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Formation of fluvial islands and its determining factors, case study of the River Neris, the Baltic Sea basin

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ABSTRACT

The aim of the present study is to determine the location and morphometric characteristics of fluvial islands in a 234.5 km long reach of the River Neris (from the Lithuanian–Belarusian border till the mouth of the river), to evaluate the changes of their number, area and location that have occurred since the second half of the 20th century, and to analyse the main geological and hydrological factors which possibly have affected the development of these islands.

The fluvial islands, i.e. river channel forms situated above the average long-term water level, separated from the land by river branches and generated by fluvial processes, i.e. by the interaction of ground and surface water flows or, in other words, by erosion–accumulation processes taking place in the river basin, are fully or partly covered by vegetation and best reflect the external scenery of the river. Islands are scattered over the whole investigated reach of the river, yet their number highly depends on morphometric, hydrogeological and geological conditions in different segments. Small islands are dominant (area <1 ha, height up to 1 m). They account up to 89% of the total number of islands, yet their total area accounts only up to 33% of the total island area in the studied segment. The minimum number of islands (1 island in a 10 km long segment on the average) is observed in the segments where the river flows across morainic massifs and in the relatively straight segments. The maximum number of islands (1 island in a 1 km long segment) occurs downstream from the eroded segments where they occupy up to 5.4% of the river channel area.

During the last 40 years, both the number and the area of fluvial islands have increased. The increasing area of the fluvial islands in the channel reduces transportability of the river flow. Investigations of the flow showed that at the end of the 20th — the beginning of the 21st century the annual peak discharge was 48% smaller than comparing to the end of the 19th start of the 20th century. Due to the reduction of the flood plain area and shorter duration of floods, the amount of sediments left in the flood plain has been continuously decreasing. This might have been caused by the increased sedimentation in the channel resulting in the intensive formation and accretion of the islands. In the future, the reduced transportability caused by the increasing number and area of the fluvial islands may predetermine higher and longer floods and higher flood hazards for the urbanised riverside territories under the conditions of the same discharge.

1. Introduction

Fluvial islands exist in almost all natural and regulated rivers. They represent accumulations of bottom and suspended materials. The fluvial islands appear as a result of processes taking place in the river channel and valley, i.e. in the whole river basin, morphometric indices of the channel, flow hydraulics, and physical geographical conditions of the river basin territory.

The aim of the present study is to evaluate the formation and evolution of fluvial islands under the conditions of climate induced changes of river flow. The transportability of the river flow and formation of dangerous ice packs depend on the morphometric parameters of the channel. Better knowledge of fluvial islands would contribute to determining the potentially hazardous flood areas. For this purpose, the geological, geomorphological and hydrological settings of the river basin were evaluated, morphometric parameters of the islands and their distribution were analysed and deformations and dynamics of islands were determined.

The formation of fluvial islands is related with decreased drift force, fluctuations of flow and channel inclination and sedimentation. Fluvial islands in their turn affect the river flow dynamics: deviate the dynamic

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axis of the river and change the planar form of the channel and channel type (Ashmore, 1982). Thus an investigation of the dynamics of fluvial islands allows the prediction of the processes of the river valley and its channel. The increase or decrease of the area and number of fluvial islands in a channel is an indication of the changed sediment budget and describes the dynamic phase of the river (Basalykas, 1958; Gusarov, 2004). Evaluation of the changes in island area provides information about the average time necessary for the formation of islands of various sizes and about the rates of their "movement".

Investigations of river islands are important both from cognitive and practical points of view. Expansion of communication systems and population of riversides requires knowledge of the possible effects of fluvial islands on the riverside territories: floods, intensity of bank erosion, etc. Knowledge about the islands also is necessary for environmental and regional studies.

The issues of formation, evolution and classification of fluvial islands have been investigated since a long time ago (Makavejev, 1948, 1955; Popov, 1961; Cheetham, 1979; Machinov et al., 1986; Smirnova, 1987; Osterkamp, 1998; Gusev, 2000). The interest in these issues has not reduced till nowadays (Chalov, 2003; Gautier et al., 2007; Hooke and Yorke, 2011; Wyrick and Klingeman, 2011; Grivel and Gautier, 2012).

Meanwhile too little attention has been paid to fluvial island analysis in Lithuania yet. They were sporadically investigated by Baltakis et al. (1982), Baubinienė (2002, 2003, 2013) and Česnulevičius (2003). Only the vegetation of some rivers' islands has been investigated in greater detail (Kovėra, 2001). The present study is an attempt to contribute to the knowledge about fluvial islands in the Baltic Sea basin (trends of transformational changes and possible environmental effects) based on a case study of the River Neris.

The available field data and the topographic maps of 1970 (1:10,000) were compared with orthophotographs of 2005 and 2010 (1:10,000) seeking to evaluate the location and morphometric indices of River Neris islands as well as the transformation processes and factors affecting the formation and evolution of fluvial islands. Comparison of the maps of different years but of the same scale allowed tracing the long-term multi-annual deformations of the islands.

The knowledge about the evolution of islands allows the prediction offurther development of channel processes and their possible influence on the hydrodynamic regime of the river.

2. Study area and methods

The River Neris was chosen for the investigation of the localization of fluvial islands and fluctuation of their morphometric indices. It is situated in the Baltic Sea basin and its total length in the territory of Lithuania is 234.5 km (Fig. 1). The total length of the river is 509.5 km and the total area of its basin is 13,849.6 km^2 (Gailiušis et al., 2001).

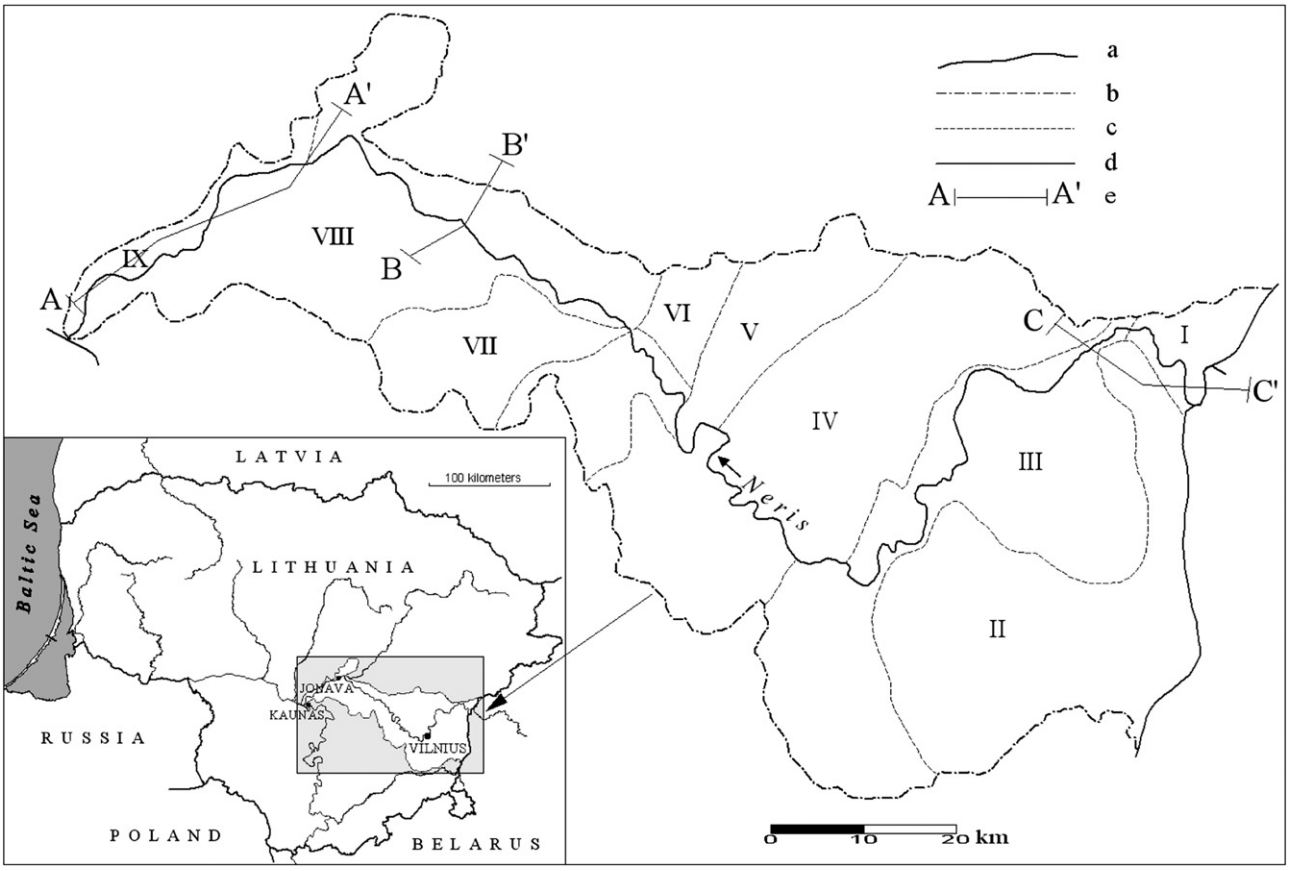

Fig. 1. Genetic zones of relief in the River Neris drainage basin (according to Česnulevičius, 1997). a — river, b — watershed of Neris drainage basin, c — boundaries of genetic zones, d — state border; genetic zones, e — sites of geological cross-sections: I, V, and VIII — glaciolacustrine (lgl), II, IV, VI, and IX — glacial marginal formations (pgl), III — glaciofluvial (fgl), and VII — base moraine (dgl). Legend. *Holocene*: 1 — deluvial deposits, 2 — deposits of swamps, 3 — alluvial deposits, 4 — eolian deposits; *Late Glacial*: 5 — alluvial deposits; *Upper Pleistocene*, *Upper Nemunas* (*Upper Weichselian*): 6 — glaciolacustrine deposits, 7 — glaciofluvial deposits, 8 — marginal glaciolacustrine deposits, 9 — marginal glaciofluvial deposits, 10 — basal till, 11 — marginal glacial deposits; *Middle Pleistocene*, *Medininkai* (*Warthian*): 12 — glaciolacustrine deposits,13 — glaciofluvial deposits, 14 — marginal glaciofluvial deposits, 15 — basal till, 16 — marginal glacial deposits; *Žemaitija* (*Saalian*): 17 — glaciolacustrine deposits, 18 — glaciofluvial deposits, 19 — basal till; *Butėnai* (*Holsteinian*): 20 — lacustrine sediments, 21 — organic sediments; *Dainava* (*Elsterian 2*): 22 — glaciolacustrine deposits, 23 — glaciofluvial deposits, 24 — basal till; *Dzūkija* (*Elsterian 1*): 25 — glaciolacustrine deposits, 26 — glaciofluvial deposits, 27 — basal till; *Lower Pleistocene*, *Vindžiūnai* (*Cromerian Complex?*): 28 — lacustrine sediments; and*Prepleistocene*, *Daumantai* (*Gelasian*): 29 — lacustrine sediments. Lithology: 30 — gravel and sand, 31 — sand with gravel, 32 — sand various size grained, 33 — medium grained sand, 34 — fine grained sand, 35 — silty sand, 36 — silty — clayey sand, 37 — sandy silt, 38 — clayey silt, 39 — clay, 40 — peat (type not identified), and 41 — lowmoor peat. Other symbols: 42 — borehole and its number, 43 — borehole near cross-section and its number.