LAND DISTURBANCE AND RECLAMATION OF PEAT EXTRACTION

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Summary

Peat is an important resource of the world. Peat resource conservation should be an important agenda of the world's community, in line with the increasing awareness over the necessity to conserve natural ecosystems. Peat, based on its structure, can be divided into two types; the raised bog and the blanket bog. Peat formation is influenced by anaerobic condition and acidity of the groundwater, which result in the accumulation of organic matter.

The acrotelm and catotelm layers influence the hydrology and topography of the bog system. With respect to structure and mode of formation, temperate and tropical bogs are similar. The uses of peat as low-grade fuel and as a source for chemicals involve extraction of peat. A number of extraction techniques were developed with the advent of technology. Extraction of peat will destroy ground cover of the peatland and hence the loss of wildlife habitat. Hydrological impacts include disruption of surface water flow

patterns and changes in groundwater elevation. When great amount of peat has been extracted the capacity of the peatland to retain water will be lost and this may increase the danger of flooding. Repair and rebuild, which involve simple and significant intervention respectively, are the two possible strategies for reclamation. The reclamation approaches are restoration of site hydrology, topography and suitable bog vegetation. Water is the most essential component of the bog ecosystem. Measures to keep water table within 0.5-1 m of the bog surface.

The restoration of topography provides stabilization in the distance between the groundwater and the bog surface. Both establishing sphagnum species as whole plant and from fragments spread by hydroseeding can be used for bog vegetation restoration. Certain binding international policies for peatland conservation has to be considered when planning for peat extraction, as peatland can be important natural and cultural heritage.

1. Introduction

Peat can be considered as one of the world's important natural resources. The use of peat in the temperate regions especially in Europe for human purposes has a history that dates back over the millennia. Before commercial exploitation was made possible, peat was used as a domestic fuel. Urban and commercial expansion, created great demands for fuel. This demand, combined with shrinking woodlands, provided the incentive to develop methods for commercial bog exploitation. The use of peat as a fuel continues up to the present, especially in peat rich, coal poor countries. Apart from being used as fuel source, drained peat areas may be put into agricultural production. Irreversible physico-chemical changes occur when peat is drained for agricultural use. A study on tropical peat indicated that the different management of peat with respect to crop types have strong influence on the changes of its physical and chemical characteristics[1].

Peat is also used extensively in horticulture as a soil conditioner, mulch and as growing media. Currently commercial peat extraction and harvesting is concentrated on the raised bog. The long history of human influence on peatland has great impact on the ecological processes to a certain degree in essentially every raised bog throughout Europe[11]. In recent years, there has been an increasing concern and awareness of the value of natural ecosystems. This concern and awareness has extended to raised bogs not only for their value as a biological resource but also for their value as a potentially renewable and thus consumable resource. The importance of raised bogs in wildlife management, in the control of hydrological regimes and as a global carbon sinks has been identified. For these reasons it is essential to identify suitable restoration techniques for raised bogs affected by peat extraction. This article attempts to give an overview on what constitute a peatland; what are the main uses of peat; how peat are extracted or harvested; what are the impacts of extraction and how peatlands can be reclaimed or restored.

2. What is Peat?

Before going into the land disturbance that can happen as a consequence of peat extraction, it is useful to understand what actually is peat and how is it formed. This is essential so that one can gauge its fragility as a natural ecosystem, which is important in the peatland reclamation and conservation efforts. Peat is a type of soil classified as Histosol under USDA Soil Classification. It is made up of partially decomposed organic matter, mostly plant materials deposited under water in depressions of land surfaces for a long period of time, perhaps thousands of years. Areas where these materials are deposited are the peat swamps. Depending on the degree of decomposition peat can be described from more to less decomposed states as sapric, hemic and fibric (Table 1). In temperate regions, generally there are two main types of peatland, fens and bog. Fens are alkaline in nature with pH value more than 7 while bogs are acid with pH range between 3 and 4.5. Fens are minerothrophic while bogs are ombrothrophic. Fens have peat materials high in ash contents (10% or more) while bogs have peat materials low in ash contents (about 3 %). The average depth of peat in fens is up to 2 m. Peat depth in bogs varies from 2 to 12 m. Generally bogs can be further subdivided into two types; raised bogs and blanket bogs based on its structure.

Peat is considered as the youngest of the fossil fuels. It is formed during a build-up of plant material under waterlogged conditions when the accumulation of vegetation occurs. The accumulation of peat occurs under the condition where the rate of plant material production exceeds the rate of plant decomposition. Recorded rates of accumulation indicate an average of 1.66 mm per year [12]. Layers of plant material are laid down over time, which gives peat a stratified structure. The amount of organic material in peat varies from 20 % to 99 % [7]. Some may comprise distinguishable plant remains but is mainly very fine, well decomposed organic matter. For geological purpose 30 cm of accumulated decomposed plant material is called peat, but only a 1-m accumulation is recognized as sufficient for mining [7].

3. Factors Contributing to Peat Formation

Peatlands in the temperate regions are composed of deep layers of waterlogged peat and a surface layer of living vegetation. Peat is made of plant organic matter that has accumulated over thousands of years. Complete decomposition of plant is prevented in areas where waterlogging occurs. Waterlogged condition is a common feature in areas of high rainfall and low temperatures resulting in low evaporation, for example in shallow basins. These waterlogged basins are anaerobic while aerobic condition is essential for the growth of the microorganisms (bacteria and fungi) that bring about the complete breakdown of plant materials. As a result of the poor microbial activity, plant materials accumulate in waterlogged areas as peat. Another factor, which contributes to the accumulation of peat, is the acidity of the water within the accumulation basin. Low acidity prevents the growth of soil microorganisms. In bogs, plants of sphagnum species known as bog mosses, contribute to the acidity of the water. These plants absorb the cations in the water and release hydrogen ions. As the water becomes more acidic, the condition becomes less suitable for micro-organisms to grow and therefore the plant organic matter accumulate at a faster rate.

3.1. Formation of Fen and Raised Bog

In temperate regions, raised bog formed in shallow lakes, which have trapped water and no free drainage. At the base of these shallow lakes there were deposits of lake marl overlying clay. Mineral-rich groundwater and springs were the main water source of the lakes. At the beginning floating plant communities thrived at the surface of the water. These produced a thin peat layer just above the lake marl. Tall reed and sedge beds dominated the lake edges. As these plants died, their remains fell into the lake and because of anaerobic condition they were only partly decomposed. They deposited on the lakebed as peat. With time this process formed a thick layer of reed peat that rose towards the water surface. As the peat surface approached the upper water level, sedges invaded, and their remains added to the accumulating fen peat. In time the fen peat layer in these shallow lakes become so thick (up to 2 m) that the plant roots growing on the surface were no longer in contact with the mineral rich groundwater. When this happened the only source of minerals for the plants came from rainwater, a very poor source of the essential minerals needed for plant growth. As a result plants that were able to grow in the mineral-poor habitats, invaded and made the ground even more acid, by its root ion exchange activity.

A raised bog in its mature stage is defined on three levels: a) its location and appearance in the landscape, b) its species composition, and c) the environmental factors that influence its development. Raised bogs are wetlands with a surface raised above that of the surrounding drainage [6]. This form is created by organic matter production, in the form of ombrogenous peat that exceeds the rate of decomposition. Its nature as a wetland is maintained by the high water holding capacity of peat material. Very few species have the necessary properties to create a raised bog and then to continue to survive in this environment. Therefore, raised bog tends to be species poor ecosystems dominated by *Sphagnums* including *S. papillosum, S. Magellanicum, S. imbricatum* and others. The *Sphagnums* are referred to as the ‘key species’ since their dominance is essential for bog formation [6]. Under suitable conditions *Sphagnums* have the capacity to accumulate peat at a rate faster than decay occurs. As an ombrogenous peat layer develops, growing conditions becomes progressively adverse with a lowering of pH and available nutrient levels and a prevailing high water table. Sphagnum species are well suited to this environment and continue to dominate in a self-perpetuating system. As indicated by their natural locations, the primary environmental requirements of raised bogs are a cool climate and rainfall levels that routinely exceed evaporation. The excess rainfall, combined with the raised surface of the bog, create an environment where most of the available minerals are obtained from the rainwater. The result is a low pH, low nutrient environment dominated by Sphagnums.

There are similarities between temperate raised bog and tropical peat in terms of structure and formation, as can be noted in the work of Anderson[2]. He documented the biconvex geometry of peat deposits and the relationships between the zonation of surface vegetation and increasing peat thickness, acdity and decreasing nutrient availability. On the periphery of mature peat domes, a diverse assemblage of large trees and dense understory grow on thin nutrient-rich peat. Towards the center of the deposit as the surface rises and the peat thickens, vegetation becomes less diverse and less dense. Near the center the peat becomes-nutrient deplete, removed from the effect of leaching. Here the deposits are often flattened and covered by herbaceous groundcover, pandans, small shrubs and sparse thin trees. Anderson described the stratigraphy of the central deposits to vary from compacted woody peat to with an amorphous matrix near the base, to a more fibrous peat in the upper portions. Peat type at the surface increases in preservation and decreases in wood content from the periphery to the center. The variations of peat type within the deposits reflect the succession and lateral propagation of the surface vegetation. Tie[10] showed that water table fluctuation within a particular tropical peat deposits between the wet and dry seasons are greater near the periphery (25-85 cm below ground surface) than at the center (0-25 cm). Tie also found that, while the amount of biomass production in terms of litterfall is greater at the periphery than in the center of the peat dome, the rate of decomposition there is also greater. This is in accordance with the distribution of more well preserved peat in the upper central portions of tropical peat domes, bordered by more decomposed peat at the base and periphery.

3.2. The formation of Blanket Bog

Initially peat formation was confined to shallow depressions on the ground surface and wet hollows and development sequence from open water to fen and acid peat. Later acid peat spread out to form a blanket covering huge areas. Heavy rainfall caused minerals such as iron to be washed out or leached from the surface layers of the soil. These were deposited lower down where they formed an impermeable layer known as an iron pan. Water cannot move down through such a layer, creating perched water condition and the soil surface become waterlogged as a result. Under these conditions the accumulation and spread of peat was made possible.

3.3. The Structure of Bog

A bog consists of two layers; the upper thin layer, and the lower much thicker peat layer. The thin layer, known as the acrotelm, is only 30 cm thick, and consists of upright stems of the sphagnum mosses, largely still alive. Water can move rapidly through this layer. The much thicker peat is known as the catotelm, where plant stems have collapse under the weight of the mosses above them to produce an amorphous, dark-colored mass of sphagnum remains. Water movement through this amorphous peat is very slow indeed – typically less than a meter a day.

This is where most of the rainwater is stored. From here the water slowly seeps down through the bog over several weeks or even months. Under normal circumstances, the water table within the bog never drops down into the catotelm. Even drainage merely empties the acrotelm of its water more quickly. Generally the water table is very stable, remaining within a few centimetres of the bog’s surface about 95% of the time. The acrotelm and the catotelm layers form under different conditions and perform different functions in the bog environment.

The catotelm is permanently waterlogged and composed of highly decayed material. It functions as an almost impermeable seal for the bottom of the bog and as the primary water storage unit forming the perched water mound. The acrotelm is the active layer of the bog ecosystem where most of the biotic activity as well as the active hydrologic fluctuations occur. The catotelm enjoys constant, unvarying conditions because it is protected from the environmental changes above by a relatively thin or surface acrotelm layer. The functions of the acrotelm include protecting the catotelm from evaporation, providing additional water storage and providing the location of biotic activity[8].

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Biographical Sketch

Abdul Rashid Ahmad was born on 30th March 1951. He was educated in English medium schools in Johore, the southern state of Peninsular Malaysia, at primary and secondary levels. In 1971-1975 he studied Science at the National University of Malaysia and was conferred BSc with honest in Geology. Shortly after that, in 1976 he went to the University of Reading, England, for his MSc in Soil Chemistry and went back to Malaysia for a job as a research officer at the Malaysian Agricultural Research and Development Institute (MARDI). Here, he was involved in carrying out research pertaining to nutrient requirements of crops in various types of soils including peat soils. In 1982, he went to the University of Oxford for the DPhil degree. In Oxford, he did research in modeling of soil chemical processes, in relation to coupled diffusion and oxidation reactions in anaerobic soils. After finishing his DPhil he went back to MARDI in 1986. His research interest then was about the development of crop models in relation to nutrient uptake. From these models, he realized that farmers have been using excessive fertilizers that were detrimental to the environment. In 1991, he was involved in the research of the environmental impacts of agricultural input, on groundwater in a number of Malaysian agro-systems. In 1994, he was offered a post as an Associate Professor at the Department of Geography, University of Malaya, to lead the Environmental Program of the department. Under this program, he is responsible in teaching environmental management of disturbed ecosystems. He is supervising a research on the effect of development on peatlands. He is also involved in doing research on modeling interactions of natural and human environments, which is useful for predicting resource requirements for development.