

CHAPTER ONE

1. INTRODUCTION

1.1 Soil

Soil is a mixture of minerals, organic matter, gases, liquids, and countless organisms that together support life on Earth. Soil is a natural body called the exosphere which has four important functions: it is a medium for plant growth; it is a means of water storage, supply and purification; it is a modifier of Earth's atmosphere; it is a habitat for organisms; all of which, in turn, modify the soil.

Soil is called the "Skin of the Earth" and interfaces with its lithosphere, hydrosphere, atmosphere, and biosphere. [1] The term eolith, used commonly to refer to the soil, literally translates 'level stone'. Soil consists of a solid phase of minerals and organic matter, as well as a porous phase that holds gases and water. [2][3][4] Accordingly, soils are often treated as a three-state system of solids, liquids, and gases. [5]

Soil is a product of the influence of the climate, relief (elevation, orientation, and slope of terrain), organisms, and its parent materials (original minerals) interacting over time. [6] Soil continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion.

Most soils have a density between 1 and 2 g/cm³. [7] Little of the soil of planet Earth is older than the Pleistocene and none is older than the Cenozoic, [8] although fossilized soils are preserved from as far back as the Arcana. [9]

Soil science has two basic branches of study: edaphology and penology. Edaphology is concerned with the influence of soils on living things. Penology is focused on the formation, description (morphology), and classification of soils in their natural environment. [10] In engineering terms, soil is referred to as regolith, or loose rock material that lies above the 'solid geology'. [11] Soil is commonly

referred to as "earth" or "dirt"; technically, the term "dirt" should be restricted to displaced soil.[12]

As soil resources serve as a basis for food security, the international community advocates for its sustainable and rasps: possible use through different types of Soil Governance.

1.2Physical properties of soil

The physical properties of soils, in order of decreasing importance, are texture, structure, density, porosity, consistency, temperature, color and resistivity. Soil texture is determined by the relative proportion of the three kinds of soil mineral particles, called soil separates: sand, silt, and clay. At the next larger scale, soil structures called pads are created from the soil separates when iron oxides, carbonates, clay, silica and humus, coat particles and cause them to adhere into larger, relatively stable. Table 1 summarizes these properties

Property/ Behavior	Sand	Silt	Clay
Water-holding capacity	Low	Medium to high	High
Aeration	Good	Medium	Poor
Drainage rate	High	Medium to slow	Very slow
Soil organic matter level	low	medium to High	High to medium
Decomposition of organic matter	Rapid	Medium	Slow
Warm-up in spring	Rapid	Moderate	Slow
Combustibility	Low	Medium	High
Susceptibility to wind erosion	Moderate (High if fine sand)	High	Low
Susceptibility to water erosion	Low(unless fine sand)	High	
Shrink/Swell Potential	Very Low	Low	Moderate to very high
Sealing of ponds, dams, and landfills	poor	Poor	Good
Suitability for after rain tillage	Good	Medium	Poor
Pollutant leaching potential	High	Medium	Low (unless cracked
Ability to store plant nutrients	Low	Medium to High	High
Resistance to pH change	Low	Medium	High

Table 1: Influence of Soil Texture on Some Properties of Soils

1.3 Soil-forming processes:

Soil formation, or pedogenesis, is the combined effect of physical, chemical, biological and anthropogenic processes working on soil parent material. Soil is said to be formed when organic matter has accumulated and colloids are washed downward, leaving deposits of clay, humus, iron oxide, carbonate, and gypsum, producing a distinct layer called the B horizon. This is a somewhat arbitrary definition as mixtures of sand, silt, clay and humus will support biological and agricultural activity before that time. These constituents are moved from one level to another by water and animal activity. As a result, layers (horizons) form in the soil profile. The alteration and movement of materials within a soil causes the formation of distinctive soil horizons.

How soil formation proceeds is influenced by at least five classic factors that are intertwined in the evolution of a soil. They are: parent material, climate, topography (relief), organisms, and time. When reordered to climate, relief, organisms, parent material, and time, they form the acronym CROPT.[13][14]

An example of the development of a soil would begin with the weathering of lava flow bedrock, which would produce the purely mineral-based parent material from which the soil texture forms. Soil development would proceed most rapidly from bare rock of recent flows in a warm climate, under heavy and frequent rainfall. Under such conditions, plants become established very quickly on basaltic lava, even though there is very little organic material. The plants are supported by the porous rock as it is filled with nutrient-bearing water that carries dissolved minerals from the rocks and guano. Crevasses and pockets, local topography of the rocks, would hold fine materials and harbor plant roots. The developing plant roots are associated with mycorrhizal fungi that assist in breaking up the porous lava, and by these means organic matter and a finer mineral soil accumulate with time.

1.4 Parent material:

The mineral material from which a soil forms is called parent material. Rock, whether its origin is igneous, sedimentary, or metamorphic, is the source of all soil mineral materials and the origin of all plant nutrients with the exceptions of nitrogen, hydrogen and carbon. As the parent material is chemically and physically weathered, transported, deposited and precipitated, it is transformed into a soil.

1.4.1 Typical soil parent mineral materials are: [15]

Quartz: SiO_2

Calcite: CaCO_3

Feldspar: KAlSi_3O_8

Mica (biotitic): $\text{K}(\text{Mg,Fe})_3\text{AlSi}_3\text{O}_{10}(\text{OH})_2$

1.4.2 Classification of parent material:

Parent materials are classified according to how they came to be deposited. Residual materials are mineral materials that have weathered in place from primary bedrock. Transported materials are those that have been deposited by water, wind, ice or gravity. Cumulus material is organic matter that has grown and accumulates in place.

Residual soils are soils that develop from their underlying parent rocks and have the same general chemistry as those rocks. The soils found on mesas, plateau, and plains are residual soils. In the United States as little as three percent of the soils are residual [16].

Most soils derive from transported materials that have been moved many miles by wind, water, ice and gravity.

Aeolian processes (movement by wind) are capable of moving silt and fine sand many hundreds of miles, forming loess soils (60–90 percent silt), common in the Midwest of North America and in Central Asia. Clay is seldom moved by wind as it forms stable aggregates.[17]

Water-transported materials are classed as either alluvial, lacustrine, or marine. Alluvial materials are those moved and deposited by flowing water. Sedimentary deposits settled in lakes are called lacustrine. Lake Bonneville and many soils around the Great Lakes of the United States are examples. Marine deposits, such as soils along the Atlantic and Gulf Coasts and in the Imperial Valley of California of the United States, are the beds of ancient seas that have been revealed as the land uplifted.

Ice moves parent material and makes deposits in the form of terminal and lateral moraines in the case of stationary glaciers. Retreating glaciers leave smoother ground moraines and in all cases, outwash plains are left as alluvial deposits are moved downstream from the glacier.

Parent material moved by gravity is obvious at the base of steep slopes as talus cones and is called colluvial material.

Cumulus parent material is not moved but originates from deposited organic material. This includes peat and muck soils and results from preservation of plant residues by the low oxygen content of a high water table. While peat may form sterile soils, muck soils may be very fertile.

1.5Color:

Soil color is often the first impression one has when viewing soil. Striking colors and contrasting patterns are especially noticeable. The Red River of the South carries sediment eroded from extensive reddish soils like Port Silt Loam in Oklahoma. The Yellow River in China carries yellow sediment from eroding loess soils. Moll sols in the Great Plains of North America are darkened and enriched by organic matter. Pod sols in boreal forests have highly contrasting layers due to acidity and leaching.

In general, color is determined by the organic matter content, drainage conditions, and degree of oxidation. Soil color, while easily discerned, has little use in predicting soil characteristics.[18][19] It is of use in distinguishing boundaries within a soil profile, determining the origin of a soil's parent material, as an

indication of wetness and waterlogged conditions, and as a qualitative means of measuring organic, salt and carbonate contents of soils. Color is recorded in the Mansell color system as for instance 10YR3/4 Dusky Red.

Soil color is primarily influenced by soil mineralogy. Many soil colors are due to various iron minerals. The development and distribution of color in a soil profile result from chemical and biological weathering, especially redox reactions. As the primary minerals in soil parent material weather, the elements combine into new and colorful compounds. Iron forms secondary minerals of a yellow or red color, organic matter decomposes into black and brown compounds, and manganese, sulfur and nitrogen can form black mineral deposits. These pigments can produce various color patterns within a soil. Aerobic conditions produce uniform or gradual color changes, while reducing environments (anaerobic) result in rapid color flow with complex, mottled patterns and points of color concentration.[20]

1.6 Mineral colloids; soil clays:

Due to its high specific surface area and its unbalanced negative charges, clay is the most active mineral component of soil. It is a colloidal and most often a crystalline material. In soils, clay is defined in a physical sense as any mineral particle less than 2 μm (8×10^{-5} in) in effective diameter. Chemically, clay is a range of minerals with certain reactive properties. Clay is also a soil textural class. Many soil minerals, such as gypsum, carbonates, or quartz, are small enough to be classified as clay based on their physical size, but chemically they do not afford the same utility as do clay minerals.[21]

Clay was once thought to be very small particles of quartz, feldspar, mica, hornblende or augite, but it is now known to be (with the exception of mica-based clays) a precipitate with a mineralogical composition that is dependent on but different from its parent materials and is classed as a secondary mineral. The type of clay that is formed is a function of the parent material and the composition of the minerals in solution. Clay minerals continue to be formed as long as the soil exists.[22] Mica-based clays result from a modification of the primary mica mineral in such a way that it behaves and is classed as a clay. Most clays are

crystalline, but some are amorphous. The clays of a soil are a mixture of the various types of clay, but one type predominates.[23]

There are four groups of clay: layer silicates; crystalline chain silicates; metal oxides and hydroxides and oxy-oxides; and amorphous and allophones. Most clays are crystalline and most are made up of three or four planes of oxygen held together by planes of aluminum and silicon by way of ionic bonds that together form a single layer of clay. The spatial arrangement of the oxygen atoms determines clay's structure. Half of the weight of clay is oxygen, but on a volume basis oxygen is ninety percent.[24] The layers of clay are sometimes held together through hydrogen bonds or potassium bridges and as a result will swell less in the presence of water. Other clays, such as montmorillonite, have layers that are loosely attached and will swell greatly when water intervenes between the layers.

1.7 Jourdiqua:

Jourdiqua is a type of a clay that found nearby rivers, mountains and desert areas. In some Sudanese area people plants it by the aid of a chemical reaction (ion exchange), where it is throwing in the soil and supplied it with water to get what known as planted Jourdiqua. It found a lot of local uses such as medication, cooking, cosmetics and water softening.

It found as a thin layer in the surface of the earth, it is sparingly soluble, its color differs according to it is source; ranging from brown to beige.

The main chemical compositions of Jourdiqua are carbonate, bicarbonate and other metallic salts.

Other uses:

1-Treatment the acidity of the stomach

2-Teatment of tonsillitis

3- Fattening

1.8The objective of this work:

This research was aimed to study the physicochemical properties (appearance, color, pH, conductivity, and solubility chemical composition) and antibacterial activity of three Jourdiga samples collected from Atbara, Shandi, Aljazeera and how these properties were reflected in its uses.

Chapter two

2.Experimental

2.1Apparatus

1-beakers (250ml, 100 ml, 50ml)

2-volumetric flasks 250ml, 100ml, 50ml

3- Filter papers

4- Pipettes

5-petri dish

2.2Reagents

1- Ammonium acetate ($\text{NH}_4\text{CH}_3\text{CO}_2$, 77.08%, CDH, MADE IN INDIA)

2- Distilled water

3- Staphylococcus

4- Standard sodium solution (2,4,6,8 PPM)

5- Standard potassium solution(2,4,6,8PPM)

2.3Instruments:

1- Flame photometer (JENWAY ,PFP7)

2- X-ray fluorescence

3- Balance (BEL , MADE IN ITALY, Ser .N0:IT1002636)

4- pH meter

2.4Procedures:

2.4.1Collection of samples:

Three jourdiga samples was collected from different location; in Atbara, the second one was from Shandi the third one was bought from local market in Aljazeera state (noted as 1, 2 and 3 respectively).

2.4.2 Physical properties (Color, Solubility, pH, Conductivity):

1.00g of the sample was weighed. The physical appearance (color) was noted and recorded. Then 100ml of distilled water was added and stirred well to insure solubilization of all soluble contents, then it was left for a while till the solution gets clear, the pH and the conductivity was measured for the clear solution.

2.4.3Determination of minerals by x-ray fluorescence device

1.00g of sample was weighted and buried with handy pump (to accomplish the compression in disc shape) and put in disc shape then it was analyzed using Cadmium lamp as a source.

2.4.4Determination of Sodium and Potassium by flame photometer:

2.4.4.1Preparation of ammonium acetate

7.7gram of ammonium acetate salt was dissolved with distilled water and diluted in 100ml volumetric flask to the mark.

2.4.4.2Preparation of the sample

1.00g of the sample was dissolved with 20ml of prepared ammonium acetate solution then it was shaken for an hour and filtered off. 10ml from filtrate solution was transferred to 50ml volumetric flask and diluted to the mark with distilled water. Then Sodium and Potassium was measured by flame photometer.

2.4.5 Anti-bacterial activity:

The anti-bacterial activity of jourdiga was checked against staphylococcus. Four concentrations of each Jourdiga sample was prepared (5%,10%,20%, saturated solution) with distilled water. Nutrient agar was prepared, sterilized and poured into petri dishes. The test organism was spread on these dishes. To each one 30 μ L of Jourdiga solution is added and plates were incubated at 37°C for 24hrs. after incubation the results were recorded by measuring the diameter of zone of inhibition surrounding the well.

Chapter three
3-Results and discussion

3.1Physical properties:

NO. of Sample	Sample1	Sample2	Sample3
Solubility	Sparingly soluble	Sparingly soluble	Sparingly soluble
Appearance	Friable layers	Friable layers	Powder
Color	brown to beige	Beige	brown
PH	10.23	10.18	9.35
Conductivity	3.37ms	3.20ms	3.01ms

Sample 1&2 have almost the same appearance and color whereas sample 3 differs apparently. Upon solublization all the samples sparingly soluble; but sample2 gives more clear solution than the two other samples which contains some sand.

Regarding the pH values its basic, may be to the presence of metal hydroxides, oxides, bicarbonates or carbonates and sodium ion. Sample 1&2 are more basic than sample3; this result has been insured from conductivity measurements which give high conductivity values for the first two samples indicates the presence of high concentration of highly conduct ions.

The physical properties results shows that sample1&2 are more likely while sample three exhibit some differences.

3.2Results of x-ray Fluorescence:

Sample 1

EL	E{KEV}	INT{C/S}	S	T	CONC {FRAC}	ERROR
K	3.312	0.083	5.35E+03	0.0133	5.34E-03	LDL
Ca	3.960	0.830	6.06E+03	0.0175	3.63E-02	1.20E-02
Ti	4.508	0.326	1.10E+04	0.0259	5.28E-03	1.79E-03
Mn	5.895	0.090	3.08E+04	0.0522	2.67E-04	1,09E-04
Fe	6.400	10.384	3.20E+04	0.0650	2.39E-02	7.78E-03
Cu	8.041	0.218	1.45E+06	0.1005	7.08E-06	2.45E-06
Pb	10.540	0.170	1.27E+05	0.1944	3.26E-05	1.15E-05
Br	11.907	0.538	1.46E+05	0.2529	6.90E-05	2.30E-05
Rb	13.375	0.200	1.35E+05	0.3147	2.23E-05	8.09E-06
Sr	14.142	2,238	1.56E+05	0.3450	1.98E-04	6.46E-05
Zr	15.746	3.074	1.90E+05	0.4025	1.92E-04	6.26E-05
Nb	16.584	0.129	2.45E+05	0.4285	5.87E-06	-LDL-
Mo	17.443	1.086	2.63E+05	0.4532.	4.35E-05	1.44E-05

Table 2

Sample2

EL	E{KEV}	INT[C/S]	S	T	CONC[FRAC]	ERROR
K	3.312	0.244	5.35E+03	0.133	1.58E-02	5.50E-03
Ca	3.690	0.512	6.06E+03	0.0168	2.34E-02	7.81E-03
Ti	4.508	0.278	1.10E+04	0.0263	4.44E-03	1.52E-03
Mn	5.895	0.072	3.08E+04	0.0532	2.10E-04	8.98E-05
Fe	6.400	10.110	3.20E+04	0.0662	2.28E-02	7.44E-03
Cu	8.041	0.224	1.45E+06	0.1029	7.11E-06	2.48E-06
Pb	10.540	0.098	1.27E+05	0.1990	1.84E-05	7.26E-06
Br	11.907	0.344	1.46E+05	0.2586	4.32E-05	1.46E-005
Rb	13.375	0.318	1.35E+05	0.3212	3.48E-05	1.20E-05
Sr	14.142	4.236	1.56E+05	0.3519	3.67E-04	1.20E-04
Y	14.933	0.224	2.31E+05	0.3816	1.21E-05	4.36E-06
Zr	15.746	2.230	1.90E+05	0.4098	137E-04.	4.47E-05
Nb	16.584	0.184	2.45E+05	0.4353	8.23E-06	3.08E-06
Mo	17.443	0.508	2.63E+05	0.4600	2.00E-05	6.79E-06

Table3

Sample3

EL	E[KEV]	INT [C/S]	S	T	CONC[FRAC]	ERROR
K	3.312	0.089	1.64E+03	0.0130	1.64E-02	LDL
Ca	3.690	0.402	1.86E+03	0.0164	5.32E-02	1.79E-02
Ti	4.508	0.398	3.36E+03	0.0228	2.09E-02	7.04E-03
Mn	5.895	0.174	9.41E+03	0.0425	2.04E-03	7.30E-04
Fe	6.400	12.940	9.81E+03	0.0525	1.20E-01	3.91E-02
Cu	8.041	0.184	4.44E+05	0.0553	3.54E-05	1.25E-05
Pb	10.540	0.056	3.90E+04	0.1065	6.44E-05	LDL
Br	11.907	0.590	4.48E+04	0.1399	4.45E-04	1.48E-04
Rb	13.375	0.284	4.14E+04	0.1778	1.83E-04	6.38E-05
Sr	14.142	2.156	4.79E+04	0.1975	1.09E-03	3.55E-04
Y	14.933	0.360	7.06E+04	0.2179	1.11E-04	3.81E-05
Zr	15.746	3.046	5.82E+04	0.2380	1.05E-03	3.42E-04
Nb	16.584	0.180	7.51E+04	0.2569	4.45E-05	1.70E-05
Mo	17.443	0.558	8.06E+04	0.2764	1.19E-04	4.03E-05

K: In sample2 and sample3 contains almost equal amount of Potassium (1.5×10^{-2} & 1.6×10^{-2}) respectively whereas **sample1 is the poorest** (5.3×10^{-3}).

Ca: They contain almost **equal amount** of Calcium: in sample1&2&3 equal (3.63×10^{-2} & 2.234×10^{-2} & 3.532×10^{-2}) respectively.

Fe: Sample1 and sample2 contains equal amount of Iron (2.39×10^{-2} & 2.28×10^{-2}) respectively where **sample3 is the richest** with Calcium (1.2×10^{-1}).

Cu: Sample1&2 contains almost equal amount of Copper (7.08×10^{-6} & 7.11×10^{-6}) respectively whereas **sample3 is the richest** (3.54×10^{-5}).

Mn: Sample1&2 contains almost equal amount (2.67×10^{-4} & 2.10×10^{-4}) respectively of Manganese whereas **sample3 is the richest** (2.04×10^{-3}).

Ti: Sample1&2 contains almost equal amount (5.28×10^{-3} & 4.44×10^{-3}) respectively, where **sample3 is the richest** (2.09×10^{-2}).

Pb: The three samples1,2&3 contains almost **equal amounts of Lead** (3.26×10^{-5} & 1.84×10^{-5} & 6.44×10^{-5}) respectively.

Br: Sample1&2 contains almost equal amount (6.90×10^{-5} & 4.32×10^{-5}) respectively whereas **sample3 is the richest** (4.45×10^{-4}).

Rb: Sample1&2 contains almost equal amounts (2.23×10^{-5} & 3.48×10^{-5}) respectively, whereas **sample3 is the richest** (1.83×10^{-4}).

Sr: Sample1&2 contains equal amounts (1.98×10^{-4} & 3.67×10^{-4}) respectively, whereas **sample3 is the richest** (1.09×10^{-3}).

Y: Sample2 contains (1.21×10^{-5}), whereas **sample3 is the richest** (1.11×10^{-4}),

But sample1 contains no Y element.

Zr: Sample1&2 contains equal amounts (1.92×10^{-4} & 1.37×10^{-4}) respectively, whereas **sample3 is the richest** (1.05×10^{-3}).

Nb: Sample1&2 contains equal amounts ($5.87 \cdot 10^{-6}$ & $8.23 \cdot 10^{-6}$) respectively, whereas **sample3 is the richest** ($4.45 \cdot 10^{-5}$).

Mo: Sample1&2 contains equal amounts ($4.35 \cdot 10^{-5}$ & $2 \cdot 10^{-5}$) respectively, whereas **sample3 is the richest** ($1.19 \cdot 10^{-4}$).

From the results we observed that there were some essential elements exist in Jourdiga which reflects its importance as a nutrient. It contains relatively high concentration of Iron which may reflects its uses in fatten. Beside Iron it contains Calcium, Potassium and other essential elements.

On the other hand, XRF results also shows that it contains toxic and carcinogenic elements like Pb, Ti, Br and Sr which have negative effects on human beings if it presents even in trace amounts. For example, Pb and Sr which are heavy metal exist in all of the samples in high concentrations.

It is clear that sample3 is the richest; almost it contains the highest concentration of all the elements essential and carcinogenic; thus this sample seems to be harmful and must be discarded. Since it was collected from a local market, probably it contains some additives (commercial fraud); and we can conclude that at least sample3 is not pure Jourdiga.

Sample1&2 almost contains equal amounts of all elements, the small variations is attributed to the source of the sample.

3.3 Sodium and Potassium concentrations:

Sample No.	Sodium Conc.\ppm	Potassium Conc.\ ppm
1	2.240	6.984
2	3.786	2.747

Sample3 was not analyzed because it gives a paste which is not easily to handle.

The obtained results for Sodium and Potassium after a series of dilutions were too high and not acceptable (more than 100%); this can be attributed to the low assay of used ammonium acetate salt and the low purity of working distilled water.

3.4 Results of anti-bacterial activity:

No observed effects (negative result) achieved with (5%, 10%, and 20%).

Results obtained with saturated solutions was:

Sample	Diameter of the zone/cm
Sample 1	0.80
Sample2	1.10
Sample3	Negative

These bacteria were chosen according to a local usage of Jourdiga in medication of tonsillitis, it is clear that sample 2 is more active than sample 1, but both of them can be applied in the medication of tonsillitis as a paste (saturated solution). This anti-bacterial activity can be attributed to the basic character of jourdiga mainly beside other factors which may need further work.

This result is in agreement with our previous results of XRF for sample3, which was concluded that it is not a pure Jourdiga, since it shows no anti-bacterial activity in all concentrations; but it enhance growing of other kind of bacteria.

CHAPTER FOUR

4.1 Conclusion:

Three type of Jourdiqqa clays (Atbara, Shandi, and Aljazeera) were characterized physically and chemically by pH meter, conductivity meter, XRF, and flame photometer, and its antibacterial activity was tested. The results show that Jourdiqqa contains many essential elements which exists mainly in the form of basic compounds. These properties were reflected in it is applications like medication of tonsillitis, acidity of stomach, cosmetics and fattening.

4.2 Recommendation:

- 1- Medical application must be managed since it may contain toxic and heavy metals.
- 2- It can be purified and compressed into dosage form.
- 3- It can be used in the manufacturing of sodium hydroxide.

4.3Reference:

Chesworth, Ward, ed. Encyclopedia of soil science. Dordrecht, Netherlands: Springer. Xxiv (2008). ISBN 1-4020-3994-8.

Voroney, R. P. "The Soil Habitat". In Paul, Eldor A. Soil Microbiology, Ecology and Biochemistry (2006) ISBN 0-12-546807-5.

Danoff-Burg, James A. "The Terrestrial Influence: Geology and Soils". Earth Institute Center for Environmental Sustainability. Columbia University. Retrieved 27 July 2014.

Taylor, S. A.; Ashcroft, G. L. Physical Edaphology.1972

McCarthy, David F. (1982). Essentials of Soil Mechanics and Foundations: Basic Geotechnics (2nd ed.). Reston, Virginia: Reston Publishing(1982). ISBN 9780835917810.

Gilluly, James; Waters, Aaron Clement; Woodford, Alfred Oswald . Principles of Geology (4th ed.). W.H. Freeman(1975). ISBN 978-0716702696.

Soil Bulk Density Calculator (U.S. Texture Triangle)". Pedosphere. Retrieved 27 July 2014.

Buol, S. W.; Hole, F. D.; McCracken, R. J. . Soil Genesis and Classification (1st ed.). Ames, Iowa: Iowa State University Press(1973). ISBN 0-8138-1460-X.

Retallack, G.J . Soils of the Past: An Introduction to Paleopedology (2nd ed.). John Wiley & Sons. p. 207 (2008). ISBN 9780470698167.

Amundsen, Ronald. "Soil Preservation and the Future of Pedology" (pdf). Faculty of Natural Resources. Prince Songkla University. Retrieved 8 June 2006.

Simonson 1957.

Raloff, Janet (17 July 2008). "Dirt Is Not Soil". ScienceNews. Archived from the original on 2013-09-30.

Michael E. Ritter. Factors Affecting Soil Development, Soil Systems, The Physical Environment: an Introduction to Physical Geography, University of Wisconsin, Stevens Point, 1 October 2009, retrieved 3 January 2012.

"Soils". Natural Resource Conservation Service. United States Department of Agriculture. Retrieved 26 May 2013.

Donahue, Miller & Shickluna 1977.

Green, D.S. 2004. Describing condition-specific determinants of competition in boreal and sub-boreal mixedwood stands. *For(2004). Chron.* 80(6):736–742.

"Arizona Master Gardener Manual". Cooperative Extension, College of Agriculture, University of Arizona. p. Chapter 2, pp 4–8. Retrieved 27 May 2013

Donahue, Miller & Shickluna 1977.

Donahue, Miller & Shickluna 1977,

Nyle C. Brady & Ray R. Weil . Elements of Soil Science ^ College of Tropical Agriculture and Human Resources. "Soil Mineralogy". www.ctahr.(2009)

. hawaii.edu. University of Hawai'i. Retrieved 7 August 2014.

Russell, E. Walter (1973). Soil conditions and plant growth. (10th ed.). London: Longman. pp. 67–70. 0582440483.

Donahue, Miller & Shickluna 1977.

Donahue, Miller & Shickluna , . 102ISBN of the Nature and Properties of Soils (3rd Edition). Prentice Hall.(1977) ISBN 978013501433