A STUDY TO IDENTIFY THE SOIL CHARACTERISTICS OF WETLANDS IN COLOMBO, SRI LANKA

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ABSTRACT

Over the past decades, the wetlands in Metropolitan Colombo have been influenced by a number of anthropogenic impacts and unauthorized activities. Many of these activities have altered the soil properties and consequently changed the overall functioning of many wetland systems. This study analysed 200 soil samples to identify the similarities and differences among the soil characteristics in each type of wetland in Colombo area for understanding their function and how they influence the ecology, hydrology and ecosystem services. Soil samples were collected from the wetlands, paddy lands and marshy lands using stratified sampling approach to identify six soil parameters including soil moisture, pH value, electrical conductivity, sand content, soil colour and organic matter content through field investigations and laboratory tests. Each Soil parameter and its spatial distribution over different wetlands was analysed applying GIS tool. Pearson correlation analysis and simple linear regression analysis were ascertained the significant relationship among pH value, electrical conductivity, sand content and moisture content. Principal component analysis discovered driving parameters of soil samples as electrical conductivity, moisture content and sand content making a differentiation with pH values. This analysis clearly divided all wetlands and paddy lands in to three clusters. Clearance of wetland boundary, empowerment of rules and regulations towards the wetland conservation, avoiding illegal encroachment and disposing of petroleum pollutants can be considered as part of wetland management strategies

***Key words*:** Linear regression, Principal component analysis, Spatial distribution

1. INTRODUCTION

When evaluating land for the presence or absence of wetlands, the existing soil conditions are a source of considerable information [1]. Soil characteristics indicate the wetland hydrology for sites that have a predominance of wetland vegetation but lack visible evidence of water at or near the surface [2]. A soil can be described as an independent body having specific properties and morphological characteristics that can be used to differentiate it from adjacent soil types [1, 3]. The properties and characteristics of each soil type are influenced by such soil forming factors as climate, parent material, time, topography and living organisms [1]. Conservation of wetlands of Metropolitan Colombo is a current requirement in order to enhance the natural functioning process of the environment and hydrology system [4]. Investigation of physical characteristics of soil is essential to identify common features of soil distribution in wetlands and paddy lands located in Metro Colombo Urban area in order to understand their function and how they influence the ecology, hydrology and ecosystem services and to identify the level of human intervention and the implications for the future management of the wetlands.

2. METHODOLOGY

The stratified sampling approach was adopted for selecting sample locations for the soil survey of this study. The relatively homogeneous areas were selected based on the differences in elevation/topography, vegetation and landform of the area. Soil investigations were undertaken through the application of a rapid field assessment technique using a hand-held auger. Consequently the emphasis was on understanding how the soils vary across the individual wetland areas rather than on satisfying the prescribed number of survey locations per hectare. Transects were walked across the boundaries of the different habitat types with hand-augured profiles. The study has covered representative wetland areas, marshy lands and paddy land areas. Investigations did not cover areas where the soils were clearly heavily disturbed or in filled. Throughout the wetlands, paddy land and other marshy lands 200 soil samples were collected from Kotte, Heen Ela, Kolonnawa,

Beddagana, Thalawathugoda park, Diyathauyana, Thalangama and Thalawathogoda

For each representative soil profile description, six parameters were recorded using field observations and laboratory test analyses which include soil moisture, pH, electrical conductivity, sand content, soil colour and organic matter content of soil. Soil moisture determines the percentage of water in a sample by drying the sample to a constant weight. Soil pH value in water was measured using a glass electrode pH meter at 1 : 2.5 , soil : water ratio. Electrical conductivity value was measured by using multi-parameter at 1 : 2.5 soil : water ratio. The soil samples were air-dried for 48 hours and crushed to pass through a 2 mm sieve and sand content was examined in each soil sample as a percentage value and balance percentage was the component of species particles. Organic matter content of each soil sample was recorded at field by comparing level of the composition of species particles by identifying through the colour and composed level as an approximated percentage value range. Accordingly the level of organic matter content was categorized in to three categories as high (60%-100%) moderate (40%-60%) and low (less than 40%). Matrix colour and Mottle colour of soil was tested considering soil samples from the top layer in depth of 0 to 20 cm and 20 - 40 cm. Soil colour was determined using the Munsell soil colour chart. Arc GIS 10.2 software was used to indicate spatial variation and distribution of each analyzed parameters in relation to different wetland areas and paddy feilds. Pearson correlation analysis was conducted to ascertain whether the relationship between two continuous soil parameters is linear or not. Simple linear regression analysis was formed to identify the association between correlated soil parameters. Finally principle component analysis was applied to understand driving soil parameters and their differences.

3. RESULTS

For the soil taxonomy the moisture availability can define the main characteristics in different land use patterns in wetlands [5]. The highest moisture content was recorded in the Heen Ela Marsh and Kotte wetland areas, with values 70% to 88%. The lowest moisture content was recorded in the Thalawathugoda paddy lands and Diyatha reclamation area with values 42% to 55%. After harvesting, most of the paddy landsare without the crop covers allowing increased evaporation of the soil water. Therefore, the moisture percentages of soils of paddy land and Diyatha reclamation area are relatively lower than moisture content of other wetland areas. Standard deviation value of the minimum moisture percentage values is 11.23% and most of the data lie between 47-70 %. Standard deviation value of the maximum moisture percentage values is 13.33% and most of the data lie between 54-81 %. Standard deviation value of the all moisture percentage values is 12.69% and most of the data lie between 50-76 %. So the distribution of moisture value can be concluded that differences between the minimum and maximum moisture contents are not fairly significant. More than 10% difference in between minimum and maximum percentages of moisture values were observed in the Heen Ela, Kotte and Baddegana wetland areas. Diyatha, Thalangama and Thalawathugoda paddy land areas are recorded low moisture differences in between minimum and maximum.

pH value is a measure which used to identify the level of acidity and alkalinity of soil. pH values between 2.5 and 4.5 were recorded at Baddegama, Kollonnawa, Thalawatugoda, Heen Ela and Kotte areas. These values are considered to represent relatively high acidity levels which are significant in most of the wetland areas generally. Thalangama paddy and Thalawathugoda paddy indicate the pH values 5.5 to 5.9 and Kolonnawa and Kotte wetlands shows pH value 3.5 to 4.5. Thalangama Paddy land and Thalawatugoda paddy land show low electrical conductivity level from minimum of 725 µs/cm to maximum of 900µs/cm. Baddagana, Heen Ela and Kotte Wetlands indicate high electrical conductivity level in between minimum of 2100 µs/cm to maximum of 4300µs/cm. Kolonnawa Marsh has 1000-2000 µs/cm electrical conductivity level. Baddagana wetland has comparatively high electricity conductivity level and relatively low pH. The relationship between pH value and electrical conductivity is negative strong and (Pearson correlation coefficient value as: r = -0.685) this association can be shown by eq. (01).

$$pH = 4.99-0.0004*EC\ (\mu s/cm) \quad (01)$$

The soils of Kolonnawa, Thalawatugoda and Diyatha wetland areas indicate comparatively high percentage of sand, with values commonly between 10-20%. There is a very low sand content (2-6%) in Heen Ela wetland, Kotte wetland, Thalangama Paddy and Thalawathugoda paddy areas while Baddagana wetland is recording lowest sand content. The soils samples taken from these areas at field were observed

more silt and clay in content from 90-92% being the balance 2-8% comprising with organic materials. So it can be concluded that these areas clearly show high clay or silt or silt clay condition in soil. The relationship between soil moisture content and sand content is negative strong (Pearson correlation coefficient: r= -0.679) and associating can be shown by eq. (02).

Moisture (%) = 75.001-1.175*Sand (%) (02)

There is a very strong positive linear relationship between soil moisture content and electrical conductivity indicating Pearson correlation coefficient value as r = 0.764. Equation of the regression model can be expressed by eq. (03).

EC= - 3963.8 + 102.38* Moisture (%) (03)

The color of a soil and its location within the soil profile can indicate the conditions under which the soil developed [6]. The colors of various soil components are often the most diagnostic indicator of hydric soils. Colors of these components are strongly influenced by the frequency and duration of soil saturation, which leads to reducing soil conditions [5]. Soil colour is a very important parameter in order to have an idea about the soil mineral composition, soil processes and hydrology. Soil colour was analysed as Matrix Colour and Mottele colour. 70-100% of soil samples were taken in 0-20cm depth of top layer and more than 90% of soil samples were taken in 20-40cm depth of top layer from Baddagana, Diyatha Uyana, Heen Ela, Kotte wetlands, Thalnagama paddy and Thalawathugoda paddy areas indicated very dark brown (7.5YR2.5/3) matrix colour. Mottle colour of 75% of soil samples taken from first 0-20 cm of Baddagana wetland, Diyatha uyana and Heen Ela marsh indicate colour of dark yellowish brown. Kotte marsh and Kollonnawa marsh is shown dark yellowish brown mottle colour in soil taken from second layer of 20-40cm.

Soils can be categorized based on their organic matter content [1, 6, 7]. Certain soils have very little organic matter content (mineral soils), while other soils are primarily composed of organic matter (organic soils). Specifically, organic soils have 20 to 30 percent organic matter (depending on the soil texture) for soils which have been saturated for prolonged periods and more than 34 percent organic matter for soils never saturated with water for more than a few days. More than 50% of the soil samples taken from first 20cm of surface layer and second layer of 20-40 cm of Beddagana marsh, Diyatha Uyana, Thalawathugoda paddy and Kotte marsh areas have high organic matter content being balance 50% is indicating moderate level of organic matter content. Figure 1 shows the spatial distribution of moisture content, sand content, electrical conductivity and pH value by emphasizing the different wetlands soil characteristics and its distribution

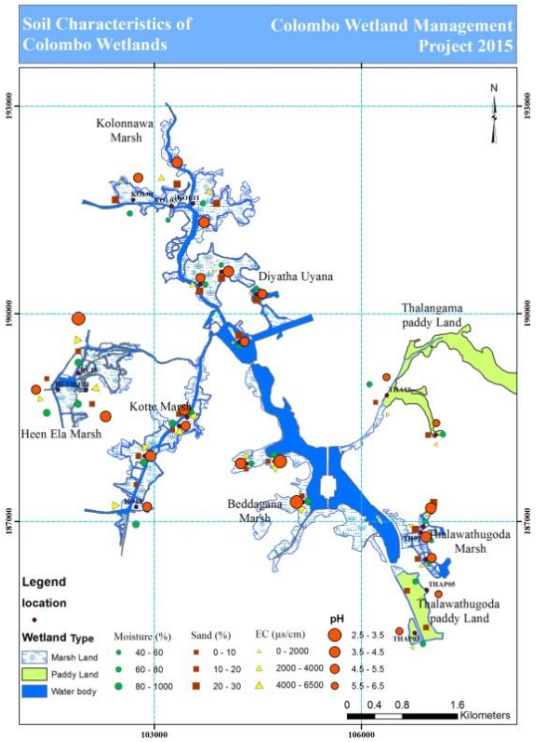

Figure 1: Spatial Distribution of Soil Characteristics of Colombo Wetlands

Moisture content, sand content, electrical conductivity and pH value are the parameter used for principal component analysis. Principal component analysis groups parameters with similar characteristics into two factors which has Eigen values 2.4 and 1.19 respectively. Electrical conductivity value (36%:0.9:0.8), Moisture content (32%:0.9:0.8) and sand content in soils (20%:-0.7:0.5) have been loaded into factor one and pH value (56%:0.8:0.67) has been loaded to factor 2 based on the contribution percentage of parameters to each factor, correlation values between parameters and factors and squared cosines of the parameters respectively. Principal component analysis facilitated to identified driving parameters of soil samples as electrical conductivity value, moisture content and sand content in soils which have similar features and characteristics with differentiation from pH values of the same soil samples.

4. CONCLUSION

All wetlands and paddy lands under this study can be divided in to three clusters. Accordingly Kolonnawa marsh, Thalawatugoda park and Diyatha Uyana areas can be identified as wetland areas which have similar physical characteristics of moisture content around 45-60%, pH value from 3.5 to 4.7, Electrical conductivity in between 1100 to 2100 µs/cm, sand content around 20-25%, major matrix soil colour is being very dark brown, moderate level (40-60%) of organic matter content and comparatively significant human interventions. Kotte marsh, Heen Ela marsh and Baddegana marsh can be identified as wetland areas which have similar physical characteristics of moisture content around 66-88%, pH value from 2.5 to 4.3, Electrical conductivity in between 2200 to 4200 µs/cm, sand content in range of 2 - 6 %, major matrix soil colour is being very dark brown colour, major mottle soil colour is being dark yellowish brown and moderate level of organic matter content in Baddegana marsh and Kotte marsh being high level of organic matter content in Heen Ela marsh. Findings of field observation were evidenced to reveal that Kotte and Hee Ela marsh areas are interconnected with main cannel networks in the area comprising with comparatively low human interventions. Baddagana marsh is interconnected with Diyawanna Lake and significant human intervention activities such as illegal human settlement encroachments and constructions can be observed. Third cluster comprises with Thalangama and Thalawathugoda paddy lands which have similar physical characteristics of moisture content around 60-62%, pH value in 5.5 to 5.9, Electrical conductivity in between 725 to 900 µs/cm, sand content as 4-8 %, major matrix soil colour of very dark brown, mottle soil colour is being vary from dark yellowish brown, yellowish brown, very dark brown and very dark greyish brown and low level of organic matter content. Thalangama and Thalawathugoda paddy lands have been cultivated with successful paddy cultivation

Clearance of wetland boundary of Kolonnawa marsh, Kotte marsh, Heen Ela marsh and Baddegana marsh is essential as prior action for wetland conservation. Empowerment of rules and regulations by doing necessary amendments for the existing ordinances and guidelines is a current need in order to avoid illegal human settlement encroachment and solid waste disposal. An attention should be paid for Kollonnawa Marsh to control the soil pollution due to petroleum pollutants discharged by Kollonnawa Oil Refinery Industry. Model Biodiversity Park currently practiced in Baddegana Marsh can be applied in other selected marsh area as a successful wetland management strategy. Main cannel networks should be rehabilitated to enhance the smooth flow of rain water that caused to remove sediments and other debris from wetlands to sea via main cannel networks. These strategies should be implemented and monitored to enhance the environment sustainability of wetlands in Colombo

5. REFERENCES

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