

The Technosols: The Anthropocene's New Soils

Monali Raut

PhD Scholar, Dept. of Soil Science & Agricultural Chemistry,
University of Agricultural Science, GKVK, Bengaluru-560065

Email: monali123raut@gmail.com

DOI: [10.5281/TrendsInAgriculture.18825348](https://doi.org/10.5281/TrendsInAgriculture.18825348)

Introduction

Traditionally, soil has been contemplated as a natural entity that is formed by topography, time, organisms, climate, and parent material. But human activity has emerged as a potent soil-forming factor in modern cities. Natural landscapes are being drastically altered, and whole new soil systems are being created by urbanization, industrialization, development, and garbage disposal.

In urban pedology, which examines the development, characteristics, and uses of soil in urban environments, these human-influenced soils are referred to as "Technosols." Technosols demonstrate the significant impact of humans on Earth's surface and are considered prototypical soils of the Anthropocene.

Given the fast growth of the world's urban population, knowledge of Technosols is now crucial for ecosystem management, environmental preservation, and sustainable urban design.



Figure 1. Technosol profiles after 1 month, 1 year, and 3 years for OP (left) and MP (right) treatment (Grard *et al.*, 2025)

What Are *Technosols*?

Technosols are soils that include large amounts of artificial or man-made materials such as ash, polymers, metals, building detritus, industrial waste, or other engineered materials, known as artefacts, and whose characteristics and origin are dominated by technical human activity. According to the **World Reference Base for Soil Resources (WRB)**, *Technosols* constitute a reference soil group characterized by strong human influence and the presence of substantial amounts of technogenic materials in the soil profile.

Key Features

- Human-made materials predominate the soil profile.
- Presence of artefacts like concrete, bricks, or waste materials
- Rapid formation driven by urban activities
- Artificial or disturbed horizons
- Strongly altered physical and chemical properties

Technosols may develop within decades due to rapid urban development instead of centuries, as natural soils do.

Technosols in Urban Pedology

Urban pedology acknowledges that the soils found in cities are diverse, ranging from almost natural soils to entirely artificial substrates. *Technosols* are at the end of this spectrum, when soil qualities and functions are dominated by human impact. They are distinct from *Anthrosols*, another group of soils that have been impacted by humans, where agricultural practices, rather than industrial or technical materials, are primarily responsible for soil modifications.

The early 2000s saw the inclusion of *Technosols* in worldwide soil categorization systems, reflecting a growing understanding that human activity is now a key global driver of soil formation. (Rodríguez-Espinosa *et al.*, 2021)

Formation of *Technosols* in Urban Environments

Anthropogenic pedogenesis is the aggregate term for the processes by which *Technosols* originate when natural soil-forming systems are altered by human activity.

Principal Pathways of Formation

1. **Activities Related to Construction and Demolition:** Building materials, cement, and debris from urban growth combine with soil to form new soil layers
2. **Manufacturing Operations:** Technogenic materials originate from metallurgical wastes, fly ash, mining residues, and industrial byproducts.
3. **Landfills and Waste Disposal:** Garbage dumps, sludge, and municipal debris eventually turn into soil-like structures

- Constructed or Engineered Soils: To maintain vegetation or repair degraded soil, *Technosols* can be purposefully made from organic and mineral wastes.

Therefore, urban soils could be both purposefully created substrates and unintentional byproducts of disturbance.

PART NO.	1	2	3	4	5	6	7	8	9
SOIL LAYERS	CONCRETE COVER	ORGANIC WASTE LAYER	GEOTEXTILE MAT	GRANULAR LAYER	HDPE LINER	CLAY LINER	PREPARED SUBGRADE	EARTH	WATER TABLE

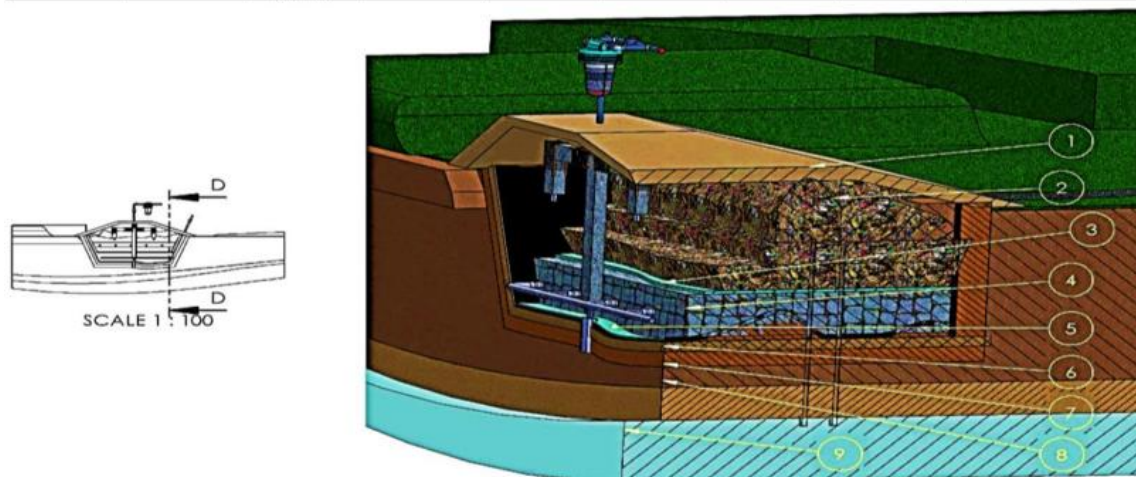


Fig. 2: Cross-sectional view of the landfill layers in Nigeria (Ikpe *et al.*, 2023)

Characteristics of *Technosols*

Technosols are substantially different from natural soils due to their heterogeneous composition and artificial origin.

Physical Characteristics

- irregular layering and High heterogeneity
- reduced porosity and Strong compaction
- Variable drainage and water retention

Chemical Properties

- Due to concrete and lime materials, the pH is often high.
- Variability in nutrient availability
- Potential contamination with heavy metals or pollutants

Biological Characteristics

- Initially, a low level of microbial diversity
- Progressive ecological development over time
- Adaptation of stress-tolerant organisms

Urban disturbances, including compaction, pollution, and altered temperature regimes, can further influence soil functioning and plant growth. (Schröder *et al.*, 2024)

Constructed *Technosols*: Designed Soils for Cities

The development of constructed *Technosols*, or engineered soils generated from organic and mineral wastes to perform particular ecological functions, is a significant advancement in urban soil science.

Commonly utilised materials consist of:

- Crushed rock and construction debris
- Ash and mining residues
- Organic waste and compost.
- Sludge from sewage or biochar

These soils are made to offer ecosystem services that are on par with or superior to those of natural soils. (Rodríguez-Espinosa *et al.*, 2021)

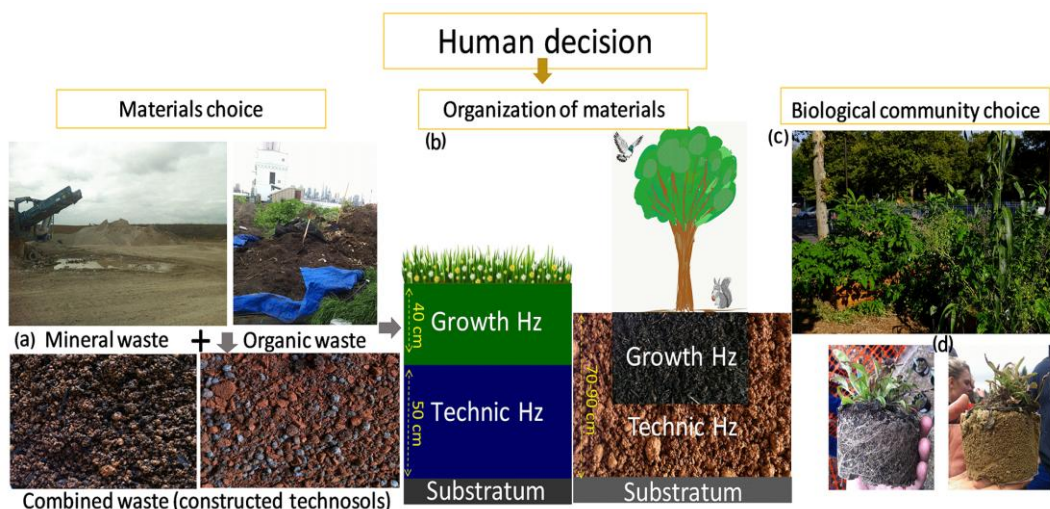


Figure 3. The diagram presents abiotic and biotic components of constructed *Technosols* (Deeb *et al.*, 2018).

Applications

- Urban landscaping and green spaces
- rooftop gardens and green roofs
- Reclamation of Brownfield
- Stormwater regulation
- Urban agriculture

By converting waste materials into valuable soil resources, constructed *technosols* also promote circular economy principles.

Environmental Functions and Ecosystem Services

Technosols have many ecological advantages despite their artificial origin:

Service	References
Vegetation and crop support, developing a root environment for the soil–water–plant system	Bolaños-Guerrón <i>et al.</i> (2014)
provision of plant nutrient	Bokaie <i>et al.</i> (2016)
Defence against flooding and damage from rainstorms	Carson <i>et al.</i> (2012)
Enhance runoff and hydrological processes	Cascone (2019)
Enable metabolic cycles to occur.	Deeb <i>et al.</i> (2018)
Erosion control	Falkowski <i>et al.</i> (2000)
Reduce the effect of the urban heat island	Lehmann (2006)
Host biodiversity	Macías <i>et al.</i> (2010)
Decontamination (retention, phytoremediation and microbial bioremediation)	Navarro-LeBlond <i>et al.</i> (20210
Building energy conservation, acid rain prevention, sound exposure reduction, and aesthetic value enhancement (rooftop with <i>Technosol</i>)	Qi <i>et al.</i> (2024) ; Rees <i>et al.</i> (2019)
Circular economy (use of wastes)	Rodríguez-Espinosa <i>et al.</i> (2021)
To combat the consequences of climate change and attain emission neutrality (carbon sink, low carbon footprint)	Rodríguez-Espinosa <i>et al.</i> (2021)
Urban Health	Rodríguez-Espinosa <i>et al.</i> (2021)

Challenges and Environmental Concerns

Additionally, *Technosols* pose managerial challenges:

- The possibility of heavy metal or hazardous material contamination
- Inadequate fertility and soil structure
- Inconsistent stability throughout the long run
- The requirement for ongoing observation
- Possible hazards to human health from urban agriculture

Therefore, before using them for food production or environmental restoration, careful characterisation and management are crucial.

Future Perspectives in Urban Pedology

Technosols are becoming increasingly prevalent as urbanisation spreads quickly throughout the world. Future urban pedology study will concentrate on:

- Constructed soils with sustainable design
- Technologies for remediating soil
- Keeping an eye on the health of urban soil
- Improving ecosystem services and microbial diversity
- Integrating soil management in urban planning

Building resilient and ecologically sustainable cities will require an understanding of *Technosols*.

Conclusion

Technosols are a novel class of soils that are predominantly formed by human activity as opposed to natural processes. They represent the transformation of Earth's surface in the Anthropocene and emphasise growing significance of urban pedology in environmental science. Technosols will be essential to the urban ecosystems' functioning, environmental quality, and sustainable development as cities continue to grow. The future of urban environments will depend on the identification and management of these man-made soils.

Reference:

- Bokaie, M., Kheirkhah Zarkesh, M., Daneshkar Arasteh, P., and Hosseini, A. (2016). Assessment of urban heat island based on the relationship between land surface temperature and land use/ land cover in Tehran. *Sustain Cities Soc.* 23, 94–104.
- Bolaños-Guerrón, D, and Macías, F. (2014). Using technosols for the treatment of eutrophication in water bodies. International perspective for water and environment IPWE. Reston, VA, USA: ASCE American Society of Civil Engineers and EWRI Environmental and Water Resources Institute.
- Carson, T.B., Hakimdavar, R., Sjoblom, K.J., and Culligan, P.J. (2012) Viability of Recycled and Waste Materials As Green Roof Substrates. *Geo Congress. State of the Art and Practice in Geotechnical Engineering*.
- Cascone, S. (2019) Green roof design: state of the art on technology and materials. *Sustainability*.
- Deeb, M., Groffman, P., Joyner, J.L., Lozefski, G., Paltseva, A., and Lin, B., Mania K, Cao, D.L., McLaughlin, J., Muth, T., et al. (2018). Soil and microbial properties of green infrastructure stormwater management system. *Ecol Eng.* 125, 68–75.
- Falkowski, P., Scholes, R.J., Boyle, E., Canadell, J., Canfield, D., Elser, J., et al. (2000). The global carbon cycle: a test of our knowledge of Earth as a system. *Science*, 290, 291.
- Grard, B.J.P., Barrier-Guillot, A., and Chenu, C. (2025). Early pedogenesis of a young Technosol made from organic wastes. *Geoderma*, 459, 117343.
- Ikpe, A.E., Akpan, N.E., and Bassey, M.O. (2023). Design and construction of an energy-specific landfill gas production system for use in Nigeria. *Advances in Engineering Design Technology*, 5(1).
- Lehmann A. (2006). Technosols and other proposals on urban soils for the WRB (World Reference Base for Soil Resources). *Int Agrophys*, 20,129–34.
- Macías F, and Camps Arbostain M. (2010). Soil carbon sequestration in a changing global environment. *Mitig Adapt Strateg Glob Change*. 15, 511–29.
- Navarro-Leblond, M., Meléndez-Pastor, I., Navarro-Pedreño, J., and Gómez Lucas, I. (2021). Soil sealing and hydrological changes during the development of the university campus of Elche (Spain). *Int J Environ Res Public Health*, 18, 9511.

- Qi, S, Cheng, Z., Hallett, R., Egendorf S.P., Reinmann, A.B., and Groffman, P.M. (2024). Feasibility of constructed soils for tree planting. A pilot study in New York City. *Urban For Urban Green*.
- Rees, F., Dagois, R., Derrien, D., Fiorelli, J., Watteau, F., Morel, J.-L., et al. (2019). Storage of carbon in constructed technosols: in situ monitoring over a decade. *Geoderma*, 337,641–8.
- Rodríguez-Espinosa, T., Navarro-Pedreño, J., Gómez-Lucas, I., Jordán-Vidal, M.M., Bech-Borras, J., and Zorpas, A.A. (2021). Urban areas, human health and Technosols for the green deal. *Environ. Geochem. Health*, 43(12), 5065-5086.
- Schröder, A., Schloter, M., Roccotiello, E., Weisser, W. W., and Schulz, S. (2024). Improving ecosystem services of urban soils–how to manage the microbiome of Technosols? *Front. Environ. Sci.*, 12, 1460099.