CHANGES OF WATER BALANCE ELEMENTS OF THE CURONIAN LAGOON IN THE 21st CENTURY

Darius Jakimavičius, Jūratė Kriaučiūnienė
Laboratory of Hydrology, Lithuanian Energy Institute, Breslaujos 3, LT-44403 Kaunas, LITHUANIA
e-mail: darius.j@mail.lei.lt

LITHUANIAN ENERGY INSTITUTE
Breslaujos str., 3
LT-44403 Kaunas,
LITHUANIA
http://www.lei.lt

Institute was founded in 1956 as the Institute of Energy and Power Engineering of the Lithuanian Academy of Sciences.

In 1967–1991 it became known among local and foreign scientific society interested in fundamental research in hydrodynamics, thermal physics, material science, simulation and control of power supply systems, hydrology as the Institute for Physical and Engineering Problems of Energy Research.

In January 1992 Government of the Republic of Lithuania granted a state science institution status to the institute, which became independent from the Academy of Sciences and was named the Lithuanian Energy Institute.

Laboratory of Hydrology

The main directions of research activities :
✓ analysis of climate change and river run-off variation;
✓ environmental impact assessment of anthropogenic activities on water bodies;
✓ collection and analysis of data of the Lithuanian water bodies (rivers, ponds, the Curonian Lagoon, and the Baltic Sea).

The Laboratory of Hydrology carries out fundamental and applied research in the field of environmental engineering employing numerous hydrographic, hydrologic, morphologic, meteorological and other data, collected by the Laboratory of Hydrology for many years, and innovative modelling software (system MIKE 21, developed by Danish Hydraulic Institute, for the modelling of wave, hydrodynamic and sediment transport processes, and pollution dispersion, hydrological process model HBV, developed by Swedish Meteorological and Hydrological Institute, as well as geographical information systems GIS.

The Curonian Lagoon is the biggest fresh water basin in Lithuania influenced by the exchange of the fresh water of Nemunas and other smaller rivers' and saline water of the Baltic Sea. The lagoon ecosystem is influenced by fresh and brackish water masses. The lagoon water balance elements have been influenced by anthropogenic activity and climate change.

Task of this research is to forecast the changes of water balance elements in the 21st century according to Global Climate Models (ECHAM5 and HadCM3) and greenhouse gas emission scenarios (A2, A1B and B1).

METHODS AND DATA

The long-term water balance of the Curonian Lagoon (Fig. 1) (further referred as Lagoon) has been calculated applying the following equation:

$$(Q_U + P - Z) + (Q_J - Q_M) = \pm\Delta V$$

where Q_U – river inflow to the Lagoon; P – precipitation on the surface of the Lagoon; Z – evaporation from the Lagoon; Q_J – inflow from the Baltic Sea to the Curonian Lagoon; Q_M – outflow from the Lagoon to the Sea; ΔV – change in the volume of the Lagoon.

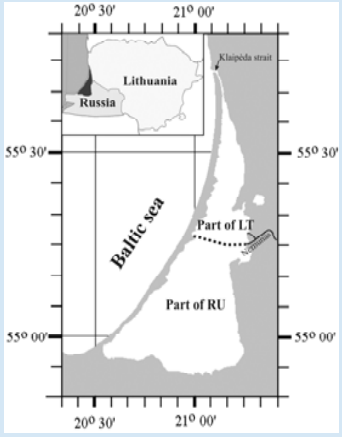

Fig. 1. Baltic Sea and Curonian Lagoon

Climate change impact on the water balance of the Lagoon has been evaluated using Global Climate Models (ECHAM5, HadCM3), greenhouse gas emission scenarios (A1B, A2, B1), and hydrological modelling (HBV model). One scenario was selected for the prediction of the Baltic Sea water level. The predictions of meteorological variables in the 21st century are carried out for 16 meteorological stations across Lithuania.

The delta change approach is used for determination of daily meteorological input data to hydrological models.

RESULTS

Changes of river inflow to the Curonian Lagoon. The annual Nemunas river runoff will decrease in the whole calculated period in comparison with the baseline period: in 2011–2040 – by 9.6–23.1%, in 2041–2070 – by 12.3–31.0% and in 2071–2100 – by 17.8–37.4% (Fig. 2a). According to all climate change scenarios, the redistribution of the Nemunas river runoff will occur in the 21st century. The spring floods will decrease slightly in 2011–2041, whereas the spring floods will disappear in 2071–2100 according to all climate scenarios. The maximal flood discharge values will decrease intensely. The winter season runoff will increase mostly in February, whereas the spring season runoff will decrease mostly in May.

Precipitation to the Curonian Lagoon and evaporation from the Lagoon. According to the six climate change scenarios, the amount of precipitation in winter and spring seasons will gradually increase (4.8% and 3.9%) and in summer season will decrease (5.2%) (Fig. 2b). The most considerable differences of evaporation, in comparison with the baseline period, are identified in winter seasons, while the differences in spring and summer seasons are smaller (Fig. 2c).

Outflow from the Curonian Lagoon to the Baltic Sea and inflow from the Sea to the Lagoon. Water exchange via the Klaipeda Strait was calculated according to the scenario in which the water level of the Curonian Lagoon will rise 4.02 mm/m in the 21st century. In the periods 2011–2040, 2041–2070 and 2071–2100, the outflow from the Lagoon into the sea decreased respectively 8.9%, 12.5% and 13.7% in comparison with the baseline period. In the periods of 2011–2040, 2041–2070 and 2071–2100, the inflow into the Lagoon will exceed the inflow of the baseline period by 13.1%, 23.2% and 36.2%, respectively. The largest increase of inflow into the Lagoon will be observed during the months of spring and autumn seasons. These changes will be determined by the increase of water level of the Baltic Sea in the 21st century, as well as by the decrease of river inflow into the Curonian Lagoon, particularly in spring season.

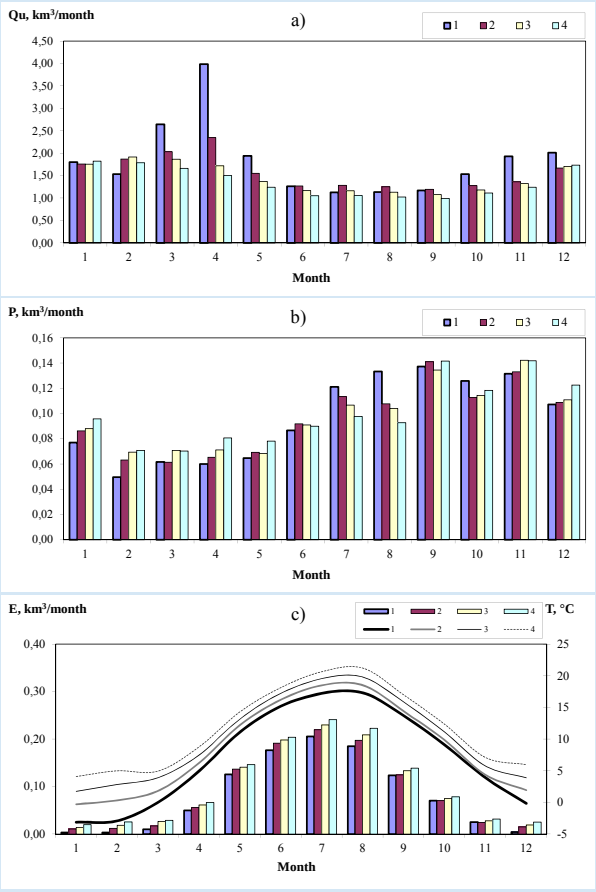

Fig. 2. The average monthly river inflow into the Curonian Lagoon (a), precipitation to the Lagoon (b), and evaporation from the Lagoon and temperature (c) according to six climate change scenarios in the periods: 1– baseline, 2– 2011–2040, 3– 2041–2070, 4– 2071–2100.

This study has been supported by the project "Lithuanian maritime sector Technologies and Environment research development" (Nb. VP13.1 ŠMM08K01019).

CONCLUSIONS

•Considerable changes of the Curonian Lagoon water balance are forecasted in the 21st century. The increase of weather temperature and changes in precipitation will influence the water balance elements of the Lagoon. The inflow of the Nemunas River into the Lagoon will be 20.4% smaller than the inflow of the background period (1961–1990). The distribution of inflow during the years will change considerably: in the winter season, the inflow will increase up to 5.4%, while in the spring, summer and autumn seasons it will decrease up to 40.5%, 1.7% and 21.8%, respectively, in comparison with the baseline period.

•Evaporation from the Lagoon will increase up to 25.1% in comparison with baseline period because of increasing weather temperature. The amount of precipitation will increase marginally (up to 3.8%). Outflow from the Lagoon to the Sea will decrease up to 16.6%, while inflow from the Sea into the Lagoon will increase up to 39.7%. These changes appeared as a consequence of climate change, but the increase of inflow from the Sea to the Lagoon can be linked to natural–anthropogenic factors (dredging of the Klaipėda Strait).