

Transition of Natural Pedology into Man Made Anthropedogenesis through Anthropocene Epoch- A review

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Abstract

The renowned science of pedology, which commenced in the nineteenth century as a study of natural processes in soil formation, is adapting to the demands of the Anthropocene, the geologic period during which planet Earth and its soils change from natural to human-natural systems. The term Anthropocene comes from the Greek words anthropos, which means "man," and cene, which means "new." Within the Geological Time Scale, the 'Anthropocene' is not yet a formally recognised geological unit. The Anthropocene Working Group (AWG) is working on a proposal to codify the word for discussion. Anthropedogenic processes are characterised as artificial settings that dramatically alter natural soil formation processes or causes. In any given setting, human actions alter one or more of the five soil-forming factors. Given that humans differ from other organisms in that they purposefully manage soils independently of other soil-forming variables, and because they employ technology to affect soils on a far larger scale than other organisms. Humans' collective impacts on soil development have been categorised as a sixth soil-forming component. The basic science of pedology, the study of natural soil formation, is evolving into the science of anthropedogenesis in the Anthropocene. The future of pedology is a resurgent discipline known as anthropedology, which draws on previous pedology but moves from "human as outsider" to "human as insider." In other words, in pedology, the human must transform from a soil-disturbing to a soil-forming agent.

Keywords: Anthropocene, Humans, Anthropedogenesis, Insider, Forming

1. Introduction:

“It is impossible to care for each other more or differently than we care for the earth”

—Wendell Berry

Among the millions of life forms on our planet, the human species has the most influence on the earth's ecosystems and biogeochemistry. From the composition of the atmosphere to the temperature of the oceans, the imprint of human activities can be found everywhere. Farming is thought to be the largest human footprint on the earth, disrupting most quasi-steady state soil processes profoundly. (Amundson *et al.*, 2015). Soils in the world's most distant locations today contain radioisotopes from nuclear devices and xenobiotic substances from the chemical industry; soils exposed by tillage and building

around the world degrade at rates more than 100 times faster than before they were touched by humans. Plow layer Ap horizons could now be found in broad swaths of the continent's soils, and many of them retain less than half of their original organic matter supply. Rice cultivation has resulted in the creation of millions of hectares of artificial wetland soils, mostly in the subtropics. Artificial drainage, on the other hand, has ruined millions of hectares of natural wetlands, primarily in milder climates. (Weil and Brady, 2017). Because of these and other developments, scientists today believe that the earth slid beyond the Holocene Epoch and into a geologic epoch known as the Anthropocene in the last century or so (the age of humans).

Table1.Official Timeline of earth

Earth	Eons (Four eons)	Most recent (Phanerozoic) - Revealed life - 541 Million Years ago (Mya)
	Eras	Paleozoic (Era of trilobites - Arthropods) Mesozoic (Era of dinosaurs) Cenozoic (Era of Mammals and Birds)
	Periods (50 Mya/period)	Paleogene (66-23.03 Mya) Neogene (23.03 – 2.588 Mya) Quaternary (2.588- present)
	Epochs (ten million years)	Pleistocene Epoch (2.588 Mya – 11.700 ya) Holocene Epoch Anthropocene Epoch
	Ages	Upper, middle, Calabrian and gelasian for pleistocene

The term "Anthropocene" was invented by Eugene Stoermer and ascribed to Paul Crutzen, a Dutch chemist and Nobel Laureate in Chemistry in 1995, for introducing it to people's attention at a conference in 2000. (Crutzen and Stoermer, 2000; Crutzen, 2002). The term Anthropocene comes from the Greek words anthropos, which means "man," and cene, which means "new." It refers to the period of geologic time when the Earth changes from a naturalistic to a human-natural planet. The International Commission on Stratigraphy, which regulates how we talk about Earth's past, has the authority to name and define geological epochs. They're still disputing whether the Anthropocene has been proven, and they're hunting for a 'golden spike,' a fossil marker that might distinguish the Holocene from the Anthropocene. The Earth's official timeline is divided into epochs. The International Commission on Stratigraphy divides the 4.6 billion years into Eons, Eras, Periods, Epochs, and Ages. The Phanerozoic, which commenced 540 million years ago, is the current Eon. The Holocene, Earth's current epoch, began roughly 12,000 years ago, with the conclusion of the last ice age.

Source: Yadvinder Malhi, 2017

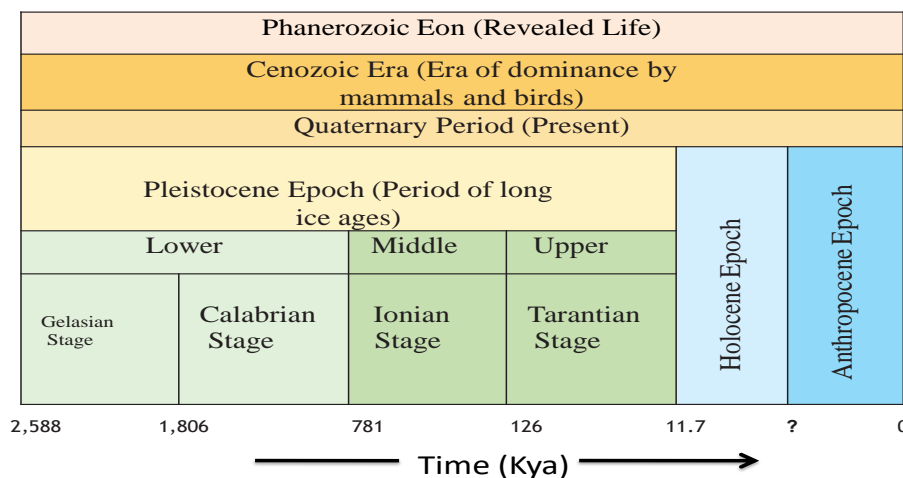


Fig 1. Geological time scale

Transition from pedology to anthropedology

Table 2. Timeline for Transition from pedology to anthropedology

Year	Contributions
1850-1890	E. W. Hilgard (1860) and Vasily Dokuchaev defined Soils as natural bodies, as fundamental parts of nature
1890-1936	Pedology is a natural and basic science that focuses nearly entirely on natural soil formation variables and processes.
1937-1990	The eight versions of Nature and Soil Properties Promoted pedology as a fundamental science and a "soil science in its purest form."
1941	Jenny was attracted by human soil change and included human influence in the Dokuchaev–Jenny state factor equation's biological element. $S=f(c,l,o,p,t,...)$. He said "Cultivation and fertilizing of soils, as well as crop removal, are extensively practiced acts that brand man as an outstanding biological soil-forming component,"
1950	Many soil scientists were uninterested in human–soil connections and saw human activities as simply interfering with soil production. If pedologists thought about human influence at all, they thought of it as a biological aspect.
1960	Soil scientists are progressively including the human component into pedology.
1970 and 1980	Anthropedology began to grow as the environmental sciences began to permeate pedology.
1988	The International Committee on Anthropogenic Soils

	(ICOMANTH) was formed to develop an anthropogenic soil classification system inside the Soil Taxonomy system.
1990	Global soil change—described and analysed how human activities were changing natural soils. Anthropedology research has exploded in popularity.
1998	First edition of WRB published with 30 RSG (including anthrosols)
2006	Second Edition of WRB published with 32 RSG (Technosols and stagnosols)
2008	Jan Zalasiewicz and colleagues proposed the Anthropocene Epoch as a defined geological interval for the first time.
2009	Establishment of Anthropocene Working Group (AWG)
2012	Richter and Yaalon - Soil Taxonomy has endeavoured to reduce human influence on soil taxa in the past.
2014	In 2014, the ICOMANTH Final Recommendation was accepted, complete with photos of landfill and rice paddy soils on the cover of the 2014 Keys to Soil Taxonomy.
2016	At the 35th International Geological Congress, the Anthropocene Working Group of the International Union of Geologic Sciences (IUGS) voted to recommend the Anthropocene as a legitimate geologic era.

Sources: Richer *et al.*, 2015 & 2020

This interval must first be approved by the IUGS and the International Commission on Stratigraphy before it can be made official.

Significantly, the transition from pedology to anthropedology is forged not only by Steffen *et al* (2015).Great Acceleration, but also by numerous pedological studies that have investigated the diachronous beginnings of human influences on soil, particularly during the time when human influence was traditionally considered to be local and part of the state factor equation's trailing dots. (Sandor, 2006; Warkentin, 2006; Edgeworth *et al.*, 2015; Schaetzl and Thompson, 2015). Soil scientists have chronicled the long history of human-soil relations in Africa, Asia, Europe, and the Americas on local to regional scales. (McNeill and Winiwarter, 2004).

2. Different depiction for defining transition from Holocene to anthropocene epoch:

2.1 Ball and cup depiction of earth system

The Holocene envelope of natural variability and basin of attraction is depicted as a ball and cup (Stefen *et al.*, 2016). The basin of attraction is more difficult to define than the envelope of variability, thus its position (Figure 2) is useful in conceptualizing the Earth System method to identifying the Anthropocene.

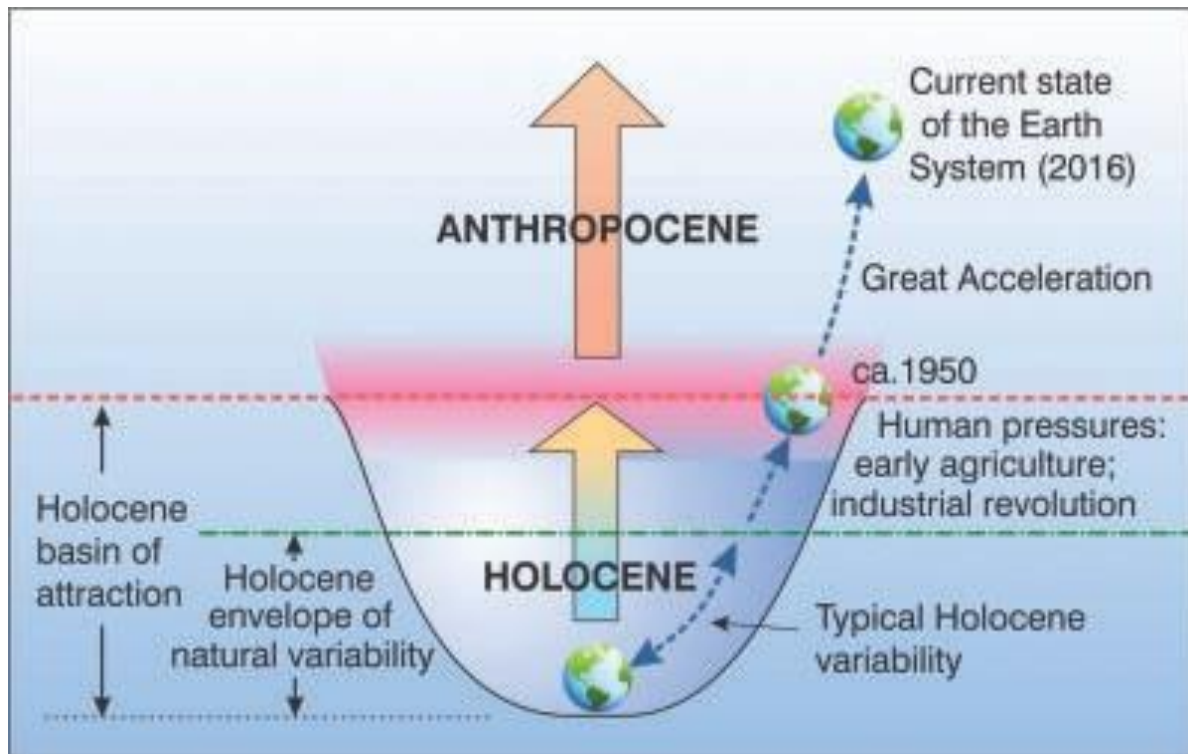


Fig 2. Ball and cup depiction of earth system

The Holocene natural variability envelope depicts the Earth System's natural variability limit (e.g., climatic and intrinsic biosphere variability that occurs in the absence of major human perturbations). Up to a point, perturbations of the Earth System, such as those driven by more intensive human activity of agriculture and then the industrial revolution, can push the Earth beyond the limits of natural variability while remaining within the Holocene basin of attraction, that is, within a state of the Earth System that is still structurally and functionally recognizable as the Holocene and within which negative feedbacks are still dominant. The developing human pressures are located between the Holocene envelope of variability and the top of the Holocene basin of attraction, signifying a period of increasing human activity that is moving the Earth System toward, but not yet into, the Anthropocene. The area below the broken red line indicates the stratigraphic Holocene Epoch, whereas the area above the broken red line indicates the stratigraphic Anthropocene Epoch. The Earth System Anthropocene is depicted as a trajectory away from the Holocene, not as a stable state.

2.2 Ball and cup depiction of regime shift

A dynamic variation of the ball-and-cup metaphor can be used to show the transition from the Holocene to the Anthropocene (Figure 3). The Earth System must be tilted out of the basin of attraction of its current state, the Holocene, to experience a regime change and transition to another stable state (Stefen et al., 2016). Alternatively, manmade forcings significantly alter the present basin of attraction, eliminating the likelihood of a return to the Holocene. The basin of attraction is deep in the early to mid-Holocene, but as human perturbations of the Earth System rise due to agricultural expansion and later the industrial revolution, the Holocene basin of attraction becomes increasingly shallow. The orange ball

depicts the condition of the Earth System, while the cup on the right represents a stable basin of attraction (the Holocene). The pink ball and the cup on the left indicate a hypothetical state of the Earth System (the Anthropocene). The cup becomes deeper and eventually evaporates as a result of human force, causing the ball to roll to the left.

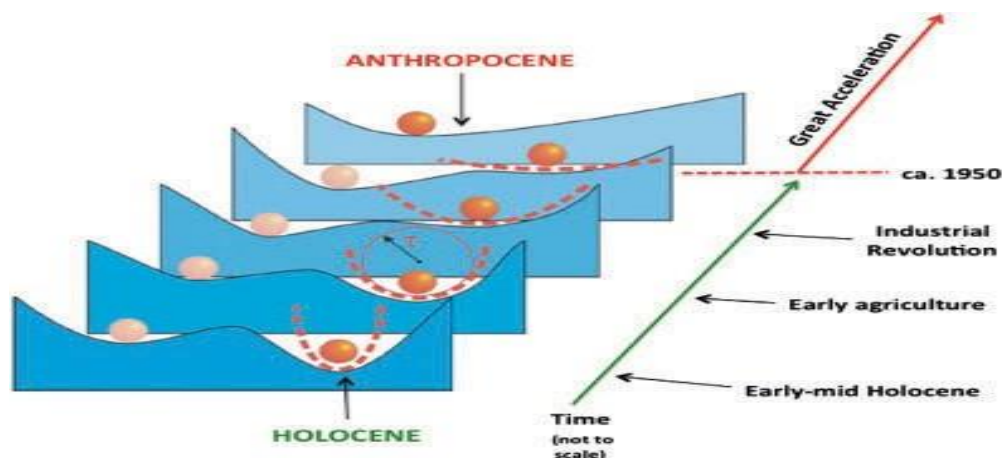


Fig 3. Ball and cup metaphor

2.3 Ball and cup depiction to denote future trajectory of anthropocene

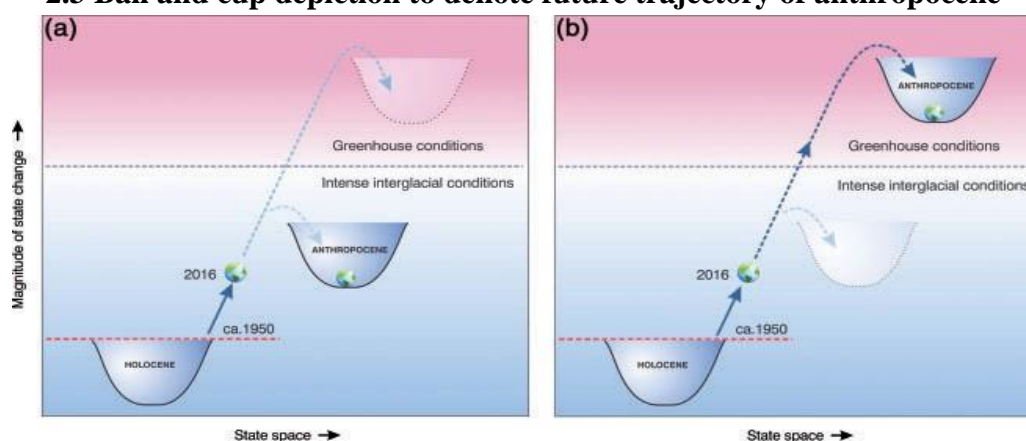


Fig 4. Future trajectory of anthropocene

The vertical axis depicts the magnitude of change in the Earth System as measured by climate and biosphere indicators, while the horizontal axis depicts the system's state space (Steffen *et al.*, 2018). The Anthropocene state is distinguished from the Holocene state by its location. The Anthropocene hypothetical states (cups) describe distinct modes of functioning of the Earth System that occur when the system's highly transient phase ends and more stable conditions emerge. We believe that these more stable settings will last for millennia within a certain range of inherent unpredictability. Figure 4(a) shows a swift and significant reduction in greenhouse gas emissions, as well as a significant shift in human exploitation of the biosphere. In comparison to contemporary conditions, biodiversity does not appear to be declining significantly. Figure 4 (b) depicts a full-fledged Anthropocene scenario in which human impacts on the climate continue to rise.

3. Basic Mechanism for formation of anthropogenic soils

- ✓ Burying a natural soil beneath one or more layers of impermeable material that has been artificially produced (e.g., concrete pavement).
- ✓ Transformation of a natural soil by human action (metagenetic), or
- ✓ Human action, usually with the help of mechanical equipment (neogenetic), creates and deposits a new soil profile in parent materials (anthrosediments) (Howard, 2017).

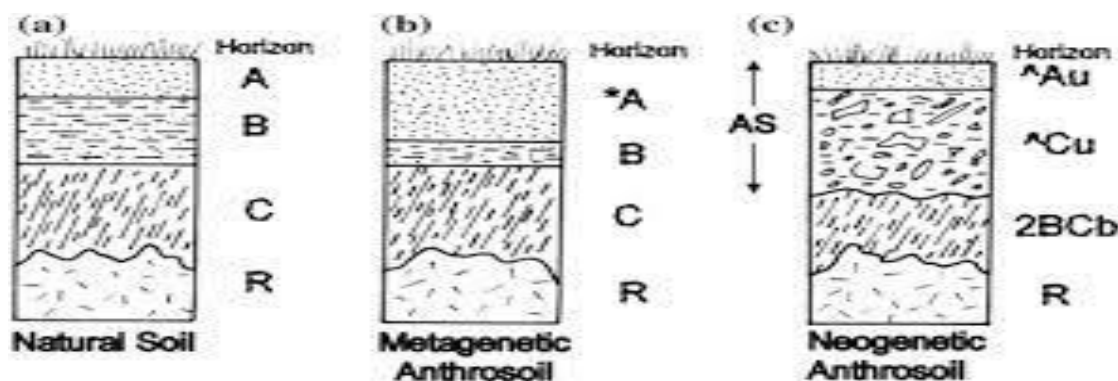


Fig 5. Anthropogenic soil formation

4. Anthrosediments (Anthropogenic sediments)

These are sedimentary deposits that have been created via an artificial sedimentation method. An anthropogenic sedimentary deposit (anthrosediment) is generated when soil and other earth components are extracted, transported about, then backfilled with building demolition rubble. Anthrosoil is the soil profile formed by these artificial parent materials. Natural materials (mine spoils, excavated soil, rock or regolith, etc.) may be mixed with artificial materials (brick, mortar, concrete, slag, etc.) in human-deposited parent material. Human activity has the ability to raise or decrease natural sedimentation rates. Overgrazing by farm animals or construction in a drainage basin, for example, can speed up soil erosion, resulting in an increase in the volume of river material downstream. Dam construction, on the other hand, may result in a significant reduction in sediment volume in a drainage basin downstream of the dam.

Because the mechanism of sedimentation is natural, only the pace of deposition is changed indirectly by human action, these sedimentary deposits are not anthrosediments. It is likewise difficult to distinguish such sediments from those of entirely natural origin in the field. As a result, anthropogenic soils and sediments will be referred to as anthrosoils and anthrosediments, respectively (Howard, 2017).

Four types of anthrosoil can be distinguished by their geocultural setting and historical context: (1) Agricultural, (2) Archaeological, (3) Mine-related, and (4) Urban. Anthrosoils in agricultural and archaeological settings were the focus of early scientific investigations dating back to the late 19th century, whereas urban and mine-related anthrosoils were only studied in the late 20th century. In the domains of agronomy and archaeology, the study of anthrosoils is critical, whereas studies of urban and mine-related soils are frequently concerned with environmental concerns.

5. Anthropedogenic processes

Anthropedogenic processes are characterised as artificial settings that dramatically alter natural soil formation processes or causes. Pedogenesis is frequently accelerated or disrupted by human activities, yet many anthropogenic processes can be classified using the same language as natural soil-forming processes. Human activities can have direct or indirect consequences, with reversible or irreversible consequences. They range from tiny alterations at archaeological sites caused by humans employing archaic tools or animal labour (e.g., a wooden plough) to major changes caused by massive pieces of automated equipment employed in modern agriculture, mining, and urbanisation.

Human actions can influence weathering and horizonation. Human alterations that impact the drainage characteristics of the soil might speed up or slow down weathering. Irrigation agriculture or the use of a sprinkler system, for example, can speed up leaching and weathering, whereas compaction or the use of a constructed layer can slow or stop it. Human activities can alter horizonation through affecting contributions, losses, translocations, and transformations in the soil.

Table 3. Comparison between natural and anthropogenic soil-forming processes

Pedogenic process	Natural Example	Anthropogenic Example
Additions to the soil		
Enrichment	Plant nutrients added via Organic matter decomposition	Chemical elements added runoff, acid rain, fertilizer additions
Littering	Organic litter on forest floor	Artificial mulch used in gardening and landscaping
Losses from the soil		
Erosion	Cut bank of meandering Stream	Excavation for building construction, borrow pit, highway, surface mine, etc
Leaching	Seasonal snowmelt	Irrigation; lawn sprinklers
Translocation within the soil		
Pedoturbation	Ground squirrel burrows	Surface mine or demolition site grading, excavation, and backfilling (anthropoturbation)
Transformations within the soil		
Mineralization	Release goethite from decomposed humic materials	Release of magnetite from decomposed fly Ash
Loosening	Pedoturbation by indigenous earthworm species; plant root development	Plowing; burrowing by invasive species of Earthworms
Hardening	Microbiotic crust formation	Compaction by farm or earthmoving equipment

Source: Buol *et al.*, 2011

Table 4. Classification and impacts of human activities on soil properties

Anthropogenic Activities	Impact on soil
Physical	
Excavation	Part or all of the old soil is removed; new parent material is exposed; earth materials are mixed; hydrological conditions are altered; and the microbial community is destroyed.
Construction	Mixing of earth elements; soil burial; alteration of hydrological conditions; microbial population annihilation
Compaction	Decreased aeration, leaching and translocation; reduction of microbial population
Cultivation, plowing	Mixing of the surface horizon; destruction of soil structure; increased soil erosion
Terracing	Modified hydrological conditions
Dam construction on Floodplains	Reduction of sedimentation and leaching; lowering of water table
Chemical	
Fertilizers	Change plant nutrient content and pH
Additions of organic wastes, charcoal, biochar, etc.	Improved aeration and water-holding capacity; increased cation exchange capacity; alteration in the composition of organic soil components
Acid rain	Accelerated leaching of plant nutrients
Mineralogical	
Ponding	Oxide and other minerals dissolve at reduced conditions, resulting in increased leaching and organic matter content.
Fire	Conversion of goethite or hematite to magnetite
Artifacts	Change nutrient concentrations, pH, base saturation, mineralogy, etc.; addition of artificial minerals not present in natural soils;
Biological	
Domesticated plants and Animals	Change in composition of soil organic matter; change in soil biota
Invasive species	Change in composition of soil organic matter; change in soil biota
Pesticides	Change or elimination of soil biota

Source: Howard, 2017

6. Human as a soil forming factor

The state factor approach to soil genesis is a theoretical framework in which soil is characterized in terms of five soil-forming factors, with $S = f(c, l, o, p, t, \dots)$ as the "mathematical" expression.

The equation has never been solved, however Jenny (1941) looked at how one factor changed while the others remained constant. In any given setting, human actions alter one or more of the five soil-forming factors.

Table 5. Impact of anthropogenic activity on soil forming factors

Anthropogenic activity	Impact
Climate	Modify temperature and precipitation by adding or withdrawing water by irrigation or artificial drainage, boosting temperature via fire, global warming, and sealing soils behind a manmade layer such as pavement, and so on.
Organism	The introduction of cultivated plants and animals, the introduction of invasive species, and the addition of organic debris such as household, human, and animal wastes all contribute to devegetation or deforestation.
Landscape	Land raising or leveling, excavation, ground subsidence, and terracing.
Parent Material	Removal of some components, such as soluble salts, and artificial additions of bone, shell, ash, and other artifacts
Time	The pedogenic clock is reset to zero when soil is buried beneath fill or sealed beneath a manmade layer, whereas scalping, excavation, or mixing and deposition of fill exposes fresh parent materials.

Source: Howard, 2017

Given that humans differ from other organisms in that they purposefully manage soils independently of other soil-forming variables, and because they employ technology to affect soils on a far larger scale than other organisms. Some people consider humans to be the sixth soil-forming factor because of their combined effects on soil formation. (Dudal, 2005 and Leguedois *et al.* 2016).

7. Classification of anthropogenic soils

USDA Classification of anthropogenic soils

Anthropogenic soils are classified on the basis of two key characteristics:

- ✓ Parent material
- ✓ The presence of diagnostic horizons

7.1 Based on parent material

Human Altered Material (HAT)

Humans have purposely mixed or disturbed HAM to a depth of 50 cm, but no indication of it having been moved from outside the pedon has been found. There is no standard horizon nomenclature for identifying material that has been altered by humans. The asterisk symbol (*) is used to indicate them informally. Organic and mineral materials can both be found in HAM. It could contain artifacts used as agricultural additives, such as shells or bones.

Human Transported Material (HTM)

HTM is a 7.5-cm-thick layer of organic and/or mineral materials that shows signs of human-caused transport and does not originate from the same pedon as the pedon it overlies. The HTM layer rests unevenly on in situ material (e.g., a buried A horizon) and frequently contains non-agricultural artifacts (e.g., concrete). The caret symbol (^) is used as a prefix in conjunction with master horizons such as O, A, B, or C.

Table 6. Diagnostic horizons of anthropogenic soils

Epipedon	Horizon designation	Description
Ochric	A, ^A	Organic-poor eluvial layer <10–25 cm thick with base saturation <50%
Anthropic	A, ^A	A 25-cm-thick organic-bearing mineral layer developed in HAM or HTM that either covers the mine or contains artifacts.
Plaggen	^A	Organic-rich layer of HTM 50 cm thick containing artifacts and spade marks

Endopedon	Horizon designation	Description
Agric	Bh, Bw, Bt a	Illuvial horizon 10 cm thick located directly below a plow layer containing illuvial silt/clay/humus
Albic	E	Light-colored eluvial subsoil horizon leached of clay and free iron-oxides to such a degree that the color of the horizon is mostly due to uncoated sand and silt particles

Argillic	Bt	Illuvial horizon 7.5 cm thick, forms as a result of the translocation of clay from an overlying eluvial layer
Cambic	W	Mineral horizon of very fine sand, loamy very fine sand, or finer texture, 15 cm thick with some weak indication of reddening/gleying

Source: Soil Survey Staff, 2014

Soil scientists and archaeologists define an artifact as any artificial thing larger than 2 mm in size found in soil. Although discrete artifacts that are non-persistent and/or non-cohesive are not termed coarse fragments, they are classified as a particular type of coarse fragment. Artifacts are significant because they can obstruct root growth and water circulation, as well as contribute significantly to the soil's trace element and total organic carbon content. Artifacts are a typical feature of anthropogenic soils, with different types depending on the geocultural environment. Brick, cardboard, glass, metal, concrete, paper, and plastic are just a few examples.

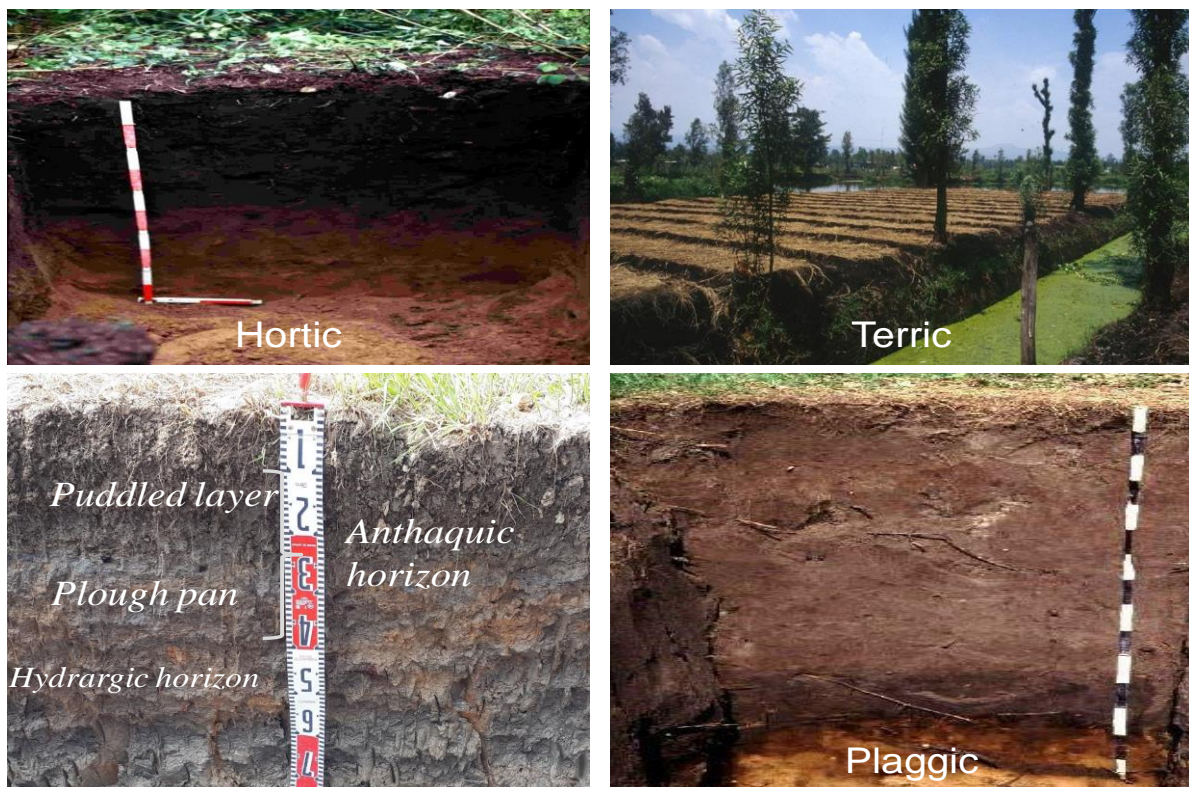


Fig 6. Diagnostic horizons of anthrosols

Entisols are a type of anthropogenic soil that is defined as a mineral soil with little or no evidence of the development of pedogenic horizons. Inceptisols are soils with cambic B horizons found in urban and mine settings. Inceptisols, Alfisols, and occasionally Ultisols are anthropogenic soils with well-developed cambic and argillic strata found on ancient burial mounds.

7.2 World Reference Base of Soil Resources

At the highest level of classification, the World Reference Base (WRB) is made up of 32 Reference Soil Groups (RSGs) (IUSS Working Group 2006, 2015). The RSG name is coupled with a set of qualifiers and supplemental qualifiers to form the second level of classification. According to the WRB, anthropogenic soils are classified using ten primary diagnostic strata and components. Many of them are identical to those used in Soil Taxonomy, while the rest are mostly unknown in the United States. At the second level of classification, various qualifiers are utilised to further identify RSGs.

Anthrosol is a naturally occurring soil that has been significantly altered by long-term human contributions of organic and inorganic components. Anthrosols have been discovered in human habitation sites (e.g., kitchen middens, burials) and in regions where agricultural operations have been undertaken for many millennia, maybe from prehistoric times.

Table 7. Diagnostic horizons of Anthrosols

Epipedon	Horizon designation
Anthraaquic	A puddled layer and a plough pan compose an anthropogenic horizon in paddy soils.
Hortic	Deep cultivation and long-term organic material inputs result in an anthropogenic horizon.
Irragric	Anthropogenic horizons on raised ground developed over time when irrigation water containing fine particles of inorganic and organic debris was continuously added.
Plaggic	Long-term additions of plaggen have built up an anthropogenic organic-rich horizon on raised soil.
Pretic	Long-term inputs of organic materials, such as biochar, have resulted in an anthropogenic organic-rich horizon.
Terric	Anthropogenic horizon on higher land created by long-term inorganic material additions

Endopedon	Horizon designation
Hydragric	Anthropogenic horizon in paddy soils with redoximorphic characteristics
Thionic	Weathering of sulphides caused by strip mining or artificial draining of swamp soils produces an extremely acidic horizon.

Source: IUSS working group, 2015

The presence of materials made, altered, or exposed by human technology that would not otherwise be present at the Earth's surface characterises a Technosol. Urban soils associated with residential and industrial landscapes that contain extensive technogenic artefacts, manufactured (paved) land, and mine soils are all included in the Technosol RSG. Technosols are neogenetic anthropogenic soils with pedogenic properties that show modern human technology's effect. Technosols are anthropogenic soils developed in HTM with 20% artefacts by volume in the upper 100 cm, or with technic hard material (made layer) at or near the ground surface. (Dazzi and papa, 2015)

Table 8. Different Qualifiers of technosols

Qualifiers	Description
Ekranic	Having a 5cm radius of technic hard material from the soil surface
Linic	Soils that have a geomembrane within 100 cm of the soil surface that entirely separates the soil material into two different soils.
Urbic	Within 100 cm of the surface, a layer > 30 cm thick comprising >20 percent by volume artifacts of rubble and rubbish from human activity
Spolic	Having a 25 cm thick layer of industrial waste artifacts within 100 cm of the surface containing >20 percent by volume (mine spoil, dredgings, rubble, etc.)
Garbic	Having a 25 cm thick layer of organic waste objects within 100 cm of the surface that contains >20 percent by volume

Source: Peter Schad, 2018

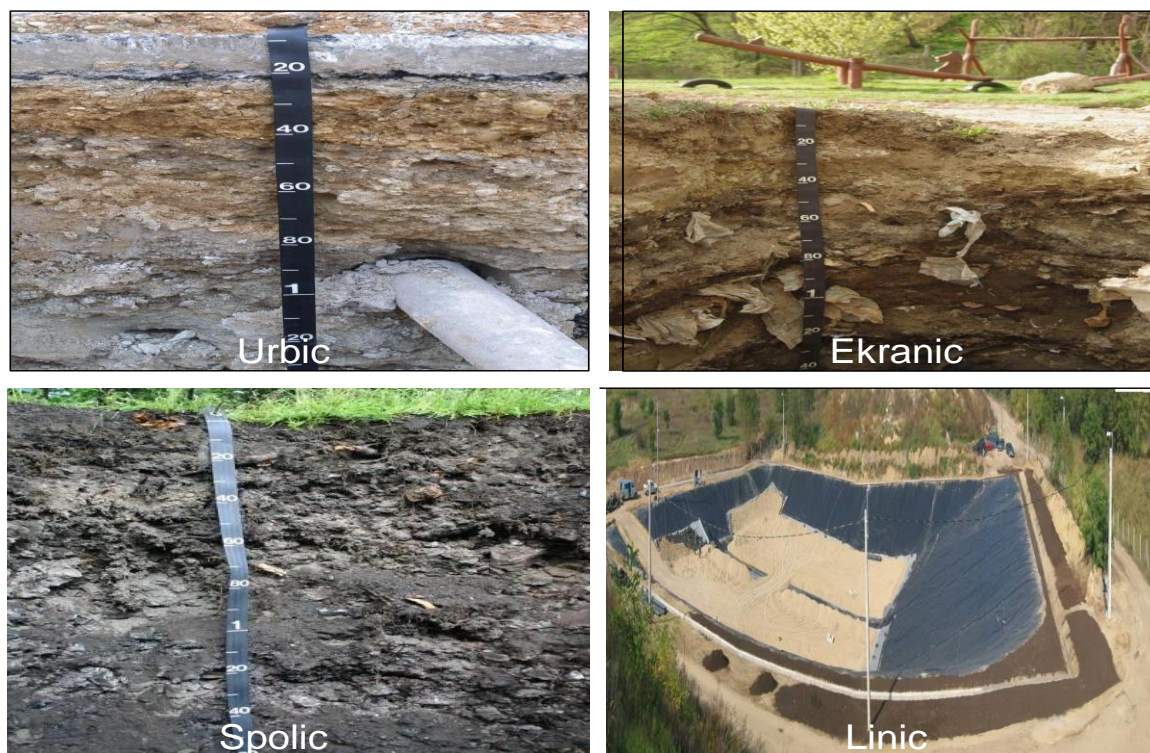


Fig 7. Different types of technosols

8. The Significance of Accelerated Erosion in the Anthropocene

Weathering's production of soil particles and solutes (W) surpassed transport-related losses of particles and solutes via erosion and subsurface runoff, according to Gilbert (1877). (T). W liberates mineral particles and inorganic solutes, T eliminates a fraction of them, and landscapes collect the rest. Agriculture and land-use development, on the other hand, have increased dramatically. Wilkinson and McElroy (Wilkinson and McElroy, 2007). As the Earth transforms from a natural to a human-natural globe, Gilbert's T relates to W. At 1000 m elevation, where most people live, grow crops, and interact with the terrestrial environment, erosion has been increased nearly fully. Natural geologic erosion, on the other hand, is primarily caused by high mountain slopes of 4,000 to 6,000.

According to Panagos *et al.* (2015), 21st-century soil losses due to erosion averaged $2.5 \text{ Mg ha}^{-1} \text{ y}^{-1}$, while Verheijen *et al.* (2009) estimated soil formation at $1.4 \text{ Mg ha}^{-1} \text{ y}^{-1}$. The rapid particle movement and particle deposition caused by Gilbert's T growing overall relative to W has had huge effects for Earth's land and aquatic ecosystems meters.

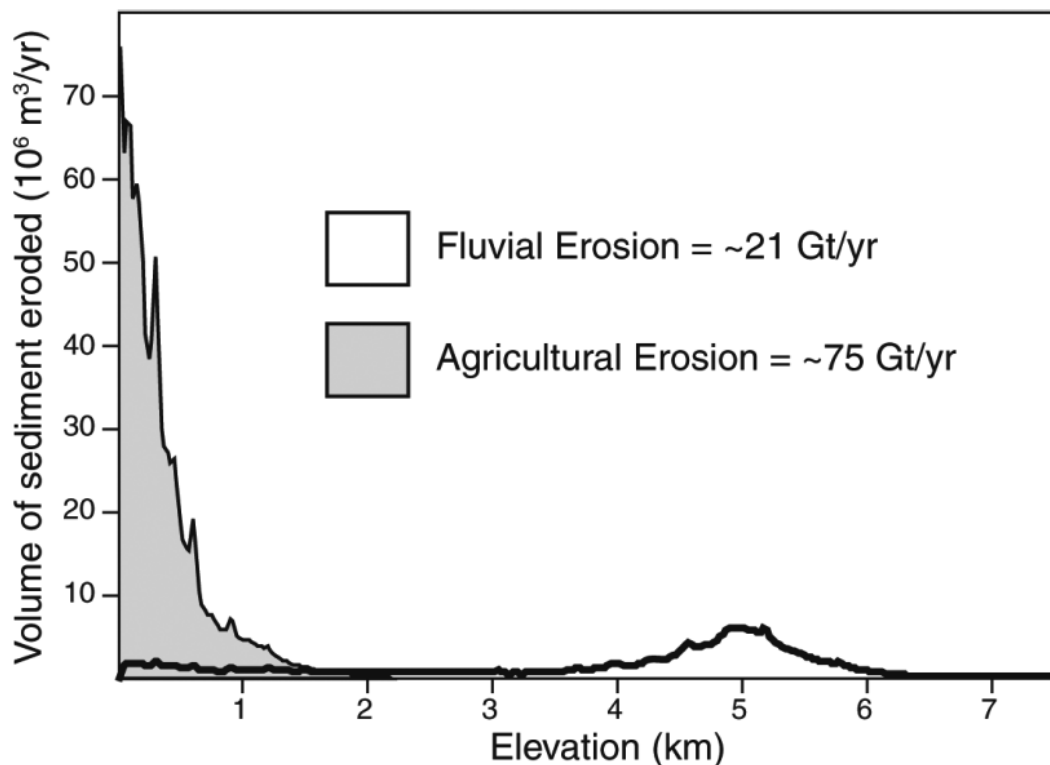


Fig 8. Soil erosion on Earth as a function of elevation and from natural fluvial and agricultural sources

The natural ageing process connected to geological erosion mechanisms is well stored in the distribution tails at larger scales, according to statistical study of gradient and slope distributions (Bonetti *et al.*, 2017). A natural process like this can be influenced by agricultural-driven rapid erosion, which results in significant changes in distribution tails at smaller sizes. The observed morphological variations between disturbed and undisturbed sites were linked to a breakdown in the natural equilibrium between soil creep and runoff erosion mechanisms. (Bonetti, 2019)

Anthropocene- a new context for social innovation and transformations to sustainability



Fig 9. Triple Bottom line thinking

The social, environmental, and economic pillars commonly associated with sustainable development and "triple bottom line" thinking have frequently resulted in trade-off decisions that either ignore or significantly favour the economic. Economic and social factors must be viewed as nested within ecosystems rather than as distinct parts to be traded off. (Olsson *et al.*, 2017).

9. Anthropocene in ecology and conservation

In the year 2000, the word 'Anthropocene' was coined to describe the current epoch in which human impacts are at least as important as natural processes (Corlett, 2015). The Anthropocene idea has centred attention on human-dominated habitats and novel ecosystems in ecology, but it has created a controversial debate in conservation biology about the continued relevance of conventional biocentric goals.

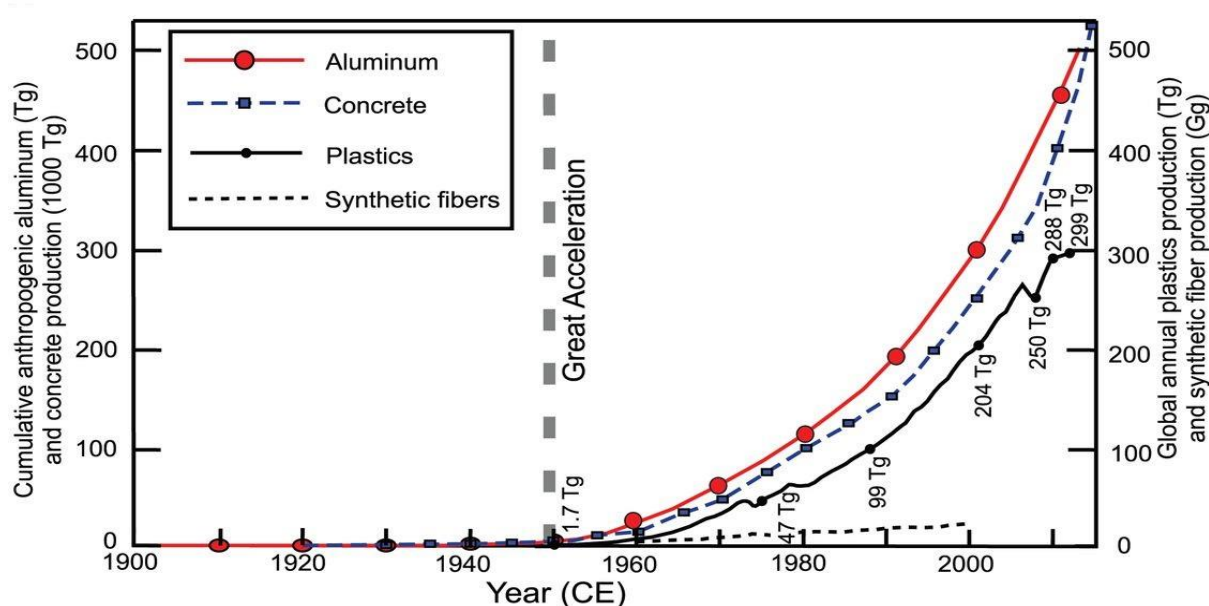


Fig 10. Production of new anthropogenic materials

Humans have created materials previously unknown on Earth, such as pottery, glass, bricks, and copper alloys, throughout millennia. Remains of these materials can be found as a durable and extensive geological signature that is time-transgressive, indicating human migration. In comparison, since 1950 CE, elemental aluminium has produced 98 percent of its total global production of 500 Tg, which was nearly unknown in its native form before the 19th century. From World War II (1939–1945CE) onward, concrete, which was created by the Romans, became the principal building material. More than half of the 50,000 Tg of concrete ever made (Fig.) was produced in the last 20 years (1995–2015), equivalent to 1 kgm² of the planet's surface. Concrete and aluminium are commonly used in terrestrial environments, particularly in metropolitan areas. Similarly, from the 1950s to the present, the production of novel organic polymers (plastics), which were first developed in the early 1900s, has increased dramatically. (Waters *et al.*, 2016).

10. Conclusion

The basic science of pedology, the study of natural soil formation, is evolving into the science of anthropogenesis in the Anthropocene. The Soil Survey Manual has been updated to include descriptions of human altered and transported materials (HAHT soils), the 2014 Soil Taxonomy Keys has been updated to include over two decades of ICOMANTH work, and the WRB now recognizes soils altered by agriculture, urban, and industrial development. In Soil Taxonomy, a new soil Order that represents "anthropogenic soils" will most likely be added in the future. Several ideas to identify the groups of anthropogenic soils have been offered, but no broad agreement has been established as of yet. The most serious issue is how to deal with the reality that there is only a basic mathematical understanding of how human forcings affect soils. Anthropology is the future of pedology, a revived discipline that draws on past pedology but goes from "human as outsider" to "human as insider." The human must change from a soil-disturbing to a soil-forming agent in pedology.

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