Available online at www.sciencedirect.com

SCIENCE DIRECT®

Geoderma 124 (2005) 253–265

GEODERMA

www.elsevier.com/locate/geoderma

Classification of anthrosols with vitric/andic properties derived from lignite ash

S. Zikeli, M. Kastler, R. Jahn*

Institute of Soil Science and Plant Nutrition, Martin-Luther-University Halle-Wittenberg, Weidenplan 14, D-06108 Halle (Saale), Germany

Received 29 August 2003; received in revised form 19 January 2004; accepted 7 May 2004
Available online 2 July 2004

Abstract

To test the applicability of the Soil Reference Base of Soil Resources (ISSS/ISRIC/FAO, 1998. World Reference Base for Soil Resources, World Soil Resources Report 84, FAO, Rome) for soils derived from anthropogenic substrates, soils developed on lignite ashes in Germany which have some similarities with andosols were compared with natural volcanic soils from different countries. Soil parameters used for comparison were bulk density, clay content, Al_o+0.5 Fe_o, and P-retention, as they serve as diagnostic criteria to define either vitric or andic horizons. For Al_o+0.5 Fe_o, and P-retention, there was no statistically significant difference between both soil groups, the bulk densities of the lignite ash-derived soils were even significantly lower than those of the natural volcanic soils. Moreover, pH, total organic carbon, cation exchange capacity as well as the contents of carbonates and gypsum were collated and differences emerged between both soil groups concerning the contents of carbonates, gypsum and total organic carbon. In case of the lignite ash-derived soils, these parameters as well as the contents of oxalate soluble oxides were strongly influenced by the composition of the anthropogenic parent material. Up to now, such soil materials are not included as soil-forming materials in the World Reference Base for Soil Resources. We therefore suggested the introduction of a new diagnostic soil material, the so-called technogenic soil material into the anthropogeomorphic soil materials and to introduce "technogenic anthrosols" as a new reference subunit. In our proposition, technogenic materials are defined as anthropogeomorphic materials which are formed by technical processes including a distinct degree of transformation and/or new formation of soil-forming materials. Soil materials are categorised as "technogenic" when they consist of more than 70% (by volume) of soil material derived from technical processes like, e.g. combustion products of fossil energy sources, sewage sludges, blast furnace slags, etc.

To include as much information as possible into the name of a soil, we developed a concept of reference soil series for the WRB combining pedogenetic and lithogenic information. Within this concept, these soils should be considered to be a subunit of anthrosols (vitri- or andi-technogenic anthrosols) and the specific properties of the soil-forming material (coaly, calcaric, gypsiric) should be given as additional information as Reference Soil Series as well as texture and kind of parent material.

Keywords: Lignite ashes; Volcanic soils; Technogenic substrates; Classification of anthropogenic soils; World Reference Base

* Corresponding author. Tel.: +49 345 55 2231; fax: +49 345 55 27116.
E-mail address: jahn@landw.uni-halle.de (R. Jahn).

0016-7061/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.geoderma.2004.05.004

1. Introduction

Large areas of urban and industrial regions are heavily influenced by the deposition of human-made materials like lignite and hard coal ashes, blast furnace slags, rubble, garbage, sewage sludges or other sludges derived from different industrial processes. As these materials are exposed to natural weathering, pedogenic processes like organic matter accumulation, decarbonatisation, changes in pH and mineral transformations take place and alter the properties of the anthropogenic parent materials. This leads finally to the development of more or less differentiated soils on such anthropogenic substrates.

Sites consisting purely of anthropogenic substrates or influenced by such materials are more and more in the focus of urban planning and development due to structural changes in many industrial areas as well as due to land protection efforts. Therefore, soils developed from such anthropogenic substrates have to be mapped and classified, which is difficult using the current soil classification systems. Conventionally, the soils in question would be classified after World Reference Base for Soil Resources (shortened in the following text to WRB; ISSS/ISRIC/FAO, 1998) as regosols or arenosols (Table 1) neglecting their specific properties. We also found arguments to classify such soils as andosols or as fluvisols (in the case of settling ponds). The WRB (ISSS/ISRIC/FAO, 1998) recognises anthrosols as soils heavily influenced by human activities. Moreover, some anthropogeomorphic soil materials were introduced which until now do not include materials which are produced by technical processes and which are now subjected to soil formation.

In this context, the question arises, whether such soils, which partly have properties like natural soils but are still dominated by the properties of the technogenic parent material, should be incorporated into the Reference Group of Anthrosols or into other Reference Groups comparable to natural soils. Moreover, when attempting to use the classification requirements provided by the WRB (ISSS/ISRIC/FAO, 1998) for the classification of natural soils, the problem of misleading data occurs. Often, the requirements for soil classification are fulfilled based on analytical data, but in reality, the soil physical or chemical processes are different from those which WRB intends to describe based on pedogenesis. For example, soils developed on sewage sludge may fulfil the requirements of a histic horizon, but in this case the high content of organic matter is a property of the parent material and not a result of organic matter accumulation.

As far as the lignite ash soils have morphological and analytical similarities to andosols our objectives were (i) to compare soils derived from lignite ash with "natural" volcanic soils to detect similarities and differences between soils developed from purely anthropogenic material and natural soils, and (ii) as well as to suggest a more appropriate classification of the former according to the classification system of WRB (ISSS/ISRIC/FAO, 1998). In our study, we worked with soils derived from lignite ash in central Germany and soils developed on volcanic parent material from different countries.

Table 1
Classification of lignite ashes-derived soils, their age and type of ash disposal

Method of disposal	Period since stop of disposal (years)	Soil unit (according to ISSS/ISRIC/FAO, 1998)	Parent material
Eolian deposition	6	gypsiric arenosol	lignite fly ash
Landfill	21	calcari-gypsiric arenosol	lignite bottom and fly ash and rubble
Landfill	32	calcaric regosol	lignite bottom and fly ash and rubble
Settling pond fine textured	17	spoli-anthropic regosol (gypsic, calcaric)	lignite bottom and fly ash
Settling pond coarse textured	17	calcari-gypsiric arenosol	lignite bottom and fly ash
Settling pond	5	spoli-anthropic regosol (gypsiric, calcaric)	lignite bottom and fly ash