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THE GEOECOSYSTEM AND ITS APPLICATION IN RESEARCH ON THE PRESENT-DAY MORPHOGENETIC SYSTEM IN THE TEMPERATE CLIMATE ZONE

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Abstract: The organisation and performance of research on geomorphological processes should be based on the methodological and methodical grounds of the empirical sciences. A well-organised observation in the form of geomorphological monitoring forms the grounds for the collection of observational data. Actually, it is not an option to consider the geoecological approach in the study of present-day geomorphological processes. This is a methodological must. Adopting a certain concept of the geoecosystem seems to be a good option in research on present-day geomorphological processes (Kostrzewski 1993). A geoecosystem is a unit of geographic space with varying size and structure. This geomorphological monitoring stands for the organisation and conduct of research on geomorphological processes (considered to be dominant) and relevant conditions (weather-related, hydrological) based on a standardised measurement system in order to obtain reliable data aimed to assess current research studies and plan future studies. Currently in Poland, geomorphological monitoring is conducted at scientific research sites; for example, at selected high schools and as part of the Integrated Environmental Monitoring Network in Poland, which is a subsystem of Poland's National Environmental Monitoring Network. The data obtained from geomorphological monitoring sites, verified on the grounds of accepted statistical tests, forms the basis for the analysis and assessment of a given geoecosystem and its operation, taking into account observed climate changes and increasing human impact.

Keywords: geoecosystem, observation, experiment, geomorphological monitoring, geoecology, Integrated Environmental Monitoring

Introduction

We have currently observed distinct changes in the applied research approaches of studying present-day geomorphological processes in Poland and all over the world. Quantitative methods based on mathematical and statistical development of prognostic observation series prevail over qualitative ones.

The application of research results in the comparative studies is however hindered. It is caused by:
– varied, often short, observation series,
– no detailed information on the applied methods of field research,
– dominance of different methods of visualisation of collected documentation over its limited interpretation which causes that works are often purely documentary,
– poorly presented methodological grounds of development,
– distinct prevalence of analytical works over synthetic ones.

All of the above factors cause that we have been observing relatively slow progress in the formulation of new patterns in relation to characteristics, course and operation of present-day geomorphological processes.

A concept of geoecosystem (Kostrzewski 1993, 1997) is a good option to be taken in research studies on the nature, course and operation of present-day geomorphological processes. It allows for the qualitative and quantitative analysis of present-day terrain transformations.

The concept of geoecosystem – based on the accurate recognition of environmental conditions, morphogenetic environment and its internal structure, interactions between and among environmental components – enables to apply this geoecological approach, which strengthens the research process and its methodological and methodical grounds.

Methodological and methodical assumptions of the study of present-day geomorphological processes within the temperate climate zone

The present-day morphogenetic system within the temperate climate zone (Peltier 1950; Tricart 1960; Klimaszewski 1978) in Poland (Fig. 1), which is relatively stable (compared to other morphoclimatic zones), has been – within the last decade – subject to constant changes both under the influence of natural as well as anthropogenic processes. To properly identify the direction of terrain development and threatening forms, this is of prime importance to be able to single out the impact of natural and anthropogenic processes based on a well-planned field measurement system.

The observed climatic changes and increased frequency of extreme processes with disastrous consequences (Starkel 1996) are another characteristic of the present-day morphogenetic system within the temperate climate zone, which should be taken into account in the organisation of field measurement systems.

The organisation and accomplishment of the research process in dynamic geomorphology should be based on clearly-defined methodological and methodical grounds subordinated to the requirements of empirical sciences (Chojnicki 2007). A well-organised observation supported by experiments in particularising research studies constitutes a basic requirement in the research methodology.

All the assumptions and accomplishment of an individual research process should be demonstrated in the form of an ideogram (Kostrzewski *et al.* 1995; Stach 2009, Mazurek 2010; Szpikowski 2010; Major 2012) being subjected to verification during ongoing research studies.

Fig. 1. Location of young glacial zones in a temperate climate in Poland. Scientific stations supervised by the Adam Mickiewicz University in Poznań

Explanations: 1 – Environmental Monitoring Station in Biała Góra on Wolin Island, 2 – Geoecological Station in Storkowo in the upper Parsęta catchment, 3 – Integrated Environmental Monitoring Station in Poznań in the Różany Strumień catchment

Source: author's own work.

An observation should be well-planned and appropriate in methodological terms and its adopted conditions should be subordinated to the thermal-precipitation and hydrological regime of the temperate climate zone. An observation and its related geomorphological monitoring (as a part of environmental monitoring) (Kostrzewski 2004) is organised for some selected areas which are considered representative (test plots, transects, measuring posts). At selected areas we set up a measuring system with the application of some standard measuring apparatus in order to obtain reliable measurement data (Marciniak 1993; Kostrzewski *et al.* 1995). All collected measurement data (observational series) verified using appropriate verification tests (Kruszyk, Wojciechowski 2014) may form the basis for quantitative and comparative analyses and studies.

A field (or laboratory) experiment constitutes a necessary complement to a given research process under so-called particularising studies. It should be remembered that conditions required to run an experiment (a field or laboratory experiment) ought to consider process characteristics and its course under natural circumstances.

Conducted research studies provide formulated statements on some regularities which significantly contribute to the cognitive process of studied phenomena. These adopted regularities may confirm or challenge previously accepted statements, they may introduce new information and make an important contribution to the development of scientific theory of a given (analysed) research subject.

Present-day geomorphological processes are the study subject of dynamic geomorphology which deals with the diagnosis of the morphogenetic environments and their operation; it also recognises present-day terrain transformations.

In order to increase the particularity of ongoing research studies, dynamic geomorphology benefits from the experience of other sciences, including geology, soil science, agricultural science, physics as well as various areas of physical geography, for example, climatology, hydrology, geoecology. Geoecology is an interdisciplinary scientific field, it deals with the study of present-day geoecosystems, their structure, operation and changes; it analyses the Earth surface, its physical processes, including geomorphological processes. Considering the geoecological approach in research studies on present-day geomorphological processes is not an option; this is a methodological must. Geoecology and its assumptions (Kostrzewski 1993; Huggett 1995) can be successfully applied in the study of present-day geomorphological processes. In the assessment of geoecosystems and their operation, geomorphological processes, their course and intensity constitute an indicative feature of ongoing landscape changes.

Dynamic geomorphology and its research studies covers the Earth surface recognised from different spatial perspectives being regarded as a system (Bertallanffy 1984), morphosystem, morpholitosystem, geosystem, geoecosystem (Kostrzewski 1993). From the methodological point of view it is of the utmost importance to delimit a spatial unit taken for research studies. Making use of geoecology and its experience it is a good option to adopt a concept of geoecosystem in dynamic geomorphological studies (Kostrzewski 1993) as a unit of the Earth surface within which we will analyse, quantify and qualify some present-day geomorphological processes.

In methodological and methodical terms, the adoption of a concept of geoecosystem fits well and extends the primary directions of research studies on present-day geomorphological processes, which could include:

– qualitative and quantitative identification of mechanisms of present-day geomorphological processes and their operation,
– recognition of the evolution of present-day morphosystems (geoecosystems) under observed climatic changes and diversified anthropopressure,

– recognition of the level of anthropogenic transformation, course and intensity of present-day geomorphological processes,
– determination of the denudative balance of present-day morphosystems (geoecosystems),
– organisation of standardised geomorphological monitoring in order to collect comparable observation series to form the grounds for diagnostic and prognostic studies,
– determination of tolerance (its thresholds) of different terrain types to present-day geomorphological processes (to their average, above average and extreme levels),
– more extensive application of GIS methods in documentation (databases) and spatial analysis of present-day geomorphological processes,
– application of new methodological and methodical concepts in the scope of present-day geomorphological processes.

A concept of geoecosystem in the study of present-day geomorphological processes within the temperate climate zone

The methodological and methodical assumptions of geoecosystem as a concept developed in geoecology and in the geoecological approach were introduced into dynamic geomorphology (Kostrzewski 1993; Hugett 1995). The application of geoecosystem as a concept in dynamic geomorphology provides additional opportunity for broader dissemination and use of information on present-day geomorphological processes because their role and importance in the operation of physical and geographical environments are paramount.

An individual research process in geoecology and dynamic geomorphology has a similar structure (Fig. 2). It should be indicated however that dynamic geomorphology turns special attention to terrain geo-variability (Kostrzewski 2000, 2001), its transformations and present-day evolution.

Well-organised environmental monitoring supported by field and laboratory experiments form the grounds of information on a given geoecosystem. Then it enables to provide reliable information on current geoecosystem conditions and making forecasts on its short- and long-term development under different scenarios.

A geoecosystem being covered by the study of dynamic geomorphology is a unit of geographic space with different dimensions and structure. Geoecosystem characteristics (type and size) depend on the accepted criterion for classification.

Spheres, elements, objects and phenomena (processes) can be distinguished in the internal structure of a given geoecosystem (Fig. 3).

Spheres include: atmosphere, biosphere, morphosphere, hydrosphere, lithosphere, pedosphere, anthroposphere. These spheres and boundaries between them are varied

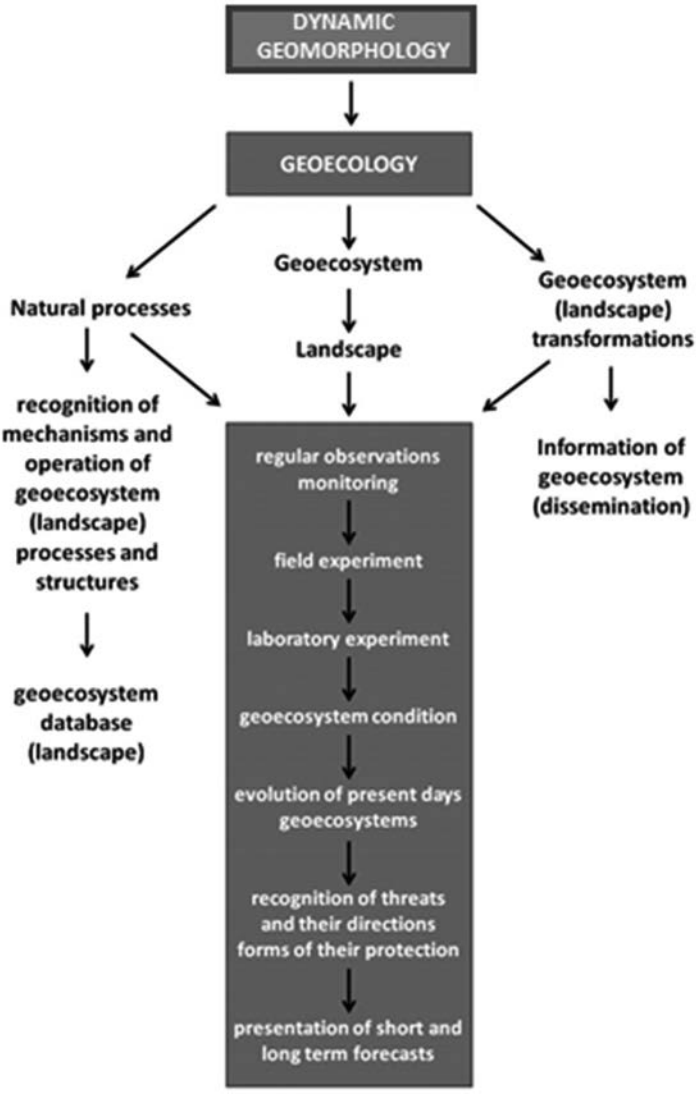

Fig. 2. Ideogram of a research process in dynamic geomorphology and geoecology

Source: author's own work.

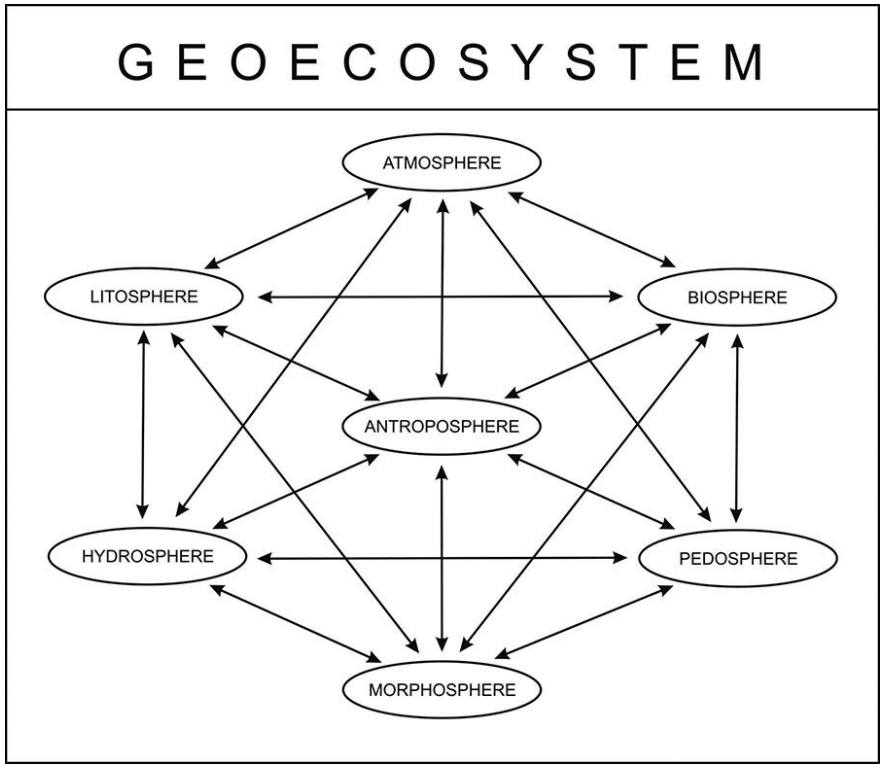

Fig. 3. Geoecosystem, inner structure

Explanations: ⇆ – interactions, dependencies

Source: author's own work.

and subject to changes in time and space. Elements define the internal diversity of individual areas, for example, types of terrains, surface waters, underground waters, soils, plant and animal communities, etc. Objects stand for units brought by humans, for example, a communication network, drainage network, buildings, etc. Phenomena stand for recognised physical processes, for example, physical processes shaping the Earth surface, physical processes in the atmosphere, hydrosphere as well as socio-economic processes, for example, migration, tourism, etc.

The primary objective of a research process is to recognise a geoecosystem, identify its internal structure and its transformations based on qualitative and quantitative

methods. Ongoing changes are stimulated by a system of relationships, dependencies, synergies which exist between spheres, elements, objects and phenomena, and which are regulated by the geographical location of a given area and properties of the Earth surface. This quantitative determination of these relations (their intensity) allows to identify (single out) dominant and secondary processes characteristic to an individual climate zone or region. The accurately-developed specification of the above-mentioned dependencies forms the grounds to organise environmental monitoring in the geoecosystem.

Organisation of environmental monitoring in the geoecosystem

It is of the utmost importance to qualitatively and quantitatively identify the current status and changes of terrain within any analysed geoecosystem. Geomorphological monitoring stands for organisation and observance of geomorphological processes which are considered dominant (and if possible secondary ones) and their conditions (weather-related, hydrological, etc.), based on a standardised measurement system, in order to obtain reliable results to run comparative studies.

The organisation of research studies on present-day geomorphological processes based on the concept of geoecosystem covers (Fig. 4):

– identification of boundaries, internal structure of geoecosystems selected to be analysed,
– identification of geomorphological processes within a given geoecosystem (slopes, river basins, etc.), hierarchy arrangement in terms of their intensity based on some adopted procedures,
– organisation of geomorphological monitoring within a given geoecosystem (for example, of denudative, fluvial, coastal processes etc.), taking into account environmental factors (including weather, hydrological conditions, etc.),
– quantitative determination of the intensity of monitored processes (pressure) and verification of observation series based on the accepted statistical tests,
– setting up an efficient IT system, development of thematic databases,
– analysis of collected measurement data and prognostic model studies taking into consideration different scenarios,
– determination of the current state of a given geoecosystem in relation to characteristics, course and intensity of present-day geomorphological processes and their effects, with the indication of threats and forms of protection within a terrain,
– dissemination of information in the form of publications intended for scientific, educational and application purposes.

Currently in Poland geomorphological monitoring is run at scientific stations (Krzemień *et al.* 2005) as well as under the Integrated Environmental Monitoring being a subsystem of the National Environmental Monitoring (Fig. 5).

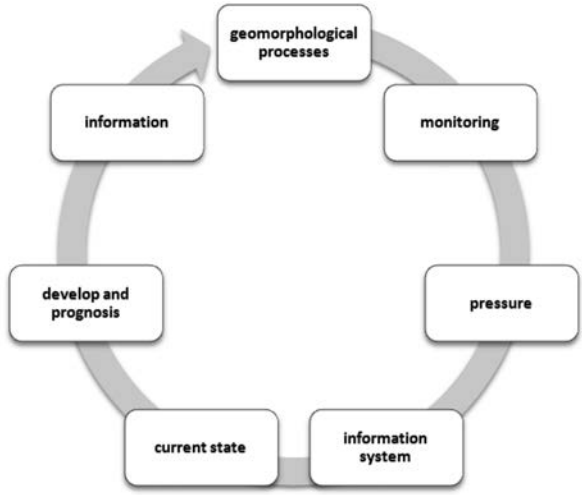

Fig. 4. Stages of organisation of geomorphological monitoring of a given geoecosystem

Source: author's own work.

Fig. 5. Base Stations in Poland's Integrated Environmental Monitoring System operate geomorphological monitoring programs both large and small

Source: author's own work.

Photo 1. Monitoring of soil erosion at the Geoecological Station run by the Adam Mickiewicz University in Poznań located in the upper Parsęta catchment (photo by J. Szpikowski)

The Base Stations under the Integrated Environmental Monitoring System located at some representative geoecosystems run geomorphological monitoring to a varying extent, among others on abrasion of cliff coasts (Station at the Wolin Island), soil erosion and dynamics of fluvial transport (Station at the upper Parsęta catchment) (Photo 1 and Photo 2), formation and development of landslides (Station in Beskid Niski), etc. It should be emphasised that a well-organised and implemented geomorphological monitoring should form the grounds for scientific and practical studies allowing for updating and prognostic analyses.

Photo 2. Monitoring of fluvial transport dynamics at the Geoecological Station supervised by the Adam Mickiewicz University in Poznań, located in the upper Parsęta catchment (photo by J. Szpikowski)

Conclusion

The application of a concept of geoecosystem in the study of present-day geomorphological processes is justified in methodological and methodical terms. This concept meets the requirements of empirical science, which is a methodological requirement of dynamic geomorphology. In terms of the methodology of research studies, standardised research methods and experiments in particularising studies are applied. It should be emphasised that the application of geoecological approach in the study of present-day geomorphological processes meet the methodological standards of empirical science.

The study of characteristics, course and intensity of present-day geomorphological processes should take into account regularities of a specified climatic zone (in this case the temperate climatic zone) to which the measuring system and observation

dates are adjusted. It is of the utmost importance to arrange the hierarchy of geomorphological processes under a given monitored geoecosystem in the range of their course, progress, intensity and effects. Geomorphological monitoring embraces dominant (primary) processes. All obtained measurement data verified on some accepted statistical tests are the basis to analyse and assess geoecosystems and their the operation. Recognised geomorphological processes are a status indicator of a given (studied) geoecosystem, taking into account observed climatic changes and increasing anthropopressure.

Dynamic geomorphology in the study of present-day geomorphological processes must take into account the theoretical development of exact sciences and natural sciences.

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