N- NO_3 (mg/L)	ND	0.05	1.95	0.76	0.24	2.18	0.10	0.67	0.74	0.77	0.79	0.64	0.05	1.95	0.8	**5.0**
N-NO_2 (mg/L)	ND	ND	ND	0.002	0.001	ND	ND	ND	0.001	ND	0.001	ND	0.001	0.002	-	-
N- NH_3 (mg/L)	ND	ND	ND	0.004	0.005	ND	ND	0.001	ND	ND	ND	0.001	0.001	0.005	-	-
TP (mg/L)	0.42	0.31	0.17	0.08	0.13	0.02	0.06	0.03	0.20	0.21	0.04	0.13	0.02	0.42	0.20	**2.0**
TA (mg/L)	44	48	36	28	44	19	26	24	26	28	25	23	19	48	31	**200**
TH (mg/L)	50	102	64	62	58	56	38	48	53	58	54	56	38	102	58	**250**
F (mg/L)	0.07	0.04	0.04	0.03	0.07	0.04	0.09	0.04	0.07	0.04	0.11	0.09	0.03	0.11	0.12	**1.5**
BOD (mg/L)	3.9	2.8	4.4	3.2	3.0	3.5	6.7	6.4	4.6	4.2	3.3	2.6	2.6	6.7	4.1	**5.0**
COD (mg/L)	34.5	44.2	31.9	28.7	19.7	20.9	28.7	31.4	29.0	41.7	39.8	57.9	19.7	57.9	34.0	**40.0**
Fe (mg/L)	0.11	0.21	0.08	0.09	0.11	0.69	0.37	0.67	0.73	0.82	0.29	0.48	0.08	0.82	0.40	**1**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	**0.0018**
Al (mg/L)	0.001	ND	ND	ND	ND	ND	ND	ND	ND	0.040	ND	ND	0.001	0.04	-	**0.005**
Cr (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	**0.05**
Mn (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	**1.0**
TC (CFU/100 mL)	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	**100**
FC (CFU/100 mL)	138	158	45	53	82	54	156	86	77	21	77	84	21	158	85	**ND**

T : Temperature EC: Electric Conductivity TDS: Total Dissolved Solid TB: Turbidity DO: Dissolved Oxygen TP: Total Phosphorus TA: Total Alkalinity

TH: Total Hardness F: Fluoride BOD: Biological Oxygen Demand COD: Chemical Oxygen Demand TC: Total Coliform FC: Feacal Coliform ND: Not Detected

CEA: Central Environmental Authority Proposed ambient water quality standards for inland waters Sri Lanka (2001) - CLASS II - Irrigation and agriculture (6)

Table 5 c: Surface water quality in Thalangama tank, Averihena tank and adjacent paddy fields (Third field visit from 7th and 12th June 2020)

Water quality parameters	Sampling Locations in Thalangama tank and paddy field												Range		Mean	CEA (2001) CL-II (06)
	T-01	T-02	T-03	T-04	T-05	T-06	T-07	T-08	T-09	T-10	T-11	T-12	Min	Max		
T (^{0}C)	27.8	28.8	28.5	28.8	27.3	29.3	29.5	29.5	29.2	29.5	29.3	28.5	27.3	29.5	28.8	-
pH	6.8	6.7	6.6	7.2	7.1	7	6.9	6.9	7.1	7	7.2	6.8	6.6	7.2	6.9	**6.0 - 8.5**
EC (µs/cm)	220.4	221.5	225.6	265.7	275.4	252.6	241.3	284.2	246.4	246.5	243.5	230.8	220.4	284.2	245.7	**700**
TDS (mg/L)	103.4	98.2	122.9	89.6	96.7	110.5	99.2	93.9	99.2	122.9	99.3	100.7	89.6	122.9	103.0	**500**
TB (NTU)	5.2	6.4	6.6	7.1	5.7	10.9	4.3	6.4	8.8	5.3	9.4	7.7	4.3	10.4	6.9	-
DO (mg/L)	2.99	5.7	4.72	5.6	3.84	4.34	5.7	3.84	4.34	5.7	5.42	4.25	2.99	5.7	4.7	**3.0 (min)**
N- NO_3 (mg/L)	0.15	0.24	0.26	0.24	0.2	0.27	0.21	0.2	0.22	0.25	0.2	0.15	0.15	0.27	0.21	**5**
N-NO_2 (mg/L)	0.051	0.062	0.071	0.152	ND	0.25	0.174	0.155	ND	0.061	0.101	0.161	0.051	0.25	0.13	-
N- NH_3 (mg/L)	ND	0.061	ND	ND	ND	0.072	0.074	0.101	ND	0.065	0.055	0.075	0.05	0.101	0.062	-
TP (mg/L)	0.06	0.07	0.05	0.06	0.04	0.09	0.1	0.15	0.14	0.06	0.12	0.1	0.04	0.15	0.08	**2**
TA (mg/L)	40.01	56.52	68.1	70.84	65.45	65.24	58.5	60.95	45.05	65.65	68.4	58.4	40.01	70.84	60.25	**200**
TH (mg/L)	58.4	60.25	67.45	52.4	64.2	56.45	52.4	48.5	50.25	58.45	45.5	60.4	45.5	67.45	56.22	**250**
F (mg/L)	0.12	0.08	0.14	0.12	0.07	0.06	0.1	0.11	0.12	0.08	0.09	0.1	0.07	0.12	0.10	**1.5**
BOD (mg/L)	2.50.	2.6	2.25	2.3	2.34	2.5	2.25	2.51	2.5	2.65	2.65	2.5	2.25	2.65	2.45	**5**
COD (mg/L)	18.2	14.5	10.15	18.25	14.25	10.15	11.2	10.4	14.25	15.5	16.4	18.25	10.15	18.25	14.30	**40**
Fe (mg/L)	0.13	0.28	0.11	0.07	0.16	0.52	0.41	0.34	0.09	0.78	0.32	0.42	0.07	0.78	0.30	**1**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.0018**
Al (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.005**
Cr (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.05**
Mn (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**1**
TC (CFU/100 mL)	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	>200	**100**
FC (CFU/100 mL)	14	24	30	20	48	50	20	15	28	10	11	5	5	50	23	**ND**

T : Temperature EC: Electric Conductivity TDS: Total Dissolved Solid TB: Turbidity DO: Dissolved Oxygen TP: Total Phosphorus TA: Total Alkalinity
TH: Total Hardness F: Fluoride BOD: Biological Oxygen Demand COD: Chemical Oxygen Demand TC: Total Coliform FC: Feacal Coliform ND: Not Detected
CEA: Central Environmental Authority Proposed ambient water quality standards for inland waters Sri Lanka (2001) - CLASS II - Irrigation and agriculture (6)

3.2 Soil quality in Thalangama tank, Averihena tank and adjacent paddy fields

Organic content (%), inorganic content (%), and water content (%) in soil samples collected from Thalangama tank, Averihena tank and paddy field was ranged from 2.1 to 16.2 %, 6.4 to 29.1 % and 39.9 to 52.3% respectively (Table 6a,6b and 6c). Each sampling time lowest organic content (%), inorganic content (%) and water content (%) were recorded in T-09 (2.1-2.4%), T-12 (6.4-6.8%) and T-08 (39.9-44.5%) respectively. Soil pH varied from 7.3 to 8.4 where concentration of nitrate, phosphate, Fe, Cd, Al, Cr, and Mn in Thalangama tank, Averihena tank, and adjacent paddy field were within the acceptable range. Al concentrations in sampling locations were moderately high except T-05. It was found that all the sampling locations were contaminated with TC and FC (Table. 6 a, b, c).

Table 6 a: Soil quality in Thalangama tank, Averihena tank and adjacent paddy fields (First filed visit from 16th to 24th February 2019)

Soil Quality Parameters	**Sampling Locations in Thalangama tank and paddy field**						**Range**		**Mean**
	T-01	**T-04**	**T-05**	**T-08**	**T-09**	**T-12**	**Min**	**Max**	
pH	8.2	8.1	8.4	7.9	7.2	7.4	7.2	8.4	**7.9**
Organic content (%)	9.3	15.6	6.0	7.5	2.1	2.6	2.1	15.6	**7.2**
Inorganic content (%)	9.1	29.1	18.1	18.7	7.0	6.4	6.4	29.1	**14.7**
Water content (%)	47.9	48.7	44.7	39.9	45.9	43.4	39.9	48.7	**45.1**
Nitrate (mg/L)	0.023	0.002	0.008	0.019	0.005	0.008	0.002	0.023	**0.011**
Phosphate (mg/L)	0.005	0.002	0.003	0.011	0.002	0.002	0.002	0.011	**0.004**
Fe (mg/L)	0.14	0.12	0.13	0.42	0.46	34.00	0.12	34.00	**5.90**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Al (mg/L)	0.040	0.070	0.004	0.034	0.032	0.034	0.004	0.070	**0.036**
Cr (mg/L)	ND	0.001	ND	0.001	0.001	ND	0.001	0.001	**0.001**
Mn (mg/L)	0.003	ND	ND	0.006	ND	0.003	0.003	0.006	**0.002**
TC (CFU)	200<	200<	200<	200<	200<	200<	200<	200<	**200**
FC (CFU)	180	200<	160	200<	200<	200<	160	180	**170**

TC: Total Coliform FC: Feacal Coliform ND: Not Detected

Table 6 b: Soil quality in Thalangama tank, Averihena tank and adjacent paddy fields (Second field visit from 7th September and 20th October 2019).

Soil Quality Parameters	Sampling Locations in Thalangama tank and paddy field						Range		Mean
	T-01	T-04	T-05	T-08	T-09	T-12	Min	Max	
pH	7.9	8	8.1	8	7.6	7.5	7.5	8.1	**7.8**
Organic content (%)	10.1	13.8	5.6	7.1	2.3	2.8	2.3	13.8	**6.9**
Inorganic content (%)	9.4	28.7	17.8	19.1	6.8	6.5	6.5	28.7	**14.7**
Water content (%)	49.1	46.5	43.7	40.1	43.2	45.4	40.1	49.1	**44.5**
Nitrate (mg/L)	0.01	0.02	0.09	0.02	0.07	0.01	0.02	0.02	**0.01**
Phosphate (mg/L)	0.007	0.003	0.005	0.01	0.003	0.001	0.001	0.01	**0.004**
Fe (mg/L)	0.09	0.14	0.15	0.42	0.37	1.78	0.09	1.78	**0.49**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Al (mg/L)	0.032	0.072	ND	0.022	0.029	0.028	0.022	0.072	**0.030**
Cr (mg/L)	0.001	0.001	ND	0.002	ND	ND	ND	0.002	**0.0013**
Mn (mg/L)	ND	ND	ND	0.008	0.003	0.002	ND	0.008	**0.0043**
TC (CFU)	200<	200<	200<	200<	200<	200<	200<	200<	**200<**
FC (CFU)	122	41	68	74	45	71	41	122	**70**

TC: Total Coliform FC: Feacal Coliform ND: Not Detected

Table 6 c: Soil quality in Thalangama tank, Averihena tank and adjacent paddy fields (Third field visit from 7th and 12th June 2020).

Soil Quality Parameters	Sampling Locations in Thalangama tank and paddy field						Range		Mean
	T-01	T-04	T-05	T-08	T-09	T-12	Min	Max	
pH	7.8	7.5	7.3	8.1	6.8	7.5	7.3	8.1	**7.5**
Organic content (%)	10.5	16.2	5.6	6.8	2.4	3.1	2.4	16.2	**7.4**
Inorganic content (%)	8.5	27.8	15.9	19.3	6.7	6.8	6.8	27.8	**14.2**
Water content (%)	49.5	52.3	48.8	44.5	47.8	45.9	44.5	52.3	**48.1**
Nitrate (mg/L)	0.018	0.001	0.006	0.017	0.003	0.011	0.001	0.018	**0**
Phosphate (mg/L)	0.008	0.001	0.001	0.009	0.001	0.001	0.001	0.009	**0**
Fe (mg/L)	0.1	0.11	0.1	0.38	0.39	11	0.1	0.38	**2.0**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	**0**
Al (mg/L)	0.035	0.069	0.001	0.028	0.038	0.029	0.001	0.069	**0.040**
Cr (mg/L)	0.001	0.001	ND	0.001	0.001	ND	0.001	0.001	**0.001**
Mn (mg/L)	0.001	ND	ND	0.005	0.001	0.005	0.001	0.005	**0.002**
TC (CFU)	200<	200<	200<	200<	200<	200<	200<	200<	**200<**
FC (CFU)	200<	200<	180	200<	200<	200<	180	200<	**200<**

TC: Total Coliform FC: Feacal Coliform ND: Not Detected

3.3 Surface water quality in Walpitayaya paddy field

Surface water pH in samples collected from Walpitayaya paddy filed ranged from 5.27 to 8.0. EC, TDS, Turbidity and DO were ranged from 46 to 214 µs/cm, 31.6 to 115.6 mg/L, 0.8 to 4.7 NTU, and 3.9 to 9.7 mg/L in first (February 2019) and second sampling times (September to October 2019) respectively. However, in third sampling time (June 2020) showed high values for EC (224.5-254.2 µs/cm), TDS (89.6-116.2 mg/L), and Turbidity (172-359 NTU) and DO (3.4-4.1 mg/L). It was found that $N\text{-}NO_3^-$, $N\text{-}NO_2^-$, $N\text{-}NH_3$ and Total Phosphate (TP) were within the CEA irrigation and agricultural water standard. The recorded TA, TH, and fluoride were ranged from 5 to 67.45 mg/L, 16 to 78 mg/L, and 0.04 to 0.14 mg/L respectively. BOD values were remaining within the proposed Central Environmental Authority Proposed ambient water quality standards. Except W-01 location, COD values were exceeded than the value given by Irrigation and agriculture water quality standard during February to October 2019 (Table. 7 a). In June 2020, all the COD values were remaining within the CEA standards. In Walpitayaya paddy field total iron (Fe) concentration in water was considerably high where other trace metals such as Cd, Al, Cr, and Mn were remained within the standard given for Irrigation and agriculture water quality (Annexure I). Further, it was found that all the sampling locations were contaminated with TC and FC.

Table 7 a: Surface water quality in Walpitayaya paddy field (First filed visit from 16th to 24th February 2019)

Water quality parameters	Sampling Locations in Walpitayaya paddy field												Range		Mean	CEA (2001) CL-II (06)
	W-01	W-02	W-03	W-04	W-05	W-06	W-07	W-08	W-09	W-10	W-11	W-12	Min	Max		
T (^{0}C)	31.3	29.0	30.2	29.9	29.5	31.1	36.3	31.1	30.6	32.9	36.6	32.1	29.0	36.6	**31.7**	_
pH	6.8	8.0	6.8	5.2	6.8	6.9	6.9	6.8	6.6	6.1	6.9	6.0	5.2	8.0	**6.6**	**6.0 - 8.5**
EC (µs/cm)	172.5	72.9	77.3	102.3	66.8	47.1	60.7	68.9	123.2	144.5	68.8	142.3	47.1	172.5	**95.6**	**700**
TDS (mg/L)	115.6	48.8	51.8	68.5	44.8	31.6	40.7	46.2	82.5	96.8	46.1	95.3	31.6	115.6	**64.1**	**500**
TB (NTU)	0.8	3.4	4.1	4.2	3.5	3.7	4.1	4.2	2.3	2.4	3.2	4.5	0.8	4.5	**3.4**	_
DO (mg/L)	3.9	5.5	6.4	6.5	5.1	7.1	9.7	6.7	6.9	7.0	5.6	6.7	3.9	9.7	**6.4**	**3**
N- NO_3 (mg/L)	0.37	0.31	0.15	0.53	0.16	0.03	0.07	0.12	0.47	0.49	0.47	1.00	0.03	1.00	**0.35**	**5.0**
N-NO_2 (mg/L)	ND	ND	0.003	0.003	ND	ND	ND	0.003	ND	ND	ND	ND	0.003	0.003	**0.003**	_
N- NH_3 (mg/L)	ND	ND	ND	ND	0.002	ND	ND	ND	ND	ND	0.051	ND	0.002	0.051	**0.027**	_
TP (mg/L)	ND	0.72	2.00	0.76	1.15	1.22	1.86	0.76	0.97	0.33	2.00	0.55	0.33	1.99	**1.11**	**2.0**
TA (mg/L)	52	12	24	22	22	8	14	24	22	28	32	45	8	52	**25**	**200**
TH (mg/L)	74	32	36	38	22	18	30	32	48	50	58	78	18	78	**43**	**250**
F (mg/L)	0.08	0.09	0.07	0.04	0.12	0.14	0.08	0.07	0.04	0.04	0.05	0.04	0.04	0.14	**0.07**	**1.5**
BOD (mg/L)	1.2	2.8	2.6	3.4	3.8	4.2	4.0	2.8	3.4	2.4	2.8	2.8	1.2	4.2	**3.0**	**5.0**
COD (mg/L)	1.3	93.1	116.1	58.7	47.2	58.7	47.2	24.3	116.1	127.5	93.1	81.6	1.3	127.5	**72.0**	**40.0**
Fe (mg/L)	0.24	0.95	1.2	1.84	0.41	0.98	0.94	1.23	1.41	1.42	1.62	1.24	0.240	1.84	**1.12**	**1**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**0.0018**
Al (mg/L)	0.015	ND	0.012	0.002	0.075	0.045	0.006	ND	ND	0.052	ND	0.004	0.002	0.075	**0.026**	**0.005**
Cr (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**0.05**
Mn (mg/L)	ND	0.002	ND	ND	0.002	ND	0.002	ND	ND	ND	ND	ND	0.002	0.002	**0.002**	**1.0**
TC (CFU/100 mL)	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200	200	**200**	**100**
FC (CFU/100 mL)	121	48	74	76	43	42	48	15	27	29	32	42	15	121	**50**	**ND**

T: Temperature EC: Electric Conductivity TDS: Total Dissolved Solid TB: Turbidity DO: Dissolved Oxygen TP: Total Phosphorus TA: Total Alkalinity
TH: Total Hardness F: Fluoride BOD: Biological Oxygen Demand COD: Chemical Oxygen Demand TC: Total Coliform FC: Feacal Coliform ND: Not Detected
CEA: Central Environmental Authority Proposed ambient water quality standards for inland waters Sri Lanka (2001) - CLASS II - Irrigation and agriculture (6)

Table 7 b: Surface water quality in Walpitayaya paddy field (Second field visit from 7th September and 20th October 2019)

Water quality parameters	Sampling Locations in Walpitayaya paddy field												Range		Mean	CEA (2001) CL-II (06)
	W-01	W-02	W-03	W-04	W-05	W-06	W-07	W-08	W-09	W-10	W-11	W-12	Min	Max		
T (^{0}C)	25.4	25.6	25.2	26.5	25.7	27.5	25.8	28.6	26.7	25.4	25.0	25.6	28.2	27.3	**25.3**	_
pH	4.96	5.33	6.27	5.82	5.86	6.10	5.27	5.63	5.47	5.46	5.89	5.69	5.27	6.27	**5.6**	**6.0 - 8.5**
EC (µs/cm)	77.4	78.8	136.9	214	89	46	61.5	89	102.6	120.6	175.8	92.4	46	214	**103.6**	**700**
TDS (mg/L)	98.7	54.7	45.3	77.9	35.6	23.4	42.3	46.2	94.5	93.5	48.9	99.4	23.4	99.4	**63.4**	**500**
TB (NTU)	1.1	3.2	3.7	4.7	2.8	3.9	3.7	4.0	1.8	2.7	3.9	4.2	1.1	4.7	**3.3**	_
DO (mg/L)	3.9	5.5	6.4	6.5	5.1	7.1	9.7	6.7	6.9	7.0	5.6	6.7	3.9	9.7	**6.4**	**3**
N- NO_3 (mg/L)	0.28	0.39	0.21	0.67	0.12	0.01	0.03	0.09	0.39	0.41	0.39	0.87	0.01	0.87	**0.3**	**5.0**
N-NO_2 (mg/L)	ND	ND	0.003	0.001	ND	ND	ND	0.003	ND	ND	ND	ND	0.001	0.03	**0.002**	_
N- NH_3 (mg/L)	ND	ND	ND	ND	0.002	ND	ND	ND	ND	ND	0.043	ND	0.002	0.043	**0.05**	_
TP (mg/L)	ND	0.67	1.22	0.56	0.96	1.18	1.21	0.87	0.65	0.29	1.78	0.43	0.29	1.87	**0.9**	**2.0**
TA (mg/L)	37	8	19	16	12	5	9	19	34	18	24	33	5	37	**19**	**200**
TH (mg/L)	69	25	31	29	17	16	28	32	48	46	58	65	16	69	**39**	**250**
F (mg/L)	0.11	0.09	0.07	0.04	0.09	0.11	0.09	0.09	0.07	0.04	0.05	0.04	0.04	0.09	**0.1**	**1.5**
BOD (mg/L)	1.2	2.8	2.6	3.4	3.8	4.2	4.0	2.8	3.4	2.4	2.8	2.8	1.2	4.2	**3.0**	**5.0**
COD (mg/L)	2.8	98.7	119.4	64.7	54.6	61.3	54.9	27.6	119.8	135.6	97.9	80.9	2.8	135.6	**76.5**	**40.0**
Fe (mg/L)	0.22	0.87	0.91	1.56	0.22	0.67	0.87	1.87	1.26	1.36	1.56	1.06	0.22	1.91	**1.1**	**1**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**0.0018**
Al (mg/L)	0.021	ND	ND	0.002	0.052	0.031	ND	ND	ND	0.044	ND	0.002	0.002	0.052	**0.005**	**0.005**
Cr (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**0.05**
Mn (mg/L)	ND	ND	ND	ND	0.002	ND	0.001	ND	ND	ND	ND	ND	0.001	0.002	**0.001**	**1.0**
TC (CFU/100 mL)	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	**200<**	**100**
FC (CFU/100 mL)	101	35	78	87	38	39	41	11	22	21	28	37	11	101	**44**	**ND**

T: Temperature EC: Electric Conductivity TDS: Total Dissolved Solid TB: Turbidity DO: Dissolved Oxygen TP: Total Phosphorus TA: Total Alkalinity
TH: Total Hardness F: Fluoride BOD: Biological Oxygen Demand COD: Chemical Oxygen Demand TC: Total Coliform FC: Feacal Coliform ND: Not Detected
CEA: Central Environmental Authority Proposed ambient water quality standards for inland waters Sri Lanka (2001) - CLASS II - Irrigation and agriculture (6)

Table 7 c: Surface water quality in Walpitayaya paddy field (Third field visit from 7th and 12th June 2020)

Water quality parameters	Sampling Locations in Walpitayaya paddy field												Range		Mean	CEA (2001) CL-II (06)
	W-01	W-02	W-03	W-04	W-05	W-06	W-07	W-08	W-09	W-10	W-11	W-12	Min	Max		
T (^{0}C)	29.9	30.3	29.7	30.6	29.5	31.6	29.1	30.4	30.1	29.7	29.5	29.9	29.1	31.6	**30.5**	_
PH	6.8	7.1	7	7.2	7.2	7.2	6.9	6.8	7	6.6	6.8	6.8	6.6	7.2	**6.95**	**6.0 - 8.5**
EC (µs/cm)	235.4	234.8	245.6	254.2	245.3	228.4	245.2	228.4	231.2	224.5	241.2	225.8	224.5	254.2	**236.6**	**700**
TDS (mg/L)	110.4	98.5	89.6	96.2	92.4	99.7	96.7	99.7	115.4	116.2	110.2	89.7	89.6	116.2	**101.3**	**500**
TB (NTU)	359	277	239	287	172	259	294	232	176	344	324	299	172	359	**271.8**	_
DO (mg/L)	3.4	3.6	4.1	4	3.8	3.8	3.4	3.6	3.7	3.7	3.7	3.6	3.4	4.1	**3.7**	**3**
N- NO_3 (mg/L)	0.18	0.29	0.3	0.35	0.21	0.28	0.24	0.28	0.3	0.25	0.2	0.15	0.15	0.35	**0.25**	**5**
N-NO_2 (mg/L)	0.151	0.264	0.171	0.102	0.085	0.152	0.185	0.186	0.25	0.151	0.162	0.205	0.085	0.264	**0.161**	_
N- NH_3 (mg/L)	ND	0.051	ND	ND	ND	0.258	0.09	0.11	0.107	0.065	0.065	0.105	0.051	0.258	**0.102**	_
TP (mg/L)	0.06	0.07	0.05	0.06	0.04	0.09	0.1	0.15	0.14	0.06	0.12	0.1	0.04	0.15	**0.08**	**2**
TA (mg/L)	46.8	58.4	60.25	67.45	52.4	64.2	56.45	52.4	48.5	50.25	58.45	45.5	60.4	45.5	**67.45**	**250**
F (mg/L)	0.12	0.08	0.14	0.12	0.07	0.06	0.1	0.11	0.12	0.08	0.09	0.1	0.06	0.14	**0.07**	**1.5**
BOD (mg/L)	2.8	2.7	2.9	2.8	2.7	2.7	2.7	2.8	2.82	2.9	2.9	2.7	2.7	2.9	**2.74**	**5**
COD (mg/L)	18.2	11.5	15.15	14.25	15.25	18.15	19.2	10.4	14.25	15.5	16.4	16.25	10.4	19.2	**14.2**	**40**
Fe (mg/L)	0.28	0.91	0.85	0.94	0.18	0.52	0.77	1.07	1.11	0.98	1.23	0.86	0.18	1.23	**0.80**	**1**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**0.0018**
Al (mg/L)	0.011	ND	ND	0.002	0.032	0.031	ND	ND	ND	0.034	ND	0.002	0.002	0.034	**0.018**	**0.005**
Cr (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**0.05**
Mn (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**1**
TC (CFU/100 mL)	30	25	30	200<	40	200<	200<	15	200<	200<	200<	200<	15	200<	**200<**	**100**
FC (CFU/100 mL)	20	25	14	5	10	21	ND	8	10	ND	20	4	ND	25	**11.41**	**ND**

T: Temperature EC: Electric Conductivity TDS: Total Dissolved Solid TB: Turbidity DO: Dissolved Oxygen TP: Total Phosphorus TA: Total Alkalinity

TH: Total Hardness F: Fluoride BOD: Biological Oxygen Demand COD: Chemical Oxygen Demand TC: Total Coliform FC: Feacal Coliform ND: Not Detected

CEA: Central Environmental Authority Proposed ambient water quality standards for inland waters Sri Lanka (2001) - CLASS II - Irrigation and agriculture (6)

3.4 Soil quality in Walpitayaya paddy field

Soil pH in Walpitayaya paddy field ranged from 7.1 to 8.9 where organic, inorganic water content percentage ranged from 1.9 to 15.6 %, 8.8 to 29.2 % and 39.9 to 54.6 % respectively. Soil nitrate, phosphate and trace metals (Cd, Al, Cr, and Mn) concentrations were remained at desirable level. Compare to the other ions detected in the study, total iron (Fe) concentration in soil was grater may due to the nature of soil in the sampling site (Table: 8a, b, c). It was found that all soil samples contaminated with TC and FC (Table: 8 a, b, c) .

Table 8 a: Soil quality in Walpitayaya paddy field sampling locations (First filed visit from 16th to 24th February 2019)

Soil Quality Parameters	Sampling Locations in Walpitayaya paddy field						Range		Mean
	W-01	W-02	W-05	W-06	W-08	W-12	Min	Max	
pH	7.4	7.4	7.6	7.8	7.9	7.8	7.4	7.9	**7.7**
Organic content (%)	2.8	2.1	7.7	6.7	12.3	6.7	2.1	12.3	**6.4**
Inorganic content (%)	9.4	8.1	14.9	13.5	23.5	17.4	8.1	23.5	**14.5**
Water content (%)	48.8	47.0	48.2	46.2	46.7	38.7	38.7	48.8	**45.9**
Nitrate (mg/L)	0.003	0.102	0.099	0.054	0.023	0.041	0.003	0.102	**0.054**
Phosphate (mg/L)	0.002	0.012	0.023	0.001	0.005	0.006	0.001	0.023	**0.008**
Fe (mg/L)	0.42	0.98	1.20	1.34	1.48	1.62	0.4	1.6	**1.2**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Al (mg/L)	0.054	0.52	0.41	0.043	0.047	0.078	0.043	0.520	**0.192**
Cr (mg/L)	0.001	ND	ND	0.001	ND	ND	0.001	0.001	**0.001**
Mn (mg/L)	ND	0.0	ND	ND	0.0	ND	0.001	0.002	**0.002**
TC (CFU)	200<	200<	200<	200<	200<	200<	200<	200<	**200<**
FC (CFU)	60	200<	180	200<	200<	78	60	180	**106**

TC: Total Coliform FC: Feacal Coliform ND: Not Detected

Table 8 b: Soil quality in Walpitayaya paddy field sampling locations (Second field visit from 7th September and 20th October 2019)

Soil Quality Parameters	Sampling Locations in Walpitayaya paddy field						Range		Mean
	W-01	W-02	W-05	W-06	W-08	W-12	Min	Max	
pH	7.6	7.9	7.2	8.2	8.4	8.9	7.2	8.9	**8.0**
Organic content (%)	2.8	1.9	8.6	7.2	15.6	7.2	1.9	15.6	**7.2**
Inorganic content (%)	10.4	8.8	15.3	17.8	29.2	19.5	8.8	29.2	**16.8**
Water content (%)	54.6	51.0	54.3	48.9	47.2	39.9	39.9	54.6	**49.3**
Nitrate (mg/L)	0.001	0.087	0.092	0.041	0.013	0.035	0.001	0.092	**0.003**
Phosphate (mg/L)	0.001	0.009	0.027	0.001	0.001	0.002	0.001	0.027	**0.003**
Fe (mg/L)	0.25	0.87	0.97	1.02	1.67	1.23	0.25	1.67	**1.0**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Al (mg/L)	0.041	0.39	0.45	0.032	0.036	0.084	0.032	0.45	**0.2**
Cr (mg/L)	0.001	ND	ND	0.001	ND	0.001	ND	0.001	**0.0**
Mn (mg/L)	ND	0.001	ND	ND	0.001	ND	ND	0.001	**0.0**
TC (CFU)	200<	200<	200<	200<	200<	200<	-	200<	**200<**
FC (CFU)	45	200<	200<	200<	200<	105	45	200<	**182**

TC: Total Coliform FC: Feacal Coliform ND: Not Detected

Table 8 c: Soil quality in Walpitayaya paddy field sampling locations (Third field visit from 7th and 12th June 2020)

Soil Quality Parameters	Sampling Locations in Walpitayaya paddy field						Range		Mean
	W-01	W-02	W-05	W-06	W-08	W-12	Min	Max	
pH	7.6	7.1	7.6	7.8	7.9	7.8	7.1	7.9	**7.6**
Organic content (%)	2.2	2.4	7.3	6.9	11.7	6.5	2.2	11.7	**6.1**
Inorganic content (%)	9.2	7.9	15.4	14.1	24.2	17.4	7.9	24.2	**14.7**
Water content (%)	45.5	46.8	48.3	45.5	45.4	37.2	37.2	48.3	**44.7**
Nitrate (mg/L)	0.04	0.09	0.09	0.03	0.09	0.05	0.04	0.09	**0.05**
Phosphate (mg/L)	0.02	0.19	0.27	0.01	0.05	0.05	0.01	0.27	**0.09**
Fe (mg/L)	0.31	0.91	0.92	0.99	1.34	1.02	0.31	1.34	**0.91**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Al (mg/L)	0.038	0.245	0.342	0.023	0.034	0.086	0.023	0.342	**0.128**
Cr (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Mn (mg/L)	ND	ND	ND	ND	ND	0.001	0.001	0.001	**0.001**
TC (CFU)	50	62	200<	200<	200<	200<	50	62	**185**
FC (CFU)	15	40	52	28	60	42	15	60	**39**

TC: Total Coliform FC: Feacal Coliform ND: Not Detected

3.5 Surface water quality in Habarakada, Hiripitiya, Pannipitiya, Jampugasmulla, Homagama, Katuwana, Homagama, Mawathagama, Homagama paddy fields and vegetable gardens.

Except BOD and COD in all the general water quality parameters of the sampling locations were remained within the standards given for ambient water quality standards for inland waters for irrigation and agriculture water. Except Habarakada (K-01 and K-02) sampling locations, all the other locations, BOD was less than 6.8 mg/ L in first and second field visits (February 2019- October 2019) where the values were ranged from 2.6-3.0 mg/L in third field visit (June 2020). In the study all the sampling locations showed high COD ranging from 43.2 to 129.5 mg/L during February –October 2019 where low values (12.2-20.2 mg/L) were found in June 2020. All the tested heavy metals were below the concentration given for irrigation and agriculture water. Further, it was found that all sampling locations were contaminated with TC and FC (Table 9 a, b, c).

3.6 Soil quality in Habarakada, Hiripitiya, Pannipitiya, Jampugasmulla, Homagama, Katuwana, Homagama, Mawathagama, Homagama paddy fields and vegetable gardens

Soil pH in the Habarakada, Hiripitiya, Pannipitiya, Jampugasmulla, Homagama, Katuwana, Homagama, Mawathagama, Homagama paddy fields and vegetable gardens were ranged from 6.1 to 8.3 where site specific variation of organic, inorganic and water content of soil is given in Table 10. In all the sampling locations low nitrate and phosphate concentrations were recorded. Cadmium was not recorded in any of the sampling locations and the other metals remained in low concentrations and all sampling location was found to contaminate with TC and FC bacteria (Table 10 a, b, c).

Table 9 a: Surface water quality in Katuwana GN and Kiriwaththuduwa GN paddy fields (First filed visit from 16th to 24th February 2019).

Water quality parameters	Sampling Locations in Katuwana GN and Kiriwaththuduwa GN paddy fields														CEA (2001) CL-II (06)
	1		2			3		4			5		Range		Mean
	K-01	K-02	K-03	K-04	K-05	K-06	K-07	K-08	K-09	K-10	K-11	K-12	Min	Max	
T (^{0}C)	29.2	26.2	27.3	27.1	26.4	27.5	27.2	27.4	29.5	29.1	29.9	28.3	26.2	29.9	**27.9**	_
pH	8.1	7	7	7.2	7.7	7.2	6.7	5.6	6.5	6.4	5.3	5.5	5.3	8.1	**6.8**	6.0 - 8.5
EC (µs/cm)	131	157	132.5	120.1	124.5	93.9	182.4	65.2	98.9	97.4	38.8	86.2	38.8	182.4	**112.9**	700
TDS (mg/L)	87.8	105.2	88.8	80.5	83.4	62.9	122.2	43.7	66.3	65.3	26	57.8	26	122.2	**75.6**	500
TB (NTU)	3.4	3.5	4.2	4.8	3.9	1.4	1.8	3.5	3.4	3.7	4.7	4.1	1.4	4.8	**3.5**	_
DO (mg/L)	5.9	4.6	5.5	4.3	4.6	5.6	4.2	4.3	3.7	4.1	1.3	3.4	1.3	5.9	**4.4**	3
N- NO_3 (mg/L)	0.4	0.27	0.32	0.29	0.37	0.15	0.24	0.11	0.82	0.73	0.05	0.13	0.05	0.82	**0.341**	5
N-NO_2 (mg/L)	0.001	0.005	ND	ND	0.003	ND	ND	0.001	0.001	ND	ND	ND	0.001	0.005	**0.002**	_
N- NH_3 (mg/L)	ND	ND	0.081	ND	ND	0.002	ND	ND	ND	0.042	ND	ND	0.002	0.081	**0.042**	_
TP (mg/L)	0.37	0.4	0.72	0.76	0.69	0.26	0.33	0.37	0.72	0.97	0.9	19.79	0.26	19.79	**0.6**	2
TA (mg/L)	62	72	52	24	34	26	52	48	42	48	12	22	12	72	**42.9**	200
TH (mg/L)	84	114	92	78	74	58	74	72	58	66	18	34	18	114	**71.64**	250
F (mg/L)	0.12	0.14	0.15	0.09	0.07	0.14	0.12	0.07	0.12	0.18	0.07	0.04	0.04	0.18	**0.12**	1.5
BOD (mg/L)	6.8	6.7	2.4	2.8	2.6	2.4	2.8	2.6	2.4	3.4	3.8	4.2	2.4	6.8	**3.52**	5
COD (mg/L)	116.1	127.5	70.2	58.7	47.2	58.7	47.2	93.1	81.6	70.2	93.1	70.2	47.2	127.5	**78.51**	40
Fe (mg/L)	0.36	0.15	0.25	0.18	0.19	0.18	0.24	0.51	0.43	0.41	0.36	0.32	0.15	0.51	**0.30**	1
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	0.0018
Al (mg/L)	ND	0.002	0.003	0.042	0.041	ND	ND	0.007	0.006	0.003	ND	ND	0.002	0.042	**0.015**	0.005
Cr (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	0.05
Mn (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	1
TC (CFU/100 mL)	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	**200<**	100
FC (CFU/100 mL)	120	84	45	15	84	74	46	42	47	78	74	16	15	120	**64**	ND

T : Temperature EC: Electric Conductivity TDS: Total Dissolved Solid TB: Turbidity DO: Dissolved Oxygen TP: Total Phosphorus TA: Total Alkalinity

TH: Total Hardness F: Fluoride BOD: Biological Oxygen Demand COD: Chemical Oxygen Demand TC: Total Coliform FC: Feacal Coliform ND: Not Detected

CEA: Central Environmental Authority Proposed ambient water quality standards for inland waters Sri Lanka (2001) - CLASS II - Irrigation and agriculture (6)

Table 9 b: Surface water quality in Katuwana GN and Kiriwaththuduwa GN paddy fields (Second field visit from 7th September 2019 and 20th October 2019).

Water quality parameters	Sampling Locations in Katuwana GN and Kiriwaththuduwa GN paddy fields														Mean	CEA (2001) CL-II (06)
	1		2			3		4			5		Range			
	K-01	K-02	K-03	K-04	K-05	K-06	K-07	K-08	K-09	K-10	K-11	K-12	Min	Max		
T (^{0}C)	25.5	25.6	25.0	25.0	25.0	25.7	27.4	27.0	26.0	25.5	25.0	26.0	25.0	27.4	**25.7**	_
pH	6.09	5.87	7.49	6.23	6.35	6.23	6.35	5.43	5.42	5.19	4.62	5.05	4.62	7.49	**5.9**	**6.0 - 8.5**
EC (µs/cm)	205.	124.8	112	108	157	300	122	105.2	110.8	199.4	51.7	149	51.7	300	**145.4**	**700**
TDS (mg/L)	78.9	98.3	82.3	74.2	71.9	55.7	101.9	38.9	63.2	65.3	22.9	56.7	22.9	101.9	**67.5**	**500**
TB (NTU)	4.2	3.1	4.3	4.8	3.9	2.1	1.8	3.1	3.4	2.9	5.2	3.8	1.8	5.2	**3.6**	_
DO (mg/L)	4.5	3.4	6.7	5.1	3.5	4.7	4.2	3.9	3.1	4.5	1.1	3.1	1.1	6.7	**4.0**	**3**
N- NO_3 (mg/L)	0.42	0.29	0.36	0.34	0.38	0.18	0.27	0.17	0.85	0.74	0.05	0.17	0.05	0.85	**0.4**	**5**
N-NO_2 (mg/L)	ND	0.004	ND	ND	0.003	ND	ND	ND	0.001	ND	ND	ND	ND	0.004	**0.002**	_
N- NH_3 (mg/L)	ND	ND	0.078	ND	ND	0.001	ND	ND	ND	0.029	ND	ND	ND	0.078	**0.004**	_
TP (mg/L)	0.29	0.32	0.68	0.72	0.63	0.22	0.31	0.34	0.68	0.86	0.83	10.91	0.22	10.91	**1.4**	**2**
TA (mg/L)	58	66	44	21	32	22	44	48	38	43	9	18	9	66	**36.9**	**200**
TH (mg/L)	84	114	92	78	74	58	74	72	58	66	18	34	18	114	**68.5**	**250**
F (mg/L)	0.18	0.16	0.16	0.09	0.07	0.15	0.12	0.09	0.14	0.18	0.07	0.04	0.04	0.18	**0.1**	**1.5**
BOD (mg/L)	7.1	6.8	2.4	2.8	2.6	2.4	2.8	2.9	2.4	3.4	3.8	4.4	2.4	7.1	**3.7**	**5**
COD (mg/L)	122.3	129.5	74.2	63.2	51.1	54.7	43.2	93.1	84.2	65.7	89.7	70.2	43.2	129.5	**78.4**	**40**
Fe (mg/L)	0.28	0.1	0.19	0.12	0.22	0.11	0.19	0.46	0.44	0.41	0.35	0.31	0.1	0.46	**0.3**	**1**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0**	**0.0018**
Al (mg/L)	ND	0.001	0.001	0.033	0.032	ND	ND	0.004	0.002	0.002	ND	ND	ND	0.033	**0**	**0.005**
Cr (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**0.05**
Mn (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**1**
TC (CFU/100 mL)	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	-	200<	**200<**	**100**
FC (CFU/100 mL)	134	86	44	12	93	74	48	49	53	83	75	18	12	134	**64**	**ND**

T: Temperature EC: Electric Conductivity TDS: Total Dissolved Solid TB: Turbidity DO: Dissolved Oxygen TP: Total Phosphorus TA: Total Alkalinity
TH: Total Hardness F: Fluoride BOD: Biological Oxygen Demand COD: Chemical Oxygen Demand TC: Total Coliform FC: Feacal Coliform ND: Not Detected
CEA: Central Environmental Authority Proposed ambient water quality standards for inland waters Sri Lanka (2001) - CLASS II - Irrigation and agriculture (6)

Table 9 c: Surface water quality in Katuwana GN and Kiriwaththuduwa GN paddy fields (Third field visit from 7th and 12th June 2020)

Water quality parameters	Sampling Locations in Katuwana GN and Kiriwaththuduwa GN paddy fields														CEA (2001) CL-II (06)
	1		2			3		4			5		Range		Mean	
	K- 01	K-02	K-03	K-04	K-05	K-06	K-07	K-08	K-09	K-10	K-11	K-12	Min	Max		
T (^{0}C)	_	_	27	26.5	26.9	28	29.1	30.4	30.7	30.2	30.4	29.2	27	30.7	**28.8**	_
pH	_	_	6.7	7.2	7.1	7.1	7.2	7	6.9	6.9	6.8	6.8	6.7	7.2	**6.9**	**6.0 - 8.5**
EC (µs/cm)	_	_	342	356	372	420	423	385	384	370	289	285	285	423	**362.6**	**700**
TDS (mg/L)	_	_	365	333	342	310	295	341	340	378	358	395	295	395	**345.7**	**500**
TB (NTU)	_	_	6.8	16.2	18	10.4	8.2	6	8.2	6.2	6	11	6	18	**8.0**	_
DO (mg/L)	_	_	3.4	4.1	4.4	4.6	4.7	3.9	3.8	3.7	3.8	3.7	3.4	4.7	**4.01**	**3**
N- NO_3 (mg/L)	_	_	0.22	0.1	0.9	0.45	0.5	0.52	0.11	0.02	0.25	0.45	0.10	0.9	**0.53**	**5**
N-NO_2 (mg/L)	_	_	0.75	0.251	0.305	0.65	0.051	0.053	ND	ND	ND	0.052	0.10	0.75	**0.585**	_
N- NH_3 (mg/L)	_	_	ND	ND	0.05	ND	ND	ND	0.051	0.053	ND	ND	0.10	0.05	**0.05**	_
TP (mg/L)	_	_	0.45	0.45	0.65	0.35	0.15	0.28	0.05	0.42	0.34	0.24	0.10	0.65	**0.33**	**2**
TA (mg/L)	_	_	110.1	112	111	102.3	98.4	104	2	100.2	98.2	99.5	2.0	112	**93.7**	**200**
TH (mg/L)	_	_	180.2	172.3	172.4	165.8	166.1	154.2	170.2	158.2	164.7	154.8	154	180	**165.8**	**250**
F (mg/L)	_	_	0.55	0.52	0.25	0.35	0.25	0.24	0.52	0.62	0.51	0.5	0.2	0.62	**0.43**	**1.5**
BOD (mg/L)	_	_	3.0	2.8	2.7	2.6	2.7	2.7	2.8	2.8	2.8	2.7	2.6	3.0	**2.7**	**5**
COD (mg/L)	_	_	15.0	12.2	18.2	18.4	18.5	20.2	16.4	16.7	19.1	20	12	20.2	**17.4**	**40**
Fe (mg/L)	_	_	0.15	0.18	0.27	0.14	0.24	0.41	0.38	0.32	0.27	0.33	0.14	0.41	**0.26**	**1**
Cd (mg/L)	_	_	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**0.0018**
Al (mg/L)	_	_	ND	0.021	0.019	ND	ND	0.002	0.002	ND	ND	ND	0.002	0.021	**0.01**	**0.005**
Cr (mg/L)	_	_	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**0.05**
Mn (mg/L)	_	_	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	**1**
TC (CFU/100 mL)	_	_	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	200<	**200<**	**100**
FC (CFU/100 mL)	_	_	19	4	20	30	48	60	>200	60	28	>200	4	200<	**65**	**ND**

T : Temperature EC: Electric Conductivity TDS: Total Dissolved Solid TB: Turbidity DO: Dissolved Oxygen TP: Total Phosphorus TA: Total Alkalinity
TH: Total Hardness F: Fluoride BOD: Biological Oxygen Demand COD: Chemical Oxygen Demand TC: Total Coliform FC: Feacal Coliform ND: Not Detected
CEA: Central Environmental Authority Proposed ambient water quality standards for inland waters Sri Lanka (2001) - CLASS II - Irrigation and agriculture (6)

Table 10 a: Soil quality in Katuwana GN and Kiriwaththuduwa GN paddy fields sampling locations (First filed visit from 16th to 24th February 2019)

Soil Quality Parameters	Sampling Locations in Katuwana GN and Kiriwaththuduwa GN paddy fields						Range		Mean
	1	2	3	4		5			
	K-01	K-03	K-06	K-08	K-09	K-12	Min	Max	
pH	7.5	7.6	7.6	7.6	7.6	7.6	7.6	7.6	**7.6**
Organic content (%)	5.4	4.45	4.45	4.45	4.45	4.45	4.45	4.45	**4.45**
Inorganic content (%)	11.3	10.2	10.2	10.2	10.2	10.2	10.2	10.2	**10.2**
Water content (%)	39.0	43.4	43.4	43.4	43.4	43.4	43.4	43.4	**43.4**
Nitrate (mg/L)	0.005	0.024	0.024	0.024	0.024	0.024	0.024	0.024	**0.024**
Phosphate (mg/L)	0.001	0.004	0.004	0.004	0.004	0.004	0.004	0.004	**0.004**
Fe (mg/L)	0.21	0.38	0.38	0.38	0.38	0.38	0.38	0.38	**0.38**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Al (mg/L)	0.042	0.047	0.047	0.047	0.047	0.047	0.047	0.047	**0.047**
Cr (mg/L)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
Mn (mg/L)	ND	0.001	0.001	0.001	0.001	0.001	0.001	0.001	**0.001**
TC (CFU)	200<	200<	200<	200<	200<	200<	200<	200<	**200<**
FC (CFU)	200<	28	28	28	28	28	28	28	**28**

TC: Total Coliform FC: Feacal Coliform ND: Not Detected

Table 10 b: Soil quality in Katuwana GN and Kiriwaththuduwa GN paddy fields sampling locations (Second field visit from 20th October and 07 September 2019).

Soil Quality Parameters	Sampling Locations in Katuwana GN and Kiriwaththuduwa GN paddy fields					Range		Mean
	K-01	K-03	K-06	K-08	K-09	Min	Max	
pH	7.9	7.1	6.9	8.1	8.3	6.1	8.3	7.7
Organic content (%)	5.9	8.2	3.9	2.3	4.2	2.3	8.2	4.9
Inorganic content (%)	11.4	21.5	8.5	8.9	7.4	7.4	21.5	11.5
Water content (%)	43.2	50.2	47.8	44.5	44.7	43.2	50.2	46.1
Nitrate (mg/L)	0.002	0.005	0.006	0.102	0.014	0.002	0.102	0.002
Phosphate (mg/L)	0.001	0.001	0.002	0.019	0.001	0.001	0.019	0.004
Fe (mg/L)	0.28	0.52	0.53	0.42	0.22	0.22	0.53	0.4
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND
Al (mg/L)	0.051	0.082	0.046	0.038	0.041	0.038	0.082	0.1
Cr (mg/L)	0.001	0.001	ND	0.001	ND	ND	0.001	0.001
Mn (mg/L)	0.001	0.001	0.003	ND	0.001	0.001	0.003	0.001
TC (CFU)	200<	200<	200<	200<	200<	200<	200<	200<
FC (CFU)	200<	54	200<	180	45	45	200<	135

TC: Total Coliform FC: Feacal Coliform ND: Not Detected

Table 10 c: Soil quality in Katuwana GN and Kiriwaththuduwa GN paddy fields sampling locations (Third field visit from 7th and 12th June 2020)

Soil Quality Parameters	Sampling Locations in Katuwana GN and Kiriwaththuduwa GN paddy fields						Range		Mean
	K-01	K-03	K-06	K-08	K-09	K-12	Min	Max	
pH	7.8	7.3	7.2	7.8	7.9	7.5	7.2	7.9	**7.7**
Organic content (%)	8.1	7.8	4.5	2.9	4.4	3.5	2.9	8.1	**4.9**
Inorganic content (%)	18.7	22.3	6.8	8.5	7.2	7.4	7.2	22.3	**11.5**
Water content (%)	44.3	45.3	45.6	42.3	44.2	46.7	46.7	42.3	**46.1**
Nitrate (mg/L)	0.03	0.005	0.005	0.091	0.011	0.015	0.015	0.005	**0.04**
Phosphate (mg/L)	0.001	0.001	0.001	0.017	0.003	0.002	0.002	0.001	**0.02**
Fe (mg/L)	0.31	0.45	0.49	0.42	0.17	0.51	0.17	0.51	**0.391**
Cd (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	**ND**
Al (mg/L)	0.049	0.072	0.038	0.022	0.035	0.021	0.021	0.072	**0.039**
Cr (mg/L)	ND	0.001	ND	ND	ND	ND	0.001	0.001	**0.001**
Mn (mg/L)	ND	0.001	0.002	ND	ND	0.002	0.001	0.002	**0.001**
TC (CFU)	200<	200<	200<	200<	200<	200<	200<	200<	**200<**
FC (CFU)	98	54	106	145	33	135	33	145	**95**

TC: Total Coliform FC: Feacal Coliform ND: Not Detected

4.0 RECOMMENDATIONS

4.1 RECOMMENDATION FOR THALANGAMA AND AVERIHENA TANK

Identification of point sources of chemical pollution

The results of the study showed greater COD in Thalangama and Averihena tank which indicate chemical pollution. It is recommended to conduct continuous monitoring of inflow water sources to the tanks to identify point sources of chemical pollution.

Protect exotic and indigenous freshwater fish species in the tanks

The tank comprises of a mix of native fish, *Puntius singhala, Etroplus maculates* and *Esomus thermoicos*. It is recommended to keep the tank clean from pollutant, plastics and garbage. Recreational fishing activity was observed during the field visit and such anthropological activities directly effect on the collapse of the diversity and abundance of native fish species.

Protect locally declining aquatic birds' species, mammals and reptiles around the tanks premises

Pelecanus philippensis and *Rostratula benghalensis* were recorded as locally declining aquatic birds' where *Lissemys punctata,* and *Xenochrophis piscator,* recorded as reptiles. Endemic primate, *Trachypithecus vetulus,* and rare mammals such as *Prionailurus viverrinus* and *Lutra lutra* have been recorded. It is recommended to keep the tank and surrounding area as protected area to minimize human and other effects on locally declining fauna.

Declaration of Thalangama tank and its surrounding area for bird watching and relaxation
Declare Thalangama Tank and surrounding paddy fields are for flood detention

Due to rapid urbanization of the area, it was identified excessive land filling and the reclamation of paddy lands for housing in illegal way. The highly concentrated human population in the Jayawadanagama housing scheme has resulted in dumping of garbage and other solid waste within the tank environment and the release of wastewater into the tank was observed during the fled visits. This may result uncontrolled encroachment of invasive aquatic plants such as *Annona glabra, Eichhornia crassipes* and *Salvinia molesta* over the tank which disturb and threats to aquatic fauna and aquatic plant diversity in the Thalangama tank.

Monitoring and pollution preventive measures should always be systemically integrated.

It is necessary to develop and implement water resource monitoring systems with a prior definition of indicators, parameters, tolerance limits, frequency and sampling points and combining this information with quantifiable data to assess the situations.

4.2 RECOMMENDATION FOR PADDY AND VEGETABLE GARDENS

Katuwana GN and Kiriwaththuduwa GN (Habarakada, Hiripitiya, Pannipitiya, Jampugasmulla, Homagama, Katuwana, Homagama, Mawathagama, Homagama paddy fields and vegetable gardens

Recommend conducting a thorough study of the economic, social, and environmental results of organic farming systems vs. conventional agriculture

Such studies should be conducted at State Agricultural experiments by multidisciplinary teams of scientists over a minimum of 3 years. Included in the experimental design should be plans to determine the most practical and workable balance between the use of organic wastes and inorganic fertilizers. A thorough study of the energy and nutrient budgets for the two farming systems should be investigated.

Develop educational programs to increase public awareness of the value of recycling organic wastes on soils

Educational programs should be developed and implemented. Information should be disseminated by way of pamphlets, brochures, radio, television, and public demonstrations to create a greater awareness of the potential value of recycling good quality organic materials on land.

Collect more information on the extent to which the utilization of organic wastes could be improved through relaxation of regulatory restraints or establishment of incentives

Opportunities may exist to redirect waste application to those kinds of soil which would benefit most from addition of organic wastes. Also, it may be possible to encourage industries, farm operators, or municipalities to increase the reuse of organic wastes for improving soil fertility.

Develop a soil-based fertilizer application system for organic farming practices and wetlands.

Agricutural Good Practices (AGP) certification

It the study it was found that the Katuwana GN and Kiriwaththuduwa GN (Habarakada, Hiripitiya, Pannipitiya, Jampugasmulla, Homagama, Katuwana, Homagama, Mawathagama, Homagama paddy fields and vegetable gardens were not contaminated with heavy metals. However, TC and FC counts were exceeded than the standards given for irrigation and agriculture water and soil. Thus, issuance of the certification is recommended for all agricultural products of the said sites that adopt standardized methods throughout the production cycle of vegetables and paddy from the seed/planting stage up to marketing. The certification must be carried out by an independent partner under guidance of the department of Agriculture.

4.3 RECOMMENDATION FOR FUTURE RESEARCH

Investigate organic farming systems using a holistic approach

Organic recycling and the avoidance or restricted use of chemical fertilizers and pesticides are to be encouraged. It is also likely that these systems are highly complex and involve unknown or poorly understood chemical and microbiological interactions. Much of the research conducted to date that relates to organic farming has been somewhat piecemeal and fragmentary. A holistic research approach, which may involve the development of new methodologies, is needed to thoroughly investigate these interactions and their relationship to organic waste recycling, nutrient availability, crop protection, energy conservation, and environmental quality.

Determine the factors responsible for decreased crop yields during the transition from conventional to organic farming systems

Many farmers report significant decreases in crop yields during the first 3 to 4 years while a rotation is being established following the shift from a conventional (chemical-intensive) to an organic farming system. Part of the problem stems from increased weed infestations, but other unknown factors is also involved. Research is needed to determine the underlying causes of yield reduction and to suggest ways that farmers could make this transition without suffering severe economic loss.

Determine the long-term effects on the productivity of selected soils from recommended applications of chemical fertilizers and pesticides in conventional farming systems

Where current information is inadequate, studies are needed to evaluate the long-term effects of repeated applications of NPK fertilizers and pesticides on the soil organic matter content, the level and activity of soil organisms, soil strength, water infiltration, and root development of crop plants.

Develop new and improved techniques for control of weeds, insects, and plant diseases using biological non-chemical methods. Methods of pest control using parasites, predator insects and other biological methods to eradicate or control unwanted species should be developed. Breeding programs should be implemented to develop crop varieties that are resistant to insect and pathogen attack and that are more competitive against weeds.

Develop through breeding programs crop varieties that are adaptable to organic farming systems

Breeding programs to develop crop varieties that are more efficient in extracting nutrients from the soil and from sources of limited solubility, and under conditions of limited fertility, should be implemented. New and improved varieties of legumes and green manure and cover crops are needed for use in organic as well as combination conventional organic systems.

Protect genetic variability of traditional paddy crops and vegetables

Research and growing of traditional crops and vegetables should be encouraged with intensives within the farming community. It is recommended to maintain a seed bank of traditional paddy seed and other crops.

Expand research on biological nitrogen fixation

Research should be expanded on nitrogen fixation. Special emphasis should be given to nitrogen fixation by non-leguminous crops. Methods of increasing the effectiveness of non-symbiotic nitrogen fixation in soil should be investigated.

5.0 References

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Metals							
21. Total cadmium (Cd)	µg/l, max	5	-	**H** <60 60-120 120-180 >180	**Cd** 0.2 0.8 1.3 1.8	5	-	5
22 .Total chromium (Cr)	µg/l, max	50	-		2	50	-	50
23. Total copper (Cu)	µg/l, max	-	-	**H** <60 60-120 120-180 >180	**Cu** 2 2 3 4	-	-	100
24. Iron (Fe)	µg/l, max	300 des, 1000 max	-		300	200	-	-
25. Lead (Pb)	µg/l, max	50	-	**H** <60 60-120 120-180 >180	**Pb** 1 2 4 7	50	-	50
26. Manganese (Mn)	µg/l, max	1000	1000		1000	1000	1000	1000
27. Mercury (Hg)	µg/l, max	1	1		0.1	1	1	2
28. Nickel (Ni)	µg/l, max	100	100	**H** <60 60-120 120-180 >180	**Ni** 25 65 110 150	100	100	100
29. Selenium (Se)	µg/l, max	10	10		1	10	-	-
30. Zinc (Zn)	µg/l, max	1000	1000		30	1000	1000	1000
31. Boron (B)	µg/l, max	-	-		-	-	500	--
32. Total arsenic (As)	µg/l, max	10	50		50	10	50	50
33. Aluminum (Al)	µg/l, max	200	-		-	200	5	-
Organic Micro Pollutants								
34. Phenol index	µg/l, max	2	5		1	5	5	5
35. Oil and grease	µg/l, max	100	200		10	100	-	300
36. Anionic surfactants (detergent) as MBAS	µg/l, max	200	300		1000	200	1000	1000
37. Total pesticides	µg/l, max	10	30		30	30	50	50
Micro Organisms								
38. Total coliform	MPN/100 ml, (*P=95%)	5000	1000		20,000	5000	1000	-
39. Faecal coliform	MPN/100 ml, (*P=95%)	250 des, 600 max	50		-	-	-	-
40. Parsite cysts and ove	Not given	-						

Annexure I: Proposed ambient water quality standards for inland waters Sri Lanka (CEA,2001)**.**

Parameter	**Unit,**	**CLASS 1 Waters**	**CLASS 11 Waters (Sensitive)**	**Class 111 Waters (General)**

		Drinking water with simple treatment 2	Bathing 3	Fish and aquatic life 4	Drinking water, conventional treatment 5	Irrigation and agriculture 6	Minimum quality other uses
General							
1. Colour (after simple filtration	Pt mg/l, max	20	-	-	100	-	-
2. Total dissolved solids (TDS)	mg/l, max	-	-	-	-	500	-
3. Conductivity	dS/m, max	-	-	-	-	0.7	-
4. Odour	-	unobj	unobj	-	unobj	-	-
5. Taste	-	unobj	-	-	unobj	-	-
6. Turbidity	NTU, max	5	-	-	-	-	-
7. Sodium absorption ratio (SAR)	-	-	-	-	-	15-Jun	-
8. Residual sodium Carbonate (RSC)	meq./l, max	-	-	-	-	1.25	--
9. Total hardness	As CaCo3 mg/l,	250 des, 600 max	-	-	-	-	-
10. pH	-	6.0-8.5	6.0-9.0	6.0-8.5	6.0-9.0	6.0-8.5	5.5-9.0
11. Dissolved Oxygen at 250C	mg/l, min	6	5	3	4	3	3
12. BOD (5 days at 200C or 3 days at 300C)	mg/l, max	3	4	4	5	5	5
Nutrients							
13. COD	mg/l, max	15	20	15	30	-	40
14. Nitrates (NO3 – N)	mg/l, max	5	5	5	5	5	5
15. Total ammonia (NH3-N) - pH <7.5	mg/l, max	-	-	0.94	-	-	9.1
pH= 8.0		-	-	0.59	-	-	4.9
pH= 8.5		-	-	0.22	-	-	1.6
16. Total phosphate (PO4-P)	mg/l, max	0.7	0.7	0.4	0.7	0.7	0.7
Other Substances							
17. Chlorides (Cl)	mg/l,max	200	-	-	200	100	-
18. Cyanides (CN)	mg/l, max	0.005	0.005	0.005	0.005	0.005	0.005
19. Fluorides (F)	mg/l, max	1.5	-	-	1.5	-	-
20. Sulphates (SO4)	mg/l, max	250	-	-	250	1000	--

*n = Natural or baseline values; H = Hardness in terms of $CaCO_3$ in mg/l; des = Desirable highest level; max = Maximum permissible substances; MBAS = Methylene blue active substances; *P=95% = 95% of the samples give a value that is equal to or less than the indicated limit; Mean – during longer period; Min. daily = average of daily waters; prevention of eutrophication, excessive weed growth, may require lower, site specific, for stagnant waters.*