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THE INFLUENCE OF ANTHROPOGENIC ACTIVITIES ON SOIL CHARACTERISTICS: A CASE STUDY FROM BELLANWILA-ATTIDIYA WETLAND

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ABSTRACT

This study demonstrates how anthropogenic activities have influenced the physical and chemical properties of soil in an urban setting. Properties of soils in Bellanwila – Attidiya Sanctuary, an urban wetland situated close to Colombo, were compared with that of adjacent areas under human influence. Selected physical parameters of soil (wet soil color, percentage of clay, moisture content, electrical conductivity and soil pH) were analyzed using standard methods. Soils of the sanctuary exhibited typical wetland properties. Except for pH and phosphates, all other parameters were significantly different in anthropogenic habitats. To ensure healthy functioning of the wetland, it is of vital importance to stop or at least minimize any unsustainable activities that includes pollution, encroachment and habitat destruction in the adjacent areas by adopting sound conservation practices.

Key words: *Anthropogenic activities, Soil characteristics, Bellanwila-Attidiya Wetland, habitats.*

INTRODUCTION

Wetlands are amongst the world's most productive ecosystems where a unique combination of water, soil and biodiversity exist (IUCN, 2004). Due to favorable topographic and climatic conditions, Sri Lanka supports a wide array of wetlands which possess various ecological functions and values (Kotagama and Bambaradeniya, 2006; Atapattu *et al.*, 2009). Attempts to understand the physic- chemical and biological interactions in wetlands often focus on different biota (Johnson, 2006) and less attention is given to one of its major components, the soil. Physical and chemical properties of soils act as major ecological factors of wetlands that greatly influence the productivity of the ecosystem (Mitsch and Gosselink, 2000).

The study of wetland soils is vital as they are often subject to various influences of urban activities and land use practices (Grunwald *et al.*, 2006). The ecological functions of wetlands partially depend on external factors which includes materials transport from outside (Maiti, 2012). Despite the expansion population and developmental pressure on urban wetlands, a few studies have been published on soils, and lack of the information, causes escalating degradation and loss of potential of the resource.

The objectives of this study were to investigate the contents of selected soil quality parameters in Bellenwila Attidiya Wetland, a protected area (sanctuary) in the outskirts of Colombo city which is under immense developmental pressure. We hypothesized that the soil quality in the sanctuary is under minimal anthropogenic disturbances. To investigate the impacts of manmade alternations, the soils of adjacent areas under different land use practices too were studied and compared with that of wetland soils.

MATERIALS AND METHODS

Study Area

This study was carried out in Bellanwila-Attidiya wetland which is located in east of Attidiya, between 6° 52' N and 79° 52' E to 6° 48' N and 79° 56' E; 759157 N and 374779 E to 751770 N and 382129 E in Colombo District, Western Province. This wetland is consisted of complex of shallow fresh water ponds,

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marshes and seasonally flooded grasslands. The total area of marshes in the wetland is about 372 hectares (Cooray *et al.*, 2012). A part of this wetland has been declared as a sanctuary because of its high biodiversity richness. However, since this wetland is located in a rapidly developing urban landscape, it has experienced severe disturbance in past few decades. Some of its landscape has been converted to areas with high anthropogenic interactions *i.e.* human settlements, agricultural areas (paddy fields and small scale crop lands) and industrial areas as shown in Figure 01. Thus, this location is best suited to investigate the impacts of anthropogenic activities on soil quality of a landscape.

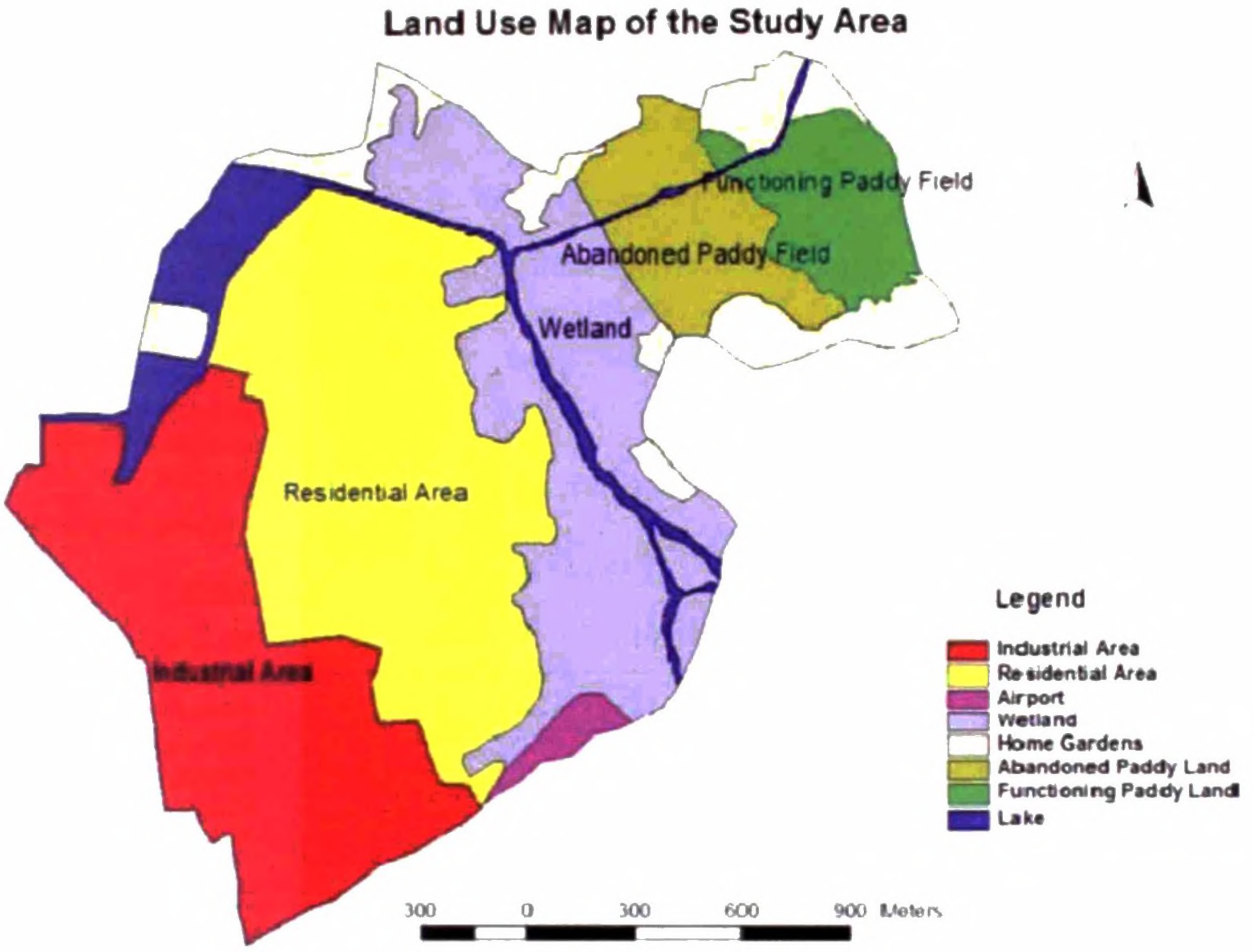

Figure 1 : Land use map of the Bellanwila-Attidiya area (natural wetland indicated in purple)

METHODOLOGY

Six sampling locations were selected starting from the Boralesgamuwa Lake towards the sanctuary representing different land use practices. The first three sites (sampling locations 1, 2 and 3) were chosen from outside the sanctuary where the land is under high anthropogenic activities due to industries (garments, motor mechanics, chemical *etc*) and human habitation. The remaining locations (4,5 and 6) were within the sanctuary and represented natural habitats that are characteristic to a wetland. Six soil samples were collected from each location using a manual soil borer. Soil was removed from the surface (top soil) to a depth of 1.25 m, at the intervals of 25 cm (surface layer, 0.25m, 0.50m, 0.75m, 1m and 1.25m). Sampling was duplicated at each site. Soils were then taken in plastic bags to the laboratory analysis. Selected physical parameters of soil were analysed using standard methods: percentage of clay, moisture content, wet soil color, pH and (EC). Standard pipette method was used to measure the clay % (content) and gravimetric method was used to detect moisture % (content) (Maiti, 2012). Soil pH was measured, dipping the pH meter in a 1:2 soil- water suspension. EC and wet colour of soil were measured by portable salinity/ conductivity meter and standard soil color chart (Munsell) respectively (Black, 1965).Concentrations of phosphates and nitrates were detected in soils at 0.5 m depth only using UV visible Spectrophotometry (Clesceri *et al.* 1999).

One –Way Analysis of Variance (ANOVA) and Tukey's test (as a multiple comparison method) were carried out to find out whether the measured physical parameters of soil were significantly different between natural habitat and anthropogenic habitats in Bellanwila – Attidiya Wetland.

RESULTS AND DISCUSSION

The analysis revealed that soils that have been sampled from the natural habitat represent typical wetland soil. The colour of wet soil from the wetland were more blackish (10YR 2/1, 10YR 2/2) than in other sites (Table: 1). Soils from anthropogenic habitats were lighter in colour and many of them could be best described as shades of brown and grey (5YR 6/2, 7.5YR 4/3, 7.5YR 3/4, 10YR 6/3, 10YR 3/2, 10YR 5/6). As Browne *et al.*, have stated in 1995, when wetland soil contains more organic matter it is called "wetland organic soil" and it can be easily recognized by its black or dark brown colour (10YR 2/1, 10YR 2/2, 7.5YR 2.5/2).

Therefore, as one expects, the wetland soils were of natural conditions. In addition, soils obtained from different strata of the wetland were not very different from each other in colour, indicating a higher degree of coherence. On the contrary, the colours of soil varied in areas under human influence.

Table 1: Wet soil colour in all sampling locations

Depth (m)	Sampling location					
	Anthropogenic habitats			Natural habitats		
	1	2	3	4	5	6
Surface (a)	Very dark greyish brown	Dark brown	Pale brown	Brownish black	Brownish black	Brownish black
0.25 (b)	Dark brown	Dark greyish brown	Pale brown	Black	Brownish black	Brownish black
0.5 (c)	Pinkish grey	Dark greyish brown	Very pale brown	Black	Brownish black	Black
0.75 (d)	Pinkish grey	Brown	Greyish brown	Black	Brownish black	Black
1.0 (e)	Pale brown	Brown	Dark greyish brown	Black	Brownish Black	Black
1.25 (f)	Pale brown	Yellowish brown	Grey	Black	Black	Black

Source: Munsell Soil Colour Chart (a) surface soil layer, (b) 0.25m depth (c) 0.5m depth (d) o.75m depth (e) 1m depth (f) 1.25 depth

Except for pH, all other parameters measured showed a significant difference between anthropogenic and natural habitats (One way ANOVA; $P \leq 0.05$). Moreover, clay % showed an increase vertically (Table 2) in each sampling location, but a similar pattern was not evident for the results of moisture % and electrical conductivity (Table: 3 and 4).

As one might expect, soil in the sanctuary contained higher percentage of clay and moisture when compared to the altered habitats. This was further proved by the soil triangle which was developed using data obtained, where it showed from outside to inside of sanctuary that the soil has become more clay in texture. The reason for recording less clay % in anthropogenic habitats might be due to the accelerated erosion rates resulting from developmental activities. According to the Street *et al.* in 2005, having high clay amount and moisture content is a characteristic property of typical wetland soil.

Table 2: Mean± SD of percentage of clay content Denotes

Depth (m)	Sampling location					
	Percentage of clay content					
	Anthropogenic habitats			Natural habitats		
	1	2	3	4	5	6
Surface (a)	20.85 ±0.21	19.95 ±1.29	25.85 ±0.24	67.05 ±1.56	42.6 ±0.38	70.88 ±0.33
0.25 (b)	18.1 ±0.85	17.3 ±0.31	29.5 ±0.68	43.15 ±0.08	63.7 ±0.99	67.35 ±0.92
0.5 (c)	54.65 ±0.64	30.5 ±0.89	71.1 ±0.18	80.2 ±0.42	94.15 ±0.74	77.12 ±0.66
0.75 (d)	55.85 ±0.64	64.3 ±0.59	49.85 ±2.60	48.35 ±0.83	44.5 ±0.4	74.63 ±0.49
1.0 (e)	52.65 ±0.91	76.35 ±0.48	40.65 ±1.39	56 ±0.78	52.8 ±0.18	64.71 ±0.54
1.25 (f)	52.65 ±0.62	62.15 ±0.86	66.85 ±0.41	69.65 ±0.52	91.45 ±0.82	92.11 ±1.32
Average	42.46 ±17.87	45.10 ±25.53	42.3 ±18.85	60.73 ±20.1	64.87 ±31.26	74.47 ±13.88

Table 3: Mean± SD of Percentage of moisture content

Depth	Sampling location					
	Percentage of moisture content					
	Anthropogenic habitats			Natural habitats		
	1	2	3	4	5	6
Surface (a)	68.86 ±4.74	53.13 ±3.14	55.85 ±3.22	50.83 ±4.17	54.72 ±3.23	86.16 ±4.09
0.25 (b)	28.78 ±1.92	49.16 ±2.77	49.57 ±3.73	57.55 ±2.74	55.73 ±4.01	82.08 ±2.72
0.5 (c)	28.9 ±3.46	37.69 ±1.99	32.49 ±3.25	58.12 ±2.98	59.08 ±8.34	69.92 ±2.98
0.75 (d)	32.89 ±3.93	34.75 ±2.63	43.6 ±2.31	61.13 ±4.13	61.18 ±1.99	69.64 ±3.75
1.0 (e)	29.55 ±1.99	37.37 ±3.54	45.14 ±4.55	61.28 ±4.89	62.96 ±2.90	65.76 ±1.67
1.25 (f)	34.76 ±2.94	37.04 ±4.41	45.33 ±4.47	63.83 ±2.31	64.35 ±3.51	66.41 ±2.38
Average	37.79 ±17.45	41.523 ±7.63	45.33 ±7.70	58.79 ±4.53	59.67 ±3.88	73.33 ±8.62

Table 4: Mean± SD of Electrical Conductivity (EC)

Depth (m)	Sampling location – Electrical Conductivity (EC) (µS)					
	Anthropogenic habitats			Natural habitats		
	1	2	3	4	5	6
Surface (a)	756 ±9.9	975 ±11.31	1056 ±15.56	357 ±15.66	2600 ±31.11	4030 ±7.17
0.25 (b)	355 ±2.83	1010 ±9.9	1169 ±9.89	680 ±14.14	800 ±18.38	3330 ±11.31
0.5 (c)	279 ±15.56	476 ±4.25	317 ±7.71	439 ±1.41	1030 ±9.98	2160 ±8.52
0.75 (d)	215 ±7.07	472 ±7.07	385 ±4.24	282 ±11.31	1190 ±5.66	3350 ±14.42
1.0 (e)	205 ±7.07	445 ±8.49	452 ±8.46	188 ±5.66	1520 ±9.94	2780 ±12.27
1.25 (f)	131 ±12.73	393 ±7.07	330 ±16.97	134 ±5.78	1650 ±8.85	3570 ±11.37
Average	323.5 ±224.99	628.5 ±283.72	618.17 ±387.51	346.67 ±197.14	1465 ±637.58	3203.33 ±651.63

One salient feature in this wetland is high values of Electrical Conductivity (EC). Even though this habitat is not very close to the sea, saline water intrusion might be the reason for this. Piyadasa and Chandrasekera (2010), reported elevated levels of salinity in the Bolgoda Lake which is connected to the surface channel network of Bellanwila – Attidiya Wetland which might have transported salts to the wetland.

Soil pH did not exhibit any particular pattern (Table: 5).The lowest average pH value was recorded in the sampling location 4, whereas highest value was given by the location 5. However, all the sampling locations showed soil pH in the acidic range which is a characteristic feature of wetland soil (Street *et al.*, 2005). Only nitrate concentrations were significantly higher (ANOVA, $p \leq 0.5$) in anthropogenic habitats than in the wetland (Table 6). Lower nitrate levels in the wetland could be due to anaerobic bacterial reactions that could lead to denitrification in the waterlogged soil (Campbell *et al.*, 2002).

Table 5: Mean± SD of soil pH

Depth (m)	Sampling location – Soil pH					
	Anthropogenic habitats			Natural habitats		
	1	2	3	4	5	6
Surface (a)	4.88 ±0.31	5.47 ±0.23	5.4 ±0.24	4.3 ±0.27	6.38 ±0.79	5.21 ±0.64
0.25 (b)	4.95 ±0.4	5.69 ±0.34	5.36 ±0.49	4.31 ±0.42	6.33 ±0.49	5.25 ±0.71
0.5 (c)	4.96 ±0.04	5.68 ±0.06	5.39 ±0.38	4.47 ±0.74	6.37 ±0.95	5.27 ±0.30
0.75 (d)	5.08 ±0.10	5.42 ±0.11	5.54 ±0.34	4.97 ±0.58	6.39 ±0.68	5.23 ±0.82
1.0 (e)	5.05 ±0.23	5.29 ±0.40	5.65 ±1.07	4.87 ±1.19	6.4 ±0.48	6.38 ±0.37
1.25 (f)	5.06 ±0.23	5.22 ±0.30	5.72 ±0.69	5.07 ±0.41	6.4 ±0.21	6.4 ±0.33
Average	5.00 ±0.08	5.46 ±0.19	5.51 ±0.15	4.67 ±0.35	6.38 ±0.03	5.62 ±0.59

Table 6: Mean± SD of soil nitrates and phosphates

Parameter	Sampling location					
	Anthropogenic habitats			Natural habitats		
	1	2	3	4	5	6
[NO3-] (ppm)	0.93±0.23	0.37±0.08	1.1±0.08	0.17±0.10	0.32±0.34	0.11±0.37
[PO4 3-] (ppm)	1.06 ±0.23	3.65 ±1.07	2.97 ±0.58	2.38 ±0.03	2.4 ±0.33	1.39 ±0.68

This condition warrants special attention of the environmentalists and policy makers to combat degradation of quality of wetland soils since these habitats are sensitive to changes. To ensure healthy functioning of the wetland, it is of vital importance to stop or at least minimize any unsustainable activity that includes land use changes, cleaning of vegetation and habitat destruction, pollution from waste water as well as from solid wastes in the adjacent areas by, for example, creating buffer zones. The interest in the policy makers in the restoration of natural ecosystems including wetlands has grown steadily during the past few years. While conservation of wetlands is a key to environmental health, there is a growing awareness that restoration, creation, and enhancement of wetland habitats are essential in sustainable development of urban landscapes. Thus, it is of vital importance to develop conservation management plans ensuring healthy functioning of wetlands, while benefiting the social and economic needs of the society.

CONCLUSION

The results of the present study indicate that although the soils of the wetland represent natural conditions, adjacent areas with different degrees of human influences possess soils with altered chemical and physical compositions. If the present trend of increasing anthropogenic pressure on wetlands continue and alter soil properties, the services and values of wetlands could be adversely affected. Thus, it is essential to establish programmes to manage wetland degradation to ensure their healthy functioning.

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