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Review

Constructing Soils to Mitigate Land Occupation by Urban Expansion and Metabolism to Improve Healthy Cities

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Abstract: The number of city residents worldwide is increasing at the same that soil consumption around cities, which can be mitigated using technosols. Urban areas need to provide a healthy environment for residents, but this is threatened by climate change. Mitigating the adverse impacts of climate change does not involve one-size-fits-all global solutions; cities face varying economic and social contexts. Cities need to offer ecosystem services in order to operate as healthy urban ecosystems. The urban soils' environmental services are often overlooked, leading to public administrations having little to no awareness about land management policies and ecosystem services. Technosols, artificial or human altered soils, have the potential to provide the same ecosystem benefits as natural soils and do not require as much time to develop in order to perform their functions. Additionally, technosols have the potential to enhance the circular economy using waste materials. In this sense, policy makers should incorporate urban technosols as a strategy to enhance the health of cities and address climate change. Our perspective on soils in urban areas needs to be altered, as technosols should be included in urban policies, have the potential to serve as a crucial component in providing ecosystem services and acting as a carbon sink and enhance urban well-being.

Keywords: ecosystem services; soil sealing; urban environments; urban well-being; zero wastes

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1. Introduction

Population is increasing and, at the same time, the increment of urban inhabitants along the world is growing. Today, some 56% of the world population (4.4 billion inhabitants) are living in cities and the projection given by the World Bank is that 7 of 10 people will live in cities by 2050 [1]. Changes in the size of human population as well as changes in the activity of sectors such as transport and tourism may lead to urban expansion and infrastructure construction [2]. The expansion of cities is basically built consuming soils in peri-urban areas affecting soils with greater agricultural potential [3]. Cities typically adhere to a disperse or compact land use model centered around a core area, often based on topography and transportation routes, among other considerations (Figure 1). In huge cities, a polyhedric model is conformed based on the same premises, considering several cores. Nickayin et al. [4] indicated that an inverse relationship between land take intensity, and soil and climate quality indexes, provides evidence that compact and dense settlements can be considered a more sustainable urban growth model than discontinuous, dispersed settlements. In general, there is an agreement that compact and dense urban areas are critical in combating climate change and inequality [5]. One of the reasons may be that soil consumption is reduced as well as urban sprawling, leaving free land that can exercise its environmental functions.

Urban areas are characterized by the need of resources and the production of wastes, which is basically known as urban metabolism. Derrible et al. [6] defined urban metabolism as it is fundamentally an accounting framework whose goal is to quantify the inflows, outflows, and accumulation of resources (such as materials and energy) in a city. However, it is important to attend to the wastes generated and soil consumption. In fact, people living in urban areas have the same necessities that those living everywhere: clean air, safe water, enough food and other materials, energy and land. Urban systems exchange materials both among the components of the system and between the system and its external environment [7]. The material impact of global urbanization was estimated from 40 billion tons in 2010 to 90 billion tons by 2050 [8]. As a consequence, many resources are required for future urbanization. Analyses of an urban metabolism and its sustainability must therefore consider the utilization of energy and materials within a hierarchy of spatial scales [9]. Urbanization is not the only challenge; However, the movement of people and goods between cities and the infrastructure necessary for this mobility are also important. All of them are associated with land consumption in urban, peri-urban and inter-urban areas.

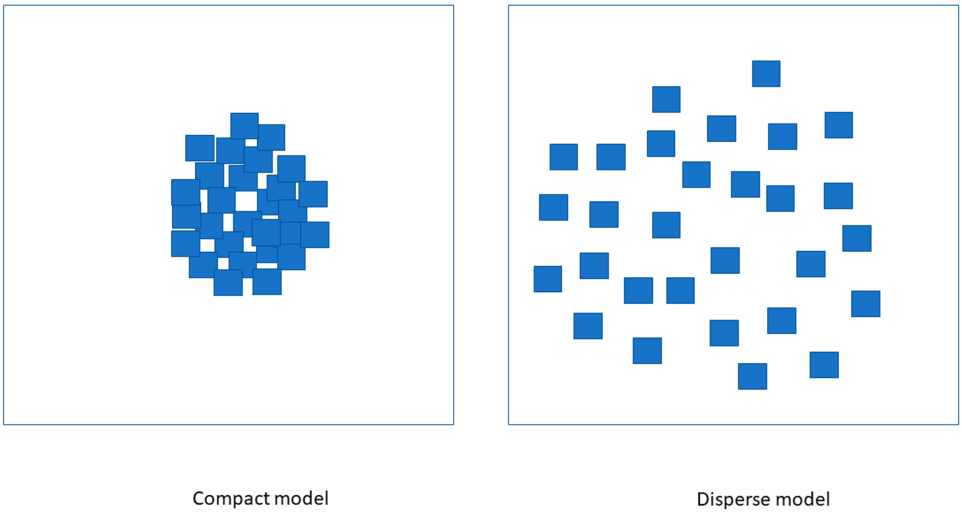

Figure 1. Compact versus disperse land occupation.

The supply of resources to urban areas is a complex task, because it is necessary an uninterrupted supply of energy, materials and water that produce a great impact, favoring climate change, mostly in disperse cities (i.e., by road transport). The activities that take place in or around cities consume about 75 per cent of global primary energy and emit between 50 and 60 per cent of the world's total greenhouse gases [10]. As mentioned above, cities have to tend to be compact and reduce energy consumption to combat the negative effects of climate change, in a future scenario in which great urban development is expected. As previous reports indicated [9,10], hierarchized, compacted and organized cities can help to mitigate greenhouse emissions, favored the internal mobility and reduce energy consumption.

However, cities should be a safe and healthy area for their inhabitants, and this is mostly based on a healthy environment. The design of urban environments and the interventions in urban fabrics should be achieved through the application of an integrated and multisectoral, multistakeholder approach, guided by policy frameworks that ensure that human and environmental health go hand in hand [11]. Herick de Sa et al. [11] indicated that identifying key challenges and opportunities for interventions is crucial to improve the health and wellbeing gains of urban dwellers and reducing exposure to stressors, shocks, and hazards, while also contributing to fostering wellbeing and reducing health inequalities. The environmental factors in a community significantly impact its residents, affecting their well-being and access to resources. Furthermore, this significantly impacts the promotion of sustainable practices relying on local resources.

Many strategies can be adopted to reduce the impact of cities and their growth, diminishing the carbon and water footprint and adapting cities for climate change. Among them, local food supply, reduction of water consumption, the increment of the use of public transport systems and implementation of renewable energy sources are considered as major topics, among others. However, it is very important to contextualize each area, looking for the synergies with the environment and considering critical the land occupation.

This concept of synergy represents an important step to increase and facilitate our adaptation. It is very common to identify the complementarity of human activities with land resources to indicate that the actions can be done accepting low impact and being sustainable. This approach considers that the solutions to mitigate climate change are not global solutions because every region or country starts from very different economic and social situations. As they have limited availability of resources, energy, water, food. . ., it is necessary to know the regional geographical context [11,12]. Nevertheless, it is almost obligatory to look for synergies between human activities and the environment to have success. Complementarity, is not sufficient to address the existing and projected impacts of climate change, especially in the land use and management. Thus, climate policy should start looking at the next possibility, synergy, which has often been overlooked or sometimes confused with complementarity [13]. Synergy favors the win-win strategies, which are basic for sustainable social, economic and environmental development. Furthermore, it is a way to promote the comprehensive development of the territory. Lack of adaptation action is costly. Currently, it is about economically quantifying the effects of not adopting climate change adaptation policies [14]. In the same way, the cost of caring for diseases derived from living in unhealthy environments is studied. Cities must offer such healthy environments.

A healthy city should be able to supply resources and wellbeing to the inhabitants. Apparently, the way forward is for cities to function as healthy urban ecosystems that provide ecosystem services. When humanity is considered a part of nature, cities themselves can be regarded as a global network of ecosystems [15]. The need for clean air, optimal urban hydrological cycles that store water as a key resource and the improvement in the production and use of energy, with the implementation of renewable energies, are fundamental tasks that must be incorporated into municipal policies. Furthermore, they must be assumed by citizens and required of administrations. Nonetheless, it seems to be a common trend in both developed and developing nations that environmental services within city limits are often overlooked or neglected in urban, regional, and national policies. The environmental benefits provided by urban soils are often overlooked by public administrations, leading to a lack of awareness about policies concerning land management and ecosystem services. Because of their growing significance, urban planners should view soils as valuable assets. Indeed, soils are expected to be multifunctional to ensure sustainable development of human societies and to resist major environmental issues [16].

Soils are a one of the keys to mitigate climate change, as it is recognized by many international administrations and organizations [17,18]. It is well known that natural soils offer ecosystem services [19] in the four major categories: provisioning, regulating, cultural and supporting services [20,21].

The development of a natural soil needs a lot of time, although it is variable, depending on environmental conditions and forming factors. It is mentioned that in optimum conditions and a mild climate, it takes between 200–400 years to form 1 cm of new soil, and that's if you don't try to grow anything in it. In wet, tropical areas soil formation is faster; here you can create 1 cm in a mere 200 years and soil profile has a low development [22]. It is therefore clear that soil loss is a serious problem and we must implement solutions that limit this issue.

All life on Earth depends on the top 20 cm of soil, and we are losing soil at an alarming rate [22]. With urban expansion projected to increase in the coming years, soil in urban and peri-urban areas will be depleted due to occupation and sealing. Urban areas are unprepared to support and enhance natural soils despite planning strategies shifting towards promoting the inclusion of green infrastructures. With the objective of making cities healthy, the role of soils is critical to keep healthy environments. For instance, less vegetated surfaces lead to a decrease in evaporative cooling, whilst an increase in surface sealing results in increased surface runoff [23]. It is essential to seek out policies that can supply soil for urban areas, delivering ecosystem services. From this perspective, the European Union's policies regarding land are advancing in several aspects that will be key for the future. Among them the following stand out by 2050: (a) all EU soil ecosystems are healthy and more resilient and can therefore continue to provide their crucial services, (b) there is no net land take and soil pollution is reduced to levels that are no longer harmful to people's health or ecosystems, (c) protecting soils, managing them sustainably and restoring degraded soils is a common standard [24].

The urban growth and city metabolism consume soil [8], sprawling the urban area and most of the times sealing soils, provoking changes transforming soils from a natural state to an anthropized, under unsustainable policies [2]. Urban environments cannot naturally develop soils due to the lengthy time required for the process. So, new strategies should be applied to recover land urban ecosystems based on soil. Urban areas must restore the health of city soils and their capabilities and functions. It is essential to consider the development of technosols in urban areas to resemble natural soils because of the difficulty of the task. It is crucial to comprehend the operation and application of designed and custom-made soils, technosols, with several types of materials, in urban areas to function as natural soils.

In this work, we highlight the need to increase functional soils in urban areas, which can offer environmental services and generate healthier cities for citizens. The strategy presented is to promote the implementation of technosols, based on our experience and recent literature, as well as on the initiatives that have been put into practice by various international organizations in the last decade, soils built with a specific purpose or purposes, adapted to the environment where they will operate and based on the use of residual materials, uncontaminated wastes, produced during urban metabolism and the supplied materials for the development of the cities.

In this article, technosols are described, starting for their current and prospective recognition in the main soil classification systems, considering that soils have a key role in the environment. Moreover, they are presented as a tool that can help to mitigate climate change and promote the incorporation into urban planning policies, under the main strategies derived from main international organizations and specially from the European Union. However, it is important to keep natural soils, warnings about soil's exhaustion and endangered ecology raise concerns marked by fears of gloomy environmental futures, prompting scientists and soil practitioners urgently to develop better ways of taking care of soils [25].

2. What Is a Technosol?

Several materials have the ability to partially perform some of the functions of soils, i.e., inert materials supporting plants in a hydroponic system, others that can supply nutrients for plant development via slow release like some fertilizers, etc., but they should not be considered like a soil. However, when we are talking about technosols, we refer to a substrate that is functioning as a natural soil, keeping all the functionality, but it has a strong human influence. Technosols were defined by the presence of technogenic materials, or artefacts, which are substances made or strongly altered by human activities, like bricks, concrete, and steel mill sludge, or brought to the surface, like excavated bedrock [26].

These can be done mixing diverse materials or can be the result of several human processes that change the surface of the Earth, for instance, accumulating artifacts or wastes. In fact, a technosol has or can be made by different materials in such a manner that they can work as a natural soil. However, this general concept must be qualified, considering the most important soil classification systems. In fact, considering the World Reference Base (WRB) for Soil Resources in the last review of 2022 [27], technosols formed as a group of soils that accomplished with the characteristics mentioned in the Table 1.

Table 1. Key to the Reference Soil Groups: Technosols in the WRB.

Other Soils:	
	1. with all of the following: a. one or both of the following: i. having ≥20% (by volume, weighted average, related to the whole soil) artefacts in the upper 100 cm from the soil surface or to a limiting layer, whichever is shallower; or ii. having a layer, ≥10 cm thick and starting ≤50 cm from the soil surface, with ≥80% (by volume, weighted average, related to the whole soil) artefacts; and b. not having a layer containing artefacts that qualifies as an argic, duric, ferralic, ferric, fragic, hydragric, natric, nitic, petrocalcic, petroduric, petrogypsic, petroplinthic, pisoplinthic, plinthic, spodic or vertic horizon starting ≤100 cm from the soil surface, unless buried; and c. not having a limiting layer, unless consisting of artefacts, starting ≤10 cm from the soil surface; or
	2. having a continuous, very slowly permeable to impermeable, constructed geomembrane of any thickness or technic hard material starting ≤100 cm from the soil surface.

Sometimes, it is not easy to classify the "constructed or built soils" inside a soil classification system, even in one of the two main classification system used worldwide. Notwithstanding, there is an important effort to include this type of soils in these systems. For instance, Galbraith proposed a new soil order "Artesols", for the Soil Taxonomy as it is available in the Natural Resources Conservation Service [28]. As this researcher proposes, humans have become a major soil forming factor, and the extent of human modification of soil is growing. So, significantly altered soils should be recognized in a new soil order. The justification of the name is given in Table 2.

Table 2. Artesols as proposed by Galbraith as a new order for the Soil Taxonomy.

Artesols	
Name	Artesols (from Latin phrase *arte factum* made with skill). Formative element: art.
Reason	Soils in the Artesols order form in human-altered soils or in human-transported material following intentional human activity. They are made with skill and many contain artifacts that are also made with skill. The art formative element starts with a vowel and fits well linguistically with the suborder formative elements. The art formative element is different enough from existing formative elements to avoid confusion in pronunciation.

Despite the problems that a mixture of materials that behave and act like a soil can present regarding the soil classification systems, we consider that those mixed is prepared expressly to function as a soil. It tries to imitate soil properties and functions so, we will consider them as built or technical soils, or technosols. Moreover, the objectives of this constructed soils, most of the times, are to reproduce and recover the environmental services that a natural soil can do at the same time that they are configuring and transforming the space where they are used and applied.

Form the point of view of forming factors and soil processes, technosols are (i) man-made soils, (ii) created under a relatively warm and humid climate favorable for soil evolution, (iii) surprisingly biologically active, (iv) generally developed on flat land surfaces showing high heterogeneity in depth, (v) relatively young, and (vi) with reactive artefacts as parent materials [29]. Pedogenic processes observed in technosols are similar to those occurring in more natural soils; however, they are associated in unusual assemblages and generally seem to act rapidly, generating a quicker soil evolution [29]. The constructed technosols have their own evolution and, similarly to natural soils, technogenic parent materials are transformed by pedogenic factors contributing to their evolution. Evidences of original pedogenic processes have been highlighted that could be considered as a general diagnostic characteristic of Technosols [30]. However, the temporal dynamics of these soils remains scientifically uncertain.

3. Making Technosols

A natural soil is composed by solids and fluids (air and water). As a common rule, most of the Soil Science manuals state that the ideal volume proportion between soil solids, soil water and air would be approximately 50:25:25 expressed in percentage (Figure 2). Considering the solid fraction of the soil, the estimation is that 45% corresponds with mineral matter and 5% organic matter [31].

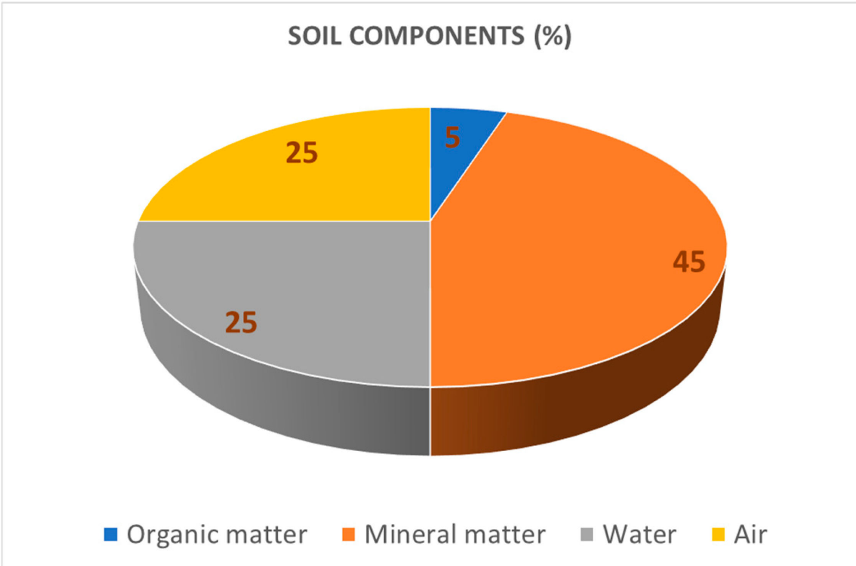

Figure 2. Typical soil fractions (in volume) in an idealized natural soil.

Under this idea in mind, the first step to construct a technosol should be to prepare a mixture of materials (some examples in Figure 3), following the basic proportion presented in Figure 2. It seems necessary to have inorganic materials as the mineral matter of the soils (45%), organic materials to form the "soil organic matter" (5%) and lead a porous space close to the 50% of the total volume, to be occupied by air and water, in a proportion that will depend on environmental conditions and soil management. This part is the soil porosity which is needed for the movement, exchange and availability of water and air for plants. The behavior and quality of soils depend on an interconnected and adjustment between physical, chemical, and biological aspects [32], and this should be considered for making a technosol.

Figure 3. Some inorganic and organic materials that can be part of a technosol: volcanic crushed rock, perlite, gravel limestone rock, sewage sludge compost, hay straw and crushed palm leaf, from left to right (photographs taken by the authors).

Nevertheless, the process of making technosols appears straightforward, focusing only on achieving a balanced mix of organic and inorganic components. However, this is far from simple. Soil is an intricate environment and various factors must be considered. It is important to prioritize the destination and functions of the soil for their intended use, basically the creation should follow the order of soil use and ecosystem services targeted. It is very different to prepare a technosol to supply nutrients for plant growth [33] or to have a soil acting as a filtration system to reduce the presence of pollutants and recovery degraded areas [34]. The use of the technosols is a priority criterion to prepare them as a main function is being sought, without underestimating the rest of the functions that a soil performs. Technosols are defined as deliberate mixtures of organic and mineral wastes and by-products constructed to meet specific requirements [35].

For instance, if the soil is going to be constructed in a temperate region and the main functions are going to be plant support and nutrient supply, probably, the inorganic fraction should be close to that of a textural class that allow an appropriate plant nutrition, because texture influenced numerous soil properties including: drainage, water holding capacity, aeration, susceptibility to erosion, organic matter content, cation exchange capacity (CEC), pH buffering capacity and soil tilth [36]. It could be, for instance, a loam soil. In general, the size of the inorganic particles is important and specially, those forming the fine earth for plant nutrition (under 2 mm of apparent diameter). Moreover, the possibilities of forming clay-humus complex with the organic matter should be critical to keep and provide nutrients for the plants (cation exchange capacity) and soil aggregation [37].

Although, it is necessary to take into account the specific plant nutrition of the different types of plants that are going to be supported by the soil, the local environment and their characteristics are also relevant. If the main role of a technosol would be the facilitation of the infiltration of water, i.e., to store water from rain and surface runoff, functioning as sustainable urban drainage systems, the sand fraction has a key role to facilitated the flow and leaching of water through the profile and the presence of coarse fragments [38]. In this situation, artificial soils could be used either as a part or constitute entirely the sustainable urban drainage systems.

However, technosols serve a similar purpose as a natural soil but can be more targeted in their intended function, so they must be carefully constructed with a balance of properties. These are some of the findings obtained from multiple experiments conducted in recent years, involving the preparation and testing of technosols [39]. Notwithstanding the foregoing, the composition and balanced between fractions should be considered as a first step to prepare functional technosols.

As Fabri et al. [40] shown, technosols appear to be a good solution to the problems of land degradation and urban green if using recycled wastes or by-products. Nevertheless, waste use requires analysis to ensure the salubrity of the starting materials. Moreover, materials produced on site or nearby minimize the cost and the environmental impact of transport, thus the involvement of local stakeholders in the urban land management must be encouraged [40]. As urban metabolism generated different types of wastes, those can be used to prepare *à la carte* soils to perform different functions that are necessary within cities, mainly focused in the ecosystem services that technosols can provide, although technosols can also fulfill and promote aesthetic functions in cities that should not be undermined. These services must not only be complementary, but must seek the existence of synergies with the urban environment and human activities that favor their implementation.

4. Technosols, Wastes and Policy Makers

Urban metabolism leads to the generation of common city waste that must be properly managed and recycled when feasible. These are premises for the adoption of a circular economy and the zero waste regulations put in place by the European Union. Those are the way to be followed and adopted, and, at the same time, cities can be adapted to climate change and minimize greenhouse gases emissions by these strategies [41].

Technosols should be considered by policy makers and are having a crucial role in the European Green Deal [39]. Inside the Zero Waste Masterplan for cities, soils and technosols should be included inside the strategies to achieve the targets of the circular economy. However, they are not included, as it can be seen [42], and this is a mismanagement. Climate Change and land use are closely connected as well as the zero-waste strategy and circular economy. They can also be linked to the beneficial practice of creating technosols when natural soils are degraded and disappeared.

Technosols can be constructed by using many urban wastes, but not all of them can be useful. In general, the selected wastes can be used after an appropriate preparation and determining first the place and functionality desired. Some of the most common wastes that can be used are demolition and construction waste [43], municipal solid waste [44], wastewater treatment sludge [45], and urban pruning remains [46], among others (Figure 3). Most of the times, these great variety of wastes, among others, should be prepared in many ways, but basically: drying, composting, cutting, grinding, sieving and selecting the components that will constitute the new soil. Their prior characterization is necessary to know if they have contaminating elements, in addition to knowing their properties that can be decisive for the formulation of the technosols.

Technosols can help to improve circular economy as they can be constructed by using appropriate wastes, linked the zero-waste strategy. This constitutes, in fact, a synergy between urban metabolism and soil formation (Figure 4). Policy makers should include the urban technosols as one of the strategies to improve healthy cities. It should be considered that the World Health Organization (WHO) defined a "healthy city as one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and in developing to their maximum potential" [47]. Since soil is essential for life, even in urban areas, technosols could play a role in the health strategies of cities, although integrating them into local policies remains difficult.

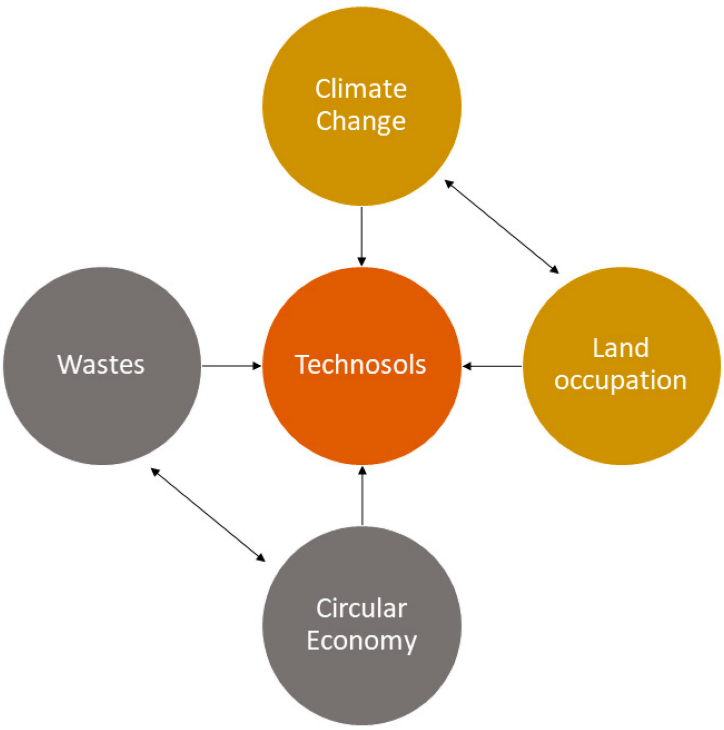

Figure 4. Linking circular economy and zero waste strategy with land use and climate change and technosols.

5. Technosol Functions for Healthy Cities

Few references include direct indicators of soil quality to evaluate urban health [48], some about urban agricultural soils [49] or urban landscape [50] and consequently, less information can be found about technosols. However, it would be considered that the same indicators used for a soil can be applied for a technosol in urban environments. Zambon et al. [51] chose soil quality index to analyze urban footprint of land consumption. Based on the need to include soils within cities, the European Commission proposes a list of soil health indicators for achieving the Sustainable Development Goals (SDGs) [52]. The European Environmental Agency (EEA) currently uses several indicators to answer key policy questions, and there are a set about land and soil, but related to soil pollution [53]. There is no doubt about the importance of controlling and remediate the soil pollution, but it is necessary to take a step forward to improve the functionality of urban spaces through the appropriate land use. One of the indicators included in this scope is the progress of management of contaminated sites and concludes that in 2011, the main sources of soil contamination in Europe were waste disposal and treatment (38.1%), and industrial and commercial activities, that usually take place in urban or periurban settings. The most common soil pollutants in Europe are heavy metals (34.8%) and mineral oils (23.8%) [53], both possible associated with industrial development. Currently, microplastics would be also considered as an important soil pollutant [54]. This showcases a significant focus on soil pollution; however, the goal should be to promote overall soil health.

A healthy soil definition can be found in the EU Soil Strategy for 2030 [24]. Soils are healthy when they are in good chemical, biological and physical condition, and thus able to continuously provide as many of the following ecosystem services as possible, which can be provide by healthy technosols as many recent research is demonstrating:

- provide food and biomass production, including in agriculture and forestry [55];
- absorb, store and filter water and transform nutrients and substances, thus protecting groundwater bodies [56];
- provide the basis for life and biodiversity, including habitats, species and genes;
- act as a carbon reservoir [57,58];
- provide a physical platform and cultural services for humans and their activities [59];
- act as a source of raw materials [33];
- constitute an archive of geological, geomorphological and archaeological heritage [60].

Following the EU policy and to measure soil health, the European Commission established 8 indicators [52]: presence of soil pollutants, excess nutrients and salts, soil organic carbon stock, soil structure including soil bulk density and absence of soil sealing and erosion, soil biodiversity, soil nutrients and acidity (pH), vegetation cover, landscape heterogeneity and forest cover. The same soil functions that are typically seen in natural soil can also be observed in technosols, making these indicators applicable to both types of soil. The assessment of soil health should be taken into consideration when evaluating the restoration of land using these artificial soils. Soil health, a cutting-edge global concern for sustainable development [61], is the consideration of soil capacity to sustain functions across landscape and temporal scales.

6. Technosol and Ecosystem Services

Ecosystem services should be implemented in urban environments by improving the urban soils and providing new soils made. Soil is the soft cover on the earth's surface, providing ecosystem services of storage and purification of water for diverse lives besides soil fertility and C sequestration [62]. Without any doubt, carbon sequestration and storage are of major concern. Technosols have the potential to act as carbon sinks by storing carbon in both organic and inorganic forms within the soil. Not only agricultural or forest soils can be sinks for carbon dioxide although many strategies are centered in these soils [63].

However, water purification and storage have a great significance in urban environments. That is because through soil structure development, soil provides retention and storage of water, organic carbon and nutrients for plant growth and diverse life conservation [64]. As a particular benefit of this function, soil mediates the quality of aquifers, which have been traditionally used as municipal water sources such as wells in many alluvial plains across the world. Thus, saving our soil, preventing land sealing, soil compaction and erosion, is a priority for conserving water and life on earth. Nature-based solutions (NbS) should be prioritized as long as there is a thorough understanding of water retention, provisioning, and global cycling. Among the well-recognized NbSs, rice terraces in mountain areas in humid zones reflects human intelligence for highly efficient water resource conservation and utilization for food production and human wellbeing [65]. The development of NbS in urban environments with the preparation of technosols to recover the functionality of land to conserve water resources for sustainable human life should be one of the main objectives pursued inside the cities.

It is necessary to consider the role of soils as support of plants. The importance of keeping substrates that can be the support of plants of different height and weight, is not a trivial matter. The aerial parts of trees start to vibrate in response to wind excitation and trees, as well as other plants, can suffer damage [65,66]. Urban areas provided with vegetation require that plants, in addition to being healthy and well cared for, have good anchoring to the ground to predict risks associated with the wind.

Technosols act as a source of plant nutrients and soil biota, a role essential for ecosystem services. Just because a soil has nutrients in it, doesn't mean those nutrients are available to the plants. To be available they need to be soluble, soil-water-plant system. Soluble nutrients require organic matter to break down over a long time. To make a soil fertile takes around 3000 years, so we really need to look after the soil we have [17,18]. There is one key to prepare fertile technosols, the organic matter and the interaction with inorganic fraction.

Cleaning pollution is another service, not only associated to the water cycle in cities. The atmospheric deposition and the presence of hydrocarbons and metals in urban environments affected the soils, both in wet and dry deposition [67]. Technosols can play a role reducing the atmospheric pollution interacting with these pollutants.

It is reasonable to think about payment for ecosystem services [68]. Although it is a topic that leads to a complicated discussion about who has to pay. Notwithstanding that it has been demonstrated that the conversion of construction land to arable land increased carbon storage [69]. Most scholars focus on forest carbon sinks and carbon emissions from urban construction land [70–72], but we should think about urban areas as places that can be carbon sinks as well as forest areas can be source of carbon emissions when they are disturbed, when trees burn or death to old age, even more if forest suffers deforestation [73].

It is necessary to consider that soils are a fundamental component of green infrastructure [74], and a none common solution for the urban needs [75]. Moreover, urban soils frequently exhibit poor biological, physical, and chemical conditions that directly affect plant growth and reduce their ability to provide multiple ecological functions [76]. Constructed soils can be prepared to improve soil quality of urban areas.

7. Conclusions

Urban areas are going to grow and without any doubt, this process is going to consume natural soils of periurban areas. This process is opposite to the strategies to mitigate climate change as soil has the potential ability of carbon store.

So, it is necessary to adopt strategies recovering soils in urban areas, both natural soils and making new soils that can supply environmental services. The technosols prepared would have a composition close to natural soils as a first approach. But the intended main function can affect the composition looking for efficiency. However, technosols can be used to alleviate and improve the situation of areas affected by anthropogenic activities or where natural soil has been lost, but they should not be considered as substitutes for natural soils since they have the capacity to offer a wide variety of services. ecosystems, which is probably lower in constructed soils made for a specific purpose.

To have a positive impact in the wastes derived from urban metabolism, these materials should be considered as a priority to prepare urban soils, participating positively in the strategy zero waste.

We need to change our mind regarding soils and urban areas, and technosols can be the key providing ecosystem services in urban areas and become a carbon sink that can help us to mitigate climate change and improve city health.

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