# Technosols – Development, Classification and Use

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**Summary**

Development of industry, building of settlements, disposal of various wastes, surface exploitation of various raw materials, and introduction of new technologies have led to the formation of new soils.

These soil damages present specific syndrome, which includes various processes, such as: infection, anthropogenic contamination, degradation and destruction (pedocide).

The paper discusses the soils which are created by processes of destruction. These soils are separated in a special soil class, denoted as a technogenous class. It emphasizes the differences relative to anthrosols.

Drastic changes occurred in the technosols, where the natural soil properties are completely destroyed, or they are deeply covered with various disposals.

The paper also addresses the properties of technosols, their classification and use, as well as the specifics of their mapping.

**Key words**

syndrome of soil damages, technosols, classification, mapping

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Received: November 23, 2006 | Accepted: February 16, 2007

## Introduction

Development of industry, technology, building of settlements, roads, disposal of various waste materials, exploitation of various raw materials, as well as continuous growth of population and demands for food, resources and energy, have led to an increasing loss of soil and continuous deterioration of the ratio between agricultural and arable land per capita. This ratio in Bosnia and Herzegovina has already reached a scale with less than 0.40 ha agricultural and less than 0.17 ha of arable land per capita.

The overall issue called for systematization, i.e. classification of these new formations (disposal sites). Namely, these formations in terms of their origin, properties, processes and ways of utilization, cannot be included into any existing soil classification system. Yet, some authors, place them into the class of anthropogenous soils, i.e. Anthrosoils (Burghardt et al., 2003; Van Deventer et al., 2004). However, with regard to a series of their unique and specific properties, these new formations significantly differ from anthropogenic soils. Additionally, anthropogenic formations also sustained certain changes related to agro and hydro-technical measures, although all these changes take place "in situ" (such as plowing, deep plowing, intensive fertilizing, drainage, etc.). On the other hand, a group of deposited substrates and soils is subject to such intensive changes which, as we have stated above, have led to a complete loss of natural properties and functions otherwise typical for natural anthropgenous soils.

The paper discusses the following:

- soil damage syndrome – options of their harmonization,
- technical substratum (materials), factors and processes,
- proposed classification of tehnogenic formations – their use value,
- rehabilitation and use options.

## Soil damage syndrome – options of their harmonization

There are different causes of soil damaging, but they are result of the following processes:

- infection,
- contamination,
- anthropogenic degradation,
- destruction.

Due to the diversity of damaging processes, they are marked as a specific sindrome. In terms of the conditions caused by these damaging processes, some specific new formations were accumulated, already covering great areas being assessed to thousands of hectares. They often look like genuine deserts, so called technogenic deserts (Resulović, 2004).

Currently, the ways of land use are being addressed from two aspects, namely, from the aspect of its environmental and technical functions.

Environmental functions pertain to the use of land from the aspect of plants, i.e. their development, as well as life processes and habitat of numerous macro and micro organisms, filtration, retention, adsorption, etc.

Technical functions pertain to the use of land for purposes outside the sphere of environmental functions, such as development, industry, road construction, etc.

Within the domain of the above stated functions, there is a constant issue of how these opposite functions could be harmonized, i.e. how we could make them as harmless as possible to the quality land resources. This topic will be elaborated in further text.

## Technogenic substratum - factors and processes

The issues related to technogenic formation can be considered from many aspects, such as:

- technogenic substratum,
- technogenic factors,
- technogenic processes.

### Technogenic substratum

Unlike natural substrates, today we can particularly distinguish technogenic substrates. Table 1 shows a part of such technogene substratum. Development of specific sub-systemic units can be expected on these different substrates.

### Technogenic factors

As it is known, there are several key factors in development of technogenic soils, such as climate, relief, organisms, age of the terrain, water. These factors are also known as external natural factors. Additionally, there are internal factors, which include the soil itself. Therefore, it can be said that the soil is its own condition of development.

However, fire is nowadays being listed as a technogenic factor. This factor leads to the formation of a specific group of soils, so called burnt soils (pirosols). Naturally, all the factors present in the formation of natural soils, participate in further development of technosols.

### Technogenic processes

The technosols soils undergo the processes similar to those in natural and antropogenih soils, but some of these processes, e.g. oxidation, intensive acidification, change of

**Table 1.** Overview of technogenic substrata

| Name of substratum | Way of formation |
|---|---|
| Overburden | By exploitation of various raw materials: coal, bauxite, iron ore, etc. |
| Fly ash and slag | Formed in processes of plant power station |
| Slag from various kind of industry | Red mud from aluminum industry, slag from varnish, dyes, glass, ceramic, etc. |
| Wastes from building settlements | Bricks, glass |
| Warriors wastes | Household garbage |
| Wastes from building roads | Natural rock, bitumen, lime, concretes, tar |

**Table 2.** Class of technogenic soils

| Division principes – sub-classes | Type |
|---|---|
| Mixed natural geological materials | Deposol<br>Rekultisol |
| Soil on various wastes | On household wastes: Garbisols<br>On industrial wastes:<br>– Soil on fly ash and slag - Cinerosols<br>– Soil on red mud – Rhodic technosols |
| Soils under impact of fire | Pirosol or Combustosols |
| Importing various materials in natural soils (artifacts): wood, cement, plastic, etc | Necrosols – soil in cemetery |
| Soils in urban areas – urbiland | Urbisols |

pH values, settling due to lack of structure, occur more rapidly in technosols soils.

## Proposed classification of technogenic formations – their use value

We want to emphasize the diversity existing in domain of systematization and classification of technogenic formations. Most authors include them into anthropogenic soils, designating them special names, thus creating a large number of different terms. One formation is often denominated differently, and this confusion makes their systemic studying more difficult. In this paper, we used different starting points, and the analysis is given from the aspect of origin. In this way, all new formations are grouped into a specific class, i.e. class of technosols. Further analysis is based on dominance of the basic sample of their origin, where we were able to determine five basic principles:

- in conditions of mixing of several different natural geological substrates,
- in cases of complete loss of natural properties of the soil, which occur "in situ", and under the influence of fire (burnt areas),
- in conditions of soil being formed on various waste materials (community, industrial), where technical substratum, such as community waste, waste disposal sites, fly ash and slag from thermo-power plants, red silt from hydrated alumina production, etc. are included,
- in conditions of introduction of various materials, such as wood, iron, cement, construction rubble, plastic (especially in cemeteries), into the natural soils,
- soils in urban areas, which include various ways of land use (include a mixture of environmental and technical functions of soil).

The classification is proposed based on the above stated principles. General characteristics of these technogenic formations could be summarized as follows:

- in their morphology (specific way of marking their strata), use of specific research methods, such as: magnetic resonance, for determination of heavy metals contents, presence of radio-active materials as a result of continued contamination of these soils, as well as their impact on health condition of humans and animals,
- some characteristics and properties of technosols are hard to describe using conventional methods, as stated by Van Deventer (2004), such as presence of brick, iron, plastic and other artifacts,
- specific way of marking the individual strata, by using some new letters, such as "Y", "y", "jY" etc.

The next table (Table 2) lists the class of technosols with identified pedo-systemic units, i.e. types.

As for further research, it will be necessary to provide a division onto systemic units below type (sub-type, variety, form), which could be significantly contributed by detail research of these new formations.

## 4. Rehabilitation and utilization options

In order for them to be used from the aspect of their environmental functions, in agriculture and forestry, all soils from the technogenic class require certain rehabilitation measures.

Measures of their rehabilitation can be determined based on their grouping tied to origin.

The rehabilitation measures are divided into five groups:

I group: encompasses favorable substrates, with mixed natural substrates. Here we have Deposol and Recultisols. In terms of utilization, most of these formations require the following measures of reclamation: humisation (particularly efficient is the application of green fertilization, especially clover – grass mixtures), adding of NPK fertilizer, protection from water erosion (maximum inclination up to 2%) and deep plowing. Naturally, if we are dealing with unfavorable substrates, especially from the aspect of texture, e.g. high percentage of clay particles (above 50%) or skeleton, some additional rehabilitation measures are required (e.g. special soil cover).

II group: includes less favorable substrates, where natural properties were destroyed, for example due to fire processes. Listed here is the Combustosols. Rehabilitation measures include: introduction of organic matter and mineral fertilizers, and especially soil loosing because of high percentage of skeleton and compaction.

III group: includes very unfavorable substrates, in terms of disposal of various waste materials, such as: fly ash and slag (from thermo-power plants), red silt (from hydrated alumina industry), and community waste (garbage). Listed here are: Cinerosol, Rhodic Technosol and Garbisol.

Production on these substrates is only possible after a sheet of natural soil or a sheet of overburden soil with favorable properties, of approximately 25-30 cm deep is placed on top of them.

IV group: extremely unfavorable – includes those land areas that due to their specific purpose of use were excluded from agriculture. These include cemetery soils, i.e. Necrosols. Horticultural plantation is present (flowers, decorative trees), with occasional application of fertilizers.

V group: conditionally unfavorable – includes those land areas on which environmental and technical functions are mixed. These are so called urban areas, i.e. Urbiland. Depending on way of use, measures similar to those in natural soils are applied. Obviously, urban soils can be used for different purposes, to include forestry, agriculture, industry and housing space. Their major characteristic is a huge superficial heterogeneity, as a result of the introduction of various exogenous materials and their mixing with natural soil materials. Basic functions of both natural soils and modified soils are represented here (Rossiter and Burghardt, 2003).

## Conclusion

The paper addresses the causes of soil damaging, with four identified groups of specific processes: infection – contamination – anthropogenic degradation – destruction. It analyses the way of formation of specific soil formations which differ from the anthropogenic. It stated differences between anthropogenic and technogenic formations, that are identified as specific classes.

In technosols class, five sub-classes are identified based on the way of formation. The sub-classes denominate a total of eight identified types.

The paper provides their use value, grouped in five separate categories. Basic rehabilitation (re-cultivation) measures are listed for each category.

Identification of the class of technogenic soils within the framework of damaged formations will provide a more comprehensive approach in researches, as well as measures for their reclamation, particularly in terms of their environmental functions. The development of the principles of their classification, as well as introduction of new methods in both field and laboratory surveys, will provide more information on the principles of their classification, especially from the aspect of systemic units below type.

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