SOIL EROSION IN THE AGROECOSYSTEM AND POSSIBILITIES OF MONITORING

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Jóźwiak M., 2010: Soil erosion in the agroecosystem and possibilities of monitoring (*Erozja gleby w agroekosystemie i możliwości jej monitoringu)* Monitoring Środowiska Przyrodniczego, Vol. 11, s. 9-12, Kieleckie Towarzystwo Naukowe, Kielce.

Abstract: The shape of conditions for the development of soil erosion processes in agricultural ecosystems depends on natural and anthropogenic factors. Soil cover, relief and climate play essential role in soil susceptibility to washing out. As a process of washing out or drifting the covering soil layer, erosion changes the soil environment to great extent. Erosion occurrence is not only a reason for changing the relief and soil degradation but also force strengthening food components' migration. Despite the fact that Polish moderate climate limits the erosion occurrence, the diversified mountain. piedmont, upland and lake district relief as well as the high degree of soil susceptibility to washing out and blowing away cause that 27,6% of arable land is endangered by soil drifting, 28,5% by water sheet erosion and 17,5% by ravine erosion (GUS, 2009). The eroded regions are very complex farming areas. They are characterized by the loss of natural balance leading to negative and most frequently permanent changes of ecological conditions. The conditions of plant growth and development become worse as a result of degradation caused by erosion, relief deformation, and water relation disturbance and washing out the components thus giving the reflection on the decrease in crops. These multi-directions of dangers resulting from erosion occurrence make it necessary to initiate activities in order to organize the erosion monitoring system.

Key words: *agricultural ecosystems, threat, soil erosion, degradation.*
Słowa klucze: rolniczy ecosystem, zagrożenie, erozja gleb, degradacja.

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1. Introduction

Erosion of the Earth surface is natural process in antropogenically non-transformed ecosystem. It is one of the essential nature factors forming the crust of the Earth. In Poland natural erosion appears solely in upper parts of the mountains where the cultivation of the steep rock walls is impossible to be conducted. With the increase of human industrial activity, erosion becomes more and more degradation factor. Therefore, even at the present moment, approximately the half of arable land in the world is more or less liable to soil erosion. Every day approximately 3200 ha of lands are devastated, however, generally the size of devastation is estimated to be 2 milliard ha of arable land which is 15% of the continent area (Achasov et al., 2000). 200 years ago the colonist, mainly the English, started ploughing the prairie of North America and cultivating wheat in monoculture, which caused the water and air erosion processes resulting in complete devastation of 20 mln ha of soil according to Bennet (1955). Cultivation became unprofitable on further 60 mln ha and approximately 300 mln ha were partially devastated. In South America "deserts of erosion" covered 300 thousand km^2 in 1939, but 24 years later 400–500 thousand km^2 are endangered by erosion and the soil loss amounts to 6 miliard tons annually on the area of 800 thousand km^2.

Erosion occurrence is visibly marked on the cultivated area. Ploghlands are system mostly transformed by man. Nature in original form ceased to exist on vast areas. Naturally balanced biocoenoses were replaced with poor agricultural coenoses in which food chains consisted of fewer links. None of human activities exerts such complex influence on biocoenosis as agriculture. Therefore, unforeseeable changes which are unwanted due to their destructive changes are parallel to consciously stimulated and controlled transformation of the former. It is very important to choose a firm cultivation system for the given place which should be executed from ecological point of view and cannot lead to degradation of ecosystems due to such process as soil erosion (Chaplot et al., 2002).

2. Entire Natural and Industrial Conditions of Development of Soil Erosion Processes in Agricultural Ecosystems

The shape of conditions for the development of soil erosion processes in agricultural ecosystems depends on natural and anthropogenic factors. Soil cover, relief and climate play essential role in soil susceptibility to washing out. According to many researchers (Bonilla et al., 2007; Fiener, 2007; Jóźwiak, 1999) dust soil formed from loessial and loessial like silt belongs to soil mostly susceptible to erosion. This susceptibility is determined by huge amount of dust fraction (particle diameter 0,1–0,01) and relatively small abundance in colloid. The second group consists of limestone silt. It is conditioned by quantitative relation of soil fraction to framing and the type of parent rock. Limestone soil is formed from lime stone such as chalk and marl which are less erosion resistant than limestone soil formed from cohesive soil. The researchers (Józefaciuk, Józefaciuk, 2001; Smolska, 2002) claim that limestone degradation due to its very small capacity of self-regeneration is even higher in comparison with loessial soil. The third group of soil consists of sandy soil. Sandy soil susceptibility to erosion is conditioned by mechanical composition. Loose and integral sand as well as soil with lighter mechanical composition belong to strongly susceptible soil but different argillaceous sand to medium-susceptible soil.

Relief is the second natural factor which has an influence on the development and intensity of erosion processes. It is generally assumed that erosion intensity depends on drop and length of a slope (Smolska, 2008). With agricultural use the admissible border of the slope amounts to 20% of arable land and 30% of grassland. The essential factor is the character of relief. The more wavy and cut with valleys the surface of arable land is the faster water run-off is. It is necessary to focus the attention on the soil slope position because at the same slope the process of washing out and silting up may occur (Yun et al., 2002).

The erosion occurrence is determined by meteorological factors such as quantity, decomposition and rainfall intensity as well as the terms of occurrence. Additionally, the depth of strata and melting of snow cover are of great importance. Rainfalls directly contribute to the occurrence of erosion. There is a close relationship between the annual volume of rainfalls and the increase of water erosion process. Rainfalls in early spring and late autumn are the most dangerous because the soil is not covered with plants. Rainfalls with great intensity during the plant vegetation period may cause destruction in crops, however, outside the arable land erosion is small. In the piedmont regions 90% of annual erosion damages are caused by snow melting. In the mountain regions its participation is considerably smaller (Gil, 1976; Chaplot, 2002). Man exerts the strongest influence on erosion occurrence. The way soil is cultivated determines whether the soil will be protected or not. Data presented by Bennett (1995) are the most convincing examples of the user's influence on soil erosion. H states that in Continental climate the soil depth of stratum – 18 cm at the slope 10% – is washed out depending on the manner of using:

- under the primeval forest within, 575000 years
- under stable sod, 82150 years
- under the agriculture (with crop rotation), 110 years
- under black farrow. 18 years

It is not difficult to notice that vegetation has smaller protective value in comparison with other forests1 and meadows' forms. This is confirmed by the research carried out by Gil (1976) who established the equivalent factor of soil denundation at the forests (0,00003 mm*year^{-1}), pastures (0,0012 mm*year^{-1}), meadows (0,0028 mm*year^{-1}), cereals (0,0043 mm*year^{-1}) and root crop (2,97 mm*year^{-1}). Other anthropogenic factors which influence the erosion occurrence comprise the along slope scheme of plots, agricultural techniques, crop mechanization transportation, roads' system and inadequate rating.

3. Side Effects of Erosion Occurrence

As a process of washing out or drifting the covering soil layer, erosion changes the soil environment to great extent. In arable land located on slopes, soil forming process is considerably shallow in relation to soil situated under the forests (Koćmit, 1992). The main reason is the radical change of sloping process denundation is prevailing and its force is directed along the slope surface in compliance with the drop. As a result of this process. the transport of soil particles takes place along the slope and its morphology is formed as well. Moreover, considerable typological and species' changes occur. A. Józefaciuk and C. Józefaciuk (2001) states that the prevailing black earth located near Opatówka in Wyżyna Sandomierska amounts to 10% of the total soil and has strongly degradated profile in comparison with proper – black earth. Many authors draw attention to soil diversification within the slope. As a result of profile reduction on the slope, there appears a great number of soil types and subtypes with a considerable share of soil susceptible to washing out. However, at the base and in the valleys there occur silted in soil with mechanically transformed level of accumulation. The change in soil morphology exerts considerable influence on such physical qualities as porosity, water capacity, water percolating rate.

Within the slope, it is possible to find a great diversification of soil humidity. It is noticeable mainly on large ploughland covering the area of different configuration – upper layer – slope of different exposition, drop and valleys. Humidity diversification at the particular element of relief delays the dates of agricultural and technical activities as well as their quality because soil at the base and in valleys get dry considerably late. It makes soil cultivation more difficult and lowers the production results. The surface processes of permanently enormous intensity may lead to considerable drying up and overmoistening of soil.

Erosion occurrence is not only a reason for changing the relief and soil degradation but also force strengthening food components migration. It is assumed that the average flow of dissolved and floating food compounds calculated to manure amounts to 60 thousand tons 18% superphosphorate, 150 thousand tons 20% potassium salt, 70 thousand tons 20% nitro-chalk, 80 thousand tons 60% burnt lime (Jóźwiak, 1999; Favis-Mortlock, 2001; Williams et al., 2002). This main reason is phosphorus quick transformation into insoluble forms. The loss of lime is conditioned by the compound content in soil substrate and soil liming. Generally speaking, erosion causes the component losses in agricultural ecosystems. The size of those losses is determined by the type of soil, topography, climate and the used fertilizers. Apart from the Jack of their use by plants washed out compounds contribute to eutrophication of natural waters, which frequently is unwanted source of changing the whole landscape.

Morphological and physical-chemical changes of soil caused by erosion have also their reflections in the lay-out and number of microorganisms. The research carried out by Nowak et al. (1992) shows that on the eroded area the decrease of biomass quantity and the number of microorganisms are notice-able. Estimated at particular localization, the average of living organisms biomass at the level of 0–30 cm shows that the highest values are noticeable in the following order: at the slope base, upper parts, the silted up slope and the washed out slope. Therefore, the worst conditions for the growth and development of plants appear at the slopes where erosion is mostly intensified. It is also worth mentioning that microorganisms (bacteria and actinomycetes) comprise the most important group of soil organisms. Their function is difficult not to be estimated. They decompose simple carbohydrates, cellulose, and cause protein mineralization, autrophic bacteria oxidize ammonia to nitrites and later nitrogen compounds to nitrites and fix the nitrogen from air. They directly influence the increase in soil utilization value. In this way, crops achieved from the area in which erosion occurs best illustrate the influence of erosion on the functioning of agricultural ecosystems. Crops illustrate and integrate the influence of all the factors having an effect on the plant organisms during its growth and development.

4. Final Remarks

Despite the fact that Polish moderate climate limits the erosion occurrence, the diversified mountain. piedmont, upland and lake district relief as well as the high degree of soil susceptibility to washing out and blowing away cause that 27,6% of arable land is endangered by soil drifting, 28,5% by water sheet erosion and 17,5% by ravine erosion (GUS, 2009).

The eroded regions are very complex farming areas. They are characterized by the loss of natural balance leading to negative and most frequently permanent changes of ecological conditions. The conditions of plant growth and development become worse as a result of degradation caused by erosion, relief deformation, and water relation disturbance and washing out the components thus giving the reflection on the decrease in crops. These multi-directions of dangers resulting from erosion occurrence make it necessary to initiate activities in order to organize the erosion monitoring system.

The objectives of the erosion monitoring are the following:

– collecting, transmitting and processing data concerning the state of natural environment components which have the direct influence on erosion occurrence and intensity,
– collecting the information about qualitative and quantitative changes in the endangered area and according to the classification of erosion occurrence (Jóźwiak, 1994),
– controlling the processes which occur in the natural environment due to erosion,
– preparing the forecast of erosion intensification and the degradating influence on the natural environment,
– preparing the project of anti-erosion procedure aiming at environment conservation and regeneration of landscape components transformed as a result of erosion occurrence,
– integrating and improving the research on soil erosion in order to accomplish anti-erosion procedures and estimate their economic effectiveness.

The fundamental principle of monitoring the phenomena of antropogenic transformations in natural environment is to accept the unified research method for the whole country. Only in this case is it possible to compare the research results achieved in different regions and determine the directions of changes.

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