Chapter 1

Introductory Chapter: Introduction to Peat

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1. Peat formation and characteristics

The word known peat is growth on organic systems where the plant growth is fast, but soils are defined as a partially decomposed organic matter deposit due to poor aeration and low temperature grades [1]. Peat is also named as turf and turba in different literatures owing to its unique property to natural areas called peatlands, bogs, mires, moors, or muskegs. The formation of such deposits is not related to particular climate regions, but it can occur wherever appropriate conditions are present. Organic soils are presented in all the continents of the world. Organic soils are mainly presented under tropical climates with above 60° northern latitudes, and about 450–500 million hectares of total world reserved areas. It is documented that about 150 million hectares of organic lands and about two-third of the world reserves are found in Russia and Canada [2].

Swamps, stagnant waters and pasturelands of the shallow ground water areas have suitable conditions for the accumulation of organic matter. In such places, plants lose their vitality and are covered with water because thousands of growing plants remain in the water. The water interrupts their association with the air and provides partial protection for organic matter and hence preventing them from being quickly decayed. Decomposition is mainly accomplished by fungi, anaerobic bacteria, algae and microscopic water creatures. They breakdown organic structures, release some gases, and thus help humus synthesis. As this process continues, the organic mass becomes brown, and even black. If this decomposition process progressed, the organic matter mass turns into a true organic soil profile. The humus formed here is almost identical to the formation of the ligno-protein complex and polyuronite which is predominant in mineral soils. In addition, triglycerides hydrolyze, yielding fatty acids and glycerol throughout decomposition [3]. This facilitates practicality of soil microbiology.

In the peatland, a plant generation accumulates following another and hence stratification can occur. Due to the accumulation of organic matter, water is gradually withdrawn from the surrounding areas of the marshes and changing plant species. In the course of time, deep water deposits give their places to the sedges and carex plants. These also leave their places to various mosses. These areas are dominated by shrubs, and finally by broad-leaved and coniferous forest trees.

The formation of peat is a relatively short biochemical process under the influence of aerobic microorganisms in the surface depths of the deposits during periods of low subsoil water. As the peat which is formed in the peat-producing layer becomes subjected to anaerobic conditions in the deeper layers of the deposit, it be preserved and shows comparatively little change in time [4]. In detail, the glycerin is quickly used in the form of carbon and oxygen by microbes under anaerobic conditions [3]. The residual fatty acids comparatively persevere by stable parts of the peat. These substances that might be obtained with non-aqueous organic solvents are together referred to bitumens. For instance, humic acids are thought to create strait from polymer or like microbiologic products.

Peats, which does not have consensus on classification, are trying to be classified in different countries and with specific requirements of different disciplines. Present classification systems are categorized based on the topography and geomorphology, surface vegetation, chemical, botanical, physical properties and genetic processes within the peatswamp [5]. Depending on the differences in their physical and chemical structures and their presence in the medium, these organic substances have been given various names. The physical, chemical and biological differences between organic soils are due to the climatic, topographic, hydrological, geological and botanical properties of the environment in which they occur [6, 7]. Organic soils are distinguished by Soil Taxonomy as the Order of Histosols. Generally, Histosols has an organic matter more than half of the upper 80 cm [8]. Organic soils are commonly named mucks and peats. Unsaturated conditions for more than a few days, organic carbon content of these soils expected to be more than 20%.

Depending on the usage purposes, peat can be characterized in numerous ways. Assessing of peat materials for different purposes requires emphasis on distinctive characteristics. The most relevant characteristics of peats for many disciplines are listed in **Table 1** [5].

Chemical properties	**Physical properties**
Composition (organic compounds; elemental)	Moisture relationships (water retention; available water content; hydraulic conductivity; water holding capacity)
Acidity (pH)	
Exchange characteristic (cation exchange capacity; exchangeable cations)	Bulk density (non-specific; specific)
Organic carbon	Porosity
Nitrogen; phosphorus; sulfur; trace elements	Texture (loss on ignition)
Free lime ($CaCO_3$)	Irreversible drying
	Swelling and shrinking

Table 1. The most relevant chemical and physical characteristics of peats [5].

The physical and chemical properties of the peats show a wide variation. Peat is found abundantly in nature in various forms whereas it is 80–90% water in its formation [3]. The chemical properties of peat differ extensively and within particularized bonds owing to the chemical reactions as part of its formation. However, it is currently fulfilled that the fundamental properties of peats help to sorption and ion exchange. A comparison of some chemical properties of loamy textured mineral soils and various peats is given in **Table 2**.

The characteristic of microbial composition of the peat production is a well-documented difficulty for incessant large-scale processing. Peats are chemically organic material, which leaves diminutive ash after it burned. Peat may be characterized by their ash content and acidity. High-moor sphagnum peats are simply marginally decomposed with high polysaccharide content and comparatively high O_2, and lower C and H concentrations in comparison to low-moor peats [3]. The peat is originated to have proteins, carbohydrates, lipids and polyphenols such as lignin whereas, nucleic acids, pigments, alkaloids, vitamins and other organic materials are existing in small amounts, along with inorganic materials [3]. Various B vitamins were found in peat [10]. Currently, the chemical and physical properties of peat have created significant environmental concerns. Number of studies has been appointed to full-scale plant operations and hence made significant production capacity of active carbon potentially by peat pyrolysis and peat coke production [3]. Pyrolysis alters peat from a material including H and O_2 with a very high carbon concentration. Peat coke might be utilized like decolorizing and de-odorizing agent and a filter medium [3]. Activated carbons are arranged in different grades from peat. Diverse properties are necessary for different responsibilities such as water purification, the removal of organics from starch, sugars and color and gas and vapor adsorption.

		Peat types			
Property	**Unit**	**Sphagnum**	**Fibrous reed sedge**	**Decomposed reed sedge**	**Peat humus**
Peat weight	gL^{-1}	88	160	240	320
Water content		930	890	835	780
Total weight		1018	1050	1075	1100
Water content	% WB	91	85	78	71
Water content	% DB	970	554	346	242
		Soil types			
Property	**Unit**	**Loam soil**	**Sphagnum peat**	**Woody peat**	**Muck**
CEC by weight	meq^{-1} 100 g	12	100	90	200
CEC by volume	meq^{-1} 100 ml	14	8	14	60

Table 2. Some physical characteristics of peat types and a comparison of cation exchange capacity (CEC) of mineral and various organic soils [9].

2. Peatlands and wetland ecosystems

Peatlands are wetland ecosystems that affect the balance of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) on a global scale. These gases are main GHG emissions from agricultural lands and responsible for 18% of the global greenhouse gases [11]. Peatlands are formed by the limited decomposition and accumulation of plant material in previous geological periods. It is also a source of coal, lignite and natural gas, and considered as fossil fuels formation. Pyrolysis can be an example of these processes, which is a potential process to produce active carbons [3]. Steam or carbon dioxide might be utilized to improve the char formation and post charring acid washing might be utilized to increase surface activity [3]. Due to their rich organic material, peatlands have been used to meet the basic needs of the local people in the past. However, they are recently more into prominence with one of the largest carbon deposits in the biosphere from the perspective of climate change, and regulation of water regime and biodiversity conservation functions [12].

Peatlands play a significant role in the global carbon dioxide cycles by carbon sequestration in its different strata of their ecosystem. These strata are known as biomass, dead cover, peat layer, mineral topsoil and pore water. Each stratum has its own dynamics and cycles. Not only the amounts of carbon in these ecosystems are still unknown but also, the quality and quantity of soil organic carbon is important for agroecosystems. For instance, Lehmann [13] has stated the importance of understanding both the quality and quantity of organic amendments and their impact on microbial diversity and soil structure. Moreover, Ozlu [14] has stated importance in different source of carbon inputs such as manure and inorganic fertilizers and reported the types and doses of organic amendments. In addition, there is insufficient information about the change in carbon dynamics in these ecosystems over time. So far, there are different results for the same areas in peatlands by using different calculation methods. These different methods are used based on determination of peat volume, calculation of carbon intensity and dating methods [15]. It is documented that peatlands store more than 550 Gt of carbon with a 3% area covered in total. This amount equals to 75% of atmospheric carbon and 30% of worldwide carbon. Peatland also stores twice as much carbon as all forest biomass in the world and this indicates that peatlands are the second most important long-term carbon storage after the oceans [16]. The global ecosystemic carbon dioxide cycle would hardly be influenced at all by destruction of the peatlands as carbon accumulating ecosystems. Peatland ecosystem has also an adsorptive function for the elements, which have been released in toxic amounts into the environment. Peat destruction can result severe environmental degradation and often toxic heavy metals.

Today, one of the miracles of nature is increasing in importance and gaining importance for organic soils. The first use of organic soils began as fuel in the Caucasus and Siberia. In the following years, organic soils had been used as fertilizer and flowerpot soils due to its suitable physical and chemical properties. Owing to its high-water retention capacity, porosity and many others suitable physical properties, peat is an extremely useful material as a plant growth medium. Peats are also widely used especially in organic agriculture and soilless culture applications. Today, there is a growing demand in this field. Organic soils have been used in cultured mushroom production, soil cultivation and animal feeding. Organic soils are also used in many fields outside of agriculture as direct and raw materials such as in the field of medicine and balneology, heavy metal adsorption, aquarium conditioning, food production, packaging and insulation, alcohol production, carotene and humic acid production.

The limited presence of organic soils in certain regions of our world and the prevalence of agricultural and industrial uses indicate the importance of these lands in terms of environmental impacts, economic values and their rational use. Managing the sustainability of production in agriculture and industrial areas and conserving of environmental values with the right strategies, the balance of conservation and use of natural resources is of utmost importance for the future of planet.

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