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BLACK CARBON CONTENT AND DISTRIBUTION IN SURFACE SEDIMENTS FROM TEMPERATE-ZONE RESERVOIRS (POLAND)

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This paper presents the results of first studies concerning the content of black carbon (BC) in sediments of three reservoirs located in south-eastern Poland (i.e. Solina, Rzeszów and Besko).

One of the organic matter (OM) fractions is the so-called inert organic matter. Under criteria adopted, this is taken to include chemically and biologically inactive substances, including black carbon (BC). The BC fraction includes, for example, kerogen, charcoal, charred parts of plants, soot, graphite and ash [Schmid and Noack, 2000]. Substances included in the composition of BC arise in the process of pyrolysis and/or incomplete combustion of biomass and fossil fuels [Goldberg, 1985] and may originate in both natural and anthropogenic sources. They are practically insoluble in water, have a high content of carbon in the molecules, rigid high-aromatic structures, a small number of polar substituents and a complicated spatial structure [Haynes, 2005]. In terms of its molecular structure, BC differs significantly from other OM fractions, because it contains granular, crystalline organic components with a porous nanoparticular structure [Cornelissen et al., 2005]. BC is ubiquitous in the atmosphere, ice, soil and sediments, due to the widely dispersed nature of its production, as well as its stability and indifference in the environment, where it may play an important role in certain key processes. One of the main problems associated with BC is its ability to absorb light energy and reduce the albedo of the surface of water, ice and snow, thereby accelerating the melting of glaciers [Gustafsson et al., 2001. BC is also considered an important carrier of certain kinds of pollution. Substances belonging to the BC fraction are characterised by complex spatial structure, large surface area and porosity, all of which allows for substantial sorption on to the surface, as well as penetration into the interior of the complex spatial structures of various dangerous contaminants, such as PAHs, PCBs and heavy metals [Pignatello, 1998, Allen-King et al., 2002, Cornelissen et al., 2004, Cornelissen et al., 2005, Lohmann et al., 2005, Koelmans et al., 2006, Lou et al., 2011].

The BC studies made use of the chemical-thermal oxidation method (CTO-375). To this end, dried sediments were first made subject to removal of carbonates, prior to the combustion of samples in a muffle furnace supplied with a constant air flow (of about 200 ml/min), for 18 hours at a temperature of 375°C. Residual carbon was then made subject to the BC determination using a CN analyser (CN Flash EA 1112, ThermoQuest). Were also determined contents of organic matter (OM), total organic carbon (TOC) and total nitrogen (TN) for the sediments under analysis.

Sediments deposited in Solina Reservoir were found to be characterised by a low content of BC. Higher values were only observed in the central and lower parts of that reservoir, where, despite low contents, BC constituted between about 5 and 10% of TOC. In Rzeszów and Besko Reservoirs, the BC content was ten times higher than in Solina Reservoir. Where comparisons with the content of total organic carbon (TOC) in sediments was concerned, Rzeszów Reservoir BC was found to constitute some 9-15%, while in Besko Reservoir the comparable figures were in the range from about 12% to almost 46%.

Analysing of potential BC sources in the catchments of the above reservoirs made it clear that the main rivers supplying Solina Reservoir are not the main sources of the BC present in sediments, with higher BC contents at stations in the Reservoir's central and lower parts rather reflecting soil erosion or atmospheric transport of BC from the combustion of fossil fuels and biomass in rural areas close by.

In turn, Rzeszów Reservoir, while faced with a wide range of anthropogenic sources, was not found to have a high share of BC in TOC, but is rather a reservoir standing out among those studied for its highest content of organic matter of autochthonous origin.

In Besko Reservoir, the content of BC is at a similar level to in Rzeszów Reservoir, yet shares of TOC accounted for by BC are so high that a significant role in the accumulation of dangerous organic pollutants in sediments may be played, especially in catchments under the strong influence of village buildings in which the combustion of coal and biomass probably ensure a status as main and most significant source of the BC present in reservoir sediments.