Transition Haslemere

Notes for a discussion on 'Soils' at Green Drinks 6th April 2017

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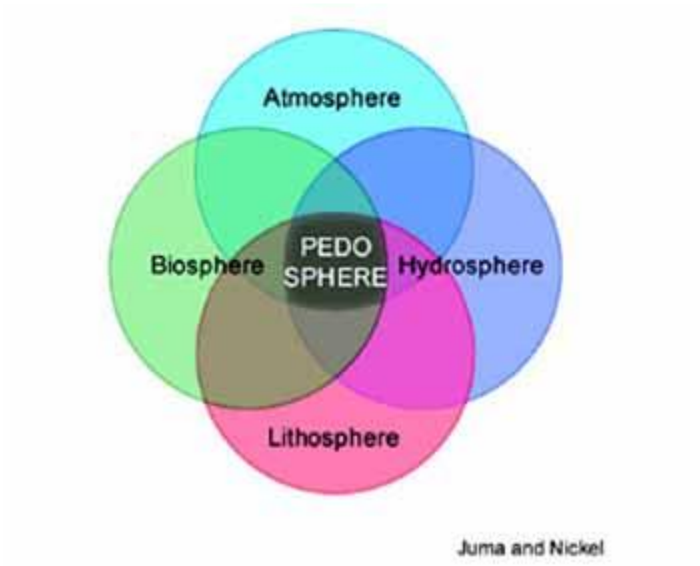
Soils

Let's start from our title – the essence of growing

Soils are the Earth's dynamic 'skin' and an essential resource for human societies and most other ecologies worldwide. The quality of soil derives from a complex interaction of physical, chemical and biological processes which enable plants to get the water and minerals they need to be healthy and grow. Most of our food comes from this soil-based foundation and life would be unimaginably different without it. Extend your roots further into this marvellous and mysterious material.

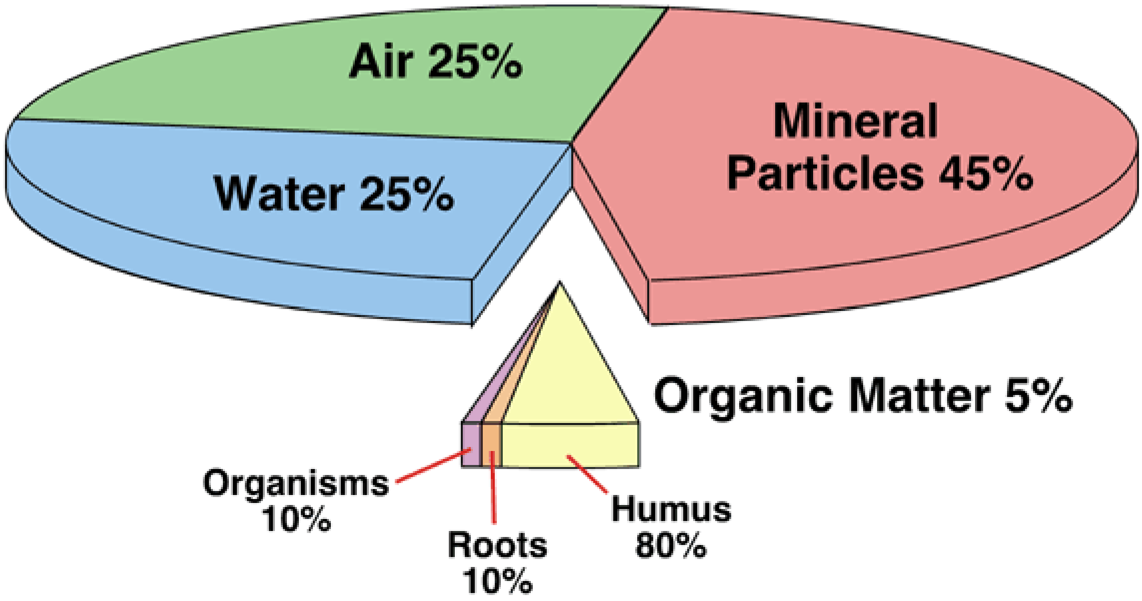
"The Connector, the Protector, the Producer"

The soil intimately connects various spheres of existence on earth – the lithosphere (rocks), the atmosphere (gases) the hydrosphere (waters fresh and marine) and the biosphere (living things)



Relationships of the Spheres

The word "soil"may be interpreted as the top 40 cm or so of the ground (more or less). It is a mixture of mineral particles and organic matter from various sources. Soils are dynamic and complex, formed by the interaction of minerals, organic materials, living organisms and their remains, water and air.



Proportions of soils constituents by volume

Soil is a **non-renewable** resource for mankind. It provides a number of functions that are vital to the environment and for societies across the world. The **quality** of soil - its ability to provide these various functions - depends on many different processes that reflect physical, chemical and biological interactions.

The study of soils is called pedology because it's under our **feet** from the Greek 'pedon' ground, earth, from PIE (proto-indo-european linguistic) root 'ped' foot

The physical, chemical and biological aspects of soil are so closely intertwined that it is almost impossible to discuss those aspects as separate things.

Physical

Soils originate in the weathering of rocks, erosion/deposition in river valleys, windblown deposits, volcanic material, glacial till and the eventual colonisation and covering of these raw deposits by vegetation.

Geological deposits in themselves are chemically and physically varied and complicated, having been created ultimately from the earth's mantle in volcanic activity that heated and pressurised the rocks near the earth's surface.

The main weight of the soil (80%) is made up of **particles** of the rocks themselves, and minerals derived from them. Although clay particles are minute, their molecules are very complex and varied, depending on the chemical origin of the rocks from which they are derived by the processes of weathering. (By volume, soils are about 45% rock particles, 25% water, 25% air and 5% organic matter)

The physical properties of a soil are largely based on the size of particles: The finest, **clay** particles have already been somewhat changed by soil making processes and are less than 2 micrometers in diameter. Clay does not easily separate into individual particles as it is very cohesive. The next size of particle is called ***silt*** (diameter of 2 to 60μm). Particles larger than this can be seen with the naked eye, and are known as ***sand*** sometimes divided into fine, medium and coarse sand. Sand, silt and clay constitute what is known as the "fine earth". Particles larger than 2000μm (2 mm) are included with ***stones*** which vary from fine grit, or gravel to large boulders.

Around the finer soil particles is a thin film of water in which are dissolved the chemical nutrients available to plant roots, and unless a soil is waterlogged, there will also be minute air pockets which allow roots to 'breathe'. The balance of gases in these air pockets will be slightly different to that in the air above ground due to the uptake and output of the products of root metabolism.

All but the newest soils are divided vertically into horizons, from the top down: O-organic layer, A – topsoil which is darker in colour with more humus and roots penetrating, B – subsoil lighter in colour and more resembling the rock beneath, C – substratum where bedrock is beginning to break up, R – bedrock. In addition there may be leached, bleached or cemented layers into which materials from above have been washed by water percolating down.

Chemical

The chemical attributes of a soil start with the parent material. This may have minerals (elements and compounds) in it which lead to a particular pH (acidity or alkalinity), fertility, and physical character. The nature of soil can vary considerably locally, even within one garden plot.

Carbon, hydrogen and oxygen, three of the essential plant nutrients, are taken up from the atmosphere both above and below ground and from water in the soil. Three further elements contribute to the general fertility of soil - nitrogen, phosphorus and potassium (NPK). In natural or organic systems nitrogen is always fixed by plants, and phosphorus and potassium derived from parent material or decomposing material. Other major nutrients derived from rocks and supplied to plants by the soil are sulphur, magnesium and calcium, which are used for making complex molecules such as chlorophyll (the green pigment of photosynthesis) and amino acids (components of proteins including enzymes). The minor nutrients, also referred to as trace elements, are molybdenum, copper, zinc, manganese, iron, nickel, boron and chlorine. A deficiency in any one of these essential nutrients will reduce growth. In organic systems these elements are bound up in complex molecules and released slowly for use by growing plants. It has become customary in conventional agriculture to apply artificial fertilisers mainly to supply NPK but also to address specific micronutrient deficiencies. Inorganic forms of the nutrients required by plant growth are soluble, and easily washed out of the soil. Once locked up in the growth of plants or harvested, nutrients must be replenished, either by the return of decomposing materials or by the addition of manures and fertilisers.

You can test your soil for pH and nutrient content, in order to find out what is lacking. Then you can consider chemical/biological additives, lime, (or in the past, marl), rock phosphate, animal waste products, seaweed meal/calcified seaweed (less available/approved now), leaf-mould, shreddings, ‘night soil’ (human manure, commonly used in China) and not peat, a formerly popular additive now frowned upon because of habitat destruction.

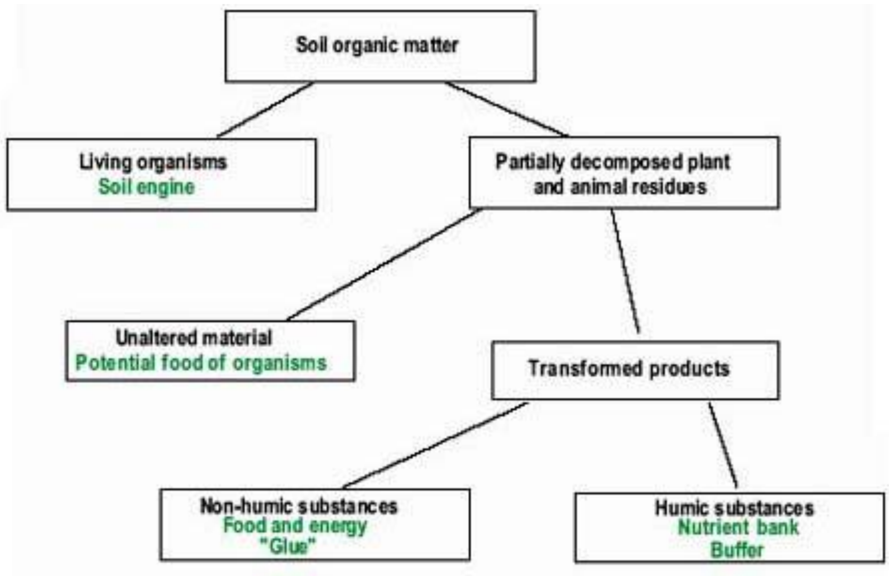
Finally and equally important is the amount of carbon present in the form of organic matter. **Humus** is on the edge between the chemical and the biological and is important for both soil fertility and its chemical and physical integrity. Sometimes it is described as the architecture of the soil. Its structure allows oxygen to interact with other minerals making them available to plant roots, since humus in the soil regulates its water-holding capacity and the availability of soluble chemical molecules used for plant growth.

The word is derived from Latin – ‘humus’ earth or soil, probably from ‘humi’, meaning on the ground, also the root of ‘humilis’, the Latin for low. Interestingly, if you go further back to the PIE root dhghem, meaning earth, there is a common origin with the word human – (dh)ghomon, literally an earthling or earthly being.

Humus is found in particular parts of the soil – especially in the topsoil, where it glues fragments of soil together, and coats the surfaces of the resulting structural units, which are known as ***peds***. If you shake some garden soil in your hand it will usually break into breadcrumb shaped fragments a few mm to a couple of cm in diameter. Their surfaces are often coated with humus, whilst pores that run through them may also contain enhanced amounts of this material. So where does it come from?

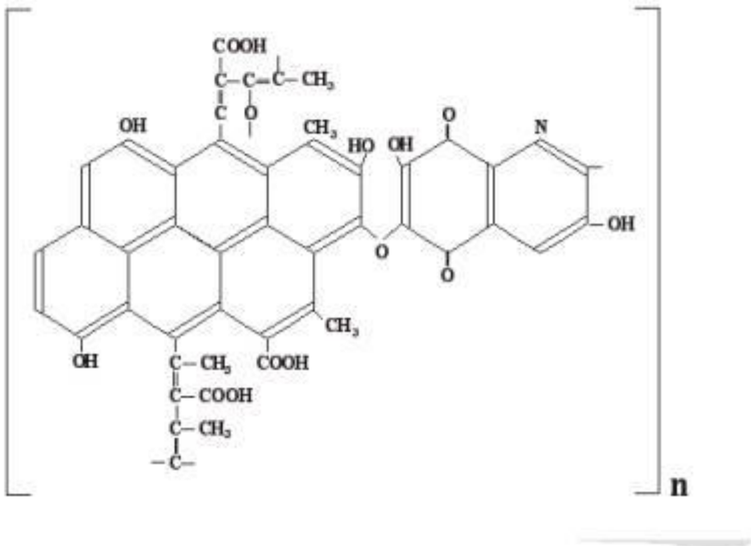
The organic fraction (carbon based) of the soil is formed from dead plant and animal remains, their waste products and the many microorganisms which decompose the larger scale material.

Plant remains contain many simple and complex organic chemicals, which decay at different rates by the intervention of many different microorganisms. Simple sugars and starches decompose quickly, waxes and resins much more slowly. The most important precursor of humus is lignin. This is a complex fibrous molecule, the most important structural component infilling and binding together the cellulose of plant cell walls, and waterproofing the conducting vessels.



Organic matter in the soil: a cascade of decomposition

‘Humus’ is not simply decomposing organic matter. New colloidal or amorphous molecules are formed from decaying animal and plant material by microbial processes which are the complex organic acids generally called humic acids.



Example of a humic substance

These substances are chemically stable and not susceptible to further oxidation and mineralisation. They are less available to plants for growth, but important for retention of other minerals and water. Much persists in soils for many years because it is attached to clay particles or hidden by clusters of fine rock particles. Unprotected humus will decay within ten years. Black earths (including the Amazonian terra preta) formed by incorporating fine charcoal have particularly oxidation-resistant humus. The dark colour of humus-rich soils is due to the carbon content and this has the further useful property of helping the soil warm up in spring.

Biological

Then there is the living organic fraction:

Plants are the most obvious bridge between the soil and the world above. Their fine, fibrous and superficial roots hold the surface together and deeper roots penetrate sometimes to the bedrock. Different plants are suited to different kinds of soils, for example the pioneers which are the first colonists of volcanic, glaciated, marine sediments and the edges of deserts. For gardeners, even weeds can tell us what kind of soil we have. What you can grow varies locally – look around and see what does well. When plants die their roots and above ground parts decompose and become incorporated in the soil.

Most animals live above ground, but contribute their wastes and dead bodies to the soil. Some bigger animals make their home in the ground and can have a significant effect on it: rabbits, badgers, moles.

There are smaller animals still visible to the naked eye: earthworms, nematodes, flatworms, mites, springtails, also more surface dwelling woodlice, hoppers, slugs, centipedes and millipedes. Animals such as these actually eat decomposing organic matter, milling it smaller and smaller, or eat the bacteria and fungi also acting as decomposers. The rove beetles and dung beetles actively bring organic material down into the ground. Worms were famously studied by Charles Darwin for their capacity to generate soil through pulling leaves into the soil, continually processing soil for its 'food' content and contributing their waste as worm casts on the surface. Worms also aerate the soil with their tunnels.

Magnify soil and you can often see microscopic animal life such as protozoans living in the water film on soil particles.

Other microscopic organisms living in the soil as active decomposers are the soil fungi and bacteria. Some bacteria fix nitrogen and coexist in nodules on the roots of leguminous plants. Some fungi live in symbiotic relationships with plants such as trees, orchids and crop species (mycorrhizae).

Metaphors

The skin of the earth is somewhat like our skin, which is an extremely significant organ for a living body, providing protection, exchange with external systems, bodily integrity and temperature control.

Soil is the ground of our being, from where we arise and where we finally descend (unless we are cremated).

This is our home, the basis of our existence and livelihood.

It is also the home to billions of invisible co-creators that co-inhabit the land under out feet. What does the soil look like, feel like and smell like? How can we regain the lost connection to the soil?

We are rooted to the soil but unlike the plants we have invisible roots.

Formation of soil, threats to soil

Soils can be very old, but are formed and grow slowly. For example soils in the British uplands may be 10,000 years old, dating from the last ice age, yet still quite thin. The process of soil formation, from the weathering of rock to the accumulation of organic material and the colonisation by living things, is called pedogenesis.

There is an easy acronym (clumsy but memorable) to remember the factors determining the formation of soils:

CLORPT - CLimate, Organic activity, Relief, Parent material, Time.

Soil formation can be encouraged by composting, better grazing practices, better cultivation and irrigation practices, crop rotation, planting trees and other vegetation, especially indigenous and well adapted species. There has been recent debate about the value of organic growing, but it seems only to make sense that mixed systems work well, and special systems – no-dig, Shumei, permaculture, biodynamics - may be beneficial, even if not for the reasons their adherents believe, simply because they involve minimal disturbance to the soil and respect for local conditions. It makes sense to care for your soil for best results with growing: with good treatment you can improve drainage, texture, warmth, physical protection as well as fertility.

There are many threats to the structure and integrity of soils, which in turn threatens the continuance of human life and culture. Despite a number of encouraging examples from around the world, the fact remains that at a global level our management of the Earth's soils has been dismal. Since 1945, Montgomery estimates that some 1.2 billion hectares of agricultural land have been moderately or extremely degraded. To put that into perspective, this roughly corresponds to the size of China and India combined.

Soil loss can be caused by cultivation and/or compaction, other agricultural practices such as over-grazing, de-forestation, climate change (desertification), or degradation by pollution and use of agrochemicals which damage the soil microbiota. Finally, soils can be lost simply by development – houses or roads are built and the ground is disrupted, filled with rubbish and covered over.

2015 was the Food and Agriculture Organisation's Year of Soils. Soil is too easily overlooked, and underestimated. But it's not too late in 2017 to think a bit more about how we can better protect this critical resource for human existence.

References/links

British Society of Soil Science http://www.soils.org.uk

International Year of Soils website http://www.fao.org/soils-2015/en/

Video from International Year of Soils 2015 https://www.youtube.com/watch?v=dzJT2O29xtM

'Safeguarding our soils: a Strategy for England ' (Defra)
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69261/pb13297-soil-strategy-090910.pdf

An introduction to soils, soil formation and terminology (pdf)

http://www.macaulay.ac.uk/soilquality/An%20introduction%20to%20soils,%20soil%20formation%20and%20terminology.pdf

Free course on FutureLearn from Lancaster University: https://www.futurelearn.com/courses/soils

Review of 'dirt: The Erosion of Civilisations' by David R.Montgomery

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'Soilscapes' at Cranfield University: detailed map with soil types for any area.
http://www.landis.org.uk/soilscapes/

National Soil Resources Institute: Information paper The National Soil Map and Soil Classification
https://www.landis.org.uk/downloads/downloads/Soil_classification.pdf

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http://www.hutton.ac.uk/

Geological map of Haslemere: http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=1001793

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