Research Article

The impact of anthropogenic activities on the physicochemical characteristics of Cheleleka peat, Ethiopia

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Abstract
Cheleleka peatland is located at the eastern side of Lake Hawassa and its biological communities face a variety of anthropogenic factors such as agricultural expansion, water diversion, settlement and subsequent peatland drainage and peat extraction. The decomposing products were influenced by various anthropogenic activities. This study aims to identify the impact of human activities on peat characteristics. The result indicates that the peat soil is acidic having a pH value ranging from 4.1 to 4.7 and containing humic acid due to excessive accumulation of organic matter and nutrients. The maturity level of the peat was almost similar in all study sites, except for the Daka site, and are classified under mostly decomposed. At Wessa, Werka, Wendo, Shalo, Cheffe, and Wendo, sites the maturity of the peat was classified under sapric soil. Exceptionally, at Daka Site, the peat maturity level was hemic. The percentage of sand, clay, and silt of the peatland range 40-50% clay, 30-40% silt and 10-20% sandy. The mean organic carbon content of Cheleleka peatland ranged from 4.48 to 38.65% and positively correlated with the thickness of the peat and negatively correlated with the ash content of the peat. The main effects of unsustainable landuse practice on peatland are peat reduction/complete loss, reduce water and nutrient retention capacity due to drainage and compaction of peat due to overgrazing. Changes in drainage, vegetation cover, and extraction of peat had resulted in differing outcomes from decomposition processes, and the properties of peats on the disturbed sites had changed.

Keywords:
acidic soil
Cheleleka peat
correlation analysis
human disturbance
sapric soil

Introduction
Peatland covers 3% of the world’s terrestrial area and stores 30% of earth’s carbon. This makes peatlands the major carbon sinks on earth (Ramsar, 2016). It has been recognized as an important global carbon pool and makes significant contributions to national carbon fluxes (Ramsar, 2016). It is also one of the most dynamic ecosystems on earth exchanging carbon across the carbon cycle. Peatlands stores 550Gt carbon, twice the global amount of biomass of forests (Parish et al., 2008). Under waterlogged conditions of peatlands, plant litter gradually losses its physical structure by losing organic matter as gas, solution or by removal by small invertebrates. Natural peat soils have high organic and water content (Huang et al., 2009). The world’s peatlands are thought to contain 180 to 455 Gt C. (Dixon et al., 1994). The concentration of carbon in peat soils ranges 30–70 kg/m³ (or 30–70 g/dm³), which is equivalent to 30–700 t/ha/m of peat depth. Thus, if a peat soil has a thickness of 10 m, then the carbon
stock in it is likely to be around 3000–7000 t/ha. In upland conditions, carbon stock in the 0–100 cm soil layer ranged 20 - 300 t/ha (Shofiyati et al., 2010) but at a depth of more than 100 cm the amount of carbon stored is so low that it usually can be ignored. Peat thickness varied from 0.5 m to deeper than 15 m but the commonly found thickness was 2–8 m.

The process of organic matter decomposition occurs mainly anaerobically, because the flux of oxygen from the air to the soil is lower than the rate at which it is consumed by the microorganisms (Clymo, 1984). Consequently, deposited plant material does not fully decay and so is progressively accumulated as peat (Rieley and Page, 2005). In addition, peatlands also provide important ecosystem services, including flood prevention, carbon storage, recreation, and cultural and spiritual wellbeing. Peatlands are special areas of interest for future climate change because their influence on atmospheric composition is significant and is linked with atmospheric CO₂ and CH₄ concentrations (Clymo et al., 1998; Korthola et al., 2010). Peatlands can be sinks for carbon, nitrogen and phosphorus (Mitsch and Gosselink, 2007) and are very sensitive to environmental change. Some environmental factors are critical drivers, such as climate change, flooding soil pH, and vegetation community type. However, most scientific studies deal with the relationship between soil elements and environmental variables such as climate and landuse change.

In Ethiopia, it covers a considerable amount of the national land area, but no recent inventory or mapping has been undertaken to quantify the spatial extent of this important resource. Few studies are done in the north part of Bale Mountain by different scholars. Hamilton (1982) studied a three-metre deep peat deposit at 4040 m above mean sea level (a.m.s.l.) on Mount Badda, north of the Bale Mountains, in order to evaluate past climatological changes. Umer and Bonnefille (1998) studied a pollen record from a 1.8 m deep mountain mire at Tamsaa (3000 m a.m.s.l.) in central Ethiopia, on the northern side of the Bale Mountains, which showed that peat formation started about 14,000 years ago after the glaciers had melted (Umer et al., 2007). Osmaston et al. (2005) examined the past glaciation of the Bale Mountains, partly on the basis of an analysis of a 2.6 m deep profile of organic matter at Orgoba (4000 m a.m.s.l.) near the town of Goba at the eastern edge of the Bale Mountains. Bikila Warkineh et al. (2015) also investigated two small peatlands in the Bale Mountains in central Ethiopia. The mires are located on the Sanetti Plateau at an altitude of approximately 4000 m a.m.s.l.

The wetland soil is hydric, humic and dark in colour due to excessive accumulation of organic matter. More than half of the watershed area 53.6% is experiencing severe soil losses, representing 80.1% of the total soil loss from the watershed (Wolka et al., 2015). The upper and middle streams experience extreme severe to severe soil loss and take the major shareholder of soil losses. Despite this, Cheleleka peatland and its biological communities face a variety of threats including agricultural expansion, settlement and subsequent peatland drainage, and peat extraction. We still do not know about the physicochemical characteristics of this ecosystem, which is a hindrance to its effective conservation. There have been few studies of the physicochemical characteristics of Ethiopian peatlands. The aim of this study is to provide scientific information on the role of peat as carbon sink and climate change mitigation, its nutrient retention capacity, and the impact of current landuse practices on peat characteristics for better conservation and management practice. The scientific questions addressed in this study were what the current physical and chemical properties of peat looks and how landuse change could affect the characteristics of peat.

The main objective of this study was to identify the impact of anthropogenic on the physical and chemical properties of Cheleleka peat.

Materials and Methods

Description of the study area

Cheleleka wetland partially found in the Central Rift Valley of Ethiopia, 263 km south of Addis Ababa. The area is located in a chain of mountains stretch out and occupies a wide flat marshy land called Cheleleka. Geographically, Cheleleka wetland is located between 38°37' E to 38°42'E and 7°02’N to 7°07’N. The altitudinal range of the wetland is from 1690 to 2700 meters above sea level (Belete, 2018). The wetland receives its water from the headwaters surface runoff of the eastern rift escarpments and groundwater discharges.

Peat sampling

The average total area coverage of the peat is 1 km². The human disturbance score assessment was done prior to peat sample collection to differentiate the impacted sites and less impacted site. Based on the result of the human disturbance score, the area was divided into three; the first one is severely disturbed, moderately disturbed and less disturbed area. Thirty five sampling points (twelve from both less disturbed and severely disturbed sites and ten from moderately disturbed sites) were identified and the samples were collected by moving zig-zag within 100 m intervals in order to include local variation as good as possible.

Peat sample collection process

The sampling site was identified, placed the auger and driven the ground until it fills with peat. Then, pulled up the auger, tapped all the peat into a plastic bag, sealed and labelled. Each peat sample was collected at a depth of one meter within 30 cm interval and made a composite. For the determination of bulk density (BD) and fiber content (FB) the peat samples were collected by using a cylindrical corer.
having 7 cm diameter and 10 cm of height until it reached 1 m (with 30 cm interval) and took the mean value from each sampling site. The parameters used to analyze the peat samples were moisture content, bulk density, fiber content, ash content, depth/thickness, pH, total organic carbon, total nitrogen and total phosphorous. The collected peat samples were put together in a large bag and transported to Hawassa University Wendogenet College of Forestry laboratory for analysis.

**Human disturbance assessment**

The human disturbance score of the wetland used a 5-point scale (Table 1). The most common assessment criteria used for this study were hydrologic modifications, vegetative modification, evidence of chemical pollutants, and watershed characterization. Each section was further divided into subsections. Under each subsection, all stressors present were checked and scored between 0 and 5 based on potential impact to the wetland.

| Severity            | Severity description                              | Rank |
|---------------------|--------------------------------------------------|------|
| Not observed        | The stressor is not observed or no impact on the wetland | 0    |
| Minimal disturbance | The stressor is present & appears to have negligible impacts | 1    |
| Low disturbance     | The stressor is present & have minor impacts on the wetland | 2    |
| Moderate disturbance| The stressor is present & moderate impact on the wetland | 3    |
| High disturbance    | The stressor is present & significant impact on the wetland | 4    |
| Severe disturbance  | The stressor is present & have major impacts on the wetland | 5    |

The values of each section (including subsections) were summed up and finally got the disturbance score of the assessed wetland site. The wetland site with total scores of 10 or less and with no single section score greater than 5 are considered as potential reference sites. According to Connors and DiFranco (2013), the score of the assessed site less than or equals to ten is considered as least impacted and reference site. The human disturbance score between eleven and thirty is considered as a moderately impacted site, and the disturbance score greater than thirty is considered as severely impacted sites.

**Soil sample analysis**

The collected peat samples were analyzed for the selected physicochemical parameters such as depth of peat, pH, moisture content, texture, bulk density, total nitrogen, total phosphorous, and total organic carbon. The peat bulk density (BD) was measured by gravimetric method (McKenzie et al., 2004). The depth of peat was measured using 1.5 meter long T-shaped metal stick and the values were recorded. The peat texture were classified by using Hydrometer; the moisture content by oven-dry method; Fiber content was determined by filtering at 100 meshes (0.149 mm); Ash content was determined by loss on ignition method at 550-600°C; pH by pH-KCl; total organic carbon by Titration-K₂Cr₂O₇; total nitrogen by Kjeldahl method; and total phosphorus by Olsen method. To calculate and determine the organic matter content of the peat, a conversion of organic carbon was done. According to Sprengel (1826), the conversion factor assumes organic matter contains 58% organic carbon for humus soil (cited in Douglas, 2010). Therefore, the conversion of %carbon to %organic matter was done with the empirical factor of 1.724, which was obtained by dividing 100 by 58 (100/58), %organic matter = 1.724 * %Carbon.

The spatial variations of the physicochemical property of peat between sites were compared by using analysis of variance (ANOVA). Spearman’s correlation coefficient was done to calculate the relationship between physicochemical variables and the sampled sites.

**Result and Discussion**

**Human disturbance assessment**

The habitat quality measurement was done based on the human disturbance assessment score (HDA) and the study sites are classified based on their disturbance level. The components of human disturbance assessment score are ranked as severely impacted, moderately impacted and least impacted. HDA score indicates there is a significant difference between the study sites (p<0.01). Shalo and Cheffe sites are severely impacted by human disturbance having score values HD 31% and 30.1% of the area is impacted by anthropogenic activities, respectively. Based on the assessment score, Daka and Wendo sites are classified under moderately impacted sites having score value of HD 16.5% and 15.13%, respectively, and the Wesha and Werka sites showed the least human disturbance having score value of HD 4.16% and 4.7% (Table 2). Therefore, based on the assessment score value Wesha and Werka sites are considered as reference site and scored less than ten. Wendo and Daka sites are considered moderately disturbed, and Cheffe and Shalo are severely disturbed sites.

**Morphological properties of peat**

The dominant peat colour of the study area was dark to dark brown due to the high content of organic matter. The top layer of the peat varied from black to dark brown, and in the lower layer it has brown to...
reddish-brown. The colour of substratum was gray to dark gray and fine textured. Based on field assessments, the maturity level of the peat based on its fiber content were almost similar in all study sites, except for Daka site and are classified under mostly decomposed. At Wesha, Werka, Wendo, Shalo, Cheffe, and Wendo, sites the maturity of the peat were classified under sapric soil (mostly decomposed with fiber content <33%). Exceptionally, Daka Site, the peat maturity level was hemic (moderate to little decomposed with fiber content >33% but <66%) (Table 3).

Table 2. Study sites characterization based on human disturbance features.

| Site | Hydrologic Modification | Vegetation Modification | Evidence of Chemical Pollutants | Watershed Characterization | HDS Score Boundary | Site Status |
|------|-------------------------|-------------------------|---------------------------------|---------------------------|-------------------|-------------|
| Shalo| 10.16                   | 16                      | 12.33                           | 13.83                     | 51.82             | >30         |
| Cheffe| 9.33                    | 10.5                    | 17.83                           | 11.83                     | 51.46             | >30         |
| Daka | 9.4                     | 8.6                     | 3.2                             | 8.2                       | 29.4              | 11-30       |
| Wendo| 4.16                    | 12.5                    | 4                               | 8                         | 26.66             | 11-30       |
| Wesha| 0.5                     | 2                       | 2.33                            | 2.5                       | 7.33              | <10         |
| Werka| 2                       | 2.33                    | 1.5                             | 2.5                       | 8.33              | <10         |

Table 3. Mean of fiber content of the peat soil along with study site.

| Site | Mean ± SD Peat Maturity Level |
|------|-----------------------------|
| Shalo| 21.31±12.1 Sapric           |
| Wendo| 25.93±15.95 Sapric          |
| Wesha| 21.23±12.03 Sapric          |
| Cheffe| 32.51±11 Sapric            |
| Daka | 34.13±8.43 Hemic            |
| Werka| 14.74±9.02 Sapric           |

Physical properties of peat

The physical property of peat mainly includes thickness of the peat, texture, moisture content, fiber content, ash content, and bulk density. The mean and standard deviation (SD) for physical property of Cheleleka peat are listed in Table 4.

Bulk density

Due to the maturity level and fiber content of peat, the bulk density (BD) of the study site was quite different. The value of BD of the area ranged from 0.03 to 0.71g/cm³ were classified as low to moderate. The higher the maturity level of peat will increase the value of bulk density. The Wesha and Werka sites having sapric maturity level of peat having the mean bulk density of 0.39 g/cm³ and 0.36 g/cm³, respectively. The hemic maturity level peat dominated Daka site has the BD value was 0.18 g/cm³ (Table 5). The relation between bulk density and fiber content of the peat is strong but negatively correlated (r²= 52.1). It indicates that bulk density was affected by the fiber content of the peat and if the fiber content of the peat increased, the value of the bulk density will decrease (Figure 1).

Texture of peat

The textural class of the peatland is clay-silt-sand (CSS). The percentage of sand, clay and silt of the peatland range 40-50% clay, 30-40% silt and 10-20% sandy.

Table 4. The mean and standard deviation (SD) for physical property of Cheleleka peat.

| Site | Severely degraded Mean ± SD | Moderately degraded Mean ± SD | Less degraded Mean ± SD |
|------|---------------------------|-----------------------------|------------------------|
| Shalo| Thickness (m) 0.39±0.23 | Moisture content (%) 63.68±14.94 | Ash content (%) 2.24±1.83 |
| Cheffe| 0.29±0.18             | 43.92±9.26                  | 2.56±1.57              |
| Wendo| 0.54±0.37             | 72±15.6                     | 2.53±1.91              |
| Daka | 0.23±0.47             | 34.82±4.56                  | 1.55±0.95              |
| Wesha| 1.73±1.04             | 82.36±6.87                  | 2.46±1.4               |
| Werka| 1.52±0.9             | 81.7±6.55                   | 2.82±2.12              |
The peat texture of less disturbed sites (Wesha and Werka) indicates, the clay>silt>sand, has the potential to hold more water within the particles due to the presence of a relatively high percentage of clay, and the peat texture of the moderately and severely disturbed sites (Cheffe and Daka) were sand>silt-clay, which have low potential of water and mineral holding capacity.

Table 5. The spatial variation of the mean value bulk density and maturity level of peat.

| Sites | Bulk density (g/cm³) | Maturity level |
|-------|---------------------|----------------|
| Shalo | 0.33                | Sapric         |
| Wendo | 0.29                | Sapric         |
| Wesha | 0.39                | Sapric         |
| Cheffe| 0.11                | Sapric         |
| Daka  | 0.18                | Hemic          |
| Werka | 0.36                | Sapric         |

Figure 1. Correlation between bulk density and fiber content.

**Thickness of peat**

The average thickness of the peat of Cheleleka wetland ranges from 0.23-to-1.73 m (Table 6). The peat thickness of Daka and Cheffe (moderately and severely disturbed) sites were very minimal having 0.23 m and 0.29 m, respectively. The major cause for this is the intensive extraction of peat as a fertilizer for a different purpose and sand extraction for local income generation and abstraction and diversion of water for a different purpose.

**Moisture content of peat**

The mean moisture content of the peatland at less degraded sites was 82.03%; 53.41% at moderately disturbed sites and 53.8% at severely degraded sites (Table 6). The amount of water remaining in a soil drained to field capacity and the amount that is available are functions of the soil type. The relation between thickness of the peat and moisture content was strong and positively correlated (p<0.01) and $r^2=51.1$. It indicates that moisture content was affected by the thickness of the peat and if the thickness of the peat increased the value of the moisture content will increase (Figure 2).

Table 6. The mean value of thickness and moisture content.

| Parameters        | Severely degraded | Moderately degraded | Less degraded |
|-------------------|-------------------|---------------------|--------------|
| Thickness (m)     | 0.34              | 0.38                | 1.62         |
| Moisture content (%) | 53.8             | 53.41               | 82.03        |

Figure 2. The correlation between thickness (m) of the peat and moisture content (%).

**Chemical properties of peat**

Cheleleka peat was generally very acidic with the mean pH value ranging from 4.1 to 4.7. The mean values of pH at severely degraded sites were 4.3 and 4.5 at Cheffe and Shalo sites, respectively. The less degraded (Wesha and Werka) sites have average pH values of 4.2. (Table 7). The peat acidity level was an indicator of the presence of organic acids that contain humic acids. The relation between the thickness/depth of the peat and pH was significant and negative (p<0.05). The deeper the thickness of peat, decrease the value pH and this is due to degradation of the area. The mean organic carbon content of Cheleleka peatland ranged from 4.48 to 38.65% (Table 7). The lowest mean value was recorded at severely degraded (Cheffe) site and the higher mean value was recorded at less degraded (Werka) site. Thickness of the peat and organic carbon has significant positive linear relationship (p<0.05) and $r^2=53.6$ see Figure 3. The larger the thickness of the peat was an indicator for the decomposition of organic matter was higher at that specific site. The mean total nitrogen (TN) values at less degraded sites ranged from 1.11% (Werka) to 1.37% (Wesha) and the severely degraded sites varied from 0.73% (Cheffe) to 1.75% (Shalo).
Table 7. The mean value of the chemical parameters of peat.

| Site    | pH Mean ± SD | TOC (%) Mean ± SD | TN (%) Mean ± SD | TP (%) Mean ± SD |
|---------|--------------|-------------------|------------------|------------------|
| Shalo   | 4.53±0.92    | 24.72±12.17       | 1.75±0.79        | 26.7±7.64        |
| Wendo   | 4.18±1.07    | 24.53±9.87        | 1.02±0.55        | 18.92±6.57       |
| Wesha   | 4.2±0.64     | 31.79±11.23       | 1.37±0.56        | 10.21±3.53       |
| Cheffe  | 4.31±1.17    | 4.48±4.16         | 0.73±0.57        | 20.61±6.73       |
| Daka    | 4.7±0.55     | 10.01±7.4         | 0.49±0.24        | 6.13±3.79        |
| Werka   | 4.25±0.93    | 38.65±8.85        | 1.1±0.54         | 9.66±4.37        |

Remarks: TOC = total organic carbon, TN = total nitrogen, TP = total phosphorous.

The mean value total phosphorous (TP) values at least disturbed sites range from 9.66% (Werka) to 10.21% (Wesha) and the severely degraded sites range from 20.61% (Cheffe) to 26.7% (Shalo). The main reasons of this variation in organic carbon content, total nitrogen and total phosphorus were human-induced factors such as landuse/landcover change, alteration of hydrology, over-grazing and conflict of interest by different individuals and institutions. Thickness of the peat, TOC, TN has a positive and significant correlation with each other, on the other hand TP negatively correlated with the thickness of peat (Table 8). It indicates that when the thickness increases, the amount of TP will decrease. The total organic carbon positively and significantly correlated with total nitrogen and thickness of the peat with $r^2=61.5$ as shown in Figure 4.

Table 8. The correlation between thickness (m), TOC (%), TN (%) and TP (%).

| Thickness | TOC | TN  | TP   |
|-----------|-----|-----|------|
| 1         | .732** | .363* | -.375* |
| .000      | .032  | .026 |
| .732**    | 1    | .528** | -.136 |
| .000      | .001  | .437 |
| .363*     | .528** | 1    | .434** |
| .032      | .001  | .009 |
| -.375*    | -.136 | .434** | 1    |
| .026      | .437  | .009 |

Remarks: TOC = total organic carbon, TN = total nitrogen, TP = total phosphorous. **Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed).

The ash content is an indicator of the mineral enrichment of the peat. The presence of a higher value of ash in a certain area is an indicator for higher mineral enrichment of the area and the peat is fertile. The lower mean value of ash content was recorded at Daka site (1.55) and the higher value was recorded at Werka site (2.82).

Generally, the ash content of the study area was low (<5%). There was a negative correlation between ash content and the total organic carbon. The mean organic content of the study area was 38.56%. The organic matter of the study area varies from 7.73% to 66.64% at severely degraded (Cheffe) and less...
degraded (Werka) sites, respectively. The main reason for this two varied result is due to stage of decomposition of the vegetation, species diversity and composition and mainly due to extensive anthropogenic activities, particularly in disturbed site.

The distribution of peat in Ethiopia plays a great role in biodiversity conservation, nutrient trap, and carbon storage. The mean moisture content of Cheleleka peat soil ranges from 34.82-82.36% and the lower and moderate moisture content was recorded at severely degraded and moderately degraded sites, respectively. The amount of water remaining in a soil drained to field capacity and the amount that is available are functions of the soil type (Mitsch and Gosselink 2007).

The degree of peat decomposition was classified into fibric, hemic and sapric. The fibric peat is little decomposed peat with > 65% volume of fiber content, sapric peat is mostly decomposed peat with <33% of fiber content, and the hemic peat is moderately decomposed and the fiber content is in between the sapric and fibtic peat (Indonesian Soil Survey Staff, 2010). The peat maturity level of Cheleleka wetland varied from sapric to hemic. More than 90% of Cheleleka peat was sapric and only 10% was hemic and this is due to the disturbance of human beings through the intensive extraction of the peat, water diversion, vegetation removal, and overgrazing are the most common.

The most important physical properties of peat soil, the fiber content and bulk density are used to determine the decomposition rate of peat (Boelter, 1969). The more decomposed peat soils have lesser fiber content and the bulk density increases. The fiber content and bulk density of Cheleleka peat were inversely correlated and this is due to the maturity level of the peat soil. The minimal and maximum value of fiber content and bulk density of Cheleleka peat were (6.35-47.03%) and (0.03-0.71g/cm³), respectively, as shown in Table 9. A similar result was shown in a study done in Indonesia by Hikmatullah and Sukarman (2014) and stated as the fiber content and the bulk density increases. The fiber content and the thicker accumulated peat were inversely correlated and this is due to the maturity level of the peat (pH).

The peat pH value tends to decrease with the increase of depth/thickness of the peat (Suhardjo and Widjaja Adhi, 1976). A similar result was observed in Cheleleka peat; the peat pH value and the depth had a negative but not significant correlation (Figure 5). There was also a significant (p<0.05) negative correlation between the ash content and the total organic carbon of Cheleleka peat. The same result was observed by Hikmatullah and Sukarman (2014) and (Chakim et al., 2020).

| Parameter | Minimum | Maximum | Mean |
|-----------|---------|---------|------|
| Thickness of the Peat | 0.11 | 3.0 | 0.8 |
| Texture | 1 | 3 | 1.6 |
| Moisture content | 30.3 | 91.8 | 63.89 |
| Ash content | 0.63 | 5.94 | 2.38 |
| Fiber content | 6.35 | 47.03 | 26.32 |
| Bulk density | 0.03 | 0.71 | 0.28 |
| pH of Peat | 3.1 | 6.4 | 4.35 |
| TOC of Peat | 0.67 | 48.8 | 22.72 |
| TN of Peat | 0.05 | 2.76 | 1.09 |
| TP of Peat | 2.38 | 34.03 | 15.64 |

Figure 5. The relationship between thickness/depth of the peat (m) and the peat acidity level (pH).

**Conclusion**

In general, the human disturbance assessment score indicates there was significant variation between the study sites. Based on the score, the Wesha and Daka sites were classified under less disturbed site, Wendu and Daka under moderately disturbed sites and Shalo and Cheffe under severely degraded sites. The dominant peat colour of the study area was dark to dark brown due to the high content of organic matter. Due to low human disturbance the higher moisture content and the thicker accumulated peat were systems.
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recorded at least disturbed sites. The severely degraded sites were rich in chemical content than moderately and least disturbed sites. The reason behind this is expansion of agricultural activities, grazing, industrial and municipal waste disposals. To minimize the level of peat degradation measures such as buffer zonation, waste water treatment, grazing and agricultural management were recommended.