2 Anthropogenic Soils and Soil Classification Systems

Several classification systems in the world address human-modified soils. Selected articles, both original and from selected from various websites are presented below to show the status of anthropogenic soils in various classification systems.

Soil Classification Systems

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http://ag.arizona.edu/OALS/IALC/soils/classifsystems.html

While systems of classification are created to facilitate communication, they are artificial and have inherent limitations. They simplify the complexity and continuum of the world through necessary bias, whether rationally or irrationally applied. Soils are described by many types of classification systems, the first criteria being the definition of soil itself (See: How Soil is Defined. NOTE: These refer to internal links through the web site above). Agriculturists, engineers, geologists, and others each have different definitions based on the needs of their particular discipline or vocation. A soil to one may not be soil to another. Classification systems can be divided into two categories, vernacular and scientific. Vernacular systems have been used for millennia, while scientifically based systems are relatively recent developments (See: A Brief History of Soil Science). Aridic soils are soils that occur in an arid environment (See: Classifications of Arid Land Soils). If aridity has a high level of importance among those developing a particular soil classification system, then aridic soils will be clearly distinguished by that system, whether the system is vernacular or scientific.

Vernacular Systems

Vernacular systems are developed by the land users. Their structure is either nominal, giving unique names to soils or landscapes, or descriptive, naming soils by their characteristics such as red, hot, fat, or sandy. Soils are distinguished by obvious characteristics, such as physical appearance (e.g., color, texture, landscape position), performance (e.g., production capability, flooding), and accompanying vegetation. These distinctions are often based on characteristics important to land management and largely they have been ignored by the scientific community until recently, with anthropologists and geographers being the first to document them. Vernacular systems can provide outsiders a language to communicate with local land users, especially regarding agricultural management and resource tenure. Vernacular systems can also provide technicians and scientists with insight into natural resource management systems that can prove valuable in inventorying and developing local resources.

Ethnopedology, the term coined by Williams and Ortiz-Solorio (1981, p. 336), is the study of these vernacular systems. The anthropologist Harold C. Conklin first started documenting vernacular systems in the 1950s. Studies conducted by the Office of Arid Lands Studies, University of Arizona, show that vernacular systems in arid lands can be very detailed with comparable usefulness to scientific systems (e.g., the Peul's system in Mauritania) or conversely may have no pedologic usefulness (e.g., the Bedouin's system in Saudi Arabia which implies that differences in soils are not perceived to be important to their livelihood). In semi-arid California the vernacular system of Malibu encompasses only one soil, the infamous "Malibu blue clay" (called Diablo soils under the U.S. Department of Agriculture (USDA) system) that limits building development and reduces property values because septic-tank drainage-fields are not allowed on that soil.

Scientific Systems

Scientific systems are of two types, those based on processes of soil development or genesis and those based on quantifiable characteristics. Many systems have elements of both types. Criteria for distinguishing soils among these systems are by no means uniform. The structure of these systems can be hierarchical, descriptive, or nominal. Also, soil classification systems are not static. As knowledge is gained old systems and class names are changed for new ones, as with plant and animal classification systems. These differences in classification systems make it important to include descriptions of classified soils when reporting so that correlation to other systems is possible. Users of classification systems need to make sure that important characteristics have class limits narrow enough to be useful. Scientific systems, especially the hierarchical ones, are useful to exclude soils from consideration, but generally a detailed soil description is needed to make recommendations for soil use and management.

Process based classification systems were developed to explain how soil characteristics and appearance change with time. Soils form distinct layers as biological, physical, and chemical processes develop zones of material accumulation and zones of loss, also called horizons. This evolution is predicable as long as climate and other processes remain constant. This assumption of constancy poses problems for these types of classification systems, especially for those aridic soils that partially developed under humid conditions. It is possible to have more than one classification for the same soil, depending on which soil forming process is assumed to be expressing itself. Due to this and other problems, the USDA abandoned its system based on soil forming processes and developed the system laid out in Soil Taxonomy based on existing quantifiable characteristics. Engineers also use systems based on existing characteristics, for obvious reasons.

Criteria for distinguishing soils are not necessarily the same for different classification systems. Soil texture is a good example of the problems involved in correlating classifications between two or more systems. Texture describes the proportion of different size classes of the mineral part of the soil. For the same soil, texture-class names can differ depending on the classification system used. Even if the names are the same, the limits often differ, as with "sandy clay" of the USDA and French systems:

The problem continues with particle-size classes. For example, clay is defined as <0.002 mm in diameter by some systems and <0.005 mm by others. Other physical, chemical, and biological characteristics have similar discrepancies between systems which makes one to one correlation between systems nearly impossible unless a detailed soil description is available.

Hierarchical, descriptive, or nominal systems of classification each have their strengths and weaknesses. Rules of hierarchical systems allow one to determine the highest to lowest levels of classification without previously knowing any of the possible classifications. The resulting classification (e.g., clayey-skeletal, mixed, hyperthermic Typic Haplargid of USDA Soil Taxonomy), while providing much information, is far from what is usually needed to make management decisions. Also, these systems can make trivial distinctions when applied in areas of the world different from those where they were developed. For example, sandy West African soils have extremely low cation exchange capacities. Very small additions or losses of base cations can cause large differences in base saturation percentages that distinguish the orders Alfisols and Ultisols (highest level of USDA Soil Taxonomy).

Descriptive soil classification systems are commonly developed for single purpose application. For example, the Fertility Capability Soil Classification System uses a string of upper and lower case letters to represent characteristics important in soil fertility management for crops. These systems are relatively simple, easy to interpret, but of limited value.

Nominal systems are much like vernacular systems but with the rigor of scientific descriptions and engineering capabilities. These systems can be detailed enough to use as a basis for management decisions, but only at a regional level. Comparing numerous soils under this system would be an onerous task. The USDA's system of Soil Series is an example of a nominal system that predates Soil Taxonomy. Soil Series have been modified so that they fit within one Soil Taxonomy classification and linked to this hierarchical system. Together, Soil Taxonomy and Soil Series systems provide powerful tools for identifying, understanding and managing soils. This merging of hierarchical and nominal systems can be copied in other countries, especially in developing countries by using existing vernacular systems.

To demonstrate how this all fits together, the aridic soil "Malibu blue clay" (vernacular name) was established by the USDA in 1910 as Diablo soil series (old nominal scientific system) and classified as a Grumusols (old hierarchical scientific system). Since then the Diablo soil series description has been modified (new nominal scientific system) and classified as fine, smectitic, thermic family of Aridic Haploxererts (current hierarchical scientific system).

Partial List of Soil Classification Systems

Israeli systems

US systems

1. USDA Soil Taxonomy is a hierarchical system and used almost exclusively in the US for agricultural, biological, and geological studies. It has been applied throughout the world (Soil Survey Staff, 1975).
2. USDA Soil Series is a nominal system of soils of the US.
3. AASHTO System is used mostly by state and county highway departments (AASHTO, 1978).
4. FAA Classification is used by airfield designers (FAA, 1967).
5. Unified Classification is preferred by most geotechnical engineers that specializing in earth dams and foundation engineering (US Army, 1967).
6. Abandon US systems occur in older literature (Marbut, 1935, Baldwin et al. 1938, Thorp and Smith, 1949).

French systems

The French systems have been widely used in former colonies and current territories.

1. French Soil Reference System (Référentiel pédologique français) is hierarchical based on soil formation processes and morphology (Duchaufour, 1988).
2. 1967 Soil Classification is also hierarchical based on soil formation processes and morphology (Finkl, 1982, p. 215-24; CPCS, 1967)

FAO system

Originally developed as a legend to its soils map of the world it has been applied throughout the world by United Nations sponsored projects and soil classifiers trained to use this system. Many countries have modified this system to fit their particular needs.

Others

- Australian systems: (Finkl, 1982, pp. 295-301; Butler, 1980; Northcote, 1962)
- Soils of Australia, Digital version of the 1:2,000,000 scale Atlas of Australian Soils
- Brazilian systems: (Finkl, 1982, pp. 247-258; Costa de Lemos, 1968)
- British systems: (Finkl, 1982, pp. 225-39; Butler, 1980; Avery, 1973)
- Canadian systems: (Finkl, 1982, pp. 240-6; Butler, 1980; DSS, 1978)
- Great Groups of the Canadian System of Soil Classification, University of Northern British Columbia
- Dutch systems: (Finkl, 1982, pp. 259-69; Bakker and Schelling, 1966)
- German systems: (Finkl, 1982; pp. 277-94; Mückenhausen, 1965)
- Polar systems: Tedrow proposed classification of Polar Desert, Subpolar Desert and Cold Desert soils (Finkl, 1982, pp. 324-6).
- Russian systems: (Finkl, 1982, pp. 92-104; Butler, 1980; Basinski, 1959)

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Australian Soil Classification for Anthroposols
Extracted from Key to Soil Orders

http://www.cbr.clw.csiro.au/aclep/asc/soilkey.htm

The material below is arranged to give the simplest way of identifying a particular soil in terms of the Orders, and is not a complete definition of each Order. Work successively through the key until an apparent identification is made, then check the full definition of the Order by clicking on the highlighted name. Words or phrases in italics are defined in the Glossary.

Concept

These soils result from human activities which have caused a profound modification, mixing, truncation or burial of the original soil horizons, or the creation of new soil parent materials. Note that the concept of soil used in this classification of Australian soils (see Introduction) also applies to the Anthroposols, and hence sealed and semi-sealed surfaces such as streets, roads etc. are regarded as 'non-soil'. Also, in depositional situations, the anthropic material must be 0.3 m or more thick where it overlies buried soils. Anthropic materials < 0.3 m thick will identify an anthropic phase of the soil below.

To qualify as soil an Anthroposol needs to possess some pedogenic features, as noted below. Key criteria in the identification of an Anthroposol are the presence of artefacts in the profile or knowledge that the soils or their parent materials have been made or altered by human action.

Anthroposols differ from other soils in that we normally know their origin with a degree of certainty, and hence we can invoke knowledge of process rather than defined pedogenic attributes to initially classify the soil. We can then subdivide at the higher levels on the basis of type of process and nature of the product which forms the parent material of the new soil. At lower levels in the classification, conventional soil properties could be used when available, although obviously these will be limited in very young soils.

Definition

Soils resulting from human activities which have led to a profound modification, truncation or burial of the original soil horizons, or the creation of new soil parent materials by a variety of mechanical means. Where burial of a pre-existing soil is involved, the anthropic materials must be 0.3 m or more thick. Pedogenic features may be the result of in situ processes (usually the minimal development of an A1 horizon, sometimes the stronger development of typical soil horizons) or the result of pedogenic processes prior to modification or placement (i.e. the presence of identifiable pre-existing soil material).

Comment

It is difficult to quantify ‘profound modification, mixing and truncation’ but this would normally exclude the usual agricultural operations (including land planing) which may change a soil from say a Chromosol to a Dermosol by mixing or removal of the upper horizons. Similarly, soils that are artificially drained or flooded are not Anthroposols but may classify as different soil orders following a permanent change in water status (see also Comment in Hydrosols).

There will also be instances where the question is how much truncation results in ‘profound modification’ or merely a truncated phase. It is difficult to give guidelines that will cover all circumstances, and inevitably judgement is required. Similarly, there will be instances where land reclamation and restoration in the past have been so successful that little evidence of a prior disturbance remains, and soil development gives no clue to past history. A good example of this is Podosol development on restored and revegetated coastal dunes following sand mining.

Suborders

Cumulic [HR]: Soils that have been formed by applications of human-deposited materials such as mill-mud, etc. or the accumulation of shells and organic materials to form middens. (Minimum depth of burial is 0.3 m).

Hortic [HS]: Soils that have had additions of organic residues such as organic wastes, composts, mulches, etc. that have been incorporated into the soil and obliterated pre-existing pedological features.

Garbic [HT]: Mineral soil or regolithic materials that are underlain by land fill of manufactured origin and which is predominantly of an organic nature. These materials may be of domestic or industrial origin and usually occur as artificially elevated landforms. The intent is to designate refuse from human activity high enough in organic matter to generate significant quantities of methane when placed under anaerobic conditions.

Urbic [HU]**:** Mineral soil or regolithic materials that are underlain by land fill of predominantly a mineral nature. The fill may be wholly of manufactured origin (glass, plastics, concrete, etc.) or contain a mixture of manufactured materials and materials of pedogenic origin. The fill usually occurs as an artificially elevated landform.

Dredgic [HV]: Soils that have formed or are forming on mineral materials that have been dredged through human action from the sea or other waterways, or deposited as slurry resulting from mining operations; eg, tailings ponds, salt ponds, coal washing residues etc. The dredged materials commonly occur as a lithologically distinctive unit overlying (buried) flood plain surfaces. Such deposits frequently occur in coastal areas, common examples being airports, golf courses and other urban developments.

Spolic [HW]: Soils that have formed or are forming on mineral materials that have been moved by earthmoving equipment in mining, highway construction, dam building etc. The materials contain too few manufactured artefacts to qualify as urbic soils. Landscapes are human-formed, and hence may present an 'unnatural' geomorphic expression. Spolic materials are increasingly being capped by pre-existing topsoil.

Scalpic [HX]: Soils that have formed or are forming on land surfaces that have been created by humans by cutting away any previously existing soil by mechanical equipment such as bulldozers and graders. Common occurrences are found along highways where they are usually associated with fill areas with spolic materials. In some instances truncated remnants of the lower horizons of pre-existing soils may occur. Scalpic soil areas typically have peculiar geomorphic expressions, often with smooth and steep slopes.

Comment

In the Garbic, Urbic and some Spolic soils it is common practice to cover the anthropic materials with a layer of soil materials as an aid to reclamation. This soil material is regarded as part of the suborder and can be used as a basis for lower category classification. In other situations sewage sludge is being used to rehabilitate mine spoil.

The Scalpic soils may also have material added to their new surface. If this is less than 0.3 m there would be, for example, a spolic phase of the Scalpic suborder; if 0.3 m or more thick the soil would classify as a Spolic suborder.

There will obviously be intergrade situations between some of the suborders. For example, it may sometimes be difficult to decide between Garbic and Urbic, Cumulic and Hortic. In these and similar situations judgement and/or knowledge of the process will be required. With the increasing emphasis on recycling, much of the garbic materials will be composted so the garbic group could become redundant.

Another likely difficult situation results when human-induced or human-accelerated erosion has removed upper soil horizons. On present thinking it would seem more appropriate for such soils to be regarded as an eroded phase of say a Sodosol, provided the original soil can be identified.

The question of soils contaminated by toxic wastes is also unresolved. They could be included in the Garbic suborder, but if the wastes are toxic to plant and animal life their host materials cannot strictly be regarded as soil. In some situations the problem could be overcome by referring to the site as a contaminated phase of the pre-existing soil.

Lower Categories

It is hoped that the seven suborders will provide a conceptual framework for the classification of most anthropic soils based on human-induced processes which provide particular kinds of soil parent materials. The suborders are a simplified relevant summary of an almost infinitely large range of anthropic processes and products. The need for subdivision below the suborder level is likely to be more desirable in some classes than others, but a major problem in creating lower category classes is the lack of data on the morphology and laboratory properties of anthropic soils. Most information seems to be available for the spolic soils created by mining operations. Here though it may be more appropriate to create a technical classification based on reclamation needs.

For some of the suborders, differentiae for lower categories could be based on appropriate traditional attributes used in classifying 'natural' soils, both morphologic and laboratory-determined. At present this is impractical due to the lack of an adequate representative profile data base. A related approach is to use at the great group level classes based on the other orders eg. Chromosolic, Sodosolic etc. as has been done for the Hydrosol great groups. In this approach Rudosolic Spolic Anthroposols would obviously be a very common class. A wide range of options is available for subgroup differentiae, but existing family criteria will probably be appropriate for most Anthroposols. A preliminary approach to classifying Australian minesoils based on proposed amendments to Soil Taxonomy has recently been made by Fitzpatrick and Hollingsworth (1994). A number of their proposed subgroups could be used in Spolic Anthroposols, and some examples are given in their paper.

Until more knowledge and experience is available, it is proposed not to formalise the classification of Anthroposols below the suborder level. Acknowledgment is due to Fanning and Fanning (1989) for a number of the concepts and terminology used in this preliminary classification of Anthroposols.

Canadian System of Soil Classification

http://www.geog.ouc.bc.ca/physgeog/contents/11f.html

Canada's first independent taxonomic system of soil classification was first introduced in 1955. Prior to 1955, systems of classification used in Canada were strongly based on methods being applied in the United States. However, the U.S. system was based on environmental conditions common to the United States. Canadian soil scientists required a new method of soil classification that focused on pedogenic processes in cool climatic environments.

Like the US system, the Canadian System of Soil Classification differentiates soil types on the basis of measured properties of the profile and uses a hierarchical scheme to classify soils from general to specific. The most recent version of the classification system has five categories in its hierarchical structure. From general to specific, the major categories in this system are: orders, great groups, subgroups, families, and series. At its most general level, the Canadian System recognizes nine different soil orders:

(1) Brunisol - is a normally immature soil commonly found under forested ecosystems. The most identifying trait of these soils is the presence of a B horizon that is brownish in color. The soils under the dry pine forests of south-central British Columbia are typically brunisols.

(2) Chernozem - is a soil common to grassland ecosystems. This soil is dark in color (brown to black) and has an A horizon that is rich in organic matter. Chernozems are common in the Canadian prairies. The images below are from the eastern prairies where higher seasonal rainfalls produce black chernozemic soils.

(3) Cryosol - is a high latitudes soil common in the tundra. This soil has a layer of permafrost within one meter of the soil surface. The mage on the left is of tundra landscape dominated by moss and lichen vegetation. The soil profile has a permanently frozen ice wedge beneath its surface.

(4) Gleysol - is a soil found in an ecosystem that is frequently flooded or permanently waterlogged. Its soil horizons show the chemical signs of oxidation and reduction.

(5) Luvisol - is another type of soil that develops under forested conditions. This soil, however, has a calcareous parent material which results in a high pH and strong eluviation of clay from the A horizon.

(6) Organic - this soil is mainly composed of organic matter in various stages of decomposition. Organic soils are common in fens and bogs. The profiles of these soils have an obvious absence of mineral soil particles.

(7) Podzol - is a soil commonly found under coniferous forests. Its main identifying traits are a poorly decomposed organic layer, an eluviated A horizon, and a B horizon with illuviated organic matter, aluminum, and iron. The forested regions of southern Ontario and the temperate rainforests of British Columbia normally have podzolic soils.

(8) Regosol - is any young underdeveloped soil. Immature soils are common in geomorphically dynamic environments. Many mountain river valleys in British Columbia have floodplains with surface deposits that are less than 3000 years old. The soils in these environments tend to be regosols.

(9) Solonetzic - is a grassland soil where high levels of evapotranspiration cause the deposition of salts at or near the soil surface. Solonetzic soils are common in the dry regions of the prairies where evapotranspiration greatly exceeds precipitation input. The movement of water to the earth's surface because of capillary action, transpiration, and evaporation causes the deposition of salts when the water evaporates into the atmosphere.[1]

[1] Note that the Canadian system does not provide for Anthropogenic Soils.

Chinese Soil Taxonomic Classification (First Proposal)

Edited by Gong Zitong
Institute of Soil Science, Academia Sinica, 1994

Anthropic surface horizons

Anthropic surface horizons are diagnostic surface horizons that are the result of agricultural activities that caused major changes in soil processes at and near to the soil surface (the case of submerged cultivation of paddy soils), or resulted in the creation of at least 50 cm thick layers on top of the natural soil surface, usually in combination with intensive agricultural practices, sometimes including (part of) the natural topsoil in the manmade layers.

1. Warpic epipedon

A warpic epipedon is a diagnostic surface horizon formed by gradual deposition of suspended particles during long-term irrigation and the mixture of cultivation. It meets the following requirements:

1. it has a thickness of 50 cm or more;
2. a uniform texture in all horizons; in at least one the fractions of 0.25-0.05 mm, 0.05-0.01 mm and 0.01-0.005 mm the maximum content is not more than 20 percent higher than the minimum content in any (sub)horizon;
3. the weighted average of organic matter is 0.8 percent or more, and the content decreases with the depth, but is at least 0.5 percent at the bottom;
4. has no double cultivated Mellowic horizon and bisquence;
5. its available P content (0.5 M $NaHCO_3$) is less than 100 mgkg-1 within a depth of 20 cm from surface;
6. significant amounts of coal cinders, charcoals, brick or tile fragments and other artifacts are present throughout the horizon;

If a surface horizon qualified as warpic except for its thickness which is between 20-50 cm, this surface horizon is defined as having warpic evidence.

2. Cumulic epipedon

The cumulic epipedon is a diagnostic surface horizon formed by long-term cultivation, applying manure or adding soil material rich in organic matter or other muds to the soil. It meets following requirements:

1. It has a thickness of 50 cm or more; and
2. A weighted average content of organic matter which is 0.1 percent or more; and
3. One of the following:
    1. a duplex segment of cultivation (old buried cultivated layer underlying the currently cultivated layer or plow layer); or
    2. A duplex segment of cultivation and duplex segment of eluviation and illuviation (there are lime illuviations such as pseudomycelium and soft powdery lime coming from upper part of old cultivated horizon), under which a buried cinnamon soil is present; or
    3. Soil materials throughout the horizon coming from another soil nearby, or consisting of mineral waste residue or mixed clay refuses, but excluding the disturbance layer due to land leveling or terrace building; and
    4. its available P content (0.5 M $NaHCO_3$) is less than 100 mgkg-1.

    If a surface horizon qualifies as cumulic except for its thickness which is between 20-50 cm, this surface horizon is defined as having cumulic evidence.

3. Mellowic epipedon

A mellowic epipedon is a diagnostic surface horizon formed by planting vegetables and/or adding night soil, organic trash or manure to the soil, under intensive cultivation and frequent irrigation during over a long period. The mellowic epipedon meets following requirements:

1. it has a thickness of 50 cm or more;
2. its weighted average organic matter content is 2.0 percent or more;
3. the available P content (0.5 M $NaHCO_3$) is 100 $mgkg^{-1}$ or more in the first 20 cm of the surface;
4. shows important amounts of wormholes and wormcasts;
5. contains important amounts of coal cinders, charcoals, brick or tile fragments and other artifacts.

If a surface horizon qualifies as mellowic except for its thickness which is less than 50 cm, but the available P content is 100 mg/kg or more within 20 cm from the soil surface, this surface horizon is defined as having mellowic evidence.

4. Hydragric epipedon

The hydragric epipedon is a diagnostic surface horizon formed under the conditions of submerged cultivation (which includes the cultivated horizon and the plow pan). It meets the following requirements:

1. it has a thickness of 18 cm or more;
2. the upper half part of the epipedon is puddled for half a month or more due to cultivation under water when soil temperature is more than 5oC;
3. the soil is saturated with water and in reduced conditions for at least 3 months each year due to artificial submergence when soil temperature is 5oC or more;
4. it has abundant rusty streaks after being drained; and it has rusty spots on void walls or on ped faces, or its chroma is 2 or less at the bottom of plow layer when moist;
5. the ratio of the bulk density of the plow pan to that of the cultivated layer is more than 1.0 when drained.

FAO Soil Classification

http://www.soils.wisc.edu/courses/SS325/fao.htm
http://www.itc.nl/~rossiter/research/rsrch_ss_class.html

The FAO (Food and Agriculture Organization) developed a supra-national classification (World Soil Classification), which conveys useful generalizations about the genesis of soils in relation to the interactive effects of the main soil-forming factors. It was first published in form of the Unesco Soil Map of the World (1974) (scale 1:5,000,000).Like the Soil Taxonomy, it makes class separations on the basis of diagnostic horizons. Some of the descriptive terminology, in simplified form, has been adopted from Soil Taxonomy, but many of the traditional Great Soil Group names have been retained, as well as new names coined, which do not suffer in translation nor do they have different meanings in different countries (Table 2.3.1.1). The Soil Units (106) are mapped as Soil Associations, designated by the dominant soil unit, with soil phases (additional soil properties, such as petric, saline, lithic, fragipan, stony), with three textural classes (coarse, medium, and fine), and three slope classes superimposed (level to gently undulating, rolling to hilly, and steeply dissected to mountainous)

Soil Units have been grouped on the basis of generally accepted principles of soil formation to form 26 World Classes. Although formulated on inferred pedogenic processes, such as gleying, salinization and lessivage, which have a bearing on soil use, the World Classes have been compiled so broadly and the total variation within each class is so large that their value in the prediction of land use is limited. The FAO soil map is far from ideal (very simple classification system, units are very broad) but it is the only truly international system, incorporating Soil Units used all over the world and most soils can be accommodated on the basis of their field descriptions. The FAO soil map is intended for mapping soils at a continental scale but not at local scale.

Table 2.3.1.1. FAO Soil Units and equivalent classification in Soil Taxonomy.

FAO Soil Unit	U.S. Soil Taxonomy
Acrisols	Ultisols
Andosols	Andepts
Arenosols	Psamments
Cambisols	Inceptisols
Chernozems	Borolls
Ferralsols	Oxisols
Fluvisols	Fluvents
Gleysols	Aquic suborders
Greyzems	Boroll
Histosols	Histosols
Kastanozems	Ustolls
Lithosols	Lithic Subgroups
Luvisols	Alfisols
Nitosols	Ultisols and Alfisols
Phaeozems	Udolls
Planosols	-
Podzols	Spodosols
Podzoluvisols	Glossic Great Groups of Alfisols
Rankers	Lithic Haplumbrepts
Regosols	Orthents, Psamments
Rendzinas	Rendolls
Solonchaks	Salic Great Group
Solonetz	Natric Great Group
Vertisols	Vertisols
Xerosols	Mollic Aridisols
Yermosols	Typic Aridisols

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FAO - Soil Unit Classification Scheme

http://www.itc.nl/~rossiter/research/rsrch_ss_class.html

AC ACRISOLS
AL ALISOLS
AN ANDOSOLS
AR ARENOSOLS

AT ANTHROSOLS

- ATa Aric Anthrosols
- ATc Cumulic Anthrosols
- ATf Fimic Anthrosols

CH CHERNOZEMS
CL CALCISOLS
CM CAMBISOLS
FL FLUVISOLS
FR FERRALSOLS
GL GLEYSOLS
GR GREYZEMS
GY GYPSISOLS
HS HISTOSOLS
KS KASTANOZEMS
LP LEPTOSOLS
LV LUVISOLS
LX LIXISOLS
NT NITISOLS
PD PODZOLUVISOLS
PH PHAEOZEMS
PL PLANOSOLS
PT PLINTHOSOLS
PZ PODZOLS
RG REGOSOLS
SC SOLONCHAKS
SN SOLONETZ
VR VERTISOLS

Anthrosols in the World Reference Base (WRB)

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Introduction. Previous attempts to define Anthrosols in the FAO system did not make a distinction between "anthropedogenesis" and anthropogeomorphology (2). Current proposals to modify the FAO system as part of WRB are designed to emphasize the unique nature of pedogenic processes in this major soil group. Anthrosols include those soils which have been so transformed by anthropedogenic processes that the original soil is no longer recognizable or survives only as a buried soil. Anthropogenic soil materials as defined for WRB refer to unconsolidated or organic materials resulting largely from anthropogeomorphic processes and considered to be "non-soil" unless modified by subsequent pedogenesis.

Diagnostic Horizons. Several diagnostic horizons for Anthrosols have been recognized, including hortic, plaggen, terric and irragric horizons (Table 1). A hydragric horizon is also proposed to accommodate soils developed under wet cultivation where subsoil properties have been considerably altered. Definition of the hortic horizon represents a return to the original concept of the anthropic epipedon although archaeological sites are specifically excluded (3). Base saturation is used to differentiate plaggen and terric horizons, and it should be stressed that color differences are attributable to source materials or substrate. Definition of the terric horizon has been heavily influenced by recent Chinese work (1) while the present definition may mean that most Irish plaggen soils would be included as Terric-Cumulic Anthrosols. Recognition of the irragric horizon seems long overdue, and it should be possible to define this more rigorously with the help of soil scientist in the Middle East and central Asia.

Table 1. Diagnostic soil horizons in Anthrols.

Hortic horizon
Same properties as mollic epipoden (3) except for moisture requirements (no restrictions) and depth (>30 cm). Citric acid soluble P>250 ppm P_2O_5. Horizon is thoroughly mixed with original strata usually not preserved. Artifacts and cultural debris commonly occur, often much abraded and finely comminuted. Earthworm casts > 25 percent by volume. Indications of tillage or mixing of soil may be present; buried soils may be preserved but are usually incorporated in horizon.

Plaggen horizon
Same as plaggen epipedon except for depth (>30cm): horizon built up gradually by addition of sods or earthy manures, either as compost or litter (3). Black and brown variants may be recognized: horizon is thoroughly mixed with color attributable to source materials or substrate. Base saturation <50 percent. Artifacts and cultural debris commonly occur, usually much abraded and finely comminuted. Indications of tillage, such as spade marks, may occur as well as old cultivation layers: plaggen horizons often overlie buried soils although surface horizons may be mixed. Micromorphological investigations may be necessary for proper identification.

Terric horizon
Similar to plaggen epipedon with depth >30 cm: horizon built up gradually by addition of earthy manures or compost. Horizon is thoroughly mixed with color attributable to source materials or substrate. Base saturation >50 percent. Artifacts and cultural debris commonly occur, often much abraded and finely comminuted. Buried soils may be present at base of horizon although contact may be obscured by mixing.

Table 1. (cont.)

Irragric horizon
Surface horizon developed under conditions of long-continue irrigation: similar to horitic horizon except for mollic color. Depth >30 cm. Antifacts and cultural debris occur commonly; often much abraded and finely comminuted. Horizon thoroughly mixed with original stratification usually not preserved: irrigation deposits may be present below horizon. Earthworm casts >25 percent by volume. Micromorphological investigations may be necessary for proper identification.

Soil Units and Subunits. Anthrosols are usually found in areas of old cultivation where tradition agriculture is of considerable age. Several soil units are recognized, having hortic, plaggen, terric, or irragric horizons >50 cm: hydragric horizons are also included if the effects of wet cultivation extend below 50 cm. A key for the various soil units is presented below with tentative definitions for each soil unit.

Hydragric Anthrosols	Anthrosols developed under wet cultivation with a hydragric horizon: usually underlies an anthrohydric horizon.
Cumulic Anthrosols	Anthrosols built up gradually an anthropedogenic processes and having hortic, plaggen, terric or irragric horizons. Evidence for "raised" anthropogenic soils consists of buried soil horizons >50 cm in depth; differences in heavy mineral content, composition of sand fraction, fine clay content, etc. resulting from the introduction of extraneous materials; and the presence of finely comminuted and abraded artifacts and cultural debris.
Hortic Anthrosols	Anthrosols having hortic horizon >50 cm.
Irragric Anthrosols	Anthrosols having irragric horizon > 50 cm.

According to the present scheme, many of the more common anthropogenic soils would only be recognized at the subunit level. Most of these occur in Comulic Anthrosols, but it may also be worthwhile to recognize deeply worked horticultural soils where the hortic horizon extends below 75 cm.

Plaggie-Cumulic Anthrosols	Cumulic Anthrosols having plaggen horizon >50 cm.
Hortic-Cumulic Anthrosols	Cumulic Anthrosols having hortic horizon >50 cm.
Irragric-Cumulic Anthrosols	Cumulic Anthrosols having irragric horizon >50 cm.
Rigolic-Hortic Anthrosols	Hortic Anthrosols having hortic horizon >75 cm.

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Soil Classification for Germany

http://grunwald.ifas.ufl.edu/Nat_resources/genesis_classification/germany.htm

Before 1994, a classification developed by Kubiena (modified by Mueckenhausen) based on soil genesis, pedogenic processes, morphologic features was used. The rationale behind the soil classification was that soils are formed as a result of the soil forming factors. The German soil classification system was revised in 1994 to consider soil texture, lithic features, and source of material.

Soil Classification

Divisions (4): Classification based on moisture regime:

a. Terrestrial soils
b. Semi-terrestrial soils
c. Semi-subhydric and subhydric soils
d. Peats (> 3 m organic material)

Divisions are subdivided into Soil Classes (14): They are differentiated based on soil genesis and morphologic features , classes are characterized by a typical sequence of horizons.

Soil Classes are subdivided into Soil Types (40): They are differentiated based on pedogenic processes. Soil types are characterized by a typical sequence of horizons. Peats and AC-soils are differentiated based on geogenetic attributes.

Soil Types are subdivided into Sub Soil Types:

a. Typical (describes the Soil Type)
b. Intergrade (describes the Soil Group but shows some additional characteristics)
c. Transition (deviating properties)

Lithic features considered in the soil classification:

- Soil texture
- Geo-genesis (e.g. glacial, periglacial, eolian, alluvial, marine, colluvium)
- Source of material (e.g. loess, gravel, shale, sandstone)

Lithic features plus pedogenic features form 'Soil Forms'

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Harmonization of Soil Survey Classification - Blending East with West

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In Germany, soil surveying is influenced by the federal character of the republic, the geological surveys of the component states of Germany are responsible for soil mapping and publishing of federal state soil maps. A working group consisting of the heads of each state soil survey and of the national soil survey of the Federal Institute for Geosciences and Natural Resources (BGR), coordinates the pedological work of the individual states.

Radical changes in all matters concerning soil mapping, soil research and soil information were caused by the German reunification in 1990. The former German Democratic Republic (GDR) and the Federal Republic of Germany (FRG) used different soil classifications, different soil mapping guides and soil analytical methods and thus compiled different types of soil maps and - referring to the national German view inhomogeneous soil information. This meant that great efforts had to he made in order to standardize soil surveying in Germany. In view of the new situation, the emphasis of the work done after German reunification was to create new versions of data keys, guidelines. method documentation and soil maps.

The differences existing between both soil classifications have been many, e. g. different soil typology (e.g. soil type names), different ranges of soil layers and soil horizons, and in parts different analytical methods. Many systems of soil regionalization were used in FRG but one well accepted system of soil regionalization existing in GDR. This became the basis of the soil regions' system of Germany involving soil regions, soil landscapes and soilscapes. Moreover, the data availability including soil maps covering the former German states was highly different.

To solve all these problems, West and East German soil scientists met to publish a new soil mapping guide (merging of both soil mapping guides including soil classification systems) to publish a new 1:200,000 soil map for Germany for the federal soil survey institutes as well as for BGR, using a special 1:200,000 soil mapping guide BGR started to produce a new digital soil map 1:1,000,000 making use of the new German and the FAO soil classifications. The first versions of 1:2,000,000 to 1.5,000,000 soil maps have now been compiled using this digital soil map.

Russian Urban Soil Classification System

http://www.soil.msu.ru/~ptv/city-eng.htm

City, soil and environment

Understanding of towns and industrial centers as specific urban ecosystems makes the soil an important component of these systems. Properties of urban soils are poorly studied and their role in cities is underestimated. Soil is a focus of all biogeochemical links within the system. Soils in towns and cities have peculiar morphology and unusual composition of biota, which includes pathogenic microorganisms and appears to be a sink for municipal wastes and technogenic pollutants.

Urban lands are used for different purposes (their functional role is different). Having some general characteristics, properties of each type of lands are specific. Properties of urban lands also reflect the type of their use and its pattern. Socioeconomic, political, and administrative aspects of city planning affect the functional zones of city and their soils.

We pioneered elaboration of the taxonomic system of urban soils located within the southern taiga. It is based on the assessment of changes in soil morphology relatively to original soils, on properties of parent material. We also developed methods for description of profiles and horizons of urban soils.

The soil cover in city is composed of natural soils (for example, soddy–podzolic, or Podzoluvisols), soils with transformed topsoil and original subsoil (urbo-soils, for example, urbo-podzolic), strongly transformed soils (urbanozems), artificial soils and sediments with high-humus surface horizons (urbotechnozems) and buried soils, or paleosols, found at some depth. The further subdivision of soils is proposed.

Table 1. Classification of urban soils located within the taiga zone of Russia

Taxa of urban soils	Natural soils in cities	Natural–anthropogenic soils	Soils transformed by humans	Technogenical surficial formations
Class	natural soils	surface-transformed natural soils	strongly transformed soils, anthropozem	human-made soils with high-humus surface horizons, technozem
Type	podzolic, gley–podzolic, alluvial, humus-gley and other soils with urbic features	soils transformed to a depth less than 50 cm, urbo-soils	soils transformed to a depth more than 50 cm, urbanozems	soils and sediments, urbotechnozems
Subtype	soddy–podzolic, peaty gley–podzolic, alluvial slightly gleyed, etc.	disturbed, truncated, filled etc. soils	1.urbanozem, 2.culturozem, 3.necrozem, 4.ekranozem; 5.industrizem, 6.intruzem	1.replantozem, 2.constructozem

URBANOZEM is the central concept of soils found in towns and cities. It is defined as a genetically individual soil, which combines properties of natural soils in neighboring areas and specific properties developed in the urban environment.

Urban soils develop through three major ways (Fig.2): (1) on loose artificial deposits; (2) on the cultural layer–anthropic material; (3) by transforming natural soils.

The following forces drive the evolution and transformation of urban soils:

* functional peculiarities of the territory predetermined by the type of land use–occurrence in residential, industrial, recreational and natural areas;

* types of substrates, their physical and chemical features: cultural layer, filled, mixed and dredged sediments and remains of natural soils;
* time: old soils of cloisters, palaces, etc. with deep cultural layer, which development was initiated in the Middle Ages and earlier, human-made and natural paleosols and soils in modern residential quarters constructed on either on arable and forested lands or on sites of waste disposals.

The formation and evolution of urban soils results in (Fig. 3):

* evolution of natural soils: zonal soil > slightly or strongly disturbed zonal soils (urbo-soil) > urbanozem.
* soil development on sediments: sediment (mineral substrate) > organo-sediment (fresh peat–compost mixture on sediment, urbotechnozem) > urbanozem.
* soil development on the cultural layer: cultural layer > urbanozem.

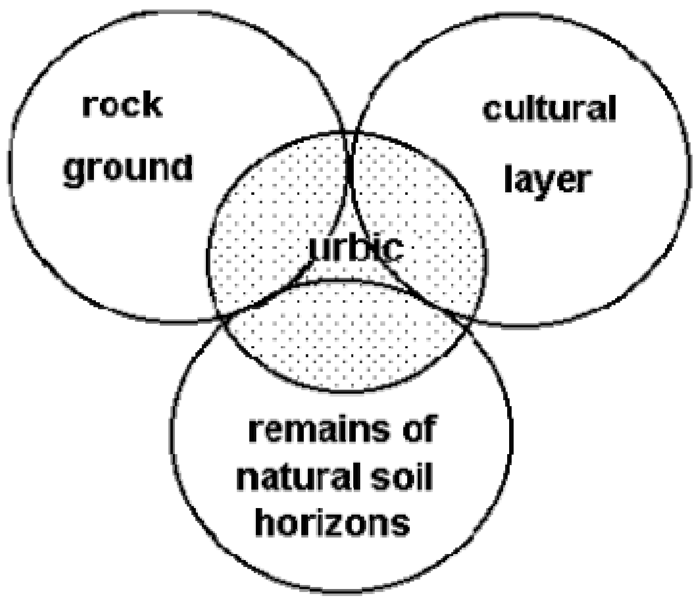

Figure 2. Formation of the urbic horizon

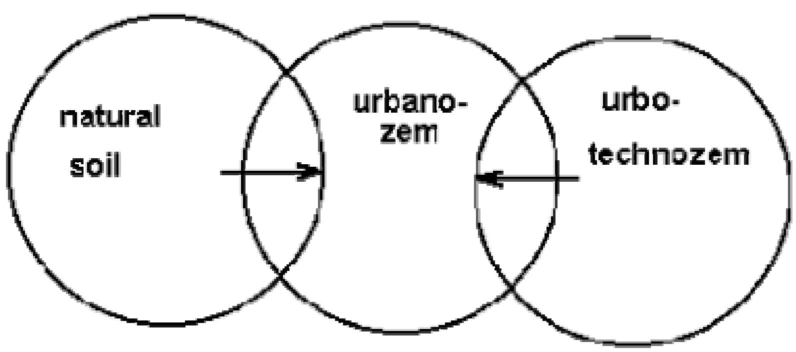

Figure 3. Evolution of urban soils

There are the following ways of development of urban soils with time, or trends of their evolution:

* natural evolution of quasi-natural soils and urbo-soils, soils that slightly affected by urbogenesis, in urban gardens or forests;

* soil formation on mineral sediments in recently constructed residential areas starting from the zero-moment;
* soil formation on organo-mineral mixed, filled and dredged sediments in suburbs and downtowns (soil on sediments) starting from the zero-moment;
* changes in properties of soils on cultural layer (dated surfaces in the downtown).

These evolution models are superimposed by a great number of specific urban processes: contamination, alkalization, calcification and salinization.

In towns, environmental functions of soils are subject to drastic changes and degradation.

We think that major functions performed by soils in urban ecosystems are similar to those in natural ones. The soils are the medium, where biogeochemical cycling and biochemical transformation of filled layers occur and surface waters are converted into ground ones. They also are a nutritive substrate for plants, seed bank, gas exchange regulator, etc.

Urban soils perform various ecological functions. Their main properties are fertility–soil suitability for plant growth–and absorptive capacity of pollutants to prevent their penetration to soil and ground waters and, with dust, into urban air.

The soil plays the significant and diverse role in towns. During formation of the environment, it alters the chemical composition of precipitation and ground waters; it is the universal biological source, sink, and regulator of CO2, O2 and N2 in the atmosphere.

In large cities, especially with high industrial development, urban soils perform their ecological functions much poorly (Table 2.).

Table 2. Changes in environmental functions of urban soils

Natural soil (Soil-water)

1. Conversion of sewage water into groundwater, and its cleaning. 2. Sorptive barrier protecting rivers and lakes against pollution. 3. Alteration of the chemical composition of water.

Urban soil (Soil water)

1. Asphalt and the surface of compacted soil prevent water penetration to soil and direct it to rivers. 2. As it moves through soil, water is contaminated with heavy metals and toxic compounds, so, when water leaves the soil, its composition differs from the original one. 3. When strongly polluted, soil stops to be a barrier against pollution (its sorptive capacity is saturated). 4. Additional water influx from pipelines (soil waterlogging and bogging).

Natural soil (Soil–substrate)

1. The barrier protecting against vertical penetration of chemical and biological pollutants.
2. Biogeochemical transformation of substratum, wastes, and disposal cites.

Urban soil (Soil–substrate)

1. The protective barrier may not function (e.g., on infertile sand fills). 2. Geochemical link between soil and substrate may absent (soil on communication conduits). 3. Mosaic or throughfall percolation. 4. Substrate is the cause of biological and chemical pollution. 5. Soil on disposal cites accumulates heavy metals and toxic compounds.

Natural soil (Soil air)

1. Gas absorptive barrier for human-induced gases, including those produced by motor transport, thermal power stations, and plants. 2. Regulation of the gas composition in the atmosphere and its cleaning (gas extraction and absorption by soil).

Urban soil (Soil air)

1. Absorption of gases, including those from motor transport, plants, and thermal power stations. 2. Elevated levels of dust production at the soil surface. 3. Gas exchange is deteriorated in compacted soil. 4. Greenhouse effect develops under asphalt or under compact soil crust. 5. The ratio between anaerobic and aerobic microorganisms changes. 6. Additional gas influx from communication conduits.

Table 2. Changes in environmental functions of urban soils (Cont.)

Natural soil (Soil biota)

1. Environment for macro-, meso-, and microbiota. 2. The basis of bioproductivity. 3. Sanitary barrier.

Urban soil (Soil biota)

1. Depletion of the environment and reduction in its biodiversity (composition, structure, and functions). 2. Lowered bioproductivity. 3. Appearance of human-associated species. 4. Appearance of pathogenic microorganisms. 5. Deterioration of sanitary functions.

Thus, for the first time the system of parameters and criteria for assessment of urban soils were proposed. The demonstrated guidelines for assessment of the urban environment are a part of its complex assessment and should be applied in nature conservation practices.

Up to the present time, there were no standards for optimal functioning and quality of urban soils. The preliminary list of parameters necessary for estimation of the ecological state (quality) of urban soils is given in Table 3. As standards, we used GOSTs (state standards) and instructions. Similar values used for arable lands within the zone of soddy–podzolic soils were corrected in accordance to the results of our studies of urban soils of Moscow. Some estimated values suit to appraisal of the state of all types of urban lands, while the others suit only to its specific types.

Table. 3. Optimal properties of urban soils

Criteria, parameters	Natural–recreational and recreational zones			Industrial zone	
	Parks and forest parks	Squares and boulevards	Lawns	Boulevards squares, and alleys	Lawns
(1) Stoniness 0–25-cm layer, %	<10	<15	<25	<15	<25
(2) Content of physical clay (<0.01 mm), %	10-40	10-30	20-40	10-30	20-40
(3)Groundwater level, m	>3-4	>2-3	>1	4-5>	>3
(4) Thickness of the fertile layer, including that of planting pit	10-75	30-75	>25	30-75	>25
(5) Humus content in the 0–25-cm layer, %	2-3	2-3	3-4	2-4	3-4
(6) pH water	5.5-6.5	5.5-7.5	6.5-8.0	5.5-8.0	6.5-8.0
(7) Bulk density 0–25-cm layer, g/cm3	0.80-1.10	1.15-1.20	1.2-1.3	1.25-1.3	1.2-1.3
(8) Radioactivity, mcR/h	<20	<20	<20	20-25	20-25
(9) Number of pathogenic microorganisms per gram of soil	Not Determined				
(10)Soil phytotoxicity (times relatively to the background)	<1.1	1.1-1.3	1.1-1.3	1.1-1.3	1.1-1.3

Presently, the qualitative assessment of urban soils is insufficiently elaborated, while it can be used for soil rating and valuing of urban lands. We attempted to make the preliminary estimate of the quality of urban lands by using several parameters (Table 4), which gradations permit to range soils from those that almost do not require rehabilitation to strongly degraded (practically unrecoverable) soils.

Table 4. Integral qualitative assessment of urban soils

Parameters/gradations	Very good do not require rehab.	Good easily rehab.	Fair moderately rehab.	Unfair poorly rehab.	Poor cost of rehab.[2] high
		Morphological parameters			
(1) Thickness of the humus layer, % of decrease relatively to the background	0	25	50	75	n/d
(2) Degree of waste deposition of surface, %	sporadic	<25	25-50	50-75	>75
(3) Stoniness in 0–0.5-cm layer, %	sporadic	<25	25-50	50-75	>75
		Physical parameters			
(1) Particle-size distribution (<0.01 mm), %	20-30	10-20 30-40	5-10 40-50	0-5 50-60	>60
(2) Bulk density, g/cm3	<1.2	1.2-1.4	1.4-1.5	1.5-16	>1.6
		Chemical parameters			
(1) Humus reserves, % of decrease relatively to background	0	25	50	75	100
(2) pH	6.5–7.0	5.5-6.5 7.0-7.5	4.5-5.5 7.5-8.0	4.0-4.5 8.0-8.5	<4.0 >8.5
(3) Content of heavy metals, ITA*	<16	16-32	32-64	64-128	>128
		Biological parameters			
(1) Mesofauna diversity	++++	+++	++	+	n/d
(2) Biomass of living microorganisms, times less relatively to the background	<5	5-10	10-50	50-100	>100
(3) Phytotoxicity, times less relatively to the background	<1.1	1.1-1.3	1.3-1.8	1.6-2.0	>2.0

*ITA is the index of total accumulation relatively to the background.

[2] Rehabilitated.

Soil Taxonomy and Anthropogenic Soils

NSSC Staff – August 2002

The original authors of Soil Taxonomy wanted to keep undisturbed soils and the cultivated or otherwise human-modified equivalents in the same taxa insofar as possible. Despite this goal the system provides diagnostic horizons and taxa for soils with morphology that was caused by humans. Two epipedons, the anthropic and plaggen, and one diagnostic subsurface horizon, the agric horizon, were defined. In addition, the sulfuric horizon is commonly the result of the modification by humans of soils containing sulfidic materials. Anthraquic conditions were added in 1992 for cultivated and irrigated soils forming under human induced flooding, such as used in paddy rice and cranberry culture. The suborder Arents is defined using fragments of diagnostic horizons that are arranged in an order that cannot be attributed to soil forming processes for soils that have been deeply mixed by humans.

Diagnostic surface horizons; the epipedon surface

In some orders, such as Gelisols, Vertisols, and Spodosols, however, horizons are not always parallel to the surface. A horizon has some set of properties that have been produced by soil-forming processes, and it has some properties that are not like those of the layers directly above and beneath it. A soil horizon commonly is differentiated from the horizons adjacent to it partly by characteristics that can be seen or measured in the field, such as color, structure, texture, rupture-resistance class, and the presence or absence of carbonates. In identifying a soil horizon, however, measurements in the laboratory are sometimes required to supplement field observations. According to the criteria we use, horizons are identified partly by their own morphology and partly by properties that differ from those of the overlying and underlying horizons.

Many of the layers that are differentiae for organic soils do not meet the definition of soil horizons. Unlike the layers of soil that are commonly called horizons, they are layers that formed in differing environments during the period when the materials that now constitute the soils accumulated. Some of the layers that serve as differentiae are soil horizons, but there are no operational methods that can always distinguish between "horizons" and "layers" that have similar properties. The importance of making a distinction between horizons and layers of organic soils is unknown. In the discussion that follows, the term "soil material" is commonly used as a broader term that includes both horizons and layers in organic soils.

The horizon designations used in this chapter are defined in Chapter 4 of Soil Taxonomy (2nd Ed.). The epipedon (Gr. *ep*i, over, upon, and *pedo*n, soil) is a horizon that forms at or near the surface and in which most of the rock structure has been destroyed. It is darkened by organic matter or shows evidence of eluviation, or both. Rock structure as used here and in other places in this taxonomy includes fine stratification (less than 5 mm) in unconsolidated sediments (eolian, alluvial, lacustrine, or marine) and saprolite derived from consolidated rocks in which the unweathered minerals and pseudomorphs of weathered minerals retain their relative positions to each other.

Any horizon may be at the surface of a truncated soil. The following section, however, is concerned with eight diagnostic horizons that have formed at or near the soil surface. These horizons can be covered by a surface mantle of new soil material. If the surface mantle has rock structure, the top of the epipedon is considered the soil surface unless the mantle meets the definition of buried soils in chapter 1. If the soil includes a buried soil, the epipedon, if any, is at the soil surface and the epipedon of the buried soil is considered a buried epipedon and is not considered in selecting taxa unless the keys specifically indicate buried horizons, such as those in Thapto-Histic subgroups. A soil with a mantle thick enough to have a buried soil has no epipedon if the soil has rock structure to the surface or has an Ap horizon less than 25 cm thick that is underlain by soil material with rock structure. The melanic epipedon (defined below) is unique among epipedons. It forms commonly in volcanic deposits and can receive fresh deposits of ash. Therefore, this horizon is permitted to have layers within and above the epipedon that are not part of the melanic epipedon.

The definition of the epipedon in Soil Taxonomy was designed to keep cultivated and natural soils in the same taxa. To avoid changes in the classification of a soil, solely as a result of plowing, the properties of the epipedon, except for structure, are determined after mixing the soil to a depth of 18 cm, or by mixing the whole soil if the depth to bedrock is less than 18 cm. Surface layers of some soil were so modified by humans that the Soil Taxonomy defined two Anthropogenic epipedons.

Anthropic Epipedon

The anthropic epipedon has the same limits as the mollic epipedon in color, structure, and organic-carbon content. It formed during long-continued use of the soil by humans, either as a place of residence or as a site for growing irrigated crops. In the former case, disposal of bones and shells has supplied calcium and phosphorus and the level of phosphorus in the epipedon is too high for a mollic epipedon. Such epipedons occur in the humid parts of Europe, the United States, and South America and probably in other parts of the world, mostly in kitchen middens. The high level of phosphorus in the anthropic epipedons is not everywhere accompanied by a base saturation of 50 percent or more, but it is accompanied by a relatively high base saturation if compared with the adjacent soils.

In arid regions some long-irrigated soils have an epipedon that is like the mollic epipedon in most chemical and physical properties. The properties of the epipedon in these areas are clearly the consequence of irrigation by humans. Such an epipedon is grouped with the anthropic epipedons, which developed under human habitation. If not irrigated, such an epipedon is dry in all its parts for more than 9 months in normal years. Additional data about anthropic epipedons from several parts of the world may permit future improvements in this definition.

Required Characteristics

In summary, the anthropic epipedon shows some evidence of disturbance by human activity and meets all of the requirements for a mollic epipedon, except for *one or both* of the following:

1. 1,500 milligrams per kilogram or more P_2O_5 soluble in 1 percent citric acid and a regular decrease in P_2O_5 to a depth of125 cm; *or*
2. If the soil is not irrigated, all parts of the epipedon are dry for 9 months or more in normal years.

Plaggen Epipedon

The plaggen epipedon is a human-made surface layer 50 cm or more thick that has been produced by long-continued manuring. In medieval times, sod or other materials commonly were used for bedding livestock and the manure was spread on fields being cultivated. The mineral materials brought in by this kind of manuring eventually produced an appreciably thickened Ap horizon (as much as 1 m or more thick). In northwestern Europe this custom was associated with the poorly fertile, sandy Spodosols. The practice more or less ceased at the turn of the 19th century, when fertilizers became available.

The color of a plaggen epipedon and its organic-carbon content depend on the materials used for bedding. If the sod was cut from the heath, the plaggen epipedon tends to be black or very dark gray, to be rich in organic matter, and to have a wide carbon-nitrogen ratio. If the sod came from forested soils, the plaggen epipedon tends to be brown, to have less organic matter, and to have a narrower carbon-nitrogen ratio. Commonly, the organic-carbon content ranges from 1.5 to 4 percent. Values commonly range from 1 to 4, moist, and chromas are 2 or less.

A plaggen epipedon can be identified by several means. Commonly, it contains artifacts, such as bits of brick and pottery, throughout its depth. There may be chunks of diverse materials, such as black sand and light gray sand, as large as the size held by a spade. The plaggen epipedon normally shows spade marks throughout its depth and also remnants of thin stratified beds of sand that were probably produced on the soil surface by beating rains and were later buried by spading. A map unit delineation of soils with plaggen epipedons would tend to have straight-sided rectangular bodies that are higher than the adjacent soils by as much as or more than the thickness of the plaggen epipedon.

Diagnostic Subsurface Horizons

The horizons described in this section form below the surface of the soil, although in some areas they form directly below a layer of leaf litter. They may be exposed at the surface by truncation of the soil. Some of these horizons are generally regarded as B horizons, some are considered B horizons by many but not all pedologists, and others are generally regarded as parts of the A horizon.

Agric Horizon

The agric horizon is an illuvial horizon that has formed under cultivation and contains significant amounts of illuvial silt, clay, and humus. When a soil is brought under cultivation, the vegetation and the soil fauna as a rule are changed drastically. The plow layer is mixed periodically, and, in effect, a new cycle of soil formation is started. Even where the cultivated crops resemble the native vegetation, stirring of the plow layer and the use of amendments, especially lime, nitrogen, and phosphate, normally produce significant changes in soil structure, flora, and fauna.

After a soil has been cultivated for a long time, changes in the horizon directly below the plow layer become apparent and cannot be ignored in classifying the soil. The large pores in the plow layer and the absence of vegetation immediately after plowing permit a turbulent flow of muddy water to the base of the plow layer. The water can enter wormholes or fine cracks between peds at the base of the plow layer, and the suspended materials are deposited as the water is withdrawn into capillary pores. The worm channels, root channels, and surfaces of peds in the horizon underlying the plow layer become coated with a dark colored mixture of organic matter, silt, and clay. The accumulations on the sides of wormholes become thick and can eventually fill the holes. If worms are scarce, the accumulations may take the form of lamellae that range in thickness from a few millimeters to about 1 cm. The lamellae and the coatings on the sides of wormholes always have a lower color value and chroma than the soil matrix.

The agric horizon can have somewhat different forms in different climates if there are differences in soil fauna. In areas of a humid, temperate climate where soils have a udic moisture regime and a mesic soil temperature regime (defined below), earthworms can become abundant. If there are wormholes that, including their coatings, constitute 5 percent or more (by volume) of the horizon and if the coatings are 2 mm or more thick and have a color value, moist, of 4 or less and chroma of 2 or less, the horizon is an agric horizon. After long cultivation, the content of organic matter in the agric horizon is not likely to be high, but the carbon-nitrogen ratio is low (generally less than 8). The pH value of the agric horizon is close to neutral (6 to 6.5).

In areas of a Mediterranean climate where soils have a xeric soil moisture regime, earthworms are less common and the illuvial materials accumulate as lamellae directly below the Ap horizon. If these lamellae are 5 mm or more thick, have a color value, moist, of 4 or less and chroma of 2 or less, and constitute 5 percent or more (by volume) of a horizon 10 cm or more thick, this horizon is an agric horizon. The agric horizon in these xeric soils is also part of an argillic horizon. An agric horizon may form in several of the other diagnostic horizons, but not in a mollic or anthropic epipedon. A soil in which an illuvial horizon has formed in the mollic epipedon is distinguished by other means.

Required Characteristics

The agric horizon is directly below an Ap horizon and has the following properties:

A thickness of 10 cm or more and *either*:

a. 5 percent or more (by volume) wormholes, including coatings that are 2 mm or more thick and have a value, moist, of 4 or less and chroma of 2 or less; *or*

b. 5 percent or more (by volume) lamellae that have a thickness of 5 mm or more and have a value, moist, of 4 or less and chroma of 2 or less.

Sulfuric Horizon

Brackish water sediments frequently contain pyrite (rarely marcasite), which is an iron sulfide. Pyrite forms from the microbial decomposition of organic matter. Sulfur released from the organic matter combines with the iron to crystallize FeS. Characteristically, the pyrite crystals occur as nests or framboids composed of bipyramidal crystals of pyrite. In an oxidizing environment, pyrite oxidizes and the products of oxidation are jarosite and sulfuric acid. The jarosite may undergo slow hydrolysis, leading to further production of sulfuric acid. Iron is precipitated as a reddish ochre precipitate, commonly ferrihydrite, which later may crystallize as maghemite, goethite, and even hematite. If free aluminum is present, alunite may crystallize in addition to jarosite. The jarosite has a straw-yellow color and frequently lines pores in the soil. Jarosite concentrations are among the indicators of a sulfuric horizon.

In some soils, the hydrolysis of jarosite is rapid and the yellow redoximorphic concentrations may not be evident, even though the soils are extremely acid (pH less than 3.5) or the soil solution is high in soluble sulfur. The low pH and high amount of soluble sulfur are indicators of a sulfuric horizon. A soil can develop low pH values, however, from highly acidic materials from other sources. Therefore, low pH and sulfuric materials in the underlying layers also are indicators of a sulfuric horizon. A quick test of sulfidic materials is a rapid fall in pH on drying or after treatment with an oxidizing agent, such as hydrogen peroxide.

A sulfuric horizon forms as a result of drainage (most commonly artificial drainage) and oxidation of sulfide-rich or organic soil materials. It can form in areas where sulfidic materials have been exposed as a result of surface mining, dredging, or other earth-moving operations. A sulfuric horizon is detrimental to most plants.

Required Characteristics

The sulfuric (L. *sulfu*r) horizon is 15 cm or more thick and is composed of either mineral or organic soil material that has a pH value of 3.5 or less (1:1 by weight in water or in a minimum of water to permit measurement) and shows evidence that the low pH value is caused by sulfuric acid. The evidence is *one or more* of the following:

1. Jarosite concentrations; *or*
2. Directly underlying sulfidic materials (defined above); *or*
3. 0.05 percent or more water-soluble sulfate.

Other Diagnostic Soil Characteristics

Aquic Conditions

Soils with aquic (L. *aqu*a, water) conditions are those that currently undergo continuous or periodic saturation and reduction. The presence of these conditions is indicated by redoximorphic features, except in Histosols and Histels, and can be verified by measuring saturation and reduction, except in artificially drained soils. Artificial drainage is defined here as the removal of free water from soils having aquic conditions by surface mounding, ditches, or subsurface tiles to the extent that water table levels are changed significantly in connection with specific types of land use. In the keys, artificially drained soils are included with soils that have aquic conditions. Elements of aquic conditions are as follows:

1. Saturation is characterized by zero or positive pressure in the soil water and can generally be determined by observing free water in an unlined auger hole. Problems may arise, however, in clayey soils with peds, where an unlined auger hole may fill with water flowing along faces of peds while the soil matrix is and remains unsaturated (bypass flow). Such free water may incorrectly suggest the presence of a water table, while the actual water table occurs at greater depth. Use of well sealed piezometers or tensiometers is therefore recommended for measuring saturation. Problems may still occur, however, if water runs into piezometer slits near the bottom of the piezometer hole or if tensiometers with slowly reacting manometers are used. The first problem can be overcome by using piezometers with smaller slits and the second by using transducer tensiometry, which reacts faster than manometers. Soils are considered wet if they have pressure heads greater than -1 kPa. Only macropores, such as cracks between peds or channels, are then filled with air, while the soil matrix is usually still saturated. Obviously, exact measurements of the wet state can be obtained only with tensiometers. For operational purposes, the use of piezometers is recommended as a standard method. The duration of saturation required for creating aquic conditions varies, depending on the soil environment, and is not specified.

Three types of saturation are defined:

a. *Endosaturation*.—The soil is saturated with water in all layers from the upper boundary of saturation to a depth of 200 cm or more from the mineral soil surface.

b. *Episaturation*.—The soil is saturated with water in one or more layers within 200 cm of the mineral soil surface and also has one or more unsaturated layers, with an upper boundary above a depth of 200 cm, below the saturated layer. The zone of saturation, i.e., the water table, is perched on top of a relatively impermeable layer.

c. *Anthric saturation*.—This term refers to a special kind of aquic conditions that occur in soils that are cultivated and irrigated (flood irrigation). Soils with anthraquic conditions must meet the requirements for aquic conditions and in addition have *both* of the following:

(1) A tilled surface layer and a directly underlying slowly permeable layer that has, for 3 months or more in normal years, *bot*h:

(a) Saturation and reduction; *and*

(b) Chroma of 2 or less in the matrix; *and*

(2) A subsurface horizon with *one or more* of the following:

(a) Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less in macropores; *or*

(b) Redox concentrations of iron; *or*

(c) 2 times or more the amount of iron (by dithionite citrate) contained in the tilled surface layer.

NOTE: The remainder of the extensive definition of Aquic conditions is general and applies to all three types of saturation mentioned above. The full definition may be found in the 2nd Edition of Soil Taxonomy (Soil Survey Staff, 1999).

Densic Materials

Densic materials are relatively unaltered materials (do not meet the requirements for any other named diagnostic horizons or any other diagnostic soil characteristic) that have a noncemented rupture-resistance class. The bulk density or the organization is such that roots cannot enter, except in cracks. These are mostly earthy materials, such as till, volcanic mudflows, and some mechanically compacted materials, for example, mine spoils. Some noncemented rocks can be densic materials if they are dense or resistant enough to keep roots from entering, except in cracks. Densic materials are noncemented and thus differ from paralithic materials and the material below a lithic contact, both of which are cemented. Densic materials have, at their upper boundary, a densic contact if they have no cracks or if the spacing of cracks that roots can enter is 10 cm or more. These materials can be used to differentiate soil series if the materials are within the series control section.

Conclusions

In conclusion, Anthropogenic soils are included in Soil Taxonomy. Diagnostic epipedons, subsurface horizons and features are defined. However, we recognize that the definitions of these Anthropogenic features need improvement ant that new features may be needed. We have organized an international committee charged with defining appropriate classes in Soil Taxonomy to better classify Anthropogenic soils.

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Time Zero in Modern Soil Classification

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In the late forties, soil scientists in many countries were reexamining concepts of soils and developing classification systems to support national soil survey programs. Colonial powers had the advantage in obtaining information on soils of the tropics and by the early 1950s, there was adequate knowledge of soils from the tundra to the tropics to allow soil scientists to begin to think about global soil systems.

In 1950, Dr. Guy D. Smith was charged with developing a new system for classifying US soils. Two years later, in 1952, the late Prof. R. Tavernier organized a discussion on soil classification at the University of Gent, Belgium. The brainpower of Europe was present. From Belgium were Tavernier, Dudal (later of FAO), Mormann (also of FAO and IITA), Deckers (father of the present Chairman of WRB), and senior staff of the Belgian soil survey. Others present included Aubert (France), Muckenhausen (W. Germany), Osmond (Great Britain), Edelman (Netherlands), Bennema (later with FAO), Bramao (Portugal and later FAO), and Pena (Spain). Although it was essentially a European meeting, the central figure was Dr. Guy Smith, whose discussions and opinions seemed to dominate the conference.

Tavernier opened the meeting with the sentiment, "Our ultimate purpose is to find a system to accommodate the soils of the world. In the long run, we want a universal system of soil classification." The floor was then given to Guy Smith to elaborate on the new US classification. He indicated that any new system must have links with previous systems but at the same time be based on new ideas and concepts so that every soil on the landscape had a place in the system. The group became bogged down on "A,B,C" horizon nomenclature, which were then poorly defined and which was poorly defined and poorly linked to classification systems. The presence or absence of these horizons was used to differentiate the great groups but as all the systems were qualitative, the discussions drifted. It is possible that this was the occasion upon which Guy Smith recognized the futility of using the A-B-C horizons and the need to search for other building blocks. He also saw the desperate need for being quantitative and for good definitions. As evidenced by future developments of Soil Taxonomy, Guy Smith was learning from the mistakes of other experts. He told me that it was at that time that he decided if similar meetings were held for the development of the US classification system, participants would focus on terms and names and not on concepts and principles. This led him to the decision to eliminate soil names and use a numbering system instead.

Although Dr. Smith appreciated the concept of "zonal-azonal-intrazonal" division of soils which was used by Russian soil scientists, he had already begun to search for a better system. He knew that at the highest level of the system, the classification should be able to demarcate broad geographic zones. At the meeting in Gent, he introduced the idea of soil moisture and temperature regimes. In general the Europeans were not excited by the notion and the general opinion was that climate should not enter the classification system (a notion that still prevails in the FAO legend and WRB). Smith argued that soil moisture and temperature were soil properties, which could be measured, and so were appropriate differentiating criteria. Smith had similar opposition from his colleague's back home but was convinced that this was the way to make the paradigm shift. Another major discussion point, which was to shape Soil Taxonomy later, was how to handle natural and managed systems. Smith argued that management should not change the classification. There were mixed opinions among the Europeans. Smith knew at that time that this was a fundamental principle in the system he was creating and that the system must be structured to accommodate this principle.

The meeting concluded with an agreement to keep the momentum alive. The meeting was most important in the evolution of classification concepts, in the development of Soil Taxonomy, in the creation of the FAO legend for the Soil Map of the World, and for the current effort to develop a World Reference Base for Soil Classification of the International Society of Soil Science. Though there were meetings prior to this and many after, this meeting was truly time zero for modern classification systems. In fact, 1952 can be considered the birth of modern pedology.

Thoughts about Anthropic Soil Materials and Processes

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Anthropic Soil Materials

Anthropic soil materials result from several human activities which include:

1. incorporation of 25 % or more of foreign non-soil materials to the soil in a layer 25 cm or more thick;
2. reworking of the soil to a depth of 50 cm or more resulting in a loss of the original horizons and retaining such horizons at the contact of the reworked material;
3. restructuring the soil after mining or related activities whereby the original surface soil material forms 50 cm or more of the current soil and the underlying
4. material consists of 25 cm or more of completely reworked materials with/without more than 10 % non-soil materials.
5. irrigation which results in the accumulation of 25 cm or more of finely stratified silty materials (Oasis soils);
6. mass movement of soil resulting in an accumulation of 25 cm or more of soil material and generally resulting from minimal erosion management up-slope;
7. ponding which results in the development of redoximorphic conditions in a layer 25 cm or more thick within 50 cm of the mineral soil surface; and
8. terracing whereby material is removed from one place and deposited in an adjoining place within 100 m distance.

There are other kinds of human activities which modify some property of the soil. These include heavy metal additions, changes in cationic or anionic composition including soil pH. Some of these activities result in profound changes such as the formation of an agric horizon or a plaggen epipedon. For classification purposes, the change must be significant enough to result in a diagnostic horizon or epipedon or a diagnostic property. However, for classification purposes and also use and management of the soils, it is important to differentiate such materials from those derived from weathering of rocks or deposited by geologic or geomorphic processes.

There are difficulties in recognizing all such materials at high levels in the taxonomy and these include:

1. Microvariability: One of the common feature of some of the anthropic materials is the short distance (both horizontally and vertically) variability of the material. For this reason, though the material is significant for use and management, it does not serve as a diagnostic feature for classification purposes, except at the lowest category (series or phases of series);
2. Role in soil processes: Criteria for the higher categories are generally major controls of soil forming processes; many of the anthropic materials are either "inert" or the accumulation is too recent to influence or result in diagnostic horizons;
3. Area occupied by the material: rehabilitated lands after mining are generally sporadically distributed and may only be depicted on very large scale maps; the material is heterogeneous both within an entity and between entities making it difficult to make reasonable statements about its behavior.

Anthropic Processes

Human induced processes which markedly change soil properties and result in diagnostic horizons or properties are anthropic processes. To be recognized as a soil forming process, both the cause and effect must be clearly established. Examples of properties or horizons resulting from such processes include:

1. Plaggen epipedon: resulting from more than 1,000 years of modifying sandy soils to make it suitable for cultivation; a layer > 50 cm thick is the recognizable product; good examples in Holland, Germany, and Ireland;
2. Agric horizon: humus accumulation in the argillic horizon resulting from long cultivation of the soil; good examples in Belgium, Rwanda, and Ganges Plains of India;
3. Anthraquic conditions (saturation): resulting from controlled flooding; examples – large areas of paddy soils;

A Technical Classification

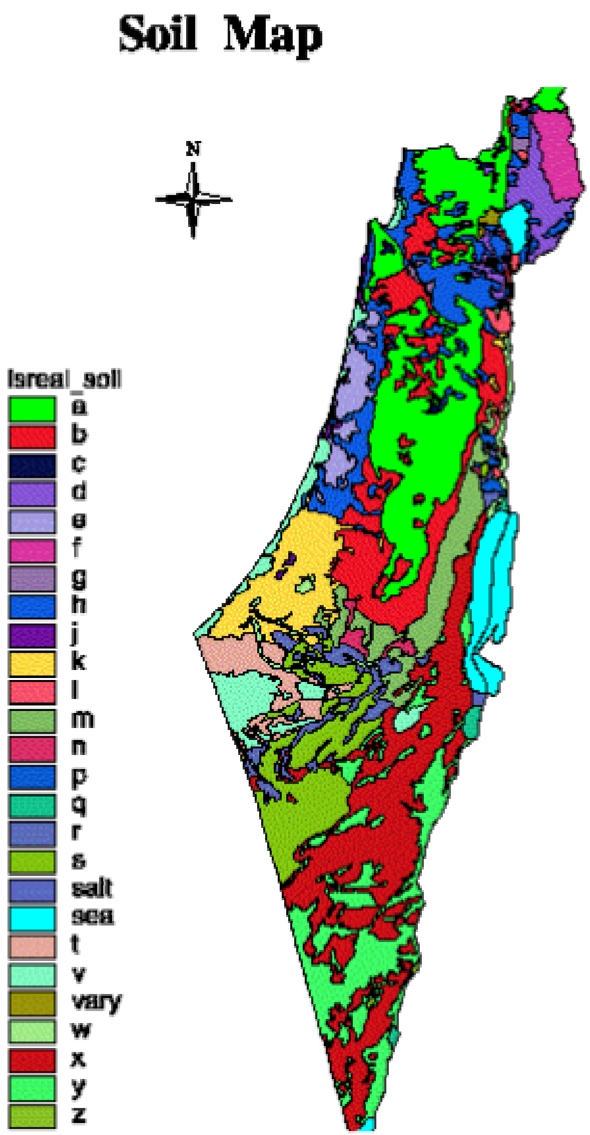
There is a need for a technical characterization and classification of anthropic materials. This has great significance and importance in local studies where the material exists. Such a technical classification may in itself prove to be inadequate for some purposes and perhaps the more important need is guidelines to characterize the material.

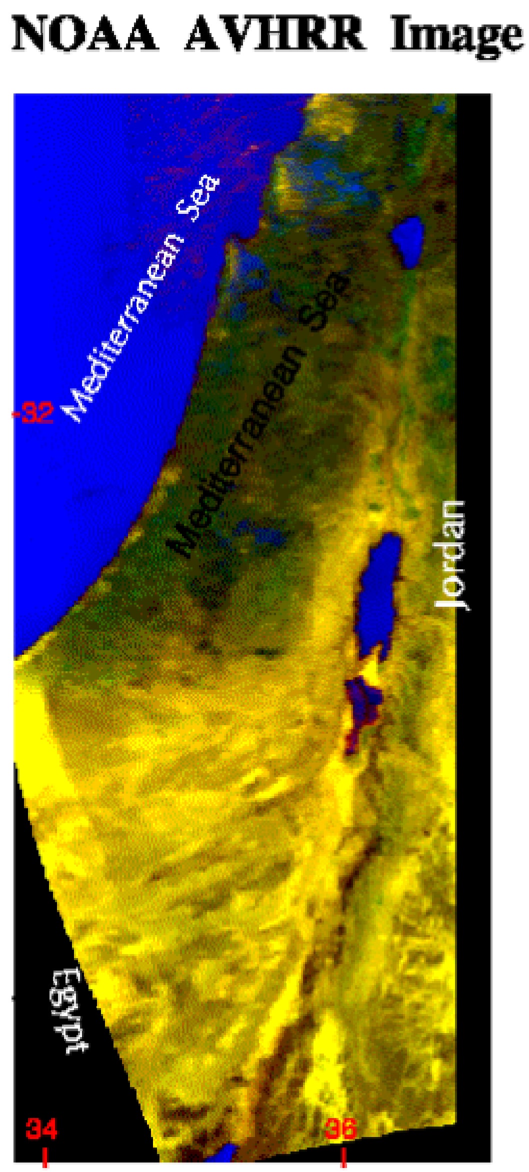
Classification for Soils of Israel

November 2001

http://ag.arizona.edu/OALS/IALC/soils/israel/israel.html

A set of images is found at this website to illustrate the soils of the aridic part of Israel. Despite the small size of the country, a variety of soils can be found, due to their origin, properties, and weathering. The major causes of this variety are the extreme conditions which form soils in Israel: climate (arid in the south and wet in the north), parent materials (basalt, Martin Sedimentary Rocks, sand dunes, alluvium, etc.), and different topographic circumstances (a West-East 70km transect shows topography varying from 0m (sea level) to +700m (above sea level) to -400m (below sea level). Also, physical weathering from both water and wind modifies the country's soils.





A soil map of Israel after Dan et al., 1977 with a georeferenced NOAA AVHRR satellite image taken during winter. A description list of the soil groups is provided in English and Hebrew.

Table 1. Legend for Soil Map of Israel

SOIL NAME (after Dan et al. 1986)	CODE
Terra rossas, brown rendzinas and pale rendzinas	a
Brown rendzinas and pale rendzinas	b
Pale rendzinas	c
Basaltic protogrumusols, basaltic brown grumusols and pale rendzinas	d
Hamra soils	e
Basaltic brown mediterranean soils and basaltic lithsols	f
Hydromorphic and gley soils	g
Grumusols	h
Pararendzinas	j
Dark brown soils	k
Calcareous serozems	l
Brown lithosols and loessial arid brown soils	m
Loessial arid brown soils	n
Alluvial arid brown soils	p
Solonchaks	q
Loessial serozems	r
Brown lithosols and loessial serozems	s
Sandy regosols and arid brown soils	t
Sand dunes	v
Regosols	w
Bare rocks and desert lithosols	x
Reg soils and coarse desert alluvium	y
Fine grained desert alluvial soils	z

Table 2. Conversion table to both the USDA and FAO classification systems. Correlation List for the Soils of Israel (abbreviated).

Israeli Classification	U.S.D.A. Classification	FAO Classification
KRASNOZEM	RHODOXERALFS	LUVISOLS
Krasnozem (Orthokrasnozem)	Typic Rhodoxeralfs; may be also transition to Oxic Rhodoxeralfs	Chromic Luvisols
Podzolic Krasnozem	Typic Rhodoxeralfs; may be also transition to Oxic Rhodoxeralfs	Chromic Luvisols
HAMRA	RHODOXERALFS, HAPLOXERALFS	LUVISOLS
Hamra (Orthohamra)	Typic Rhodoxeralfs	Chromic Luvisols
Brown Hamra	Mollic Haloxeralfs (Vertic Haplozeralfs)	Orthic Luvisols
Nazzazic Hamra	Typic or Aquic Rhodoxeralfs, Aquic Haploxeralfs	Gleyic Luvisols
BROWN (AND DARK BROWN) SOILS	HAPLOXERALFS OR CALCIXERALFS, HAPLARGIDS	LUVISOLS, XEROSOLS
Husmas	Typic or Calcic Rhodoxeralfs	Chromic, Orthic or Calcic Luvisols
Grumusolic dark Brown soils	Vertic Haploxeralfs or Vertic Calcixeralfs (Typic Chromoxererts) Calcixeralfs (Typic Chromoxererts)	Orthic or Calcic Luvisols, Chromic Vertisols
Dark brown soils	Mollic & some Vertic Haplozeralfs or Calcixeralfs; some Mollic Calcic and Vertic Calcic Haploxeralfs	Orthic or Calcic Luvisols

Table 2. Conversion table to both the USDA and FAO classification systems (Cont.)

Israeli Classification	U.S.D.A. Classification	FAO Classification
Light Brown soils	Typic Haplargids, Typic or Xerollic Calciorthids (Petrocalcic Palexeralfs, Petrocalcic & some Paleargids, Arenic Haplargids)	Xerosols including Luvic Xerosols, Calcic Xerosols Haplic Xerosols; Calcic Luvisols.
Siltic Alluvial	Typic Haplargids	Luvic Xerosols
Saline siltic alluvial brown soils	Typic Haplargids	Orthic Solonchaks
SIEROZEM	YERMOSOLS (ALSO XEROSOLS AND SOLONCHAKS)	
Stony Sierozem	Petrocalcic or Lithic Paleargids, Typic Paleorthids, Typic Calciorthids	Calcic Yermosols
Calcareous Sierozem	Typic Calciorthids	Calcic or Haplic Xerosols
Hydromorphic Calcareous Sierozem	Aquic Calciorthids	Calcic or Haplic Xerosols
Sierozem (Orthosierozem)	Typic Haplargids (arenic Haplargids)	Orthic Solonchaks, Luvic Yermosols
Saline-Gypsipherous Calcareous Sierozem	Aquic Calciorthids	Gypsic Yermosols
Saline Hydromorphic Calcareous Sierozem	Aquic Calciorthids	Orthic Solonchaks
Marly Sierozem Gypsic or Calcic	Typic & Lithic Calciorthids	Gypsic or Calcic Yermosols
REG	CALCIORTHIDS, CAMBORTHIDS, HAPLARGIDS	
Lithosolic Reg	Lithic Calciorthids, Lithic Camborthids Lithosols	Orthic Solonchaks
Regosolic Reg	Typic Calciorthids, Typic Camborthids	Orthic Solonchaks
Reg (Orthoreg)	ditto	Orthic Solonchaks
GRUMUSOL	CHROMEXERERTS, PELLOXERERTS VERTISOLS	
Hydromorphic Grumusol	Aquic Chromoxererts	Pellic Vertisols
Calcareous Grumusol	Entic Chromoxererts	Chromic Vertisols
Reddish Brown Grumusol	Typic Chromoxererts	Chromic Vertisols
Brown Grumusol	Typic Chromoxererts	Chromic Vertisols
Solonezic Grumusol	Typic Chromoxererts, Aquic Chromoxererts	Chromic Vertisols
TERRA ROSSA	RHODOXERALFS, XEROCHREPTS, HAPLOXEROLLS	CAMBISOLS, PHAEOZEMS
Hamric Terra Rossa	Lithic Rhodoxeralfs	Chromic Luvisols, Lithosols
Reddish Brown Terra Rossa	Lithic & some Typic Rhodoxeralfs	Chromic Luvisols or Eutric & Vertic Cambisols
Red Terra Rossa	Lithic & some Typic Rhodoxeralfs	Eutric Cambisols
DARK RENDZINA	RENDOLLS; (SOME HAPLOXEROLLS AND XEROCHREPTS)	RENDZINAS, LITHOSOLS
Dark Pararendzina	Lithic Rendolls; Lithic Xerochrepts	Rendzinas
Brown Rendzina	Lithic, some Vertic & Haplustic Rendolls	Rendzinas, Lithosols
PROTOGRUMUSOL	XEROCHREPTS, HAPLOXEROLLS	CAMBISOLS, LITHOSOLS
Protogrumusol	Lithic Vertic Xerochrepts	Vertic Cambisols
BROWN LITHOSOL	TORRIORTHENTS	LITHOSOLS
Brown Lithosol	Lithic Torriorthents	Calcaric Lithosols
YELLOW SOILS	ARGIXEROLLS	PHAEOZEMS
Yellow soils	Calcic Lithic & Lithic Argixerolls	Luvic Phaeozems
BROWN FOREST SOILS	HAPLOXEROLLS	PHAEOZEMS, CASTANOZEMS
Brown forest soils	Typic, Calcic or Cumulic Haploxerolls	Calcaric & Haplic Phaeozems

Table 2. Conversion table to both the USDA and FAO classification systems (Cont.)

Israeli Classification	U.S.D.A. Classification	FAO Classification
SHALLOW BROWN MEDITERRANEAN SOILS	HAPLOXERALF, ARGIXEROLLS	LUVISOLS, PHAEOZEMS
Shallow brown Mediterranean soils	Lithic, Lithic Mollic & Mollic Haploxeralfs	Orthic Luvisols
LIGHT RENDZINA	XERORTHENTS, RENDOLLS XERORTHENTS, RENDOLLS	RENDZINAS, RHEGOSOLS
Grumusolic light Rendzina	Vertic Xerorthents, Vertic Rendolls	Calcaric Rhegosols
Light Rendzina (Ortholight Rendzina)	Lithic & Typic Xerorthents	Calcaric Lithosols
Brown Light Rendzina	Lithic Rendolls, Typic Xendolls	Rendzinas
Light-colored Pararendzina	Lithic & Typic Xerorthents	Cambic Arenosols
DESERT LITHOSOLS	TORRIORTHENTS, TORRIPSAMMENTS	LITHOSOLS
Rendzinic Desert Lithosols	Lithic Torriorthents	Calcaric Lithosols
Marly & Chalky Desert Lithosols	Lithic Torriorthents	Calcaric Lithosols
Gypsiferous Desert Lithosols	Lithic Torriorthents	Calcaric Lithosols
Siliceous Desert Lithosols	Lithic Torriorthents, Lithic Torripsamments	Calcaric Lithosols
NON-DESERTIC LITHOSOLS ON SILICEOUS ROCKS	XERORTHENTS; HAPLOXEROLLS	LITHOSOLS
Basaltic Lithosols	Lithic Xerorthents, Lithic Haploxerolls	Eutric Lithosols
REGOSOLS	XERORTHENTS, QUARZIPSAMMENTS, XEROPSAMMENTS	RHEGOSOLS, ARENOSOLS
Brown fine-textured Regosols	Vertic Xerorthents	Calcaric Rhegosols
Regosols	Typic Xerorthents	Calcaric Rhegosols
Hamric Regosols	Typic Xerorthents	Eutric Rhegosols
Sandy Regosols	Typic Quarzipsamments, Typic Xeropsamments	Cambic Arenosols
Loessial Regosol	Typic Xerorthents	Calcaric Rhegosols
Stony Regosol	Typic Xerorthents	Calcaric Rhegosols
Tuffic Regosol	Typic Xerorthents, Typic Vitrandepts	Vitric Andosols
COLLUVIAL ALLUVIAL SOILS (WEATHERED)	HAPLOXEROLLS, XEROCHREPTS, XEROFLUVENTS	PHAEOZEMS, FLUVISOLS
Red Colluvial Alluvial soils	Typic, Calcic or Fluventic Haploxerolls	Haplic Phaeeozems
Brown Rendzinic Colluvial Alluvial Soils	Typic, Calcic, Fluventic/Cumulic Xerofluvents	Calcaric Fluvisols
Brown Basaltic Colluvial Alluvial soils	Vertic, Typic, Calcic & Fluventic Haploxerolls	Calcaric Phaeozems
Light-colored Chalky Colluvial Alluvial soils	Typic Xerofluvents, Calcic Haploxerolls	Calcaric Cambisols
Light-colored Kurkaric Colluvial Alluvial soils	Typic Xerofluvents; Typic Xerochrepts	Calcaric Fluvisols
Yellow Colluvial Alluvial soils	Typic Argixerolls	Luvic Phaeozems

Table 2. Conversion table to both the USDA and FAO classification systems (Cont.)

Israeli Classification	U.S.D.A. Classification	FAO Classification
ALLUVIAL SOILS (WEATHERED)	HAPLOXEROLLS, XEROCHREPTS, XEROFLUVENTS	PHAEOZEMS, CAMBISOLS
Hamric Alluvial soils	Fluventic, Typic or Vertic Haploxerolls	Haplic Phaeozems
Brown Alluvial soils	Fluventic, Typic or Vertic Haploxerolls	Calcaric Phaeozems
Grumusolic Alluvial soils	Vertic Xerofluvents	Eutric Fluvisols
Weathered Alluvium	Typic Xerofluvents	Calcaric Fluvisols
COARSE ALLUVIUM	TORRIFLUVENTS, TORRIPSAMMENTS, XEROFLUVENTS	FLUVISOLS
Coarse Desert Alluvium	Typic Torrifluvents, Typic Torripsamments	Calcaric Fluvisols
Coarse Regosolic Alluvium	Typic Torriorthents	Calcaric Rhegosols
Coarse Chalky & Marly Alluvium	Typic Torrifluvents	Calcaric Fluvisols
Coarse Silty & Clayey Stony Alluvium	Typic Xerofluvents	Calcaric Fluvisols
SANDY SOILS	QUARZIPSAMMENTS, XEROPSAMMENTS	ARENOSOLS
Aeolian sand	Typic Quarzipsamments	Albic Arenosols
Alluvial Sand	Typic Torripsamments, Typic Xeropsamments	Calcaric Fluvisols
LOESS & FINE DESERT ALLUVIAL SOILS	TORRIFLUVENTS	FLUVISOLS
Gravelly & Stony Loessial Alluvial Soils	Typic Torrifluvents	Calcaric Fluvisols
Gravelly Desert Alluvial Soils	Typic Torrifluvents	Calcaric Fluvisols
Sandy Loessial Alluvial Soils	Typic Torrifluvents	Calcaric Fluvisols
Loess & Fine Desert Alluvium	Typic Torrifluvents	Calcaric Fluvisols
Chalky & Marly Alluvial soils	Typic Torrifluvents	Calcaric Fluvisols
ORGANIC SOILS	HISTOSOLS	HISTOSOLS
Peat	Histosols	Dystric & Eutric Histosols
Organic Mineral soils	Histosols	Eutric Histosols
GLEY	HAPLAQUENTS, PSAMMAQUENTS, HAPLAQUEPTS	GLEYSOLS
Grumusolic Gley	Typic & Vertic Haplaquents	Mollic Gleysols
Gley	Typic Aeric Haplaquents, Mollic Haplaquents	Mollic Gleysols
Sandy Gley	Mollic or Typic Psammaquents	Mollic & Eutric Gleysols
Calcareous Gley	Typic or Aeric Haplaquents	Calcaric Gleysols
Saline Calcareous Gley	Typic or Aeric Haplaquents	Calcaric Gleysols
NAZZAZ	ALBAQUALFS (ALSO SOME OCHRAQUALFS) &	PLANOSOLS
Nazzaz	Typic Albaqualfs (grey Nazzaz)	Eutric Planosols
SOLONCHAK	SALORTHIDS	SOLONCHAKS
Organic Solonchak	Mollic Salorthids	Mollic Solonchaks
Aeolian & Alluvial Solonchak	Typic Salorthids	Orthic Solonchaks
Gley Solonchak	Typic Salorthids	Gleyic Solonchaks
Marly Solonchak	Typic Salorthids	Orthic Solonchaks
Sterile Solonchak	Typic Salorthids	Orthic Solonchaks

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World Reference Base for Soil Resources

http://www.fao.org/ag/agl/agll/wrb/newkey.stm
http://www.itc.nl/~rossiter/research/rsrch_ss_class.html

World Reference Base (WRB)

This international standard soil classification system was developed by an international collaboration coordinated by the International Soil Reference and Information Centre (ISRIC) and sponsored by the International Union of Soil Science (IUSS) and the FAO via its Land & Water Development division.

> "*A world reference system for soil resources is a tool for the identification of pedological structures and their significance. It serves as a basic language in soil science and facilitates (1) the scientific communication; (2) the implementation of soil inventories and transfer of pedological data, elaboration of different systems of classification having a common base, interpretation of maps, etc.; (3) the international use of pedological data, not only by soil scientists but also by other users of soil and land.*"

The WRB is a two-level classification:

1. 30 Reference Soil Groups. Examples: Histols, Fluvisols, Luvisols
2. Subdivisions of the Reference Soil Groups, using any defined combination of 121 qualifiers. Examples: Leptic Umbrisols, Chromi-Vertic Luvisols. It is possible to use either a single qualifier (the most important) or all relevant qualifiers.

The subdivisions do not take into account all possible differences among soil map units. In particular: climate, parent material, vegetation, depth of water table or drainage, and physiographic features such as slope, geomorphology or erosion are not considered as such, except insofar as they have affected soil morphology. These features can be used locally to defined mapping phases, but they are not considered soil properties to be classified as such.

Some detailed internal properties are also not considered at this level of detail, namely, substratum layers, thickness and morphology of solum or individual horizons. These can be used to define series or forms locally, for detailed soil survey.

The WRB borrows heavily from modern soil classification concepts, including Soil Taxonomy, the legend for the FAO Soil Map of the World 1988, the Référentiel Pédologique, and Russian concepts. The emphasis is on soil morphology, and a major difference with Soil Taxonomy is that soil climate is not part of the system, except in so far as the effects of climate affect soil properties. As far as possible, diagnostic criteria match those of existing systems, so that correlation with national and previous international systems is as straightforward as possible.

The WRB is not intended to be used in semi-detailed or detailed mapping; many detailed soil properties that are important for land use and soil behaviour are not specified in sufficient detail in the two levels of the WRB. For detailed mapping and site characterisation, local organisations or survey projects are expected to use locally-defined soil series, soil forms, or similar. The WRB is used to group these locally-defined soils for correlation and communication.

Classification Key[3]

ANTHROSOLS (AT)

Other soils having

either

a hortic, irragric, plaggic or terric horizon 50 cm or more thick

or

an anthraquic horizon and an underlying hydragric horizon with a combined thickness of 50 cm or more

[3] For this document, only Anthrosols are presented.

WRB N 1 – November 2001

http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/agll/wrb/doc/newsletter1.pdf+Alan+Kosse

New WRB developments

WRB for students has been published by FAO under the title: **'Lecture Notes on the Major Soils of the World'** as **World Soil Resources Report No 9**4. It is available now from the FAO Publications and Sales Office, FAO, Via Delle Terme Di Caracalla, 00100 Rome, Italy or from ISRIC (sales@isric.nl). A free copy is being sent to each working group member of WRB. The price is still being negotiated.

Special FAO discounts are as follows:

For Sales Agents 50% in developed countries, 60% in developing countries 50% to other UN and governmental bodies, UN staff and FAO field projects 35% for individuals in developing countries.

The **'CD-ROM on the Major Soils of the World'** is being finalized by ISRIC, Wageningen. It will be produced by FAO early 2002. **WRB translation**s: WRB is now published in 9 international languages: English, French, German, Spanish, Italian, Lithuanian, Japanese, Romanian and Vietnamese. We are coming near to an arrangement for translation into Russian. I do hope that we shall find a volunteer to translate into Chinese, Arabic and Portuguese. Candidates are most welcome to put forward their name. October has been a rather busy month for WRB. First of all there was the **'International Symposium on Soil Classification, 8 – 12 October, 2001, Velence, Hungary**'. This meeting was organized by the Hungarian Society of Soil Science, Szent Istvan University, Hungary and was supported by a number of international institutions such as IUSS, EU Joint Research Centre, FAO and USDA. It was a very successful event with attendance exceeding 50 international experts and soil scientists of more than thirty different nations attended including the US, Russia, Canada, Australia and nearly all European countries. About 50 Hungarian soil scientists attended in addition. A report on this meeting is attached in annex 1. Then there was the **'International Symposium on Soil Classification'** organized by the American Society of Soil Science, at **Charlott**e, North Carolina, USA from 18-27 October 2001. WRB was represented by Ahrens (USA), Costantini (Italy), Dudal (Belgium), Deckers (Belgium), Eswaran (USA), Laker (RSA), Nachtergaele (FAO), Napoli (Italy), Markku (Finland), Karklins Aldis (Latvia). I'm pleased to report that WRB was referred to as a means of soil correlation in many papers presented. We have some 30 American colleagues who have enlisted to our mailing list. I look forward to get more interaction from USA on WRB in the future. From 2 – 11 December a **Regional WRB training course for West Africa** is being organized by the FAO Regional Office for Africa, Accra, Ghana, in collaboration with the Soil Research Institute (SRI) Ghana, the Institute for Environment and Agricultural Research (INERA) and the National Bureau of Soils (BUNASOLS) Burkina Faso. Participants are from 13 West-African countries. If all goes well Andrei Rozanov (Stellenbosch University, South Africa and Nikola Filippi (ISPRA, EU Joint Research Centre) will serve as international resource persons to facilitate the training. In fact we are happy to report that we received a very positive response from numerous candidates. It only proves that WRB is alive and that we can now rely on powerful ambassadors to represent WRB in international fora. The next general meeting of our IUSS Working Group will be at the event of the **17th World Congress of Soil Science** at Bangkok, Thailand from 14 – 20 August 2002. Suzanna Pazos is organizing Symposium Nr. 21, 'Soil classification, accomplishments and future'. Deckers will present a paper on WRB. As promised we are not proposing major changes, but will report on findings from all field testing since 1998. We'll also throw light on the rationale behind the WRB system and look into the future. Congress tours: The 4th circular of the 17 th World Congress of Soil Science reports on very exciting congress tours. I trust that each of these tours will be attended by a number of WRB members who will carry the WRB flag on the soil profile pits. As we have never been in Australia on a WRB testing I trust that the South-Western Australia tour (B7) should offer a rather exciting opportunity. A number of WRB members (Blume, Deckers, Napoli, Frederico, Fitzpatrick) have already expressed strong interest to join the party! Deckers is meanwhile investigating if we could also hop over to Canberra and Sydney to see some soilscapes in Eastern Australia with the participating WRB team. For the future of WRB as a Working Group some important decisions have to be taken. One of them is the **WRB leadershi**p. The present chairman (Deckers), vice-chairman (Nachtergaele) and secretary (Spaargaren) have been in office since 1994. We were re-elected in 1998 at Montpellier. They thank the people who endorsed their mandate. It has been a rewarding job. However it is felt that time has come for a change, so as to keep up momentum of WRB. This does not mean that we shall not be continuing our full support to WRB, on the contrary. For practical reasons it would be wise to have one of the present three WRB taskforce members continue for the sake of 'institutional memory'. Otto Spaargaren whose Institute is the depository of World Soil Information (International Soils Reference and Information Centre (ISRIC), Wageningen is willing to keep his post. Otto will be proposed at Bangkok as Secretary of WRB. Candidates are needed to step into the mandate of Deckers (chairman) and Nachtergaele (vice-chairman). What is needed is people with (1) a good experience in international soil classification, (2) good knowledge of languages; (3) access to resources to support international travel; (4) the necessary time availability to organize/attend international meetings on soil classification; (5) good sense for pedo-politics. You are kindly invited to submit nominees (either yourself or a colleague) by e-mail to Deckers (seppe.deckers@agr.kuleuven.ac.be), copied to Spaargaren (spaargaren@isric.nl) and Nachtergaele (freddy.nachtergaele@fao.org) by January 31 2002. Please find in Annex 2 a Nomination form. We shall inform you on progress of the election procedure, the final steps of which will be held at the WRB business meeting at Bangkok in August 2002. In order to guarantee a smooth transition and institutional support needed, both Deckers and Nachtergaele will remain available to serve as resource persons in the WRB task force. The Beta version of the CDROM 'Horizon Identification' has been released by E.A. Fitzpatrick. It contains a comprehensive data set of all known soil horizons and aims to identify unknown ones through getting the closest match to one of these horizons using numerical data within the framework of Excel. People who are interested to test this new approach to horizon identification can contact Dr. Fitzpatrick at following address: e.a.fitzpatrick@btinternet.com

Your opinion?

There are a number of issues for which we would appreciate your opinion: A. Minor changes have been made on the key (ref. Annex 3). Then there are a number of decisions to be made for which we would like to request your opinion. Options have been put together in table format and we would be grateful if you could fill out your opinion and mail it back to us before January 31/02 (see Annex 4).

Following issues are at stake:

1) Key out Cryosols before Histosols?

This is a proposal from Charles Tarnocai. For the time being WRB has been very reluctant to do this for following reasons: (1) In most soil classifications systems (including USDA Soil Taxomomy (until 1999) the key starts with the basic distinction between organic soils and mineral soils; (2) Dokuchaev also made the distinction between soils which grow from top up and the ones developing in the sub-soil; (3) WRB is rooted in FAO, which has always keyed out the Histosols first; (4) The Russian soil classification system keys out Histosols first; (5) WRB avoids to put a climatic criterion (Cryic) first in the key, which is in contradiction to the basic principle that climatic criteria should be avoided as much as possible in the classification system. On the other hand it is important to be in line with the two of the three countries where these soils are dominant and it is also fundamental that WRB retains a good link with Soil Taxonomy to ease correlations.

2) Delete Alisols from the key and lump them with the Acrisols

A major problem with Alisols is to map them at World scale. The present maps showing Alisols work with strong educated guesses based on lots of assumptions. Furthermore the definitions of Alic properties as defined in WRB at present are rather unpopular among WRB users, especially in developing countries. The laboratory requirements are rather complicated and most people identify the Alisols based on incomplete datasets.This is why Hari Eswaran proposes to delete Alisols as a reference Group and have instead Alic qualifiers which indicates high aluminium saturation on the CEC complex. To follow this suggestion would have a number of advantages: (1) we come close to FAO 1974 which also had Acrisols and Alisols under one group – the Acrisols; (2) reduction of the general bias in WRB on soils with an argic horizon at the highest level; (3) simplification of analytical requirements to key our soils at Reference base level. An alternative solution is to go back to the Revised Legend definitions , keep the Alisols but redefine them as soils with a high CEC of the clay but with low base saturation. The balanced quadruplet Luvisols/Alisols/Acrisols/Lixisols pleased many pedologists.

3) Neosols instead of Anthropic Regosols

Alan Kosse is proposing to introduce a new Reference Group which would replace the Anthropic Regosols namely the Neosols. This group would comprise the enormous variety of city soils, garbage soils, mine spoils etc…It is of course true that this type of soil cover is ever increasing and is the subject of front-line research in present-day soil science (e.g. geochemistry of heavy metals etc…), so we may have a good reason for upgrading them to a Major Reference soil in WRB.

4) Anthric qualifier in all other Reference Groups

In view of the ever increasing anthropogenous influence on the Globe, it may be warranted to have an Anthric qualifier for all Reference soil groups. For instance in Mediterranean areas Chromic Luvisols commonly occur in areas which have been terraced for several centuries. An Anthri-bancanic qualifier would be very useful to specify this situation. For more background information I attach an article from Dudal et al. For easy reference (Annex 5)

5) Add soil family criteria for full classification purposes in WRB.

In order to enhance the usefulness of our Reference Groups a simple addition on soil texture, mineralogy and slope of the land is proposed. To keep things simple texture and slope criteria of the FAO Soil map of the World is proposed (only three classes for each). For mineralogy a semi-quantitative appreciation in terms of e.g. 'kaolinitic or montmorillonitic' would be aimed at.

6) Ranking order of the qualifiers: Unique – Intergrades – Others

It is proposed for international correlation purposes to rank the qualifiers of the WRB Reference groups in following order: (1) First the strong expression qualifiers are keyed out in alphabetic order; (2)

then follow the Intergrades in order of the Key to the WRB reference Groups and then (3) the others in alphabetic order.

Example of the Ferralsols

Strong expression qualifiers

Geric
Gibbsic
Posic

Intergrade qualifiers (in order of key)

Histic
Gleyic
Andic
Plinthic
Mollic
Acric
Lixic
Umbric
Arenic

Other qualifiers (in alphabetic order)

Alumic
Dystric
Eutric
Ferric
Humic
Rhodic
Stagnic
Vetic
Xanthic

The Mossi Indigenous Soil Classification in Burkina Faso

Basga E. Dialla

http://www.nuffic.nl/ciran/ikdm/1-3/articles/dialla.html

A growing number of field studies have focused on the importance and usefulness of indigenous soil taxonomies as they relate to agricultural production. Drawing upon a dissertation on indigenous soil taxonomies and conservation, this article describes the Mossi indigenous soil classification system. Different soil types identified by local farmers are based on soil characteristics such as texture, colour, consistency, geographical location, drainage and fertility. Four major classes of soil related to the suitability of specific crop production are also distinguished.

Soil classification has always been an area of interest for soil scientists. Evidence of such interest goes all the way back to early Chinese writings (Harpstead et al., 1988). More recently a great deal of research has focussed on the importance and usefulness of soil taxonomies as they relate to agricultural production (McMillan, 1980; Dvorak, 1988; Osunade, 1988; Kerven and Sikana, 1988; Dolva et al., 1988; Behrens, 1989; Tabor, 1990).

While inquiry on indigenous soil taxonomies is expanding, it is noticeable that a limited number of field studies have been conducted in the West African countries (Carney, 1991). Evidence indicates however that the African farmer has an extensive knowledge of his/her soil. Local soil taxonomy is based on soil characteristics as they relate to specific crops and, traditionally, provides the insight and ecological knowledge required for making good use of available agricultural resources (Richards, 1985).

This article explores the Mossi**1 indigenous soil classification system in Burkina Faso. It draws upon fieldwork**2 on indigenous soil taxonomies conducted during April and May 1991 in Yatenga Province.

Small scale farmers from two selected villages (Ranawa and Aorema) composed the target population. A total of 120 male household heads were interviewed. They were asked to:

- name the different types of soil on their cultivated land;
- indicate the characteristics associated with each type of soil; and
- indicate specific crops that grow well on each type of soil.

Farmers from both villages identified a total of 17 types of soil. *Zþka* (lateritic soil), *zþ-kugri* (stony soil), *rasempuiiga* (gravelly soil), *bþisri* (sandy soil) and *bolle* (clay soil) are based on texture. Based on colour are *zþ-sabille* (black soil), *zþ-miuugu* (red soil), *zþ-peele* (white soil), *bþs-miuugu* (red sandy soil) and *bþs-sabille* (black sandy soil). *Zþ-naare* (wet loamy clay soil), *dagre* (hard clay soil) and *zþ-bugri* (very soft soil, easy to cut) are based on consistency. *Naare* refers to the wet-muddy aspect of the soil that makes it easy to cut; *dagre* describes the 'hard' aspect of the type of soil that is very difficult to cultivate when it is dry, whereas *bugri* means tender. *Tþnga* (mountainous soil) is an upland soil and *bþoogo* (loamy soil) is located in a low land usually close to water. Both are based on geographical location. *Zþ-kotþka* (a clay soil in a low land where water stagnates) is based on permeability. Based on vegetal cover is *kþongo* (black soil with a dense growth of bushes as vegetal cover). *Kþongo* expresses the idea of a thick, dark and woody area. Usually the farmer cuts the thick bushes and burns them before sowing.

Comparing the two villages, it appears that *zþ-kotþka* (a clay soil with stagnant water) and *zþ-bugri* (very soft soil) were not mentioned by farmers in the village of Ranawa. On the other hand, *rasempuiiga* (gravelly soil), *zþ-peele* (white soil), *bþs sabille* (black sandy soil) and *zþ-naare* (wet loamy soil) were not mentioned by farmers in the village of Aorema. This variation was due to a difference in geographical location. Ranawa and Aorema are located respectively in the southeast and northeast of Yatenga Province.

From the results it can be seen that the Mossi farmers' indigenous soil classification system is based on various soil characteristics such as texture, colour, consistency, geographical location, drainage or permeability and fertility or vegetal cover. In this respect the Mossi farmers' indigenous soil classification system is comparable with indigenous soil taxonomies elsewhere reported in the literature (Acres, 1984; Osunade, 1988; Kerven and Sikana, 1988).

The Mossi farmers also classify soils in terms of cropping potential, that is, the usefulness of soil or its suitability for a specific crop production. In this respect it can be noted that the Mossi farmers' indigenous soil classification system is based on four major types or classes of soil from which different types of soil are derived (see table).

Table 1: Four major classes of soil.

Major classes	*Zþ-kugri*(stony soil)	*Bþisri*(sandy soil)	*Bolle*(clay soil)	*Bþoogo*(loamy soil)
Derived soils	*Zþka*(lateritic soil)	*Bþs-miuugu*(red sandy soil)	*Dagre*(hard clay soil)	*Zþ- bugri*(very soft soil)
	Rasempuiiga(gravelly soil)	*Bþs-sabille*(black sandy soil)	*Zþ-sabille*(black soil)	*Zþ-naare*(wet loamy clay soil)
	Tþnga(mountainous soil)	*Zþ- peele*(white soil)	*Zþ-kotþka*(a clay soil in a low land where water stagnates)	*Kþongo*(black soil with a dense growth of bushes as vegetal cover.
	Zþ-miuugu(red soil)	<TD.		

Zþ-kugri (stony soil) is good for millet, *bþisri* (sandy soil) is good for peanuts; however *zþ-peele* (white soil) is a very poor soil on flat land on which no crop can be grown. *Bolle* (clay soil) and *bþoogo* (loamy soil) are good for both the red and white sorghum. Such a pragmatic soil classification allows Mossi farmers to make an appropriate use of their land, by associating specific crops with specific soil types on which these crops grow particularly well.

The indigenous soil taxonomy is not only useful to the farmer but also could serve as a guiding complementary tool to scientifically based systems. However, many soil surveys have ignored the indigenous soil classification (Tabor, 1990). But evidence indicates that the soil scientist may gain time and insights if he/she knows the local indigenous soil classification system. For instance, based on investigations in Tabora region (Tanzania), Acres (1984) indicates that the results of systematic soil survey can be related to the soil *nomenclature* used by local farmers and their assessment of soil suitability for cultivation. In addition, the use of local names helps to alleviate the language barriers between administrators, planners, soil specialists, agriculturalists and farmers.

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Endnotes

**1 The Mossi form the major ethnic group in Burkina Faso. They make up about two-thirds of the total population of nine million people.

**2 Fieldwork for dissertation. B.E. Dialla (1992) *The adaption of soil conservation practices in Burkina Faso: The role of indigenous knowledge, social structure and institutional support.* Ames: Iowa State University.

Indigenous Soil Classifications

What is their structure and function, and how do they compare to scientific soil classifications?

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Spring 1994
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http://www.itc.nl/~rossiter/Docs/Misc/IntroToEthnopedology.pdf

Introduction

Inferior and backward. Only recently has indigenous knowledge (partly) lost these seemingly indelible labels. This development started in the 60's with anthropologists' ethnoscience research and the discovery and publication of 'indigenous knowledge success stories', and continued in the 70's by the development of Farming Systems Research philosophy and the sprouting of formal studies on indigenous knowledge. Nowadays it has lead to many research scientists and extension workers recognizing that rural people in many developing countries have a rich understanding of their resources (Thrupp 1989, Warren 1989). Indigenous knowledge, also referred to as ethnoscience, traditional, local, folk, and native knowledge (without dwelling on semantic controversies I will use the term 'indigenous knowledge' in this paper) can be defined, relative to agriculture in its broadest sense, as accumulated knowledge, skill and technology of local people derived from their direct interaction with the environment (Altieri 1990). Information is passed on through generations and refined into a system of understanding of natural resources and relevant ecological processes (Pawluk et al. 1992).

Given the central role of soil resources in subsistence production, and the fact that soil, as a non renewable resource on the human time scale, is a major aspect of sustainable agriculture (Marten & Vityakon 1986, Pawluk et al. 1992), the indigenous knowledge of soils, or *ethnopedolog*y, has recently received more attention (Pawluk et al. 1992). As imported ideas and scientific interpretation of tropical soils have failed to bring about desired results, it has become more and more apparent that the knowledge of people who have been interacting with their soils for a very long time can offer many insights about sustainably managing tropical soils (Hecht 1990, Osunade 1992b). Although farmers in Mexico often refer to educated people from the outside (agronomists, engineers) as *'los que saben'* (they who know) in constrast to themselves being *'los que no saben'* (they who don't know), in the domain of soil knowledge they often claim expert knowledge over that of engineers (Williams & Ortiz-Solorio 1981), an example which indicates the importance of indigenous soil knowledge and the pride of the people who own it.

Ethnopedology encompasses many aspects, including indigenous perceptions and explanations of soil properties and soil processes, soil classifications, soil management, and knowledge of soil-plant interrelationships (Williams & Ortiz-Solorio 1981, Hecht 1990). This paper focuses on two themes in the study of ethnopedology. First, I will discuss the how's and why's of indigenous soil classifications. Secondly, I will discuss the differences and overlaps between indigenous soil classifications and western soil classifications, to come to a synthesis of how to link the two sources of information to improve the success of cooperation in sustainable agricultural development.

Indigenous Soil Classification

Indigenous soil classifications are found throughout the world, and have been documented for peoples in Latin America, Southeast Asia, and Africa (Table 1). They form the basis for many management practices, such as the fine attunement of cropping systems to the agricultural capabilities of the site, and adjusting soil conservation practices (Weinstock 1984, Marten & Vityakon 1986, Pawluk et al. 1992). Compared to ethnobiology (indigenous knowledge of plants and animals), the study of ethnopedological classification has not yet received much of a structured approach. In a monumental work on ethnobiological classification, Berlin's (1992) main point is that there are striking similarities in both structure and content of biological classification systems in traditional societies from many distinct parts of the world. These are not strictly based on utilitarian, or intellectual needs, but "are most plausible accounted for by human beings' inescapable and largely unconscious appreciation of the inherent structure of biological reality" (Berlin 1992). This pattern-recognizing ability is most probably innate to human beings (Brosius et al. 1986, Berlin 1992). Still, why certain natural domains are named or not, is probably better investigated from the utilitarian approach (Posey 1984). Linking these findings in ethnobiological classifications to indigenous soil classifications, there is some useful analogy to Weinstock's (1984) practical approach to distinguish between 'physical' and 'perceptual' dimensions of soil classification. The 'physical' dimension concerns the most readily observable criteria that farmers use to differentiate their soils, namely soil characteristics that can be discerned by sight, feel, taste or smell (Osunade 1992b); in Berlin's (1992) terminology, these can be the, for classifiers 'inescapable', 'natural' and 'salient' (outstanding) patterns. Indeed, as I will conclude in the course of this paper, the two most obvious physical characteristics of soil, which are *texture* and *colou*r, are 'inescapable' and found to be the basis of many indigenous soil classifications throughout the world (Table 1).

Criteria of the 'perceptual' dimension are not as concrete as those in the physical dimension nor are they always readily recognized (through the senses) as soil characteristics. Examples are soil workability, suitability classes for certain crops, sensitivity classes to certain agricultural problems, and non-agricultural classes based upon the use of soil as building and pottery material. In general, they reflect distinctions and priorities that are relevant to the creators of the system (Pawluk et al. 1992, Stacishin de Queiroz & Norton 1992), and the 'utilitarian approach' of Posey (1984) might be a useful one to study at least part of these perceptual criteria.

The division between the two dimensions is far from absolute (Weinstock 1984), and examples I give below may cross the divisional line. Still, I found the terms useful to organize my discussion and analysis, in the following sections, of the several indigenous soil classifications that I encountered in the literature. First I will discuss examples of physical and perceptual criteria that people use to differentiate soils, and than I will consider which of those traits people actually use for classification and how that is organized.

The physical dimension**:** Many soil properties involved in indigenous soil determination are visible to the eyes (Osunade 1989). The most important of those is soil colour, being used throughout many descriptions (Table 1). One of the most elaborate classifications based on soil colour is found for the Baruya people of Wonenera, New Guinea. These people use soils as a source of pigment for their ceremonies, and discern 9 colours for pigment yielding soils and 6 other colours for agricultural soil (Ollier et al. 1971). Other aspects of soil that can be visually perceived and used for classification are organic matter, moisture condition, and earthworm casts (Osunade 1989). In general, dark soils are considered more fertile than light soils, associated with their organic matter content (Marten & Vityakon 1986, Taylor-Powell et al. 1991). Farmers in Niger distinguished three colour classes and related these to land degradation: black soil *(labu bir*i), which is most fertile and contains relatively high levels of organic matter, changes to white soil *(labu kwar*e) when through cultivation and erosion valuable nutrients are depleted. Further degradation results in red soil *(labu kire*y) (Taylor-Powell et al. 1991).

Next to vision, touch is involved in assessing soil texture. For instance, the Yoruba people in Nigeria rub soil between two fingers to tell whether it is *Yanrin* (sandy), *Bole* (clay), or *Alaadun* (loamy), or textures in between such as *Bole alaadun* (loamy clay). Any soil that causes itching is regarded as injurious not only to human beings, but also to plants (Osunade 1989) (I have no idea what this could be). E.g. Lari people in Peru classify soils into eight major classes based primarily on texture (Furbee 1989, Guillet 1992). Bulk density is assessed by the feeling of soil weight and the ease of penetrating the soil with a cutlass (Osunade 1989).

Taste is used to assess soil acidity and salinity. For example, farmers in Malaysia categorise soil on the basis of taste into sweet *(tanah paya*u), neutral *(tanah tawa*r), and sour soil *(tanah masa*m), relating fairly well to the western concept of soil pH (Weinstock 1984). In Northeast Thailand taste is used to recognize salinity (Marten & Vityakon 1986). An interesting case is found for the Lari people in Peru, who have a separate taxon for eatable (as opposed to agricultural) soils. Some of the high tundra soils are very mineral and salt rich, and are eaten by the Lari people as condiments, or given as mineral supplements to fatten animals. The comestible soils may also act as agents to absorb phytotoxins such as the glycoalkaloid solanine typical of Andean tubers (Furbee 1989). Smell is used among a few of the

Nigerian Yoruba people to determine 'good' or 'bad' soil (Osunade 1989). No other reports mentioned this as an existing technique.

The perceptual dimension: Criteria of the perceptual dimension basically include any feature other than the purely physical characteristics of soil (Weinstock 1984), and reflect importance of local environment, distinctions and priorities. For instance, people of the Tobriand Islands, Melanesia, name their soils after their suitability for growing yam or taro, which form their main diet: *dumya* (soil good for dry season taro, never for yam), *butuma* (soil excellent for yam, unsuitable for taro). *malala* (soil unsuitable for taro but good for hardy yam), *sawewo* (soil good for large yam), *galaluwa* (soil perhaps good for all cultivation), and *kwala* (very fertile soil, good for all crops) (B. Malinowski, cited in Weinstock 1984). Kekchi people from Guatamala shape their soil classification primarily to their *milpa* agriculture (a mixed cropping based on maize, beans and squash, which they practice in a form of shifting cultivation), using colour, texture, drainage, and root content as soil suitability criteria (Carter 1969). Local problems with flooding result in Kekchi's fine distinction of soils with different drainage characteristics (Carter 1969, Weinstock 1984; note that this is an example where criteria of the physical and the perceptual dimension intermingle). In the Bolivian highland, where soil erosion is a common problem, soil/land classifications include several categories which indicate the degree of degradation (Zimmerer 1994). From the perspective of people practicing shifting cultivation, it is not surprising that their soil classifications are based on vegetation cover rather than soil properties (William & Ortiz-Solorio 1981). In fact, these 'biological indicators of soil suitability' are also common to non-shifting cultivators in many parts of the world (Table 2), who use certain types of vegetation to find out about soil fertility level, drainage characteristics, and acidity. Other biological indicators of soil fertility used are soil macrofauna such as earthworms and termites.

Which of these criteria are included in a formal classification?: Distinguishing criteria is a first step in forming a classification (Berlin 1992). Hypothetically, indigenous soil perception might range from unstructured observations of individual attributes, through soil classification, to highly developed taxonomies (Williams & Ortiz-Solorio 1981). The difference between classification and taxonomy is the absence in the former and the presence in the latter of hierarchical relationship between (groups) of soil classes. We can call classifications and taxonomies 'formal' when they are commonly accepted, used and agreed upon by the indigenous group. Not many of the reports on indigenous soil classification that I read explicitly discuss taxonomic relations. Some of the tables presented could well reflect more the inclination of the investigator to group the soil classes, than a taxonomy actually employed by the informants. Methods used by the investigators in their surveys are often not clear, and only a few mention the use of systematic ethnoscience procedures such 'controlled elicitation', 'triadic sorting' and survey questionnaires. An other problem I encountered is that it is often unclear whether the reported soil terms and names are descriptive phrases rather than taxonomic labels ('black bird' is descriptive while 'blackbird' is a taxonomic label); for instance, is 'sweet soil' (see under 'physical dimension', 'taste') as distinguished by Malaysian farmers a soil class or a description of a soil feature?

Taking the above into account, only few conclusions can be made. Overall, it appears that soil colour and texture are the two basic determinants for many indigenous soil classifications, while other physical characteristics are recognized but often not used in formal classification. Table 1 outlines for several classifications the order (if present) in which texture and colour are taken into account for classification. Mostly texture is the first classifier (see also Furbee 1989) and colour the second. Texture and colour are not only physically salient characteristics, people also highly associate them with other soil qualities, such as organic matter content, moisture retention and drainage, workability and friability (Williams & Ortiz-Solorio 1981, Osunade 1992a, Stacishin de Queiroz & Norton 1992). The finding that texture and colour are the primary characteristics of indigenous agricultural soil classifications with other relevant characteristics being predictive of them, reflects a classification system oriented towards the functional (Furbee 1989). The inclusion of classes with a perceptual dimension, such as suitability classes for crop A, or sensitivity classes to problem B, increases this functional orientation. Does this all seem too simple? Let me conclude with Williams and Ortiz-Solorio (1981) that the apparent simplicity of indigenous classifications undoubtedly relates to the lack of systematic investigation in ethnopedology.

Comparing Indigenous and 'Western' Soil Classifications

Quite some of the cited reports in this paper had as objective to test the 'validity' and 'objectivity' of indigenous classifications, using technical analysis methods (Bellon & Taylor 1993) and clustering programs and other statistical procedures (Stacishin de Queiroz & Norton 1993, Behrens 1989). Their conclusions were that distinctions made by indigenous people were all scientifically valid and statistically testable. Soil quality ranking by indigenous perception and scientific method gave similar results (Bellon & Taylor 1993).

Much more interesting are the nature of the classifications and how western soil classifications relate to them. Keeping in mind that comparing indigenous and western soil classifications includes gross generalizations as both have very diverse forms, some patterns can be seen. Indigenous classifications, *as far as they have been adequately described* (italic words are my addition), tend to be much more shallow compared to western classifications (Ollier 1971, Osunade 1989, Williams & Ortiz-Solorio 1981), for which there appear to be two reasons which are partly overlapping. While indigenous soil classification seems primarily functional in orientation *(e.g.* Furbee 1989), common western soil classifications (of which there are many! see e.g. Finkl, Jr. 1982) divide their soils primarily based on knowledge about pedogenesis (Williams & Ortiz-Solorio 1981). Secondly, indigenous taxa seem to be derived from the properties of the surface horizon only (not that people are not aware of the vertical dimension, but it is ignored for taxonomic purposes), while main diagnostic features that differentiate western soil taxa are the character and sequence of soil horizons. In other words, the perception of the taxonomic unit is two-dimensional for indigenous classifications, and three-dimensional for western classifications (William & Ortiz-Solorio 1981), resulting in a fundamental difference between indigenous and many western soil classifications. Other differences reported are the lack of exclusive taxonomic membership in indigenous classifications (i.e. categories of finer levels can belong to several categories of coarser levels, instead of one only) (Zimmerer 1994), but whether this is a widespread pattern or restricted to the people in Zimmerer's (1994) study, is not clear.

Thrupp (1989) argues that in order to legitimize indigenous knowledge, it should not be necessary to measure and 'scientize' it in terms of formal Western methods and scientific principles, since the value of such knowledge has been proved over centuries and scientific systematization may misinterpret the cultural value and subtle complex nuances of these knowledge systems. Although I agree with her point, in my opinion, analyzing indigenous knowledge using 'our scientific methods' could still yield many valuable lessons for scientists and extensionists and provide complementary information useful for both 'them' and 'us'. Very pragmatically speaking: respect and empowerment for indigenous people, although they deserve that regardless of the scientific validity of their knowledge (Thrupp 1989), will greatly increase when scientific amazement about their knowledge system grows.

Ethnopedology, Soil Science, and Sustainable Development

One encouraging trend over the past years is that the number of agricultural researchers and extensionists recognizing the value of indigenous knowledge has increased (Warren 1989). Although the potential of indigenous knowledge systems should not be over-romanticized (Thrupp 1989, Warren 1989), they contain a wealth of local ecological knowledge and are at the same time the key to understanding the sociocultural context of rural producers, thus representing a way to address problems that have plagued agricultural development programs for a long time (Pawluk et al. 1992).

How, in the case of soil science and ethnopedology, could western and indigenous knowledge be linked to improve the success of cooperation in sustainable agricultural development? The analysis in this paper shows that western and indigenous soil classifications vary greatly in their purpose and scale. Often the classification a soil scientist makes in a development project is meaningless to the local people. If the resulting soil maps ever reach the farmers, they are usually on a scale not relevant to small farms, and advices about suitability of a soil for a specific crop are often not of interest to farmers who want to be able to grow multiple crops (Osunade 1992b). If soil surveys would start with indigenous soil classification, research and development efforts would gain time and insight (Pawluk et al. 1992), and communication between farmers and scientists and extensionists will be greatly improved if local soil nomenclature is used (Dialla 1993, Rajasekaran et al. 1993). The hope for sustainable agricultural development really rests on the integration of all experiences rather than reliance on one tradition at the expense of the other (Osunade 1992b). As indigenous knowledge is being eroded due to fast socio economic changes (Osunade 1989, Behrens 1989, Thrupp 1989, Mundy & Lin Compton 1991, Mazur & 'Tunji Titilola, 1992), western peoples should act now to stop the threatening of their 'brothers and sisters in arms' and the valuable knowledge they own.

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Table 1. People for whom indigenous soil classifications have been reported, and the importance of texture and colour in these classifications.

Source People (from)	Texture	Colour
Bellon & Taylor 1993 Chiapas, S. Mexico	2	1
Williams & Ortiz-Solorio 1981 Tepetlaozoc, E. Mexico	2	1
Carter 1969 *Kekchi* people, Guatamala	1	1
Furbee 1989, Guillet 1992 *Lari* people in Peru	1	2
Behrens 1989 *Shipibo* people, Peru	1	-
Stacishin de Queiroz & Norton 1992 Caatinga region, Brazil	1	2
Posey 1989 *Mebengokre* people, Brazil	1	1
Zimmerer 1994 Cochabamba, Bolivia	1	2
Knapp 1991 Andes, Ecuador	1	-
Ollier et al. 1971 *Baruya* people, New Guinea	-	1
Conklin, (Marten & Vityakon 1986) *Hanunoo* people, Phillipines	1	2
Marten & Vityakon 1986 Java, Indonesia	1	1
Marten & Vityakon 1986 Thailand	1	1
Malinowski, (Weinstock 1984) Trobriand Islands, Melanesia	1	1
Weinstock 1984 Malaysia	?	?
Taylor-Powell et al. 1991 Hamdallaye, Niger	2	1
Osunade 1989, 1992ab *Yoruba* people, Nigeria	1	2
Dialla 1993 *Mossi* people, Burkina Faso	1	2
Malcolm, cited in Weinstock 1984 *Sukuma* people, Tanzania	1	1
Arntzen, cited in Reijntjes et al. 1992 Gabarone, Botswana	1	?

* 1= primary, most important classifier, 2=secondary classifier, as far as I could conclude from the available information. If two '1's are given, this means that I could not distinguish an hierarchical order between the two classifiers.

Table 2. Indigenous use of biological indicators of soil quality: vegetation and soil macrofauna

VEGETATION

Malaysia: *kedukuk* bush *(Melastoma*) indicates high Al level
Pohon bakan (Hanguana) tree indicates acid soil with stagnant water
Imperata grass, *keriang* berry bushes and cashew indicate low soil fertility
Shipibo, Peru Use indicator plants for soil hydrology
Caatinga, Brazil Thinly wooded vegetation indicates imperfect drainage
S. Mexico Sparse vegetation is general indication for *tierra delgad*a, thin soil
Maya, Mexico Dark coloured vegetation indicates high soil fertility
*Kekch*i, Guatamala Use indicator plants for site suitability fo*r Milpa* agriculture
*Mebengokr*e, Brazil Use indicator plants for general site suitability
Gabarone, Botswana Use indicator plants for soil fertility
Yoruba, Nigeria *Odundun (Kalanchoe sp)* indicates high soil fertility, while *Eran (Digitaria horizontalis), Okan (Combretum platypterum)* and *Pepe (Mallotus oppositifolius)* indicate poor fertility
Niger Dark, dry roots of millet seedlings indicate 'sick' soil which is not fertile

SOIL FAUNA

Yoruba, Nigeria Earthworm casts indicate fertile soil
Sukuma, Tanzania Termite soil is fertile, soil classification based on their presence/absence
Niger, Sierra Leone Soil close to ant and termite hills is fertile and planted with special crops
Ecuador Earthworm casts and grub casts (?) indicate good soil
Thailand Soil from termite hills is used as soil fertility improver

Sistema Brasileiro de Classificação de Solos[4]

http://www.cnps.embrapa.br/search/novids/oqvai8/oqvai8.html

A Embrapa Solos lançou o livro Sistema Brasileiro de Classificação de Solos.

O novo Sistema Brasileiro de Classificação de Solos é um referencial taxonômico para uso de pesquisadores, técnicos, professores, estudantes e profissionais envolvidos na pesquisa de solos. O atual sistema é resultante de aperfeiçoamentos contínuos ao longo de várias gerações de estudiosos da Ciência do Solo no Brasil, sintetizando, no estágio atual, a experiência e resultados de pesquisa de campo e laboratórios nas linhas de morfologia, física, química e mineralogia de solos. É o produto de uma parceria bem sucedida entre a Embrapa Solos e instituições nacionais de ensino, pesquisa e planejamento. Cerca de 25 instituições participaram desta empreitada, envolvendo cerca de 65 representantes destas instituições, fundamentais no processo de reformulação do sistema, conceituações, definições e organização geral da classificação.

A classificação de solos no Brasil iniciou-se em 1947 e baseava-se nos conceitos americanos sintetizados em publicações de 1938 e revisadas em 1949. Nestes 50 anos ininterruptos de estudos de solos, várias mudanças ocorreram quanto aos conceitos originais, nomenclatura e definições de classes.

A edição atual, em processo de publicação, inova completamente a estrutura do sistema, tendo-se chegado ao tipo desejável de classificação hierárquica, multicategórica, descendente e aberta para inclusão de novas classes à medida que o país vai sendo melhor conhecido.

Da forma que está estruturado, o sistema permite a classificação de todos os solos do território nacional em seis níveis categóricos diferentes (Ordem, Subordem, Grande Grupo, Subgrupo, Família e Série), correspondendo, cada nível, a um grau de generalização ou detalhe definidos. À Ordem corresponde o nível mais genérico de classificação, distinguindo verdadeiras províncias de solos e à Série correspondendo o nível mais detalhado e preciso de classificação, separando unidades bastante homogêneas, precisamente definidas e abrangendo pequenas áreas do terreno. Entre a Ordem e a Série, variam os graus de abstração, nesta seqüência, diminuindo o grau de generalização e aumentando o grau de especificação e detalhe.

A classificação de solos tem aplicações práticas principalmente em levantamentos de solos, constituindo a fonte permanente de conhecimento para este ramo de atividade técnica. Além dos levantamentos, a classificação é útil para referenciar, precisamente, pontos de amostragem de solos, rochas, plantas, materiais genéticos, facilitando a extrapolação de resultados experimentais de manejo, conservação e fertilidade de solos.

A classificação do solo em pontos de amostragem, associada ao Georreferenciamento (latitude, longitude e altitude), é uma ferramenta poderosa para o conhecimento de segmentos da paisagem ou do território como um todo, constituindo uma informação indispensável na estruturação de bases de dados e para os Sistemas de Informação Geográficas (SIGs) para fins de estudos ambientais.

Nesta linha de organização, interpretação e integração da informação, a classificação de solos, do ponto de vista do planejamento territorial, desempenha importante papel na segmentação de paisagens, identificando áreas de maior potencial para fins de utilização e ocupação e áreas impróprias ou não recomendadas, contribuindo desta forma para a preservação ambiental e uso adequado de ecossistemas, dos quais, o solo, é um componente básico.

O novo sistema é estruturado com base em características de gênese do solo e propriedades pedogenéticas que imprimem marcas distintas em cada tipo de solo conhecido.

Uma visão geral do sistema mostra 14 classes no nível de Ordem (1O nível categórico), 44 classes no nível de Subordem (2O nível), 150 classe no nível de Grande Grupo (3O nível) e 580 classes no nível de Subgrupo (4O nível). No 5O e 6O níveis, Família e Série, respectivamente, o número de classes é imprevisível no momento, dependendo da intensidade de levantamentos semidetalhados e detalhados que venham a ser executados nos anos futuros.

[4] Classification is in Portuguese. No English translation is available.

As novas classes do sistema, apenas do 1O nível categórico (Ordem) e a correspodência aproximada com as designações empregadas na classificação que vinha sendo utilizada, são mostradas a seguir:

ALISSOLOS: Solos com alto teor de alumínio e horizonte B textural, anteriormente conhecidos com Rubrozem, Podzólico Bruno Acinzentado, Podzólico Vermelho-Amarelo

ARGISSOLOS: Solos com horizonte B textural e argila de atividade baixa, conhecidos anteriormente como Podzólico Vermelho-Amarelo, parte das Terras Roxas Estruturadas e similares, Terras Brunas, Podzólico Amarelo, Podzólico Vermelho-Escuro

CAMBISSOLOS: Solos com horizonte B incipiente, assim designados anteriormente

CHERNOSSOLOS: Solos escuros, ricos em bases e carbono. Anteriormente designados por Brunizem, Rendzina, Brunizem Avermelhado, Brunizem Hidromórfico

ESPODOSSOLOS: Solos conhecidos anteriormente como Podzois

GLEISSOLOS: Solos com horizonte glei, conhecidos como Glei Húmico ou Pouco Húmico, Hidromórfico Cinzento, Glei Tiomórfico

LATOSSOLOS: Solos com horizonte B latossólico, anteriormente tinham a mesma designação

LUVISSOLOS: Solos ricos em bases, B textural, correspondendo aos Brunos não Cálcicos, Podzólicos Vermelho-Amarelos Eutróficos e similares

NEOSSOLOS: Solos Pouco Desenvolvidos, anteriormente designados por Litossolos, Aluviais, Litólicos, Areias Quartzosas e Regossolos

NITOSSOLOS: Solos com horizonte nítico, correspondendo Terra Roxa Estruturada e Similar, Terra Bruna Estruturada e Similar, alguns Podzólicos Vermelho-Escuros

ORGANOSSOLOS: Solos orgânicos, conhecidos anteriormente por Solos Orgânicos, Semi-Orgânicos, Turfosos, Tiomórficos

PLANOSSOLOS: Solos com grande contraste textural, estrutura prismática, presença de sódio, anteriormente designados por Planossolos, Solonetz Solodizado, Hidromórfico Cinzento

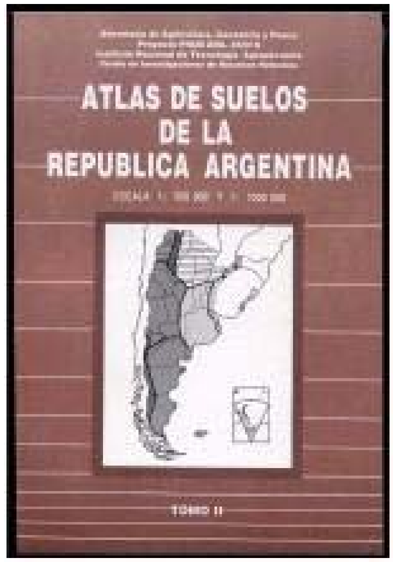
PLINTOSSOLOS: Solos com plintita, conhecidos como Laterita Hidromórfica, Podzólicos Plínticos, Latossolos Plínticos

VERTISSOLOS: Solos com propriedades provenientes de argilas expansíveis. Anteriormente tinham a mesma designação

Atlas de Suelos de la Republica Argentina[5]

Instituto de Suelos - Castelar elsitioagricola

http://www.insuelos.org.ar/publicaciones/publicacionesPapel.htm#atlasargentina



INTA
Buenos Aires, 1990
2 Tomos, 677 páginas

El Atlas de Suelos de la República Argentina describe las regiones naturales, los Suelos y tablas de evaluación y degradación decada provincia.

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[5] Classification is in Spanish. No English translation is available.

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