Soil Monoliths Collection for Soil Museum Establishment in Federal College of Education (Technical), Omoku, Rivers State, Nigeria

Nnah, M. B., Ezekiel, P. O. & Okole, P. A.
Department of Agricultural Education
School of Secondary Education (Vocational)
Federal College of Education (Technical), Omoku, Rivers State, Nigeria.
Correspondent author: Nnah, M. B., +234 816 042 1515 / 807 207 5208
Email: mbnnah@yahoo.com, maxwell.nnah@fcetomoku.edu.ng

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Abstract

This paper presents the procedures used for the collection of soil monoliths for establishing soil museum in Federal College of Education (Technical), Omoku, Rivers State, Nigeria. Soil monoliths are used as an essential education facility for dissemination of information about the soil profile, its uses, relationship with the environmental conditions and human impact. The method of collecting this soil snapshot from the soil profile and its preservation in almost its natural undisturbed conditions are of great concern to soil scientists. Soil monolith exposes the soil morphological characteristics from topsoil to subsoil, including the colour variations, texture, structure, horizontal differences and thickness among properties. These features are important in determining the soil-related limitations to land-use. Soil monoliths on display are beautiful and attractive to young learners, and increase their inquisition about the soil. The procedure involved in its collection include selection of suitable soil profile site, sinking of the profile pit, construction of the soil sample collecting box, marking and collection of the soil sample. Others are preservation of the collected sample as the monolith and display in the display box in the soil museum. The procedures are conferred in the article in conjunction with the description of the pedon from where the soil monolith was collected.

Key words: *Collection, Soil profile, Pedon, Monolith*

1.0 Introduction:

A soil monolith is a vertical slice of soil collected from a profile pit, usually from top to subsoil, showing the different layers and colours in positions. Kew (2020) defined soil monoliths as permanent intact visual artistic examples of the changes in a landscape and reflects the history of soil development in unique locations. Soil monolith represents the soil in its natural position on display in a museum or laboratory. It shows the properties of a natural soil profile in a simple form and preserves the actual particle structure as found in the field. Soil monolith displays the soil properties for a number of educational purposes (Haddad *et al.*, 2009) and is used by extension officers repeatedly for representative profiles. It is also used to educate students to experience how soils vary or differ spatially and temporally across the landscape. Hence, it shows the analytical properties of a diversity of soils in an environment. Monoliths on display afford others who are not able to examine the soil in *situ* the opportunity to observe a cross section of it.

The learning goals of soil monoliths include the following, but not limited to: understand the major soil forming factors and processes within an environment, identify the various soil horizons, give a detail account of the soil characteristics and why there are variations in soils, have an in-depth understanding of a specific soil type, complete a soil profile description, gain hands on experience in professional field soils methods and successfully acquire the experience of step by step collection of a monolith for display. This exercise is preferably for students who have gained some understanding of introductory soil science, particularly for those with understanding of soil characteristic features like soil colour, texture, structure, horizons and soil description processes.

The usefulness of this soil reference collection referred to as soil monolith include the following:

(a) **For scientific training:** This include the education of students in natural and environmental sciences. The undisturbed soil material is used as teaching aid which reveals the soil varieties and their differences in regional, national or international scale. It also exposes the influence of different management techniques on soils. Sequences of soils in landscape and over time are also shown. The potential of visualization is being recognized in science communication and education (Evagorou *et al.*, 2015).

(b) **It is useful for soil classification and correlation:** The display of soil monoliths in museums or laboratory helps to form a basis for discussion amongst soil scientists and students alike. Monoliths on display can be used for soil classification, correlation and interpretation. Visitors can also exchange useful information about soils on display and their production potentials.

(c) **It is a veritable tool for planning purposes:** Soil monoliths are helpful to study the nature and behavior of the soils of an environment. This takes into account information on climate physiography, land use and other ecological factors which influence soil characteristics and their use limitations. The nature and characteristics of the soil determine the planning process of the soil by soil scientists, agronomists, extension officers, policy makers, land use planners, administrators and farmers. Monoliths are valuable components of extension programmes and training courses for land-holders and natural resources management authorities (Handdad *et al.*, 2009).

(d) **For educating the general public:** There is a growing concern of the outstanding role of soil as natural resource that needs conservation. The general public can become more 'soil conscious' through the media, especially social media. To awaken this consciousness soil monolith displayed in museums and laboratory will play a major role. Visits to the museums create the consciousness about the soil. To increase the visibility of soil to the general public, several soil educational displays were developed for parks and natural centres, soil trails and soil monoliths are some of such displays (Hamsmeyer & Cooper, 1993). These displays are viewed by adults and children who otherwise might not have been introduced to the study of soil.

Recent development in the international community indicates that there is increasing attention for the conservation of soil for various reasons around the world. For instance, there is strong initiatives on soil health (Stott & Moebius-clane, 2017), the United Nations and International Union of Soil Sciences (IUSS) declarations of the International Year of Soil (FAO, 2015), International Decade of Soils (IUSS, 2015) and the clear congruence of how soil can help accomplish the United Nations Sustainable Development Goals (Bouma & Montanarella, 2016) among others. The importance of soils therefore can be appreciated in their multidisciplinary functions and benefits, as the core of agriculture and basis of life on planet earth. Preserving this natural gift in soil monoliths can bring soils to life for education and outreach (Lawrie & Enman, 2010) or as a display of art work (Breaker, 2013). Though it was thought to be challenging to capture soil profiles, a simple twist to an old method now makes the construction of soil monolith a simple activity for soil scientists and other soil users.

Soil monolith construction involves the impregnation of a soil face with a fixation agent (such as glue and/or resin) and their final product is usually mounted on a wall for study of undisturbed soil layers and characteristic properties, or simply for act purposes (Stoof *et al.*, 2019). This mounting makes it easier and useful for a range of different features in soil studies such as differences between soil types, soil processes including weathering, eluviation and illuviation of clay minerals, iron and organic acid content, gley and human impacts. Others include biological activities including root patterns, bioturbation and burrowing activities of soil animals. Geological processes such as cryoturbation, fluvial and Aeolian layering can also be captured. Interestingly, soil monoliths show splendid colours present in soils, from top soils to sub soils. The colours displayed by soil monoliths are more realistic than drawings, paintings and/or colour photographs of soil profiles. Nevertheless, they have their values as illustrations in communication of information to the public. Megonigal *et al.* (2010) noted that these natural snapshots of the subsoil surface are effective ways of inspiring people about soils. Hence, museums, universities, schools and research institutions around the world adopt this valuable asset for teaching and outreach on the values of soils, processes occurring in soils, effect of management, among other factors. This valuable asset makes it possible for learners and teachers to compare soils in a classroom or museum environment in a short while and increasing accessibility to soil science without necessarily going to visit soil profile in situ.

Soil monoliths were first collected in the late 19th century by Russian soil scientists (Allaire & van Bochove, 2016). The monoliths comprised a number of natural bodies of soil profiles which were kept in wooden boxes. The soils were said to have been collected using an iron box with shape edges driven into the face of a soil profile pit. The method was said to be cumbersome and time consuming. The methods of collection have improved over the years following advancement in technology. The precision for the collection of soil monolith and the choice of material to be used depends on the studies required. Monoliths can be formed from any kind of soil type, ranging from clay to sandy soils, loam to peat soils, as the case may be. Its construction requires two rectangular boxes – one for the collection of the soil and the other for the impregnation of the collected soil samples with fixation agents. Specialized expertise in the field and museum are also involved.

This paper gives a step by step description of a simple process of soil monolith collection. The technology for the collection appears to be a bit cumbersome but its success is a beautiful snapshot of the soil profile. Soil monoliths are scarcely found in most universities in Southern Nigeria. It is against this backdrop that this study was carried out.

2.0 Materials and Methods

2.1 Selection of a Good Site:

A suitable site was selected for the excavation of the profile pit for the study. This was achieved by critically studying the surrounding environment. Few centimetres of an exposed road was cut to reveal the original soil beneath. Besides, soil mapping of the College site soil was helpful in this direction. Four main factors were considered in determining the suitability of the location of the profile pit as recommended by Stoof *et al.* (2019), they are: soil texture, ground water depth, natural or man-made exposure and accessibility. The soil of the site had a good textural classes of sand and loamy sand. This is adjured the best for soil monolith impregnation. The site had low groundwater depth and the soil was at field capacity. There was no natural or man-made exposure in the site. The site selected had good accessibility for movement of personnel and vehicle, as shown in fig. 1. The authorities of the college through the Department of Agricultural Education, School of Secondary Education (Vocational), Federal College of Education (Technical), Omoku, approved the site for the sinking of the profile pit at the Teaching and Research Farm of the college.

The following tools were used for the sinking of the profile pit: spade, shovel, pickaxe, crowbar and measuring tape.

2.2.2 Smoothening the surface of the profile pit:

Tools used for surface smoothening of the soil profile pit include saw, knife, pruning shears, pruning saw, hand saw and hammer.

2.2.3 Collection of the profile soil:

Rectangular sample box with dimension 200 x 30 x 10 cm made up of timber, rim and bottom 15 mm thick, top 4 mm thick screwed together, bungee cords, polythene wrapper and angle-iron frame.

2.2.4 Monolith display box:

The materials for the monolith display box include rectangular display box similar to the collection box, tin of glue, wire mesh, brush, cooper nails and resin.

2.3 Sinking of the Soil Profile:

A 2.0 x 1.5 x 2.0 m dimension profile was dug at the Teaching and Research Farm of the Federal College of Education (Technical) Campus II, Omoku, Rivers State, Nigeria. Site information of the soil profile is described below:

Geographical coordinate:	05.37687°N, 006.67382°E
Elevation:	23m above sea level
Climate:	Humid tropical rainforest
Topography:	Table land
Slope:	0 – 5%
Vegetation:	General – tropical humid forest
Land use:	Previously cultivated
Uncultivated stop:	Yes
Erosion:	No evidence of surface erosion
Drainage:	Well drained
Depth to water table:	Not encountered
Depth to impenetrable layer:	Not encountered

Description of the Pedon:

Horizon Depth (cm)	Description
0 – 12 (Ap 1)	**ColourMatrix**: 7.5 YR 2/3 **Colour:** Dark brown **Texture:** Fine grains **Plasticity:** Non-sticky to touch when wet. **Structure:** Granular structure **Drainage:** Well drained **Root outcrop:** Abundant macro roots **Presence of animals:** Common ants, termites and other pores **Boundary:** Clear smooth boundary **Visual classification:** Loamy sand
12 – 36 (Ap2)	**Colour Matrix:** 10 YR 3/3 **Colour:** Light brownish grey **Texture:** Fine grains **Plasticity:** Non-sticky to touch when wet. **Structure:** Granular **Drainage:** Well drained (there were few fine distinct mottles) **Root outcrop:** Macro roots **Presence of animals:** Abundance medium ants, and termite holes. **Boundary:** Clear smooth boundary
36 – 58	**Colour Matrix:** 7.5 YR 5/4

(AB)	**Colour:** Brownish grey **Texture:** Slightly coarse **Plasticity:** Gritty and non-sticky to touch when wet. **Structure:** Granular **Drainage:** Well drained **Presence of animals:** No animal hole **Root outcrop:** Macro roots were present **Boundary:** Gradual boundary
58 – 67 (B)	**Colour Matrix:** 5 YR 5/4 **Colour:** Brown **Texture:** Slightly coarse **Structure:** Moderate sub-angular blocky **Plasticity:** Non-sticky to touch when wet. **Drainage:** Well drained **Root outcrop:** Presence of macro roots **Presence of animals:** No animal hole
67 – 200 (B)	**Colour Matrix:** 2.5 YR 4/8 **Colour:** Brownish yellow **Texture:** Fine grains **Plasticity:** Slightly sticky **Drainage:** Well drained **Root outcrop:** Presence of micro roots

2.3.1 Collection of the soil sample from the profile:

The surface of the profile walls were smoothened with the knife, especially the side from which the soil sample was to be collected. The collection box was used to mark the smoothened surface. The collection box was aligned onto the surface of the profile wall, with the top of the lid level with the land surface. This provided the template that ensured the accurate dimensions of the monolith. The knife was used to cut a groove in the surface of the pit so that the cut flushed with the sides of the tool. The marked surface of the soil was dug deeper into the pit wall until the surface protruded from the wall (as shown in fig. 2). The scoring tool was removed soon afterwards. Similarly, the bottom of the scored area was cut to the same depth as the sides. Hence, the rectangular face of the soil, its width and height were sharpened differently from other portions of the profile pit.

Fig. 2: Marking of the soil sample before collection

The dimension of the marked monolith was the same as the inside of the collecting box. The box was placed on the face of the soil to fit into the cuts on the pit wall. (The picture in fig. 3 shows the insertion of the collection box to the cut groove in the soil profile). The collection box was braced with the angle iron frame so that it fits tightly onto the smooth surface of the cut groove without movement. A cut of about 12cm deep was made at a 45-degree angle to the collecting box up and down the profile pit wall. Three (3) evenly spaced 5cm holes were borne through the soil on the pit face. The bungee cords were thread through the holes to ensure stability of the soil sample in the collection box. The cords were attached at the back of the collection box after the brace boards were fixed in place. The brace boards were placed on the open sides to keep the soil in place. The collection box were secured with the bungee cords.

Fig 3: Inserting collection box to collect the soil profile sample

The monolith was loosened by back-cutting, beginning from the ground level and working downward. Soon after the back-cutting, the monolith was lifted to the ground level. The monolith was placed on a raised surface for trimming. The bungee cords and brace boards were removed and the excess soil materials were trimmed using the handsaw and knife. Trimming was done to cut the soil so that it will flush with the collecting box. The monolith was wrapped with polythene wrap for safe transport to the museum.

The display box was laced with the wire mesh fastened in position with the cooper nails and applied with a single layer. This was done fairly quickly so that the glue will not get dry before the soil profile was transferred to the box.

The display box was placed on top of the unwrapped soil sample in the collecting box. The edges of the boxes were perfectly lined and the display box was turned over so that it was now at the bottom. By so doing the soil profile was transferred from the collecting box to the display box. The display box was tapped with the hammer to ensure the soil stick to box by reducing the pore spaces between the particles. The soil monolith was worked with resin covered with polythene wrapper and allowed to dry for two weeks. This slow and steady drying ensured that the glue fully solidify the soil sample in the display box. After the two weeks period, when the glue and resin were firm and odourless, the finished soil monolith was installed in its final position in the museum (see fig. 4). It was placed in a slanting position on a wall in the museum for display.

Fig. 4: Display of soil monolith on the wall of the museum

3.0 Discussion:

The increased interest in the value of soil for life (FAO, 2015) motivated the authors in high participation to collecting this soil monolith. At the same time, the potential of visualization in science communication and education (Evagorou *et al.,* 2015) is being recognized as a tool for teaching and learning, particularly in soil science. The success of the collection of soil monolith was as a result of both. The materials for the collection can be locally sourced. The methods described became quite simple and straight forward when repeated in other sites. The main step involved were the impregnation of the collection box inserted with wire mesh and glue with smooth surfaced soil collected from a profile pit, which was later worked with resin to ensure its stability and durability. The method is successful as it is safer, simple, durable and accessible. The process was done when the soil moisture was at field capacity level. This moderate moisture content helps the soil particles and structure to stabilize during the collection process. This is in line with recommendation of Stoof *et al.* (2019) about soil monolith collection procedure.

4.0 Conclusion:

A simple method for collecting a beautiful snapshot of soils has been described. This method applies to a wide range of soils with different textures and moisture content and other environmental conditions for beautiful appearance. The methodology involved in the collection of soil monolith has been defined, this comprises of sinking a profile pit, extraction of the soil sample, preservation, display of sample intact conservation.

This display of soil monolith in the museum to raise awareness of the importance of soil, both for agricultural and environmental protection, cannot be overemphasized. It is a variable tool for teaching and demonstration purposes. Its beautiful science and visual impact catch students' attention for knowledge. Soil monolith is a very reliable visual testimony of the structure and composition of the soil profile of an environment.

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References

Allaire, S. A. and Bochove, E. V. (2016): Collecting large soil monoliths, *Canadian Journal of Soil Science*, 85, 885-896.

Bouma, A. H. and Montanerella, L. (2016): Facing policy challenges with inter- and transdisciplinary soil research focused on the UN Sustainable Development Goals, Soils, 2, 135 – 145, *https://doi.org/10/5194/soil-2-135-2016*.

Breaker, J. (2013): The Current Disturbed, in: *Geoscientist*, *The Geological Society*, London, UK.

Evagorou, M., Erduran, S. and Mantyla, I. (2015): The role of visual representations in scientific practices: from conceptual understanding and knowledge generation to "seeing" how science works, *International Journal of STEM Education*, 2, 11, https://doi.org/10:1186/s40594-015-0024-x.

Food and Agriculture Organization (FAO, 2015): International Year of Soils, available @ *http://www.fao.org/soils-2015/about/key-messages/en/* (last access: 22 March, 2018).

Haddad, N., Lawrie, R. and Eldridge, S. (2009): Improved method of making soil monoliths using an acrylic bonding agent and proline auger, *Geoderma*, 151, 395-400.

Hansmeyer, T. L. and Cooper, T. H. (1993): Developing Interpretive Soil Education Displays. *Journal of Natural Resources and Life Science Education*, 22(2), 131-133.

International Union of Soil Sciences (IUSS): International Decade of Soils (2015-2024): available @: *https://iuss.boku.ac.at/files/ids-general-intro-for-egu-and-web-v3.pdf*. (last access: 20 May, 2019).

Kew, G. (2020). Soil Monoliths, Soil Variability and Terrior. *XIIth International Terrior Congress*. 17-18 November, Virtual Congress, Adelaide, Australia.

Lawrie, R. and Emman, B. (2010): "Using soil monoliths to communicate soil information". In: *Proceedings of the 19th World Congress of Soil Science: Soil Solutions for a changing World*. Brishane, Australia. 1-6 August 2010. Symposium, 4.4.1 Delivering Soils information to non-agriculture.

Megonigal, J. P., Stouffer, B., Starrs, S., Pekarik, A., Drohan, P. and Havlin, J. (2010): "Dig it". How an Exhibit Breathed Life into Soils Education, *Soil Science Society of America Journal*, 74, 706 – 716, https://doi.org/10.2136/sssaj2009.0409, 2010.

Stoof, C. R., Candel, J. H. J., van DerWal, L. A. G. M. and Peek, G. (2019): *Soil lacquer peel do-it-yourself: Simple capturing beauty*. Published by Capernicus Publications on behalf of the European Geosciences Union. Soils, 5, 159-175. Available @: https://doi.org/10-5194/soil-5-159-2019.

Stott, D. E. and Moebius-clune, B. N. (2017): Soil Health: Challenges and Opportunities, In: *Global Soil Security*, Springer International Publishing, Cham, 109-121.