Organic matter composition in sediments, dump materials and technosols from Maritsa Iztok Basin (Bulgaria) – a comparison

Сравнение на състава на органичното вещество в седименти, насипищни материали и техногенни почви от Източномаришкия басейн (България)

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Introduction

Since the beginning of open-pit mining works in Maritsa Iztok Basin (MIB) in 1962 until 31.12.2013 1 038 217 911 tons of lignite have been extracted (www.marica-iztiok.com). Huge masses (4 278 655 232 m^3) of dump materials have been generated as a result of open-pit mining, too. Lignite reserves can last for the next 50–60 years and the necessity of long term ecological monitoring and remediation activities will extend.

The aim of the study is to collect, compare data available, and outline main tendencies in organic matter (OM) characteristics and transformation in a sequence: sediments–dump materials–technosols (WRB, 2007) developed on humus-free reclaimed dumps.

Background and scope

First data received on organic carbon (C_{org}) content and composition in sediments and dump materials have been submitted by Filcheva et al. (2009) and Milakovska et al. (2011). The sample set comprises 10 core samples of gray and black clayey sediments (borehole B-69, Troyanovo-2 Mine and borehole C-3, Troyanovo-3 Mine) and 12 surface samples from an internal dump of Troyanovo-2 Mine and 4 from external dumps (Staroselets, Dryanovo, Gledachevo and Iztok). OM studies on reclaimed soils from MIB commenced by Garbuchev et al. (1975) and continued with more detailed studies of Banov (1989), Ivanov (2007) and Hristova et al. (2011) on 11 technosol profiles in Ovcharitsa, Iztok and Mednikarovo Dumps 5, 10, 15, 20 years, and one – 45 years after reclamation. The method of study is a modified method of Tyurin and Kononova described in the articles above cited, accepted in “N. Poushkarov” ISSAPP, so the data are completely comparable. The discussion and conclusion have been drawn from a combined consideration of published data.

Comparison of sediments, dump materials and technosols and differences outlined

Gray and black clayey sediments differ in C_{org} content and composition (Milakovska et al., 2011). Four samples (black clays interbedded 1st and 2nd coal seams) have high values for C_{org} content (1.44–3.88%). The values for C_{org} in light to dark gray and black clays are much lower, ~1% (0–0.80%). Along the borehole log C_{org} distribution is irregular for borehole B-69 samples. A fairly good trend of increasing downwards could be outlined for borehole C-3 samples. The data range for carbon bound in humic acids (HA) is broad (0–3.05%). Data for carbon bound in fulvic acids (FA) are in the range 0.04–1.94%. Concerning borehole C-3 samples, a faint tendency of C_{FA} decreasing with depth could be marked. Organic matter type in sediments varies broadly: fulvic (2 samples), humic-fulvic (3 samples), fulvic-humic (1 sample), and humic (4 samples). HA are predominantly bound to alkaline earth ions, 2 samples only contain HA that are mainly “free” and/or bound to Al and Fe ions. Organic carbon extracted in the most mobile and low molecular fraction of the organic matter is presented in negligible values (0.01–0.06%). In contrast, the values of unextracted C_{org} are very high (66.89–88.43%) and mark a presence of OM components very strongly bound to minerals of the sediments.

Surface dump samples show also considerable differences in C_{org} characteristics (Filcheva et al., 2009). Data of C_{org} content fall in the range 0.60–9.61%.

According to C_{HA}/C_{FA} ratio organic matter is mainly of humic type, and rarely – fulvic-humic or humic-fulvic. Humification degree varies from low, high to very high. It was established that unextracted C_{org} content is in a wide range (22–85%), and in 2 samples only, the main part of C_{org} is unstably bound to the mineral components. HA fraction bound to alkaline earth ions strongly prevails. In all samples, the content of FA aggressive fraction is very low (0.83–3.33%).

Samples from 4 naturally grassed technosol profiles in Ovcharitsa, Iztok and Mednikarovo Dumps show weakly expressed development of soil surface layers after 5, 10 and 20 years (Tsolova et al., 2009). C_{org} content is the lowest for all profiles compared (0–0.02%). Unextracted C_{org} values vary, but are still high (43.06–89.29%), a feature previously mentioned for technosol profiles studied by Banov (1989). C_{org} and HA show very faint enrichment downwards. FA movement downwards could not be traced, as in 2 of the profiles FA are absent. Three technosol profiles developed on eastern and western areas of Iztok Dump and on Ovcharitsa Dump have passed 5, 10 and 20 years agricultural activities (Tsolova et al., 2009). There are not any differences in C_{org} distribution downwards and any enrichment of C_{org} content after 5 and 10 years. A clear increase in C_{org} (from 0.20 to 0.48%) and HA content after 20 years agricultural activities could be pointed out. All HA fractions are bound to alkaline earth ions as found by Banov (1989) too. Values of unextracted C_{org} decrease slowly from profiles of 5–10 to 20 years period. FA movement and enrichment downwards is clear. Four soil profiles developed on Mednikarovo and Iztok Dumps (Tsolova et al., 2009) show still weak development of initial soil forming processes after 10 years tree plant activities. HA bound to alkaline earth ions are present in the first 5 cm layer mainly, but FA have reached the deeper layers. Twenty years reclamation results in HA movement downward to 20 cm, and FA enrichment in depth to 40 cm. A new, humus-cumulative (AC) horizon has been formed in the oldest technosol profile in MIB after 45 years tree plant activities (Hristova et al., 2011). Fractional composition shows prevalence of humic acids bound to alkaline earth ions and humic type OM. OM is still stably concentrated in unextracted fraction mainly, but is the lowest among the soil profiles described.

There are no strong differences between cultivated and naturally grassed profiles in C_{org}, C_{HA} and C_{FA} content downwards the profiles. Higher is the content of C_{HA} in the surface layer and of C_{FA} in depth in profiles after 20 years tree planting. The highest is C_{HA} content in naturally grassed profile after 10 years reclamation. As a whole, humic type of C_{org} is preponderant for technosols studied. The comparison outlines that newly formed OM in humus-free reclaimed technosols is mainly of humic type, stated also for profiles described by Banov (1989). The thickness of the newly formed humus horizon depends on weathering period, soil forming processes and vegetation cover and riches max 25 cm in the oldest technosol profile.

In conclusion, distribution of C_{org}, C_{HA} and C unextracted in sedimentary rocks, dump materials, and technosols show no distinct differentiation. Generally, higher concentrations of C_{org}, C_{HA}, and C unextracted occur in sediments or dump materials. Higher are values for C_{FA} and carbon in low molecular and more mobile fraction of FA in most samples from naturally grassed and tree plant reclaimed soils.

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