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# Occurrences of technosols in Montevideo city, Uruguay

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Man-made deposits are widespread in and near urban areas of many countries. In the recent years, researchers of the Department of Geotechnical Engineering, Geotechnical Section, of the Structures and Transportation Institute at the Engineering Faculty of Montevideo, Uruguay, have examined areas in the City of Montevideo that contain similar soils. These man-made deposits are also referred to as urban soils when they are in urbanised areas and have developed a respective pedological structure and principal soil functions. The administrative definition of urban soils for land use planning in Montevideo is inconsistent and needs to be improved. These soils result from spreading of materials in urban and suburban areas and on nearby flood plain sites, and infilling of old quarries. They give rise to difficult ground conditions and may be contaminated, causing health problems. The initial data on these soils have been collected, and further researches are planned.

**Key words:** technosols, urban soils, pollution, ground conditions, Montevideo

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## INTRODUCTION

Man-made deposits are widespread in and near urban areas of many central European countries, the United States of America and Mexico, where they are called technological soils, but in other areas man-made deposits are referred to as urban soils (El Khalil et al., 2009; Rossiter, 2007). It is only in the recent years that researchers of the Department of Geotechnical Engineering, Geotechnical Section, of the Structures and Transportation Institute at the Engineering Faculty of Montevideo, Uruguay have examined areas in the City of Montevideo that contain similar soils.

The City of Montevideo is underlain by Precambrian crystalline rocks which include the Montevideo Formation and intrusive igneous rocks such as granitoids. These form the basement of the Santa Lucía sedimentary basin within which most of the city is developed. This basin received deposits of Mesozoic and Cenozoic sediments of the Liberty, Villa Soriano and Dolores Formations (Fig. 1, after Spoturno et al., 2004). These are covered in the urban, suburban and some nearby areas with man-made deposits that are the subject of recent studies.

## TERMINOLOGY

The World Reference Base for Soil Resources (Rossiter, 2006, 2007) describes technological soils as "soils whose properties and pedogenesis are dominated by technic materials or originate as human-transported material, as well as soils with a continuous impermeable constructed liner". An alternative

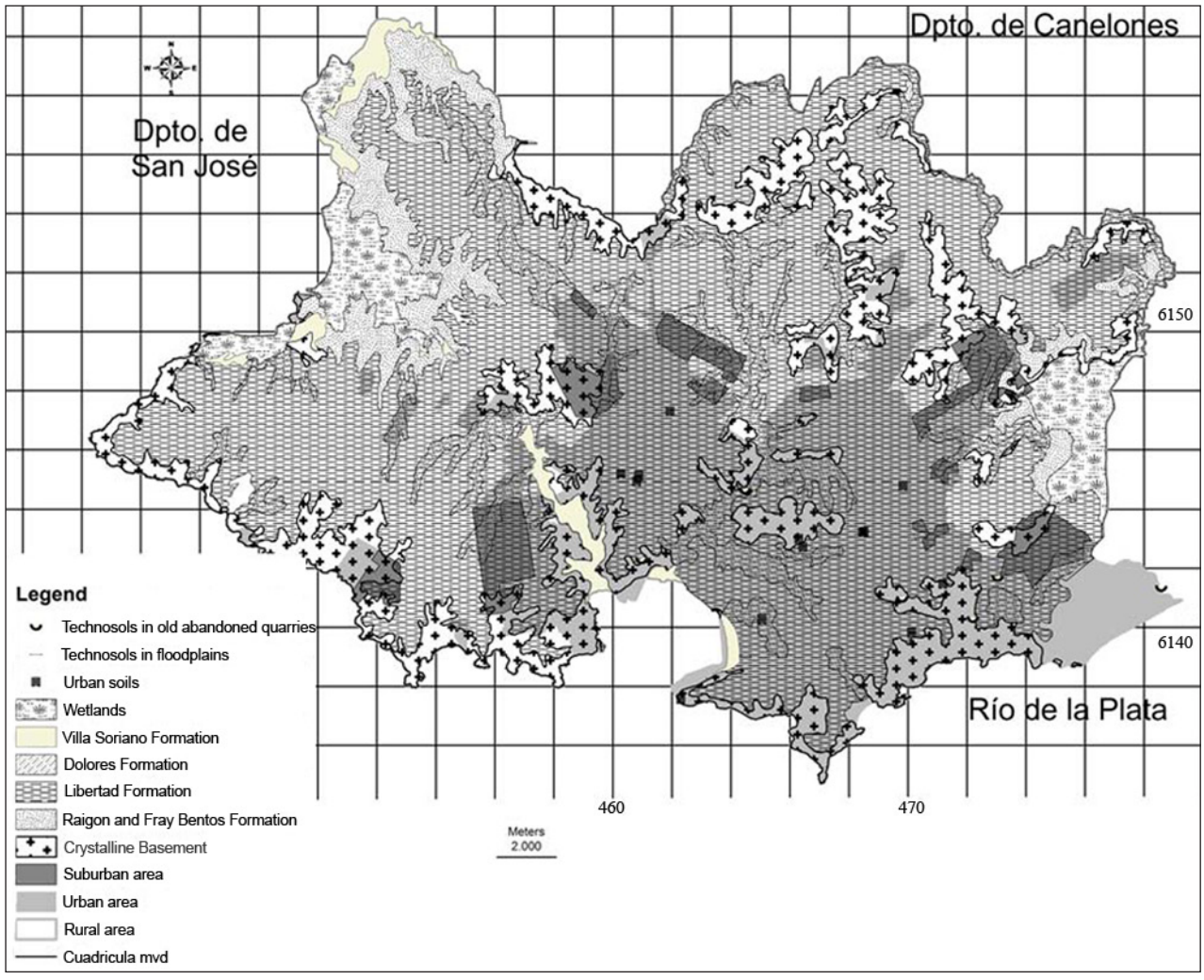


**Fig. 1.** Geological Map of Montevideo City, showing the location of technosols and urban soils (modified from Spoturno et al., 2004)
**1 pav.** Montevidėjo miesto geologinis žemėlapis. Technogeninio grunto paplitimas (modifikuota pagal Spoturno et al., 2004)

term for man-made deposits is "urban soils", but this term applies specifically to soils in urban areas that are often polluted by industrial activity, traffic and other processes causing adverse effects on human health (El Khalil, 2008; Lehmann, Stahr, 2007; Schwartz et al., 2007; Seré et al., 2008), while the term "technosoils" is applied to soils both within and outside urban areas.

The Municipality of Montevideo (IMM 1999) defines urban soils as those "where today the city is developed, including areas not yet constructed but that are on the horizon of the Plan with adequate urban services". However, since 2006, the Ministry of Housing, Land Management and the Environment (MOVTMA) regards urban soils as those that are within an urbanised area which relates to economic and real estate values. There is a need to develop a consistent definition of urban soils for adminstrative, including land use planning, purposes. However, the use of the term "technosols" is the same in Uruguay as it is internationally.

## PROBLEMS ASSOCIATED WITH TECHNOSOLS AND URBAN SOILS

Most of knowledge existing worldwide about man-made strata refers specifically to soil profiles and the related soil pollution problems. Many authors consider health problems due to toxicity, but some consider mechanical aspects. In the latter context, for instance, Short et al. (1986) have considered soil characterization issues, particle density, particle

size, solubility of salts, among other parameters such as the content of organic matter and cation exchange capacity along profiles on anthropogenic materials nearly 6 m thick in an area of approximately 60 hectares of central Washington D. C, while the New York City Soil Survey Program (Hernandez, 2006) took account of the geology of the substrates on which urban soils rest and characterized the soils in terms of edaphic and mechanical properties as a basis for land use planning.

In general, technosols near urban areas can cause harm to health when they contain industrial waste or other materials or pollutants arising from human activities and are either used for agriculture or covered by urban expansion (Lehmann, Stahr, op. cit.).

The situation is also similar in Montevideo.

## HISTORY OF URBANISATION IN MONTEVIDEO

Montevideo is the capital of the Oriental Republic of Uruguay, South America, located at the geographic coordinates 34° 53' S and 56° 11' W. It was founded in December 1726 on the coast of the Rio de la Plata and covers an area of 525.54 km$^2$ with 1,338,408 inhabitants. The metropolitan area, where Montevideo makes part of it, now covers 192.418 ha with a population of 1,973,380 inhabitants, mainly of European descent (Spanish and Italian). Economic activity in the city was initially dominated by commercial and livestock enterprises. The industrial development commenced in the middle of the nineteenth century, leading to the development of communications infrastructure including ports, roads and railways. The meat and spinning industries expanded, and mining of construction materials, mainly sand and granitic rocks, took place outside, but sometimes close to, the Department of Montevideo. In the early twentieth century, extraction of limestone for making lime and portland cement commenced.

In the first half of the twentieth century, tanneries, textile mills, paint factories, metal industries, oil depots, brick kilns and other industry developed within the suburbs of Montevideo (Fig. 2)

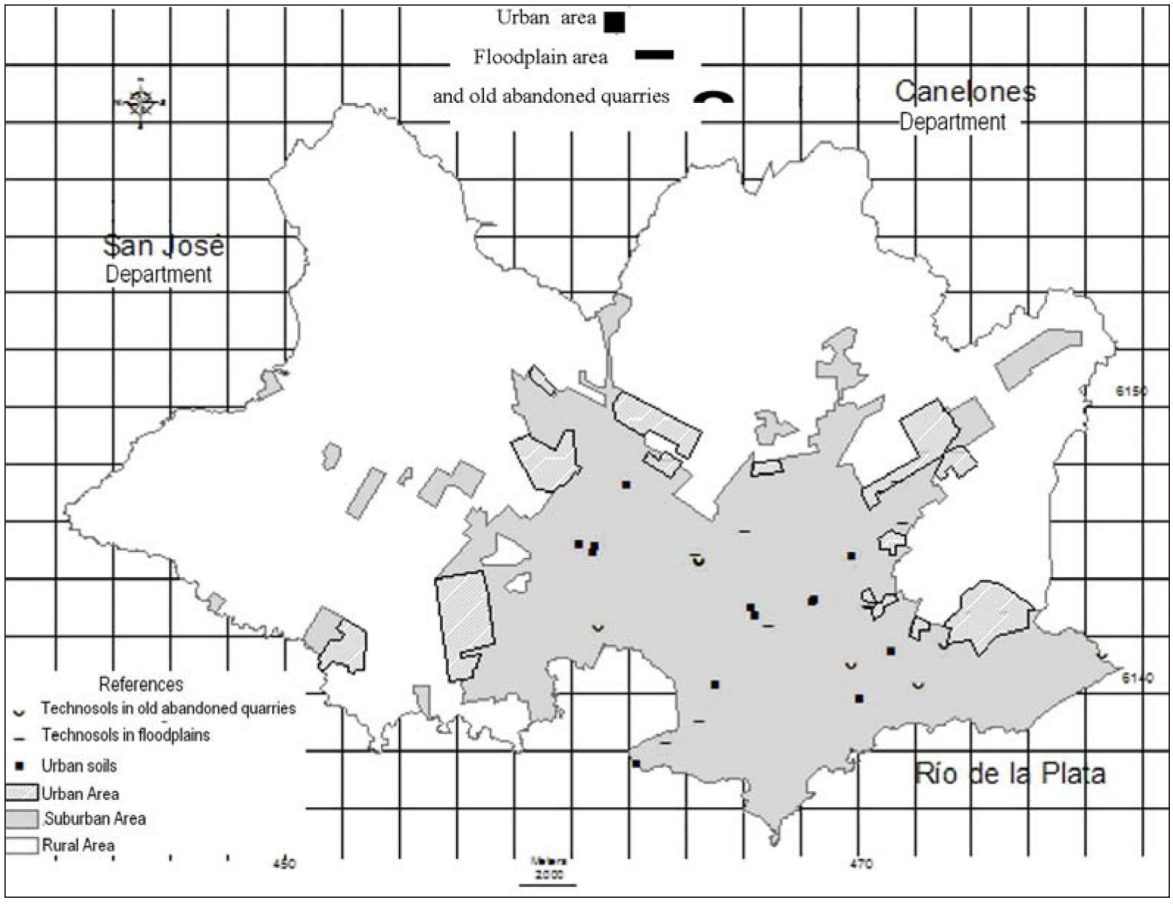


**Fig. 2.** Geographical distribution of the data collected for Montevideo City (modified from http://sig.montevideo.gub.uy/)
**2 pav.** Montevidėjo mieste surinktų duomenų pasiskirstymas (modifikuota pagal http://sig.montevideo.gub.uy/)

close to the areas that had been mined during the nineteenth century. Due to social, political and economic changes, during the 1960s and 1970s most of these industries closed, but they left a legacy of contaminated soils in urban and floodplain areas.

Over the past fifty years, the city of Montevideo has expanded into suburban areas and beyond into the former rural areas. Most of those areas did not have main sewerage system, and the supply of potable water to the rural areas of Montevideo was insufficient. Similarly to land left by the industries in suburban areas that had closed, other areas have been used for disposal of domestic, industrial and / or hospital wastes. Many sites in peripheral areas were developed by infilling of old abandoned quarries.

As the understanding developed, health problems due to different types of pollution began to be identified, and newly developed areas also showed problems linked to poor geotechnical conditions and the presence of heavy metals in both soils and groundwater.

The geographical distribution of these soils is closely linked to the city growth in the last 200 years, as well as to the changes that society has had in relation to the industrial and technological development.

## RESULTS

Groundwater pollution and the development of urban soils and technosols are now being studied in Montevideo to characterize their profiles and understand their geotechnical behaviour and pollution characteristics. Data gathered so far are grouped into three categories: 1) soils of old quarry voids, 2) soils of floodplain, and 3) soils of the urban area. They are presented in Table.

## DISCUSSION

In Montevideo, like in other cities, techonosols / urban soils vary greatly and are often formed of waste materials (El Khalil et al., 2008; Lehmann, Stahr, 2007). Natural soils take geological time periods to mature and develop thick fertile horizons that can be used for agriculture and livestock pasture. Technosols and urban soils have not had time to mature. Most of them were originally deposited outside the city but, because of urban expansion during the first half of the 20th century, now they are located mainly within the city. In this large area, two deposition patterns have been identified: many are at infilled abandoned quarries, while others are being developed on flood plains of creeks and streams in the suburban area close to the urban area. These regions are currently being developed because of the high demand for new residential areas.

Technosols and urban soils have also been identified in areas outside the urban land and / or the geomorphological setting mentioned above. The existing Land Management Plan (1998–1999) of the Municipality of Montevideo sets out territorial zones including urban, suburban and rural zones for the land surveyed to date (Fig. 2).

## CONCLUSIONS

The recent research by the Geotechnical Section demonstrates that technosols and urban soils are extensive under the City of Montevideo, primarily in the urban and suburban zones defined by the

Table. **Data showing three categories of areas where technosols have developed**
Lentelė. **Trijų kategorijų duomenys iš technogeninio grunto plotų**

| Type | Quantity of study profiles | Localization | Thickness | Description |
|---|---|---|---|---|
| Technosols | 8 | Old abandoned quarries | 2 to 5 m, exceptionally >10 m | Masonry debris (e. g., bricks), building scrap metal, and household waste, prunings, etc. |
| Technosols | 10 | Floodplain | 2 to 3 m | As above and also removed (allochthonous) sediments |
| Urbic Soils | 15 | Urban area | 2 to 3 m | Removed (allochthonous) sediments with industrial waste (tannery, oils, paints, etc.) |

Municipality of Montevideo. Because of urban expansion, many formerly suburban areas have now been covered by the urban zone.

There is a need to characterize both the urban soils and technosols in the city, to study their geotechnical behaviour in more detail, and to develop a consistent definition of urban soils for land use planning purposes.

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**TECHNOGENINIO GRUNTO PAPLITIMAS MONTEVIDĖJO MIESTE (URUGVAJUS)**

*S a n t r a u k a*

Miestuose yra plačiai paplitęs žmogaus suformuotas gruntas. Pastaraisiais metais Montevidėjo mieste buvo pradėti intensyvūs šių gruntų tyrimai. Žmogaus suformuotas gruntas dažnai vadinamas urbanistiniu. Planuojant žemės panaudojimą Montevidėjo mieste, administracinė urbanistinio grunto klasifikacija neatitinka šiuolaikinių poreikių, todėl būtina šią schemą peržiūrėti ir tobulinti. Minėtas gruntas formuojamas plečiant medžiagos transportavimą miestuose, gretimose užliejamose lygumose, užpildant senas kasyklas. Toks gruntas gali būti užterštas, todėl kyla įvairių ligų rizika. Surinkta pradinė medžiaga, atlikta jos preliminari interpretacija.

**Raktažodžiai:** technogeninis gruntas, urbanistinis gruntas, Montevidėjas