1. The objective of the project

The key objectives of the project comprise the innovative use of non-metric multidimensional scaling (NMDS) and pattern recognition methods, such as artificial neural networks (ANNs), to analyze the obtained catchment data in terms of hydrological, physical, chemical, bacteriological and ecotoxicological properties to identify critical points for water pollution (hotspots) in the catchment itself and in rivers, to establish a hierarchy of factors responsible for the transfer of loads of pollutants into rivers, and to determine the routes of migration and transformation of pollutants and their impact on the environment and living organisms. The project employs innovative interpretation and statistical processing of environmental data that will generate new utilitarian tools for research in Earth sciences, and which will offer significant added value to Science. The research objectives of the project are complete and, in addition to an innovative analysis of mathematical and statistical data, also emphasize chemical analysis focusing on biogenic compounds and dioxins, microbiological analyses of the presence of pathogenic bacteria in the Pilica river and wastewater, and ecotoxicological analysis of total toxicity.

2. A description of conducted research

The research will take place throughout the entire 9,258 km^2 Pilica River catchment in central Poland. The Pilica River, 342 km long, is the largest left-bank tributary of the Vistula River, which itself, at 1,092 km long, is the second longest river draining into the Baltic Sea. The project will be realized simultaneously on the Pilica catchment and the experimental scale. Hydrological, physical, chemical, and microbiological and ecotoxicological data will be obtained concerning the quality of wastewater, contamination of water resources and transformation of pollutants in the catchment. These will be identified using spatial analysis GIS, non-metric multidimensional scaling (NMDS) and pattern recognition analysis. The result of the analysis will be to develop a multi-faceted environmental models that provide detailed knowledge of existing ecological processes and the impact of anthropogenic sources of pollution on water quality in the catchment area. As such studies have not yet been performed at the catchment scale, a very important and novel element of the study comprises both bacteriological analysis and a determination of the overall toxicity (the acute and chronic) of the water from the Pilica river and its WWTPs. These analyses are important, as determination of the risk depends not only on an accurate knowledge of the concentrations of nutrients, but also of harmful substances, such as dioxins, as these demonstrate a range of biological activities (toxicities), and may interact with other components of the analyzed water. Furthermore, the study design incorporates a detailed analysis of the processes occurring in the Model Biofiltering System (MBS) of the Rozprza Town WWTP in order to reveal the physical, chemical, and biological mechanisms responsible for the effective capture of nutrients, dioxins and pathogenic bacteria in the biofiltering system. Another innovative element of the project is its use of a wide range of statistical and mathematical data analysis methods, in particular the use of artificial neural networks (ANNs), non-metric multidimensional scaling (NMDS) and other pattern recognition methods together with multidimensional ordinations and GIS analysis, which will be used to analyze the ecological processes and the impact of anthropogenic sources of pollution on water quality in the catchment.

3. Reasons for choosing the research topic

Export of nutrients and other pollutants to rivers and coastal zones driven by human-related activities is a major problem in river catchments and coastal marine ecosystems. To meet the requirements of the Water Framework Directive (Directive 2000/60/EC), and the Nitrates Directive (91/676/EEC), and to reduce nutrient load to meet the Nutrient Reduction Targets agreed by the Baltic Sea Action Plan (2007), and the last requirements (New Reduction Targets) agreed at the 2013 Ministerial Meeting in Copenhagen, it is necessary for Poland to reduce its pollution from anthropogenic sources. To achieve this, a better understanding is needed of the impact of anthropogenic sources of pollution on water quality on the catchment scale. The prevention of eutrophication and degradation also demands a deeper knowledge of the processes of pollutant migration and transfer to the river system in individual catchments, followed by the development of sustainable water resource management on the local, regional and transborder scales. Therefore, it is crucial to analyse the problem of anthropogenic chemical and microbiological contaminants released from Wastewater Treatment Plants and identify any link between this outflow and the processes of increasing overfertilisation and degradation in the river catchment. This interdisciplinary and innovative study of water quality in the catchment will bring new and utilitarian knowledge about the spread and transformation of pollutants in the river catchments and encourage sustainable social practices, especially in the Baltic Sea region. Innovative studies in the Pilica River catchment will act as a basis for the management of other river catchments, both in Poland and abroad. This in turn will contribute to the reduction of eutrophication and degradation of water resources prescribed by the Water Framework Directive, Wastewater Directive and the Baltic Sea Action Plan. The project is in accord with both European Union policy and the "Horizon 2020" Framework Programme for Research and Innovation concerning the protection and improvement of marine ecosystems, preventive measures aimed at reducing eutrophication within those bodies, and also the reduction of environmental impact to enhance ecosystem services and their value for society. The project focuses on the innovative interpretation and statistical processing of environmental data that will generate a new utilitarian tool for research in Environmental sciences, and provide significant added value to Science.