A BRIEF HISTORY OF SOIL SCIENCE

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Contents

1. Introduction
2. Soil Science/Agriculture in Ancient Times and Early History (up to 4th Century AD)
2.1. Mesopotamia
2.2. Greeks and Romans
2.3. Other Mediterranean Civilizations
2.4. Northern Europe
2.5. Asia
2.6. Americas
2.7. Ancient Times and Early History Summary
3. Soil Science in the Middle Ages (5th to 14th Centuries AD)
3.1. Byzantium and Europe
3.2. Arabia and the Middle East
3.3. Southeast Asia
4. Soil Science in the Renaissance Period (15th to 17th Centuries)
4.1. Studies in Soils and Plant Nutrition
4.2. Soils and Government
4.3. Soils Recognized by Geologists
4.4. Drainage of Wet Soils
5. Soil Science in the Age of Enlightenment (18th Century)
5.1. The "Humus Theory"
5.2. Soil as an Evolutionary Body
5.3. Beginnings of Soil Mapping
6. Soil Science Becomes a True Science (19th century)
6.1. Lewis and Clark
6.2. The "Mineral Theory"
6.3. Agrogeology
6.4. Soil Mapping
6.5. Darwin and Soil Biology
6.6. The Profile Concept
6.7. Dokuchaiev and the Birth of Genetic Soil Science
7. Modern Soil Science (20th Century)
7.1. Genetic Soil Science Spreads
7.2. National Detailed Mapping Programs
7.3. Soil Erosion
7.4. The Internationalization of Soil Science
7.5. Soil Science Moves beyond Agriculture
8. Concluding Remarks

Acknowledgements
Glossary
Bibliography
Biographical Sketch

Summary

The roots of soil science go deep into human history. Some level of soils knowledge would have been necessary when the earliest known agricultural practices were used around 11,000 BP. Civilizations all around the world showed fairly advanced soil knowledge by the 4th century AD, including irrigation, the use of terraces to control erosion, various ways of improving soil fertility, and ways to create productive artificial soils. In many ways, the Greeks and Romans excelled in early soils knowledge. However, these early civilizations did not take soils knowledge to the level of a true science.

Early soils knowledge was based on observations of nature; experiments to test theories were not conducted. Through the Middle Ages, Renaissance Period, and Age of Enlightenment many advances were made and famous scientific names such as Francis Bacon, Robert Boyle, and Leonardo da Vinci worked on soils issues. However, soil science did not become a true science in its own right until the 19th century with the development of genetic soil science, lead by Vasilii V. Dokuchaev.

In the 20th century, soil science moved beyond its agricultural roots. Soils information is now used in residential development and the planning of highways, campgrounds, building foundations, septic systems, wildlife management, and many other applications. In short, soils have become an important component across the board in land use evaluations. However, soil science today is at something of a crossroads. Whether it continues to stand alone as a separate, distinct scientific field or is absorbed into related fields such as crop science, geology, and geography is one of the biggest questions facing soil science in the 21st century.

1. Introduction

Most people probably think of farming or gardening when they think of soil. As a group, people tend to think of soil in the context of its ability to supply us with food. This is certainly a relevant perspective of soil, but we rely on it in many other ways.

Soil is found at the interface between the biologic, hydrologic, lithologic, and atmospheric spheres of our planet. It is a complex material that serves as the foundation to our construction projects, is intimately tied into changes in global climate, is an integral component in responsible environmental management of our planet, provides us with needed raw materials such as aluminum, and from which medicines have been developed, to name but a few. In short, there is much more to soil than most people who don't study soil realize.

Just exactly what soil is depends somewhat upon the perspective of the person viewing the soil. A farmer views soil differently than an engineer, a geologist differently than a

soil scientist. For this reason, there is not a single, uniform definition of soil. A quick look at some sample definitions helps to demonstrate the differences:

- engineer - all unconsolidated materials above bedrock;
- geologist - the natural medium for the growth of land plants;
- soil scientist - a naturally occurring surface layer formed by complex biogeochemical and physical weathering processes that contains living matter and is capable of supporting plant life.

All these definitions are for the same name, yet they differ considerably because each group approaches soil from a different perspective.

The history of soil has largely been a history of the use of soils to grow plants, or soil as it relates to agriculture. However, in our modern society soils knowledge is increasingly important for land use evaluations for non-agricultural purposes, including construction, environmental work, community planning, taxation, and others. This paper will explore how human soils knowledge has evolved over time, and how that has altered the way we use soil knowledge.

2. Soil Science/Agriculture in Ancient Times and Early History (up to 4th Century AD)

Agriculture was probably the first systematic use of soils, and the move to agriculture likely represented one of the first times that humans considered soil properties, be it directly or indirectly, in land use decisions. The earliest known evidence of agricultural practices comes from a site near the modern village of Jarmo in Iraq, where implements for harvesting and tilling were found dating back to 11,000 BP. It is likely that ancient people used a *trial and error* approach in determining where to farm, but without question ancient agricultural settlements were established in places where the soils were favorable for crop growth. Evidence of irrigation has also been found in southern Iraq dating as far back as 9,500 BC, showing early human efforts to manage soils for a given land use application.

2.1. Mesopotamia

The area between the Tigris and Euphrates Rivers in modern Iraq became home to the ancient civilizations of Mesopotamia. Southern Mesopotamia was ruled by the Sumerians from about 5,000 to 1,700 BC. Then the Babylonians gained dominance from their northern Mesopotamia base until about 1,000 BC. The people of Mesopotamia recognized differences in fertility between soils, early evidence of a "soil science".

Mesopotamia had an advanced system of irrigation canals under both the Sumerians and the Babylonians. However, irrigation was also intimately linked to the demise of the Mesopotamian civilizations. Political power in Mesopotamia shifted from the Sumerians to the Babylonians when the soils of Sumer became too saline for crop growth because of salts introduced through the irrigation process. Babylonian rule failed as their canals filled with silt eroded off the surrounding hills. The Babylonians had

removed timber from the hills to build their cities and grazed their sheep and goats on the hills, increasing erosion rates and leading to the deposition of as much as 4 m of sediment in the area around Babylon.

2.2. Greeks and Romans

The Ancient Greek philosopher-scientists developed a clear understanding of soils, recognizing differences between soils as early as the 2nd millennium BC, and have been credited with creating the first recorded works that show knowledge of soil properties. The philosopher Xenophon recognized that life started and ended in the soil, Hesiod wrote of different types of plows that were developed to work different soils, and Aristotle and Plato linked soil to the giving of life by comparing it to a woman or mother. Greek philosophers also developed a concept of the soil profile and recognized that the soil supplies nutrition to plants. Theophrastus wrote what was probably the first agronomic work, including a classification for soils. The Greeks were quite successful at choosing crops appropriate to the soils found in their various colonies around the Mediterranean and had literature devoted to soil management practices.

Despite their advanced knowledge of soil at an early age, the Greeks did not create a true science in their study of the soil. The Greeks were excellent observers of nature, but they did not conduct experiments to test theories, and thus did not move into the realm of science. Also, as with the Babylonians before them, soil erosion became a serious problem in ancient Greece and the Greek agriculturists apparently never developed techniques to combat this erosion.

The agricultural knowledge of the Romans was originally developed under the influence of the Greeks. Italy had been colonized by Greece and produced grains under the Greek system for several centuries before the rise of the Roman Empire. Therefore, Roman knowledge of agriculture and soils was an extension of Greek knowledge, rather than something that developed independently. Krupenikov (1992) breaks the development of soil knowledge in Rome into four distinct periods:

- 2nd Century BC, a time when the role of soil in agriculture was being recognized,
- 1st Century BC, differentiation of soils knowledge into its own special subfield of agronomy,
- 1st Century AD, a period that saw a decline in Roman knowledge of soils, particularly soil fertility,
- and 2nd to 4th Century AD, a period when no new soil knowledge was gained.

The first period of Roman soils knowledge was dominated by Cato, who advocated the use of manure and green manure as amendments to improve soil fertility. In particular, the use of green manure was a step beyond Greek ideas concerning soil fertility, and Cato made the first recorded reference to what we now know as compost. At some point the Romans also began terracing their fields to reduce erosion, another step beyond Greek practices.

Varro ushered in the second period of Roman soils knowledge, and did so in large part by re-introducing works from Greek authors such as Theophrastus to the Roman

literature. Varro proclaimed farming to be a science with soils as one of two important components of farming, developed a classification system for the soils of Italy, and continued to advocate methods for improving soil fertility. However, by the third period of Roman soil knowledge, scientists such as Pliny the Elder were arguing that soil fertility declined with use and could never be replenished. While others (i.e., Columella and Strabo) offered opposing views, Roman ideas of soils and soil fertility as a whole took a step back.

By the 2nd Century AD, Roman science began to decline, and the biggest contribution made by Rome at this time was in the recording of soils knowledge gained to that point, allowing it to be passed on to future workers. Given that the Roman Empire completely encircled the Mediterranean Sea at its height, Roman ideas on soil science probably had a profound influence on soil science throughout the Mediterranean at that time.

2.3. Other Mediterranean Civilizations

Other Mediterranean civilizations were certainly tied to the soil, but did not develop the same level of understanding of the soil as the Greeks and Romans at early stages in their histories. Long before the Greek or Roman Empires rose to prominence, the Egyptians developed an organized civilization around the Nile River that lasted some 3,000 years, from about 3300 BC to 332 BC.

The Egyptian civilization was based on irrigation and the fertility of the agricultural soils was naturally maintained through frequent flooding of the Nile River, which led to deposition of rich silt. The Egyptians had a cultivated agriculture, therefore they understood preparing soil to receive seed. The Egyptians also apparently understood that the Nile floods watered and fertilized the soils as well as removing accumulations of undesired salts.

The Phoenicians, who were at their height from about 1200-800 BC, are credited with being one of the first to construct bench terraces on steep slopes in modern day Lebanon and Syria, and they practiced a cultivated, irrigated agriculture on these terraces. This terracing shows an understanding of soil management to prevent erosion and thus allow for successful cropping.

Another early Mediterranean civilization was based out of the city of Carthage, in modern Tunisia. Eventually conquered by the Romans, the Carthaginians were excellent farmers with advanced cultivation and irrigation systems. However, wind and water erosion eventually removed the topsoil, and today the region can not support the populations it once did.

2.4. Northern Europe

Agriculture-based groups also existed in more northerly parts of Europe in the pre-Roman era. The Celts in Britain cultivated fields across the slope to slow erosion, bench terraces have been used in modern day France that possibly date back to the Phoenicians, and cultivation began in modern day Poland as early as 5,500 BC, but in general agricultural techniques were improved in Europe when the Romans arrived.

Farther east, farming tribes lived along the Dniester River as early as the 4th century BC and a clay jug with an agricultural calendar that dates to the 4th century AD has been found.

While all these examples display some level of soil knowledge from an agricultural perspective, nothing has been found that would indicate knowledge as refined as that of the Greeks and Romans.

2.5. Asia

Farther east in Asia, humans were also learning about soils at a fairly early stage. Farmers worked sand and manure into the soils of the Amu Darya delta, found in present day Uzbekistan along the south shores of the Aral Sea, to improve fertility and other soil properties as early as 4,000 years ago. In India, Neolithic (3rd to 2nd centuries BC) farming communities are found in areas with fertile *black regur* soils on the Deccan Plateau, and writings from the 4th century AD mention irrigation of fields and fines or penalties for those who allowed breaches in the irrigation system. These farming communities expanded at an early date to include the fertile floodplains of major rivers like the Ganges.

Land in China was drained and ameliorated as early as the 23rd century BC, agricultural literature existed by the 14th century BC, and a farming calendar can be documented as early as the 2nd century BC. More to the point of soils specifically, Chinese accounts exist of Count Hui dividing soils according to their quality and location in the 2nd century BC, the earliest records of soil conservation in China date to 956 BC, and Fan Sheng-chih wrote of soil properties and of optimal times for tillage in the 1st century BC. Early agriculture in China centered on the fertile floodplain of the Huang He, or Yellow River.

2.6. Americas

Soil knowledge was also developing in the Americas during ancient times. Farming existed in Mexico by the 5th century BC, and included terracing and irrigation techniques. In Mexico, the Maya farmed flat valley lands with readily available water, and commonly used an artificial soil made of aquatic plants, clay from lake or river bottoms, marl, and manure, a system that required a working knowledge of a number of soil properties. In Peru, the Inca developed bench terraces on mountain slopes, filled the area behind the terraces with non-soil material to within about a meter, then filled the final meter with fertile soils carried up from bottomland areas.

The Aztec, Inca, and Maya all also farmed areas of fertile soils derived from volcanic ash. These various agricultural techniques succeeded in supporting some large cities such as Teotihuacan, which had approximately 125,000 inhabitants at its height.

2.7. Ancient Times and Early History Summary

A true soil science was not formed during ancient times and early history. Human knowledge of soil was based on observation, not on experimentation and testing of

theories. Despite this, much was learned about soils. In places all over the world, various people discovered irrigation, basic erosion controls such as terracing, the value of the plow in preparing the soil for planting, and recognized that some soils were more productive than others. In some places, humans had even discovered how to create artificial soil or to improve soils not well suited to crops. Therefore, a solid knowledge base of soils as an agricultural medium had already been formed.

3. Soil Science in the Middle Ages (5th to 14th Centuries AD)

In western societies the Middle Ages represented a period of repression for science and a temporary loss of soils knowledge held by groups such as the Greeks and Romans. This loss was due in large part to the dominance of religion in western life. However, soils knowledge still existed in this period, and in some parts of the world was expanded.

3.1. Byzantium and Europe

Following the sacking of Rome in 410 AD, Roman culture shifted to Byzantium in modern Turkey. Many Roman manuscripts, including agricultural manuscripts, were moved to Byzantium. Therefore, many of the scientific ideas developed by the Roman Empire were preserved and advanced over the next 1000 years by the Byzantines. A 10th century AD agricultural encyclopedia showed Byzantine soils knowledge. It includes works by Roman soils specialists, but many new Byzantine authors are also represented. Important information included a description of the soils of the Byzantine Empire, discussions of which crops were most appropriate for different soils, and ways to evaluate the quality of soils.

Agriculture declined in Europe following the fall of the Roman Empire, a decline that included both the area of land under cultivation and the yields obtained during crop growth. Brief periods of renewed interest occurred in the 8th and 9th centuries AD, but real agricultural improvement didn't take place until the 11th century. Draining of marshlands, fertilization of the soil with manure and marl, and use of a plow that turned over the upper layer of the soil all helped to increase agricultural yields considerably; manure was in fact a highly valued commodity due to its fertilizing abilities. Cultivated lands on steep slopes were returned to forest as early as the 10th century AD in an effort to reduce soil erosion.

3.2. Arabia and the Middle East

During the Middle Ages Islamic-based societies, which had formed and spread from the Arabian Peninsula, were among the world's leaders in science, math, and technology. This included the agricultural sciences. Earlier works from civilizations such as the Greeks, Romans, Chinese, and Indians were known to Muslim scientists, who studied, combined, and built upon these earlier works. In agriculture, one hallmark of Middle Ages Muslim government was the development and support of extensive networks of irrigation canals. Advanced Muslim mathematics contributed greatly to the engineering of these irrigation systems. Muslim agronomists were also adept at identifying soils suitable to the crops being grown. Libraries in major Muslim cities typically contained

numerous agricultural works, and the Muslim scholar Cordoba developed an agricultural calendar in the 10th century that listed, among other items, monthly tasks related to the preparation of soil for agriculture. Soil fertility was maintained through the use fertilizers such as manure, and it was recognized that different crops had different fertility requirements.

3.3. Southeast Asia

Southeast Asia was a region in which soils knowledge expanded during the Middle Ages. Chinese government documents from this period separated soils into 12 categories based on the crops they were most suited to and regulated the time of working the fields. In each community an individual was responsible to look after fertilizers and soil fertility. Terracing of farm fields in China for erosion control can be documented as early as the 7th century AD. The decrees of Chinese emperors showed a strong appreciation for soils. Emperor Hinn included soil quality in the determination of land taxes in 1115, Emperor Ming ordered that all lands be divided based on their location and soils in 1387, and land surveys, including soils information, were made for large portions of the country.

Japanese agriculture was influenced by the Chinese until the 9th century AD, after which the Japanese halted immigration and moved away from Chinese influence. The lack of good land led the Japanese to place a high value on soil. Many forms of maintaining soil fertility, including manure, green manure, the growth of legumes, and crop rotations were used. Terraces were used on steep slopes, artificial soils were created, and land surveys were common. In India, irrigation, fertilization through manure application, and fallow periods to restore fertility were widely used by the 14th century AD and land surveys including soils were made for many parts of the country.

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Biographical Sketch

Eric C. Brevik is an Associate Professor of Geology and Soils at Dickinson State University, USA. He

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Dr. Brevik is active in teaching and research in environmental applications of soils and soil geomorphology. His research focuses on issues such as soil mapping, carbon sequestration by soils and surface sediments, teaching of soils in geoscience curricula, and soil science history. The results of his research have been published in several peer-reviewed journals. Dr. Brevik is also an active member of the Commissions on the History, Philosophy, and Sociology of Soil Science of both the Soil Science Society of America and the International Union of Soil Sciences.