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RESEARCH ARTICLE

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Effect of Water Hyacinth (*Eichhornia crassipes*) Infestation on Selected Surface Water Quality Parameters

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ABSTRACT

Background: Infestation of aquatic weeds indicates surface water pollution, thus questioning its potential use. The present study was aimed to investigate the effect of water hyacinth infestation in surface water in terms of surface cover and morphological characteristics.

Methods: Surface water samples at a depth of less than 30 cm were collected from water hyacinth covered and uncovered sites and analyzed for water quality parameters such pH, TSS, DO, turbidity and EC. Water hyacinth plants were also collected using a 1 m^2 quadrate to investigate the relationship between water quality and weed morphological characters.

Result: The water quality was comparatively low at water hyacinth covered sites than uncovered sites for pH (7.09-7.89), TSS (0.5-1.86), DO (4.15-6.08), turbidity (5.57-25.9) and EC (91-748). Amongst, TSS ($p<0.05$) only showed a significant difference. Hence, morphological characters, leaf length and width were significantly and positively (0.956) correlated to each other. Further turbidity and EC respectively showed positive and negative correlation to leaf length ($r=0.219$, $r=-0.290$) and leaf width ($r=0.194$, $r=-0.257$). Though water hyacinth infestation lowered the water quality, the values were within the tolerance limits for standard surface water. Therefore, the present study concluded that water hyacinth infestation did not degrade the surface water quality intensively and the surface water could be utilized for aquaculture, agriculture or recreational purposes with or without minimal treatment.

Key words: Surface cover, Surface water, Water hyacinth, Water quality.

INTRODUCTION

Water pollution, either surface or groundwater pollution, is also one of the main global environmental issues in Sri Lanka. Surface water bodies such as streams, lakes, ponds and rivers are polluted easily due to several natural and anthropogenic causes and may affect various operations like agriculture, industrial activities, hydropower generation, drinking water supply. Untreated effluent release from industrial operations, poor sanitation, contamination with agrochemicals from agricultural operations and waste disposal from household activities are the well-known causes for water pollution, which creates attention about water quality as it expresses the suitability of water for different applications. Among various causes, the invasion and growth of aquatic weeds are seen as one of the possible means for pollution of surface water and an indicator of water pollution. Sengupta *et al.* (2010) observed alterations in water quality variables, namely dissolved oxygen and phosphorous concentration, in ponds with duckweed growth.

Water hyacinth (*Eichhornia crassipes*) is an invasive species (Villamagna and Murphy, 2010) and causes environmental and social menace in many countries (Wittenberg and Cock, 2001). Due to their prolific growth rate, enormous biomass and larger surface cover of natural water ecosystems (Gupta, 1980), it blocks sunlight, decreasing the photosynthesis rate of aquatic plants (Yan and Guo, 2017; Lekamge *et al.*, 2020). Furthermore, water hyacinth has been reported to degrade the water quality of lakes and rivers (Tobias et al, 2019) and, in turn, causes loss in aquatic lives (Gunaratne *et al.*, 2009). Water hyacinth can alter water clarity and decrease phytoplankton production, dissolved oxygen, nitrogen, phosphorous, heavy metals and concentrations of other pollutants (Villamagna and Murphy, 2010). The pronounced effect of water hyacinth is mostly dealing with enormous dense coverage of water hyacinth in standing water (Lynch *et al.*, 1947). In Sri Lanka, the growth of water hyacinth in surface water bodies has become prominent in recent years, which questions water quality parameters.

On the other hand, the utilization of surface water for human needs and requirements largely depends on water quality parameters. Optimum surface water quality would result in comprehensive breeding sources for fisheries, bathing, agricultural irrigation and even drinking. Lekamge *et al.* (2020) stated that the presence of invaded water hyacinth reduced nitrate concentration in the Anawilundawa

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reservoir located within Ramsar wetland in the northwestern region of Sri Lanka. Since surface water bodies located in South Eastern regions are also heavily infested with this invasive aquatic weed, no scientific reports have been reported in this regard. Therefore, the present study was aimed to investigate the impact of water hyacinth infestation on surface water quality concerning surface coverage and its morphological characters.

MATERIALS AND METHODS

Sampling

Four regional surface water bodies (lakes) where water hyacinth growth is prominent were selected for a sampling of water and aquatic weed (Fig 1). Water samples at two sites, covered and uncovered with water hyacinth in each water body, were collected using Van Dorn horizontal bottle sampler at a depth of less than 30 cm. The field sampling was done during August 2020. Three water samples were collected at each point and filled into the labelled sampling bottles, rinsed with waterbody water prior to sampling. Sampling bottles were closed tightly, preserved in an icebox and immediately transferred to the laboratory for analysis. For a sampling of water hyacinth, 1 m^2 quadrate was used and collected water hyacinth plants were brought to the laboratory for morphological characterization.

Analysis

Water quality testing and morphological characterization were done at Biosystems Engineering Laboratory at Faculty of Technology, South Eastern University of Sri Lanka. Water quality parameters such as electrical conductivity (EC), dissolved oxygen (DO), pH and turbidity were measured using multiparameter (HI9829) and turbidity meter (TL2350), while Total Suspended Solids (TSS) were analyzed by standard procedures (APHA 2017). Prior to analysis, tools were subjected to calibration.

For morphological analysis, prior to characterization water hyacinth plants were washed with tap water to remove sand and dirt particles. The plant morphological parameters such as root length, leaf length and leaf width were measured.

Statistical analysis

Descriptive statistics (Mean, Standard deviation) was done for each variable measured and results were compared with standard values of surface water quality proposed by either Central Environmental Authority (ADB, 2010) or Sri Lankan Standards Limits (as cited by Rajasingham and Sivaruban, 2018) or Environmental Protection Agency (EPA, 2014). Further, independent samples t-test was used to test the significance between surface covered and non-covered mean values. Hence, the data were subjected to a correlation test to predict the relationship between dependent variables (water quality parameters) and independent variables (weed morphological parameters). All the analysis was performed using SPSS (Version 25.0).

RESULTS AND DISCUSSION

Water quality parameters evaluation

Pollution by various means alters the water quality. Table 1 presents the means values of surface water quality parameters concerning water hyacinth coverage in terms of density (no of plants/1 m^2). It indicates that the surface water quality decreased across the water bodies when water hyacinth covers the water surface, the extent of decrease in water quality varied with the degree of surface cover. However, there were no significant differences between water hyacinth coverage and water quality except TSS ($P<0.05$) (Table 1).

Water hyacinth forms a thick mat that blocks sunlight, decreases contact with air and reduces water quality in terms of DO. Higher water hyacinth coverage decreased the DO

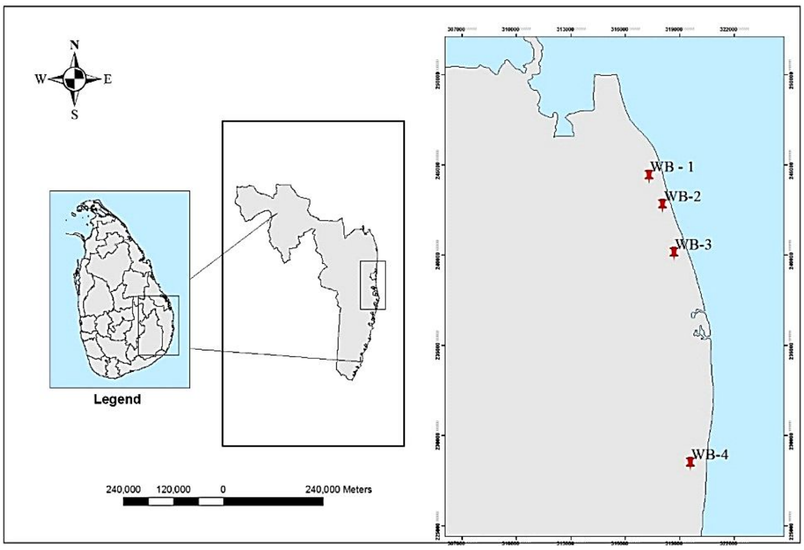

Fig 1: Four regional surface water bodies for a sampling of water and aquatic weed.

Table 1: Descriptive statistics for water quality parameters across selected surface water bodies.

Water bodies	Surface coverage	Dense of water hyacinth (No of plants/m^2)	Water quality parameters				
			DO (ppm)	EC μs/Cm	pH	Turbidity (NTU)	TSS (ppm)
Water body 1 (WB1)	Uncovered	-	7.40±0.02	197±1.12	7.59±0.34	19.5±2.35	31.2±1.23
	Covered	85	5.04±0.91	91±2.42	7.31±0.21	12.3±6.25	1.06±0.12
Water body 2 (WB2)	Uncovered	-	7.54±0.07	1048±2.64	7.42± 0.14	3.76±2.89	27±1.95
	Covered	56	5.32±0.07	748±1.54	7.18±0.54	7.6±4.38	1.55±0.35
Water body 3 (WB3)	Uncovered	-	7.13±0.09	323±1.98	7.91±0.24	5.7±1.26	14±2.01
	Covered	43	6.08±0.10	115.5±2.01	7.89±0.35	5.57 ±4.21	0.5±0.61
Water body 4 (WB4)	Uncovered	-	6.93±0.10	104±2.05	7.47± 0.15	28.7±8.52	44±1. 75
	Covered	97	4.15± 0.96	301±1.85	7.09± 0.11	25.9±7.16	1.86±0.38
P values			P>0.05 (0.106)	P>0.05 (0.621)	P>0.05 (0.366)	P>0.05 (0.106)	P<0.05 (0.038)

Table 2: Descriptive statistics for morphological parameters of water hyacinth across selected surface water bodies.

	No of plants/1 m^2	Leaf length	Leaf width	Root length
WB1	85	10.695±1.50	9.715±1.26	16.11±7.03
WB2	46	10.91±2.66	9.56±2.21	4.56±1.9
WB3	53	10.93±0.95	10.17±0.65	9.56±3.84
WB4	97	10.17±0.65	9.56±3.84	9.715±1.26

values more than lesser coverage. This is in line with Wang *et al.* (2013), who mentioned that DO of water bodies could be reached to a low level (2.3 mg/l) at full coverage of water hyacinth. Similarly, depletion in DO associated with aquatic weeds coverage was observed by several researchers (Sengupta *et al.*, 2010; Troutman *et al*, 2007; Toft *et al.,* 2003; McVea and Boyd, 1975; Lynch *et al.* 1947). Furthermore, regardless of surface cover, DO values were higher than the tolerance level (4 mg/l) for standard surface water (SLS institute, 1985; Rajasingham and Sivaruban, 2018). Hence, reductions of DO may vary spatially, depending on hydrology and water exchange characteristics (Yan and Guo, 2017).

When considering the other two water quality parameters, EC and TSS, the mean values were generally lower when water hyacinth covers the water surface due to its inherent characteristics of the high absorption of nutrients and pollutants. The extent of reduction in TSS was found to be more at greater water hyacinth coverage and variation in mean values of TSS values at two sites; surface covered and uncovered was significant ($p<0.05$). Meanwhile, no distinct pattern for change in EC was observed with surface coverage. The observed EC values (91-1048 μS/cm) were lesser than the standard limit for surface water (1275 μS/cm) regardless of surface coverage (Rajasingham and Sivaruban, 2018). Meybeck and Helmer (1996) stated that conductivity might exceed 1000 μS/cm when water polluted. Hence, it was observed that the conductivity increased to 2850 mS/ cm when the growth of water hyacinth stopped (Yan *et al*, 1994).

Concerning turbidity, it is ranged from 5.57-25.9, where water hyacinth covered the water surface and ranged from 3.76-28.7 NTU whereas no surface coverage is present. Like other quality parameters, water hyacinth coverage decreased the turbidity values; however, higher surface cover (dense) higher the turbidity values. The study results follow Nguyen *et al.* (2015), who also noted lesser values for turbidities when water hyacinth was present.

Water hyacinth growing in acidic or alkaline water can gradually alter pH to neutral (Yan and Guo, 2017). However, the pH values obtained in the study ranged from near neutral to slightly alkaline. Water hyacinth coverage decreased pH values. Lesser coverage allows much light to penetrate the water bodies and increase the photosynthesis of aquatic plants, increasing pH. Whatever, the observed pH values were found to be within the standard limit (6.5-8.5) for surface water (ADB, 2010; Rajasingham and Sivaruban, 2018). Similarly, a higher pH (7.8-8.5) was observed in the uncovered lagoon than the water hyacinth lagoon during the day due to the algal photosynthesis, while during the night, pH values descended to less than 7 (Giraldo and Garzon, 2002).

Morphological parameter evaluation

The observed variation in water quality parameters between covered and uncovered cites in water bodies was expected to be because of morphological characters of water hyacinth. The mean values for morphological variables of water hyacinth plants across the studied water bodies are shown in Table 2. From this, it was clear that the variation in morphological variables across the water bodies is not solely dependent on plant density. In addition, other environmental factors like rainfall, temperature, light, nutrient availability that influence the growth of water hyacinth also might result in variation in these morphological variables.

Table 3: Pearson correlation coefficients between surface water quality and morphological parameters of water hyacinth.

Variables	Leaf length	Leaf width	Root length	Turbidity	DO	EC	pH	TSS
Leaf length	1	.956**	0.015	.219*	0.055	-.290**	-0.015	-0.140
Leaf width		1	0.021	.194*	0.050	-.257**	-0.048	-0.102
Root length			1	-0.019	0.125	-0.102	0.038	0.004
Turbidity				1	-.540**	-.567**	-.432**	-0.095
DO					1	-.383**	.613**	-.478**
EC						1	-0.168	.606**
pH							1	-.559**
TSS								1

Furthermore, the results of correlation analysis performed to identify the possible relationship between dependent (water quality) and independent (morphological) variables are shown in Table 3. It indicates that the morphological variables are positively highly correlated while the correlation with water quality parameters was less. The leaf length and leaf width showed a higher correlation (0.956) and these two variables showed less correlation with root length. Hence, all three variables showed a positive correlation for DO, whereas only root length showed a positive correlation for the water quality parameter, especially pH and TSS. This could be a possible reason for the higher mean values observed for water quality parameters at lesser plant density (coverage).

Nevertheless, these correlations were non-significant. Sengupta *et al.* (2010) observed a positive correlation for DO and pH with morphological variables of leaf length, leaf width and root length of duckweed. On the other hand, the water quality parameters except for turbidity and DO negatively correlate with leaf width and length. Since root length is being high comparatively at higher plant dense (coverage) conditions, this could result in more lowered values of turbidity and EC.

Conclusion and Future Prospects

Proliferated growth of invasive aquatic weed; water hyacinth is seen as an indication of pollution of surface water bodies located in South Eastern regions of Sri Lanka and expected to alter the water quality, which may threaten the aquatic life biodiversity and other functional purposes of surface water. However, from the study results, it could be concluded that water hyacinth infestation does not worsen the water quality and make the water hyacinth infested surface water potential to be utilized for various purposes like agriculture or recreation with or without minimal treatment processes. Hence, this study lacks information on the nutrient and heavy metal content of surface water infested with water hyacinth, which would impact water quality for other purposes. Therefore, to assure the potential use of water hyacinth infested water, the particular study has to be explored more in the future in this regard.

Conflict of interest: None.

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