Peat

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Peat (/pi:t/), also called **turf** (/tɜ:rf/), is an accumulation of partially decayed vegetation or organic matter that is unique to natural areas called peatlands, bogs, or mires.[1][2] The peatland ecosystem is the most efficient carbon sink on the planet[2] because peatland plants capture the CO_2 which is naturally released from the peat, thus maintaining an equilibrium. In natural peatlands, the "annual rate of biomass production is greater than the rate of decomposition", but it takes "thousands of years for peatlands to develop the deposits of 1.5 to 2.3 m [4.9 to 7.5 ft], which is the average depth of the boreal peatlands".[2] One of the most common components is *Sphagnum* moss (peat moss), although many other plants can contribute. Soils that contain mostly peat are known as histosols. Peat forms in wetland conditions, where flooding obstructs flows of oxygen from the atmosphere, slowing rates of decomposition.[3]

Peatlands, also known as mires, particularly bogs, are the most important source of peat,[4] but other less common wetland types also deposit peat, including fens, pocosins, and peat swamp forests. Other words for lands dominated by peat include moors or muskegs. Landscapes covered in peat also have specific kinds of plants, particularly *Sphagnum* moss, ericaceous shrubs, and sedges (see bog for more information on this aspect of peat). Since organic matter accumulates over thousands of years, peat deposits also provide records of past vegetation and climates stored in plant remains, particularly pollen. Hence, they allow humans to reconstruct past environments and changes in human land use.[5]

Peat is harvested as an important source of fuel in certain parts of the world. By volume, about 4 trillion cubic metres (5.2 trillion cubic yards) of peat are in the world, covering a total of around 2% of global land area (about 3 million square kilometres or 1.2 million square miles), containing about 8 billion terajoules of energy.[6] Over time, the formation of peat is often the first step in the geological formation of other fossil fuels such as coal, particularly low-grade coal such as lignite.[7]

Depending on the agency, peat is not generally regarded as a renewable source of energy, as its extraction rate in industrialized countries far exceeds its slow regrowth rate of 1 mm per year (0.039 in),[8] and as peat regrowth is also reported to take place in only 30-40% of peatlands.[9] Because of this, the United Nations Framework Convention on Climate Change (UNFCCC),[10] and another organization affiliated with the United Nations classifies peat as a fossil fuel.[11] However, the Intergovernmental Panel on Climate Change has begun to classify peat as a "slow-renewable" fuel.[12] This is also the classification used by many in the peat industry.[10]

At 106 g CO_2/MJ,[13] the carbon dioxide emission intensity of peat is higher than that of coal (at 94.6 g CO_2/MJ) and natural gas (at 56.1).

Peat fires have been responsible for some large public health disasters, including the 1997 Southeast Asian haze.

Peat gatherers at Westhay, Somerset Levels in 1905

Peat stacks and cutting at Westhay, Somerset Levels

Harvesting the peat at Westhay, Somerset Levels

Peat in Lewis, Scotland

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Peatlands distribution

In a widely cited article, Joosten and Clarke (2002) defined peatlands, or mire (which they claim are the same)[Notes 1][1] as,

> ...the most widespread of all wetland types in the world, representing 50 to 70% of global wetlands. They cover over 4 million square kilometres [1.5 million square miles] or 3% of the land and freshwater surface of the planet. In these ecosystems are found one third of the world's soil carbon and 10% of global freshwater resources. These ecosystems are characterized by the unique ability to accumulate and store dead organic matter from Sphagnum and many other non-moss species, as peat, under conditions of almost permanent water saturation. Peatlands are adapted to the extreme conditions of high water and low oxygen content, of toxic elements and low availability of plant nutrients. Their water chemistry varies from alkaline to acidic. Peatlands occur on all continents, from the tropical to boreal and Arctic zones from sea level to high alpine conditions.

— Joosten and Clarke 2002

Peatlands are areas of land with a naturally accumulated layer of peat. Peatlands are found in at least 175 countries and cover around 4 million km² or 3% of the world's land area. In Europe, peatlands extend to about 515,000 km² (199,000 sq mi).[14]


Peat extraction in East Frisia, Germany

Peat deposits are found in many places around the world, including northern Europe and North America, principally in Canada and the Northern United States. Some of the world's largest peatlands include the West Siberian Lowland, the Hudson Bay Lowland, and the Mackenzie River Valley.[15] The amount of peat is smaller in the Southern Hemisphere, partly because there is less land, yet South America (Southern Patagonia/Tierra del Fuego) has one of the world's largest wetlands, the vast Magellanic Moorland, with extensive peat-dominated landscapes.[15] Peat can be found in New Zealand, Kerguelen, and the Falkland Islands, Indonesia (Kalimantan (Sungai Putri, Danau Siawan, Sungai Tolak), Rasau Jaya (West Kalimantan), and Sumatra). Indonesia has more tropical peat land and mangrove forests than any other nation on earth, but Indonesia is losing wetlands by 100,000 hectares (250,000 acres) per year.[16]

About 60% of the world's wetlands are peat. About 7% of total peatlands have been exploited for agriculture and forestry.[17] Under proper conditions, peat will turn into lignite coal over geologic periods of time.

Formation

Peat forms when plant material, usually in wet areas, is inhibited from decaying fully by acidic and anaerobic conditions. It is composed mainly of wetland vegetation: principally bog plants including mosses, sedges, and shrubs. As it accumulates, the peat can hold water, thereby slowly creating wetter conditions, and allowing the area of wetland to expand. Peatland features can include ponds, ridges, and raised bogs.[4]

Most modern peat bogs formed in high latitudes after the retreat of the glaciers at the end of the last ice age some 12,000 years ago.[18] Peat usually accumulates slowly, at the rate of about a millimeter per year.[8]

Peat in the world's peatlands is currently believed to have been forming for 360 million years and contains 550 Gt of carbon.[19]

Types of peat material

Peat material is either fibric, hemic, or sapric. Fibric peats are the least decomposed, and comprise intact fiber. Hemic peats are somewhat decomposed, and sapric are the most decomposed. *Phragmites* peat is one composed of reed grass, *Phragmites australis*, and other grasses. It is denser than many other types of peat. Engineers may describe a soil as peat which has a relatively high percentage of organic material. This soil is problematic because it exhibits poor consolidation properties.

Characteristics and uses

Peat is soft and easily compressed. Under pressure, water in the peat is forced out. Upon drying, peat can be used as fuel. It has industrial importance as a fuel in some countries, such as Ireland and Finland, where it is harvested on an industrial scale. In many countries, including Ireland and Scotland, where trees are often scarce, peat is traditionally used for cooking and domestic heating. Stacks of drying peat dug from the bogs can still be seen in some rural areas. Peat's insulating properties make it of use to industry.


A peat stack in Ness on the Isle of Lewis (Scotland)

Although peat has many uses for humans, it also presents severe problems at times. Wet or dry, it can be a major fire hazard, as peat fires can burn almost indefinitely (or at least until the fuel is exhausted). Peat fires can even burn underground, reigniting after the winter, provided a source of oxygen is present. Peat deposits also pose major difficulties to builders of structures, roads, and railways, as they are highly compressible under even small loads. When the West Highland Line was built across Rannoch Moor, in western Scotland, its builders had to float the tracks on a mattress of tree roots, brushwood, and thousands of tons of earth and ashes.

Peat bogs had considerable ritual significance to Bronze Age and Iron Age peoples, who considered them to be home to (or at least associated with), nature gods or spirits. The bodies of the victims of ritual sacrifices have been found in a number of locations in Scotland, England, Ireland, and especially northern Germany and Denmark, almost perfectly preserved by the tanning properties of the acidic water. (See Tollund Man for one of the most famous examples of a bog body). Peat wetlands formerly had a degree of metallurgical importance, as well. During the Dark Ages, peat bogs were the primary source of bog iron, used to create the swords and armour of the Vikings. Many peat swamps along the coast of Malaysia serve as a natural means of flood mitigation. The peat swamps serve like a natural form of water catchment whereby any overflow will be absorbed by the peat. However, this is effective only if the forests are still present, since they prevent peat fires.


Worked bank in blanket bog, near Ulsta, Yell, Shetland Islands

In Scotland

Some Scotch whisky distilleries, such as those on Islay, use peat fires to dry malted barley. The drying process takes about 30 hours. This gives the whiskies a distinctive smoky flavour, often called "peatiness".[20] The peatiness, or degree of peat flavor, of a whisky is calculated in ppm of phenol. The normal Highland whiskies have a peat level of up to 30 ppm, and the whiskies on Islay usually have up to 50 ppm. In rare types, like the Octomore,[21] the whisky can have more than 100 ppm of phenol.


Falkland Islanders shovelling peat in the 1950s

In Ireland

In Ireland, large-scale domestic and industrial peat usage is widespread. In the Republic of Ireland, a state-owned company called Bord na Móna is responsible for managing peat production. It produces milled peat which is used in power stations. It sells processed peat fuel in the form of peat briquettes which are used for domestic heating. These are oblong bars of densely compressed, dried, and shredded peat. Peat moss is a manufactured product for use in garden cultivation. Turf (dried out peat sods) is very commonly used in rural areas.

In Northern Ireland there is small-scale domestic turf cutting in rural areas, but areas of bog lands have been diminished because of changes in agriculture. Afforestation has seen the establishment of tentative steps towards conservation, such as at Peatlands Park, County Armagh, which is an Area of Special Scientific Interest.[22]

Industrial milled peat production in a section of the Bog of Allen in the Irish Midlands: The 'turf' in the foreground is machine-produced for domestic use.

In England

The extraction of peat from the Somerset Levels is known to have taken place during Roman times, and has been carried out since the Levels were first drained.[23] On Dartmoor there were several commercial distillation plants formed and run by the British Patent Naphtha Company in 1844. These produced naphtha on a commercial scale from the high-quality local peat.[24]

Fenn's, Whixall and Bettisfield Mosses are elements of a post-Ice Age peat bog that straddles the England-Wales border. Only lightly hand-dug, it is now a national nature reserve which is being restored to natural condition and contains many rare plant and animal species due to the acidic environment created by the peat.[25]

Peat fire

In Finland

The climate, geography and environment of Finland favour bog and peat bog formation. Peat is available in considerable quantities: some estimates put the amount of peat in Finland alone to be twice the size of the North Sea oil reserves.[26] This abundant resource (often mixed with wood at an average of 2.6%) is burned to produce heat and electricity. Peat provides around 6.2% of Finland's annual energy production, second only to Ireland.[27] The contribution of peat to greenhouse gas emissions of Finland can exceed a yearly amount of 10 million tonnes carbon dioxide, equal to the total emissions of all passenger car traffic in Finland.

Finland classifies peat as a slowly renewing biomass fuel,[28] and that position has also been taken by the European Union. The Intergovernmental Panel on Climate Change has taken the position that peat is not a fossil fuel. Peat producers in Finland often claim that peat is a special form of biofuel because of the relatively fast retake rate of released CO_2 if the bog is not forested for the following 100 years. Also, agricultural and forestry-drained peat bogs actively release more CO_2 annually than is released in peat energy production in Finland. The average regrowth rate of a single peat bog, however, is indeed slow, from 1,000 up to 5,000 years. Furthermore, it is a common practice to forest used peat bogs instead of giving them a chance to renew, leading to lower levels of CO_2 storage than the original peat bog.

The Toppila Power Station, a peat-fired facility in Oulu, Finland

At 106 g CO_2/MJ,[13] the carbon dioxide emissions of peat are higher than those of coal (at 94.6 g CO_2/MJ) and natural gas (at 56.1). According to one study, increasing the average amount of wood in the fuel mixture from the current 2.6% to 12.5% would take the emissions down to 93 g CO_2/MJ, though little effort is being made to achieve this.[29]

Peat extraction is also seen by some conservationists as the main threat to mire biodiversity in Finland. The International Mire Conservation Group (IMCG) in 2006 urged the local and national governments of Finland to protect and conserve the remaining pristine peatland ecosystems. This includes the cessation of drainage and peat extraction in intact mire sites and the abandoning of current and planned groundwater extraction that may affect these sites. A proposal for a Finnish peatland management strategy was presented to the government in 2011, after a lengthy consultation phase.[30]

In Russia

Use of peat for energy production was prominent during the Soviet Union, with the peak occurring in 1965 and declining from that point. In 1929, over 40% of the Soviet Union's electric energy came from peat, which dropped to 1% by 1980.

In the 1960s, larger sections of swamps and bogs in Western Russia were drained for agricultural use and to generate peat fields for mining.[31] Plans are underway to increase peat output and increase peat's contribution to Russian energy generation.[32] However, there is concern about the environmental impact as peat fields are flammable, drainage degrades eco-systems, and burning of peat releases carbon dioxide.[32] Due to 2010 forest and peat fires the Russian government is under heavy pressure to finance re-flooding of the previously drained bogs around Moscow. The initial costs for the programme are estimated to be about 20 to 25 billion rubles, which is close to 500 million euros.

Currently, Russia is responsible for 17% of the world's peat production, and 20% of the peat that it produces, 1.5 million tons, is used for energy purposes.[33][34] Shatura Power Station in Moscow Oblast and Kirov Power Station in Kirov Oblast are the two largest peat power stations in the world.

Shatura Power Station. Russia has the largest peat power capacity in the world

Use in agriculture

In Sweden, farmers use dried peat to absorb excrement from cattle that are wintered indoors. The most important property of peat is retaining moisture in container soil when it is dry and yet preventing the excess of water from killing roots when it is wet. Peat can store nutrients although it is not fertile itself – it is a polyelectrolytic with a high ion exchange capacity due to its oxidized lignin. Peat is discouraged as a soil amendment by the Royal Botanic Gardens, Kew, England, and has been since 2003.[35] While bark-based peat-free potting soil mixes are on the rise, particularly in the U.K., peat remains an important raw material in horticulture in Canada, as well as parts of the United States. However, it is recommended to treat peat thermally, e.g., through soil steaming, in order to kill inherent pests and reactivate nutrients.

The Bor Peat Briquette Factory, Russia

Freshwater aquaria

Peat is sometimes used in freshwater aquaria, most commonly in soft water or blackwater river systems, such as those mimicking the Amazon River basin. In addition to being soft in texture and therefore suitable for demersal (bottom-dwelling) species such as *Corydoras* catfish, peat is reported to have a number of other beneficial functions in freshwater aquaria. It softens water by acting as an ion exchanger; it also contains substances that are beneficial for plants, and for the reproductive health of fishes. It can even prevent algae growth and kill microorganisms. Peat often stains the water yellow or brown due to the leaching of tannins.[36]

Water filtration

Peat is used in water filtration, such as for the treatment of septic tank effluent, as well as for urban runoff. Due to its purifying properties, peat also serves as a filter for septic tanks and may be used as a water purifier.

Balneotherapy

Peat is widely used in balneotherapy (the use of bathing to treat disease). Many traditional spa treatments include peat as part of peloids. Such health treatments have a very long tradition in Europe, especially in Poland, the Czech Republic, Germany and Austria. Some of these old spas go back to the 18th century, and they are still active today. The most common types of peat application in balneotherapy are peat muds, poultices, and suspension baths.[37]

Peat archives

Authors Rydin and Jeglum in *Biology of Habitats* described the concept of peat archives, a phrase coined by influential peatland scientist Harry Godwin in 1981.[38][39][40]

> "In a peat profile there is a fossilized record of changes over time in the vegetation, pollen, spores, animals (from microscopic to the giant elk), and archaeological remains that have been deposited in place, as well as pollen, spores and particles brought in by wind and weather. These remains are collectively termed the peat archives.
>
> — "Rydin 2013"

In *Quaternary Palaeoecology*, first published in 1980, Birks and Birks described how paleoecological studies "of peat can be used to reveal what plant communities were present (locally and regionally), what time period each community occupied, how environmental conditions changed, and how environment affected the ecosystem in that time and place."[39][41]

Scientists continue to compare modern mercury (Hg) accumulation rates in bogs with historical natural archives records in peat bogs and lake sediments to estimate the potential human impacts on the biogeochemical cycle of mercury, for example.[42] Over the years different dating models and technologies for measuring date sediments and peat profiles accumulated over the last 100–150 years, have been used, including the widely used vertical distribution of 210Pb, the ICP-SMS[43] and more recently the Initial Penetration (IP).[44]

Peat hags

Peat "hags" are a form of erosion that occurs at the sides of gullies that cut into the peat or, sometimes, in isolation.[45] Hags may result when flowing water cuts downwards into the peat or when fire or overgrazing exposes the peat surface. Once the peat is exposed in these ways, it is prone to further erosion by wind, water and livestock. The result is overhanging vegetation and peat. Hags are too steep and unstable for vegetation to establish and so they continue to erode unless restoration action is taken.[45]

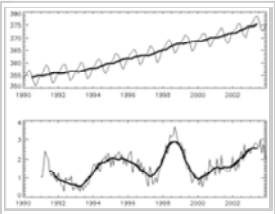
Peat hags at the start of Allt Lagan a' Bhainne tributary on Eilrig

Environmental and ecological issues

Because of the distinctive ecological conditions of peat wetlands, they provide habitat for a distinctive fauna and flora. For example, whooping cranes nest in North American peatlands, while Siberian cranes nest in the West Siberian peatland. Such habitats also have many species of wild orchids and carnivorous plants. It takes centuries for a peat bog to recover from disturbance. For more on biological communities, see wetland, bog or fen.

Recent studies indicate that the world's largest peat bog, located in Western Siberia and the size of France and Germany combined, is thawing for the first time in 11,000 years. As the permafrost melts, it could release billions of tons of methane gas into the atmosphere. The world's peatlands are thought to contain 180 to 455 billion metric tons of sequestered carbon, and they release into the atmosphere 20 to 45 million metric tons of methane annually. The peatlands' contribution to long-term fluctuations in these atmospheric gases has been a matter of considerable debate.[46]

One of the characteristics for peat is that bioaccumulations of metals are often concentrated in the peat, of significant environmental concern is accumulated mercury.[47]



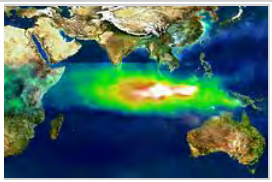
Increase, and change relative to previous year, of the atmospheric concentration of carbon dioxide.

Peat drainage

Large areas of organic wetland (peat) soils are currently drained for agriculture, forestry, and peat extraction. This process is taking place all over the world. This not only destroys the habitat of many species, but also heavily fuels climate change. As a result of peat drainage, the organic carbon—which was built up over thousands of years and is normally under water—is suddenly exposed to the air. It decomposes and turns into carbon dioxide (CO_2), which is released into the atmosphere.[48] The global CO_2 emissions from drained peatlands have increased from 1,058 Mton in 1990 to 1,298 Mton in 2008 (>20%). This increase has particularly taken place in developing countries, of which Indonesia, China, Malaysia, and Papua New Guinea, are the fastest growing top emitters. This estimate excludes emissions from peat fires (conservative estimates amount to at least 4,000 Mton/CO_2-eq./yr for south-east Asia). With 174 Mton/CO_2-eq./yr the EU is after Indonesia (500 Mton) and before Russia (161 Mton) the World's 2nd largest emitter of drainage related peatland CO_2 (excl. extracted peat and fires). Total CO_2 emissions from the worldwide 500,000 km^2 of degraded peatland may exceed 2.0 Gtons (including emissions from peat fires) which is almost 6% of all global carbon emissions.[49]

Peat fires

Peat has a high carbon content and can burn under low moisture conditions. Once ignited by the presence of a heat source (e.g., a wildfire penetrating the subsurface), it smolders. These smoldering fires can burn undetected for very long periods of time (months, years, and even centuries) propagating in a creeping fashion through the underground peat layer.


Smoke and ozone pollution from Indonesian fires, 1997.

Despite the damage that the burning of raw peat can cause, bogs are naturally subject to wildfires and depend on the wildfires to keep woody competition from lowering the water table and shading out many bog plants. Several families of plants including the carnivorous Sarracenia, Dionaea, Utricularia and even non-carnivorous plants such as the Sandhills Lily, Toothache Grass and many species of orchid are now threatened and in some cases endangered from the combined forces of human drainage, negligence and absence of fire.[50][51][52]

Recent burning of peat bogs in Indonesia, with their large and deep growths containing more than 50 billion tons of carbon, has contributed to increases in world carbon dioxide levels[53] Peat deposits in Southeast Asia could be destroyed by 2040.[54][55]

It is estimated that in 1997, peat and forest fires in Indonesia released between 0.81 and 2.57 Gt of carbon; equivalent to 13–40 percent of the amount released by global fossil fuel burning, and greater than the carbon uptake of the world's biosphere. These fires may be responsible for the acceleration in the increase in carbon dioxide levels since 1998.[56][57] More than 100 peat fires in Kalimantan and East Sumatra have continued to burn since 1997. Each year, the peat fires in Kalimantan and East Sumatra ignite new forest fires above the ground.

In North America, peat fires can occur during severe droughts throughout their occurrence, from boreal forests in Canada to swamps and fens in the subtropical southern Florida Everglades.[58] Once a fire has burnt through the area, hollows in the peat are burnt out, and hummocks are desiccated but can contribute to *Sphagnum* recolonization.[59]

In the summer of 2010, an unusually high heat wave of up to 40 °C (104 °F) ignited large deposits of peat in Central Russia, burning thousands of houses and covering the capital of Moscow with a toxic smoke blanket. The situation remained critical until the end of August 2010.[60][61]

Wise use and protection

In June 2002, the United Nations Development Programme launched the Wetlands Ecosystem and Tropical Peat Swamp Forest Rehabilitation Project. This project was targeted to last for 5 years until 2007 and brings together the efforts of various non-government organisations.

In November 2002, the **International Peat Society** and the International Mire Conservation Group (IMCG) published guidelines on the "Wise Use of Mires and Peatlands — Backgrounds and Principles including a framework for decision-making". The aim of this publication is to develop mechanisms that can balance the conflicting demands on the global peatland heritage, to ensure its wise use to meet the needs of humankind.

In June 2008, the International Peat Society published the book *Peatlands and Climate Change*, summarizing the currently available knowledge on the topic. In 2010, IPS presented a "Strategy for Responsible Peatland Management" which can be applied worldwide for decision-making.

See also

- Acid sulfate soil
- Acrotelm
- Gytta
- Histosols
- Irish Peatland Conservation Council
- List of bogs
- Peat-fired power stations
- Tropical peat
- Turbary
- Unified Soil Classification System

Notes

1. Supported by the "Dutch Ministry of Foreign Affairs (DGIS) under the [www.wetlands.org/projects/GPI/default.htm Global Peatland Initiative], managed by Wetlands International in co-operation with the IUCN- Netherlands Committee, Alterra, the International Mire Conservation Group and the International Peatland Society."

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11. http://www.un-documents.net/ocf-07.htm Today's primary sources of energy are mainly non-renewable: natural gas, oil, coal, peat, and conventional nuclear power. There are also renewable sources, including wood, plants, dung, falling water, geothermal sources, solar, tidal, wind, and wave energy, as well as human and animal muscle-power. Nuclear reactors that produce their own fuel ("breeders"), and eventually fusion reactors, are also in this category.
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External links

- International Peat Society (http://www.peatsociety.org)
- International Mire Conservation Group (http://www.imcg.net)
- Cutover and Cutaway bogs (http://www.ipcc.ie/infocutbogtypesfs.html) from IPCC
- Gardening without peat (http://www.rbgkew.org.uk/ksheets/peat.html) information supplied by Kew gardens in London
- Peat-free gardens (http://www.rspb.org.uk/advice/gardening/planting/peatfree.asp) from the RSPB
- Massive peat burn is speeding climate change (http://www.newscientist.com/article/dn6613) From The New Scientist
- King Class Torf (http://www.kingclasstorf.com) in Turkey
- Meadowview Biological Research Station (http://www.pitcherplant.org)
- Industry - Peat (http://industry-peat.at.ua)
- Equipment for peat extraction (http://www.rm-eco.ru/tehnika_dlya_dobichi_torfa/)

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