

INDIGENOUS SOIL CLASSIFICATIONS

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

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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 *ethnopedology*, 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 contrast 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 focusses 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 *colour*, 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 then 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 biri*), which is most fertile and contains relatively high levels of organic matter, changes to white soil (*labu kware*) when through cultivation and erosion valuable nutrients are depleted. Further degradation results in red soil (*labu kirey*) (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 payau*), neutral (*tanah tawar*), and sour soil (*tanah masam*), 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 Guatemala 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 practising 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, 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-romantized (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.

REFERENCES

- Altieri, M. A., 1990. Why study traditional agriculture? *In*: C. R. Carroll et al. (Eds.), *Agroecology*, pp. 551-564. McGraw-Hill, New York.
- Berlin, B., 1992. *Ethnobiological classification. Principles of categorization of plants and animals in traditional societies*. Princeton University Press, New Jersey, 335 p.
- Behrens, C. A., 1989. The scientific basis for Shipibo soil classification and land use: changes in soil-plant associations with cash cropping. *American Anthropologist* 91: 83-100.
- Bellon, M. R. and J. E. Taylor, 1993. "Folk" soil taxonomy and the partial adoption of new seed varieties. *Economic Development and Cultural Change* 41(4): 762-786.
- Brosius, J. P., Lovelace, G. W. and G. G. Marten, 1986. Ethnoecology: an approach to understanding traditional agricultural knowledge. *In*: Marten, G. G. (Ed.), *Traditional Agriculture in Southeast Asia. A Human Ecology Perspective*. Chapter 9, p. 187-197. Boulder, CO, 358 p.
- Carter, W. E., 1969. New lands and old traditions. Kekchi cultivators in the Guatamalan lowlands. *Latin American Monographs*. Gainesville: University of Florida Press.
- Dialla, B. E., 1993. The Mossi indigenous soil classification in Burkina Faso. *Indigenous Knowledge & Development Monitor* 1(3): 17-18.
- Finkl, Jr., C. W., (Ed.), 1982. *Soil Classification*. Benchmark Papers in Soil Science/ 1. Pennsylvania, 391 p.
- Furbee, L., 1989. A folk expert system: soil classification in the Colca Valley, Peru. *Anthro. Quart.* 62(2): 83-102.
- Guillet, D. W., 1992. Crop choice and soil management. *In*: D. W. Guillet, *Covering Ground*. Chapter 5, p.67-84. Univ. of Michigan Press, 250 p.
- Guillet, D. W., 1989. A knowledge based-systems model of native soil management. *Anthro. Quart.* 62(2): 59-67.
- Hecht, S. B., 1990. Indigenous soil management in the Latin American Tropics: neglected knowledge of native peoples. *In*: Altieri, M. A. and S. B. Hecht (Eds.), *Agroecology and*

- Small Farm Development*. Chapter 16, p. 151-160. CRC Press, Boca Raton, FL, 262 p.
- Knapp, G., 1991. *Andean Ecology - Adaptive Dynamics in Ecuador*. Westview Press, Dellplain Latin American Studies, No. 27. 220 p.
- Marten, G. G. and P. Vityakon, 1986. Soil management in traditional agriculture. *In*: Marten, G. G. (Ed.), *Traditional Agriculture in Southeast Asia. A Human Ecology Perspective*. Chapter 10, p. 199-225. Boulder, CO, 358 p.
- Mazur, R. E. and S. 'Tunji Titilola, 1992. Social and economic dimensions of local knowledge systems in African sustainable agriculture. *Sociologia Ruralis* 32(2/3): 264-286.
- Mundy, P. and J. Lin Compton, 1991. Indigenous communication and indigenous knowledge. *Development Communication Report* 74(3): 1-4.
- Ollier, C. D., Drover, D. P. and M. Godelier, 1971. Soil knowledge among the Baruya of Wonenara, New Guinea. *Oceania* 42(1): 33-41.
- Osunade, M. A., 1992a. The significance of colour in indigenous soil studies. *Intern. J. of Environmental Studies* 40: 185-193.
- Osunade, M. A., 1992b. Identification of crop soils by small farmers of South-western Nigeria. *J. of Environmental Management* 35: 193-203
- Osunade, M. A., 1989. Optimisation of traditional systems of soil resources inventory to achieve increased sustainable production. *Third World Planning Review* 11(1): 97-108.
- Pawluk, R.R., Sandor, J. A. and J. A. Tabor, 1992. The role of indigenous soil knowledge in agricultural development. *J. of Soil and Water Conservation* 47(4): 298-302.
- Posey, D. A., 1989. Alternatives to forest destruction: lessons form the Mebengokre Indians. *The Ecologist* 19(6): 241-244.
- Posey, D. A., 1984. Hierarchy and utility in a folk botanical taxonomic system: patterns in the classification of arthropods by the Kayapo Indians of Brazil. *J. Ethnobiol.* 4: 123-134.
- Rajasekaran, B., Martin, R. A. and D. M. Warren, 1993. A framework for incorporating indigenous knowledge systems into agricultural extension. *Indigenous Knowledge & Development Monitor* 1(3): 21-23.
- Reijntjes, C., Haverkort, B. and A. Waters-Bayer, 1992. *Farming for the Future. An*

Introduction to Low-External Input and Sustainable Agriculture. ILEIA, MacMillan Press Ltd., London, 250 p.

Stacishin de Queiroz, J. and B. E. Norton, 1992. An assessment of an indigenous soil classification used in the *Caatinga* region of Ceara State, Northeast Brazil. *Agricultural Systems* 39: 289-305.

Taylor-Powell, E., A. Manu, S. C. Geiger, M. Ouattara, and A. S. R. Juo, 1991. *Integrated management of agricultural watersheds: land tenure and indigenous knowledge of soil and crop management*. TropSoils Bulletin 91-04. Texas, 30 p.

Thrupp, L. A., 1989. Legitimizing local knowledge: from displacement to empowerment for Third World People. *Agriculture and Human Values* 6(3): 13-24.

Warren, D. M., 1989. Linking scientific and indigenous agricultural systems. In: Compton, J. Lin (Ed.), *The Transformation of International Agricultural Research and Development*. Chapter 7, p. 153-170

Weinstock, J., 1984. Getting the right feel for soil: traditional methods of crop management. *The Ecologist* 14(4): 146-149.

Williams, B. J. and C. A. Ortiz-Solorio, 1981. Middle American folk soil taxonomy. *Annals of the Ass. of Am. Geographers* 71(3): 335-358.

Zimmerer, K. S., 1994. Local soil knowledge: answering basic questions in highland Bolivia. *J. of Soil and Water Conservation* 49(1): 29-34.

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

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

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

VEGETATION

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

SOIL FAUNA

<i>Yoruba</i> , Nigeria	Earthworm casts indicate fertile soil
<i>Sukuma</i> , 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