

What is soil?

When rock is exposed to a new environment – following lava flow, sediment uplift, retreat of glaciers – soil begins to form. Physical and chemical weathering changes the rock, as do the actions of living organisms. A **soil** eventually forms, which changes over time, as a result of the rock type on which it is developed, the climate, the vegetation that grows upon the soil, the organisms that lives in the soil and the topography (slope and aspect) on which the soil is found. Soil, air and water are three major factors affecting life on Earth. All three factors are strongly dependent upon each other. For example, soil cleans much of the water that passes through it to the groundwater and soil can act as a sink or source of carbon dioxide and methane (greenhouse gases) to the atmosphere.

Soil is an ecosystem, important for **biodiversity**. It is the basis of **food production**. It is the source of valuable **materials** ranging from gold to iron.

Table 1: Great groups, sub groups and series

Group	Description
Great Groups	Soils are grouped according to a single dominant characteristic affecting the nature of the soil. 11 Great Groups exist in Ireland. For example, podzols are soils, that formed under acidic conditions, where Iron and Aluminium has been lost (leaching) from the surface horizon and is deposited in lower horizons.
Sub Group	Each Great Group is further sub-divided based on the main diagnostic features found within the soil. Diagnostic Features are described as the main characteristics of a soil profile that describe the main soil forming processes and/or soil forming factor taking place. Nine key diagnostic features are recognized; <ol style="list-style-type: none"> histic (peaty surface horizon present), gleyic (mottling as a result of groundwater table), stagnic (mottling as a result of a slowly permeable horizon), spodic (leaching of iron/aluminium into the lower horizon), Calcareous nature of the soil, Humic (organic matter in the surface horizon, but not histic), Soil that has been significantly artificially drained, Peat soils that are cut for turf, Anthropic soils that have been significantly changed as a result of human management.
Series	Series consist of soils within a subgroup that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition and arrangement in the profile. Series names are place names of townlands, etc. from the area where the soil was first defined. Series are defined on the basis of the following hierarchically: — Great group, subgroup, texture and parent material.

It **filters water, sequesters carbon** from the atmosphere and to an engineer, it is a **surface upon which houses and roads** are built and the source of **raw material**. It also protects many of the **archeological resources** that are preserved in Ireland. The characteristics of a soil and how they may be modified need to be known. In agriculture one must know the type, quantity and quality of food that can be produced on that soil. In habitat restoration, is the soil still suitable for the original species? Builders need to know whether that land might subside or flood easily.

If the different types of soil can be classified in an efficient and repeatable way, then soil characteristics are more easily communicated. Through history classification systems have been developed for each individual country. In Ireland we apply the Irish Soil Classification <http://gis.teagasc.ie/soils/>. However, this means that comparison of soils across countries can often be very difficult, therefore a World Reference Base (WRB) system was created that all countries can relate to and this allows comparisons across countries <ftp://ftp.fao.org/docrep/fao/009/a0510e/a0510e00.pdf>.

Developing a universal soil classification

Early civilisations knew that soil quality varied. In ancient Egypt, black alluvial (kemet) and red desert (deshret) were two recognised soil types. In the 16th century Russians described soils in terms such as poor, sandy, clayey stony, etc. By the 20th century, scientists were classifying soils on the basis of their environment and the processes that formed them. Ultimately this was regarded as inadequate. Systems evolved where physical and chemical features (**pH**, temperature, minerals, water, particle nature, etc.) were quantitatively recorded along with the effects of processes such as those involving; **leaching, gleying** and **organic matter** build up and climate.

The World Reference Base

The **World Reference Base (WRB)** for soil resources is a more recently developed system. It draws on ideas from the USDA, Russian and other systems. The basic concept is to distinguish soils according to their **morphology** as an expression of **diagnostic features** (similar to the system we now use in Ireland, but with diagnostic features that apply to soils all over the world!). The detail is comparable to that of the USDA system but it omits soil climate except in cases where the climate influences soil characteristics.

This system recognises 32 basic reference soil groups (histosols, podzols, andosols and others). Globally, the WRB system can be used as a benchmark. A soil classification derived from one system can be correlated with the WRB system and by extension with other systems. Workers can apply it (and other systems) using a 'key' similar to those used in biological classification. The table below describes each of the 11 Great Groups found in Ireland in the new Irish Classification System, the "old name" used until last year and the equivalent WRB references groups to which it can be compared.

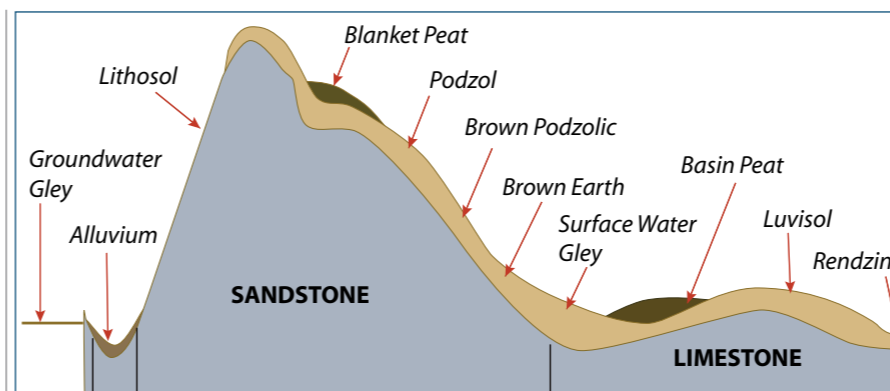


Fig. 1: Soil types commonly associated with particular landscape features

Table 2: The new Irish Soil Classification System

Distinguishing Criteria	Great Group	Description	"Old name"	WRB correlation
Soils with thick organic layers	Ombrotrophic Peat	Rain-fed peat	Blanket peat, basin peat	Histosol
	Minerotrophic Peat	Groundwater fed peat	Fen peat	Histosol
Shallow or extremely gravelly soils	Rendzina	Shallow calcareous soil (<40 cm deep)	Rendzina	Regosol
	Lithosol	Shallow non-calcareous soil (< 40 cm deep)	Lithosol	Leptosol
Soils influenced by water	Alluvial	Soil derived from alluvium. No distinct layer development	Regosol	Fluvisol
	Groundwater Gley	Soil gleyed within 40 cm of the surface due to watertable.	Gley	Gleysol
	Surface-water Gley	Soil gleyed within 40 cm of the surface due to slowly permeable horizon.	Gley	Stagnosol
Soils affected by Fe/Al chemistry increase	Podzol	Infertile acidic soils with an ash-like subsurface layer. They show effects of acid leaching . Typically formed under coniferous forest.	Podzol	Podzol
	Brown Podzolic	Some leaching has taken place, but not as severe as podzols.	Brown Podzolic	Cambisol or Podzol
Soils with clay enriched subsoil	Luvisols	Loss of clay minerals from the surface horizon to lower horizons (clay illuviation). Generally found in limestone areas	Grey brown podzolic	Luvisol
Relatively young, or soils with little profile development	Brown Earth	Uniform throughout.	Brown Earth	Cambisol or Regosol



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Syllabus references

The main syllabus references for the lesson are:

Leaving Certificate Agricultural Science

- Soils

Leaving Certificate Geography (HL)

Geoecology

- General composition of all soil types with reference to mineral matter, organic matter, water and air
- Soil characteristics: texture, colour, structure, water content, organic content, water retention properties etc.

Science and Technology in Action is also widely used by Transition Year classes.

Learning Outcomes

On completion of this lesson, students should be able to:

- Describe the main of soils types
- Explain the need for soil classification systems
- Outline how different classification systems have evolved in different countries
- Explain why soil classification is an ongoing area of study.

General Learning Points

These are additional relevant points that are used to extend knowledge and facilitate discussion.

- A soil profile is the vertical division of a soil exposed by excavation from the surface to the parent material. Layers distinguishable by tangible features such as colour, hardness are called horizons. The upper A layer (topsoil) from which materials are generally washed downwards is described as eluvial. The B layer (subsoil) in which they may accumulate is illuvial. The C horizon constitutes the parent material. There are many possible subdivisions. O denotes organic layers as in peat. Bf indicates a thin iron pan.
- Soil particles in descending order of size are sand, silt and clay. Sandy soils have good drainage, poor mineral retention. Clay retains minerals but is prone to waterlogging. Loams are mixed soils with good intermediate characteristics. Sand is gritty to the touch, silt smooth and clay sticky. The texture (feel) of a soil is a good indicator of its quality.

Student Activities

1. Print out a map of the world's soils. Print out similar maps showing the world's climatic regions and agricultural activities. If possible, list the soils and their characteristics. Can you make any connections between soils, climate and agriculture?
2. Measure 50 cm³ of soil into a graduated cylinder and add 50 cm³ of water. Note the final volume. Volume of air = 100 – final volume. Convert the answer to a percentage and repeat the experiment with soil from different places.
3. Use a soil test kit to find the levels of different minerals in the soil.
4. Weigh a sample of soil. Dry it at 100 °C in an oven overnight. Weigh again. Loss in mass = mass of water present. Now heat that soil on a burner until it is reduced to ash and weigh again. Loss in mass = mass of humus present.
5. Use a soil auger to obtain a soil profile. Describe the profile's appearance. Carry out the foregoing tests on each horizon.
6. Make up a classroom museum displaying soil samples from around Ireland.
7. List the ways earthworms improve the quality of soil. In recent times, predatory flatworms have been accidentally introduced to some countries, including Ireland. What might the consequences be for soil and agriculture?
8. "You change a soil's classification by improving it". Discuss.
9. What is the Munsell value of a soil?
10. Read Patrick Kavanagh's poem "Stony grey soil".

True/False Questions

- | | |
|---|-----|
| a) Rendzina is shallow calcareous soil. | T F |
| b) Alluvial soil has distinct layers. | T F |
| c) Podzol refers to infertile acidic soils typically formed in coniferous forests. | T F |
| d) Brown Earth shows a distinct profile development. | T F |
| e) Lithosols are found in limestone areas. | T F |
| f) A single dominant characteristic is used to divide soils into 32 Great Groups. | T F |
| g) Eleven Great Groups are found in Ireland. | T F |
| h) Gley soils do not retain water very well. | T F |
| i) Peat is always acidic. | T F |
| j) Minerotrophic peat is usually neutral or alkaline. | T F |
| k) The World Reference Base (WRB) for soils is largely based on systems developed in Russia and the USA.. | T F |

Check your answers to these questions on www.sta.ie.

Examination Questions

Leaving Certificate Geography (Higher level) Q. 16

Explain how soil characteristics impact on soil development.

Leaving Certificate Geography (Higher level) Q. 17

Soil profiles are the result of the operation of soil-forming processes. Discuss.

Leaving Certificate Agricultural Science (HL) 2014, Q. 11

(a) Read the following paragraph about the formation and development of podzol soils and match the words from the list below with the numbered spaces. Write your answers in your answer book and not on this examination paper.

List: Iron pan Leaching Forestry
Iron B horizon Lime

Podzols are poor soils with high _____ and fertiliser requirements. They are formed as a result of _____. Aluminium and _____ are moved from the A horizon to the _____. Podzols show a distinct red layer called the _____. Podzols are widely used for _____.

(b) Humus is a very important soil component. Describe three benefits of humus in the soil. Give two methods of increasing soil humus content. Describe an experiment to estimate the percentage (%) organic matter in a soil sample.

(c) Soil texture influences the crops grown on a farm. Explain what is meant by the term soil texture.

Compare sandy soils and clay soils under the following headings:

1. Drainage.
2. Fertility.
3. Ease of tilling.

Leaving Certificate Agricultural Science (OL) 2009 Q. 2

The diagram shows the soil profile of a podzol. Name the parts P, Q, R, S.

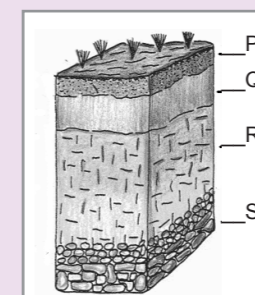
P: _____

Q: _____

R: _____

S: _____

Describe a suitable activity that would remove the iron pan in a podzol.



Did You Know?

- 2500 years ago in China, soils were classified on the basis of their colour, texture, hydrologic and other characteristics. The aim was to assess the value of the land for taxation purposes.
- Soils have their own unique chemistry and ecology. Soil types can often be inferred from the types of plants growing in them. Rushes are typical of gley soils and bog cotton grows on peat. Rhododendrons like acid soils. There are other plants that are adapted to living in soils that have high concentrations of specific minerals; prospectors have long looked out for those plants to tell them where to start digging.
- The Occupational Health and Safety Administration (USA) classifies soils as cohesive plastic, cohesive and granular cohesive based on their compressive strengths.
- People applying for permission to build are obliged to dig a hole so it can be filled with water and the drainage ability of the soil can be observed.

Biographical Notes

Vasily Dokuchayev 1846 - 1903

Vasily Dokuchayev was born in Russia in 1846. He became curator of geology at the University of Saint Petersburg in 1872. Between 1892 and 1895, he reorganised and directed the Novo Aleksandr Institute of Agriculture and Forestry, establishing departments of soil science and plant physiology. He organised major soil surveys in Russia and is regarded as having pioneered the modern science of soil classification. He had noted that a single type of bedrock would give rise to different soils in different climates. Soil to Dokuchayev was an entity resulting from the interaction of parent material, climate and living organisms over time and he developed his classification system on that principle. Mathematically it can be expressed in the form:

Soil = f (climate, parent material, biological process) × time



Revise The Terms

Can you recall the meaning of the following terms?
Revising terminology is a powerful aid to recall and retention.

acid leaching, alluvial, biodiversity, brown earths, edaphic, gleys, leaching, mature soil, mineralisation, morphology, parent material, peat, pedogenesis, podzols, soil horizon, soil profile, soil taxonomy.

Check the Glossary of terms for this lesson on www.sta.ie