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Eliminating Water Erosion within the System of Land Sanation Measures

1. Introduction

In Poland, it is water erosion that contributes most to the erosional degradation of environmental assets. About 28% of the territory of Poland is threatened by water and sheet erosion and about 18% by ravine erosion. Mountainous and upland areas, situated in the southern part of the country, are mostly threatened by water erosion. It is estimated that on average about 10 million tons of soil are washed down a year, of which 5 million tons are transported to the sea by rivers [13]. Average annual soil losses, according to [3], equal 76 t/km^2; in the area of the Flysch Carpathians [8] estimates them to be as high as 280 t/km^2.

The results of erosion in rural areas are reflected in unfavourable transformations of ecological conditions (relief transformations, changes in physical-chemical and hydrological soil properties), water regime disruptions, damages to technical infrastructure (buildings, roads, bridges, river training constructions), which, as a result, leads to the degradation of productive and natural assets of rural areas. Relief transformations caused by sheet erosion, particularly with intensive agricultural activity, are rather significant. Ravines and suffusion processes (suffusion sinkholes) transform rural landscape most destructively.

In terms of spatial range, changes in morphological properties and soil moisture, caused by sheet erosion (rinsing, mud-flows, solifluction), are most significant. As a result of land being deeply cut through by ravines, the surrounding areas are drained and alluvial fans at ravine mouths distort water regimes. Suffosion processes and mass movements, in turn, devastate the soil profile and deteriorate moisture regimes. Damages to technical devices and facilities occur due to rinsing or accumulation of soil or rock material. Bed load transported by mountain streams generates particularly significant damages in that respect.

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Negative effects of water erosion, both regarding environmental (ecological) and economic dimensions, concern, above all, agriculture and water economy. As far as agriculture is concerned, this means that the yield and quality of crops decrease, as a result of soil degradation, crop devastation and mudding. Moreover, water erosion generates space disorganisation caused by dismembering of relief. As far as water economy is concerned, the negative effects boil down to the deterioration of hydrological regimes (among other things increasing the share of floods) and conditions for operating hydrotechnical devices (silting-up of water reservoirs and damages to hydro-melioration devices).

Due to their scale and negative influence on the environment and economy, the processes of water erosion constitute then a serious problem which needs to be addressed within initiatives aiming at earth surface conservation. This is a legal obligation pointed out in Polish regulations concerning environmental protection [11].

This paper mainly aims at placing the issues connected with water erosion of soil within the system of soil sanation measures. It presents basic sanation measures and outlines the question of anti-erosional soil conservation in spatial planning.

2. Land sanation measures

Sanation (restoration, improvement, revitalisation) of degraded and devastated land (soil) which is defective by nature, involves carrying out activities within: hydro-meliorations, agrotechnical meliorations (agromeliorations), and phytomeliorations – which are subsumed under the following terms: agricultural meliorations, forest meliorations, and anti-erosion meliorations – referred to as special meliorations or land reclamation (recultivation).

If melioration activities, as the term itself points out, basically aim at ameliorating, improving defective land, then recultivation activities aim at repairing damages done to soil as a result of economic, mainly industrial, activity. This most often concerns soilless, drained, water-logged, or contaminated areas. A systematic review of sanation measures will be presented below, taking into consideration the type of activities, their aim, character (direction), and technological aspects [7].

2.1. Hydro-meliorations

Hydro-meliorations **aim** at regulating (improving) water regime.

With respect to their **character** we can divide hydro-meliorations into: drainage and irrigation.

Regarding **technological** aspects, drainage measures amount to applying such solutions as open ditches, drainage systems (systematic, non-systematic), mole drainage, and the like.

Irrigation measures include: surface, flood, downward, sprinkler, drip, upward, seepage irrigation, etc. [9].

2.2 Agrotechnical meliorations (agromeliorations)

They **aim** at improving agrotechnical properties of soil.

In **character**, they are similar to methods applied in farming.

Technologically speaking, these are: deep ploughing (with a subsoil plough), melioration ploughing, mole ploughing, deep fertilization (manure, peat placement), liming, screening (plastic film, asphalt, geosynthetics), stone clearing, clay addition, loam addition, intensive fertilisation, etc.

2.3. Phyto-meliorations

This **type** of meliorations **aims** at protecting soil from degradation, improving ecological conditions – water regime, microclimate, etc.

They take on a **character** of woodlots: mid-field, roadside, wind protection, anti-erosional; and turfs. They involve escarpments, slopes, dunes, etc.

As far as **technological** aspects are concerned, phyto-meliorations involve afforestation, planting shrubs (with methods used by foresters), turf (hydroseeding, manual sowing).

2.4. Forest meliorations

Their **aim** is to improve forest habitats (soil).

The **character** of these measures is similar to agromeliorations, hydro-meliorations, and phytomeliorations.

Technologically, these are activities based on technical, biological and biotechnical methods by means of ploughing, fertilizing, liming, regulating water regime, planting trees and shrubs.

2.5. Anti-erosional meliorations

This **type** constitutes a branch of meliorations, adjusted to the specificity of areas with rich landform, and the **aim** is to protect soil from water or wind erosion [10]. With regards to the type of measures, we can mainly distinguish activities of a agrotechnical, phytomeliorational (bioengineering), etc. **character**. **Technologically** speaking, as far as water erosion is concerned, they involve such solutions as anti-erosional crop rotation, anti-erosional field patterns (ribbons, terraces), afforestation, mechanical reinforcement of ravine slopes and escarpments, etc; and as far as wind erosion is concerned, also wind-protection belts, irrigation, soil stabilisation (loam addition), reinforcement of dunes [6].

Sometimes, the entire group of melioration activities, including land development, is subsumed under the term comprehensive meliorations.

2.6. Land reclamation

The **aim** of this type of activities is restoring productive or other functional assets to destroyed (degraded, devastated) areas as a result of anthropogenic activity. Restoring functional value to unproductive areas, which developed naturally, is sometimes called adaptation.

In terms of **character** of the applied measures, two fundamental types of land reclamation (recultivation) can be distinguished: technical and biological.

Technical recultivation includes: proper relief shaping, improving physical and chemical properties of soil, regulating water regime, soil reconstruction, reinforcing escarpments, etc. Biological recultivation involves various measures of an agrotechnical (cultivation) character – which serve as a transition to productive land use.

Technologies applied in technical recultivation generally boil down to using appropriate methods of land levelling (moderating steep slopes), preventing mass movements, biotechnol`ogical reinforcement of escarpments, drainage or irrigation, soil reconstruction with technical methods (insulation, deconcentration, neutralisation), stone clearing, felling trees and removing shrubs, removing remaining elements of engineering constructions, removing the humus layer, etc.

3. Anti-erosional meliorations within the system of soil sanation measures

Anti-erosional meliorations, referring to areas under the influence of water erosion, mainly involve such basic measures as: improving and reconstructing soil with technical and biological methods, planting trees, shrubs, and turfs as well as technical reinforcement of ravines. They are very often connected with agricultural engineering work (land consolidation).

Anti-erosional meliorations can be therefore placed in the borderline between a few fields of science and practice constituting a set of measures which help to protect and restore soil (land) destroyed by natural forces in combination with anthropogenic impacts. This is due to the fact that areas in which anti-erosional measures are undertaken developed as a result of impacts of various types of water erosion (surface, ravine, subsurface), their degradation has therefore a varied character. Moreover, there are different improvement technologies and different forms of the target spatial development: agricultural, fruit farming, forest, recreational, hydrological, etc.

There is a range of problems that need to be solved within anti-erosional meliorations, mainly concerning spatial planning, sozology, economy. These problems have to be addressed taking into consideration the aspects of agriculture, forestry, recreation, water economy.

The aim of measures preventing water erosion is not only the improvement of imbalanced ecological systems (agro- and pratoecosystems), through proper shaping of natural elements (relief, soil, water regime) in accordance with the accepted directions of spatial development of a given area, specified in its local plan.

4. The range of basic anti-erosion measures

Apart from the analysis of soil threats presented in an adopted scale, the following data and parameters inform about the needs concerning anti-erosion land protection:

- the level of urgency of anti-erosion soil protection [1],
- the index of agrotechnical soil protection against erosion [4],
- the average index of intensity of a given erosion type (the value weighed by an area of particular degrees of phenomenon intensity).

On the basis of a diagnosis concerning the urgency of anti-erosion soil protection measures (level 1: more than 25% of the area suffering from erosion at the levels 3–5, level 2: 10–25%, and level 3: below 10% of the area) we can distinguish the following sets of measures referring to sheet and ravine (linear) erosion [6].

In the case of water sheet erosion at the 1st level of urgency, comprehensive measures are recommended, such as agricultural technology and anti-erosional crop rotation, benching for special crops, land transformation (grasslands, woodlots), changes of the field-forest border; at the 2nd level of urgency – agricultural technology and crop rotation, changes in the field pattern, slope benching for arable use or orchards; at the 3rd level the recommended measures are: agricultural technology and crop rotation, change in the field pattern – from parallel-to-slope to angled- or perpendicular-to-slope.

With reference to water linear erosion, at the 1st level of urgency, developing active ravines is recommended carried out within comprehensive anti-erosion systems; at the 2nd level of urgency, developing active ravines is recommended, and at the 3rd level – reinforcing beds and slopes of active ravines.

5. Eliminating water erosion in land development

Research and implementation activities carried out in many Polish agricultural centres constitute the theoretical framework for activities within anti-erosional soil conservation in spatial planning.

Research and implementation activities mainly concentrate on:

- quantitative and qualitative description of erosion processes, and recently also on implementing mathematical models of soil loss prognosis;
- developing and improving anti-erosion melioration methods on arable lands and wasteland recultivation;
- drawing up principles and models for comprehensive development of eroding areas, including:
  - assessing conservation effectiveness of various systems of developing eroding areas,
  - improving the methods of ravine development,
  - drawing up principles of reinforcing rural roads.

Anti-erosional soil protection is an important element of spatial planning and development.

Instead of voivodeship comprehensive programmes of anti-erosion soil protection, developed until the 1990s, the following are being currently worked out:

- agricultural conditions for voivodship spatial development studies (i.a. determining erosion threat, the need for afforestation, soil recultivation);
- ecophysiographical studies for communes (municipalities), which also take into consideration soil erosion;
- prognoses concerning the results of the impact of local spatial development plans on the natural environment; particularly in areas suffering from erosion these plans should also deal with this aspect of soil degradation.

The Act on Protection of Agricultural and Forest Lands of 1995 obliges owners of land to prevent its degradation, especially including erosion. It is the owner's responsibility to keep anti-erosional devices in good technical condition. Moreover, the competent administrative organ can order the owner to plant trees or shrubs on a given area or change it into a permanent grassland.

Preventing erosion was and currently is a very important element of land consolidation projects through rational distribution of arable land with respect to houses and farm buildings, the layout of roads – taking into account relief and land use. Moreover, it is the owner of land, who, according to the Act on Protection of Agricultural and Forest Lands, is responsible for keeping the anti-erosion devices in good condition or carrying out, as required by administration, phytomelioration activities.

The need for soil conservation is also pointed out in the rural areas management and development bill. The so-called agricultural engineering municipal plan, corresponding to the local plan for rural areas, should outline the needs and conditions for soil erosion prevention, wasteland transformation, soil recultivation, and the prognosis of decision results on the environment [5].

Developing a system managing the agricultural production area threatened by erosion requires a specific approach and should be realised in two basis stages [2]:

1) Identification-diagnosis studies, whose aim is to define conditions and directions for the system of village management, on the basis of the inventory of current agricultural production conditions (climate, soil, actual erosion, spatial land pattern, etc.).
2) Planning-project studies, which aim at developing a system of agricultural space management. It should include all activities within the technical-ecological organisation of the area, which primarily means developing a project of:
   - wasteland recultivation and shaping eroding relief,
   - transforming farmlands as well as land, field, and rural road patterns,
   - technical infrastructure in the area (hydrotechnical constructions).

The above mentioned engineering measures create the basis of the system of plant production, which protects soil, based on anti-erosional agrotechnology, taking into consideration, as much as it is possible, perpendicular-to-slope farming and perpendicular-to-slope direction of sowing, planting, and vegetation nursing. Moreover, the system is based on protective crop rotation adjusted to the elements of relief (valley bed, slopes, upper areas).

6. Conclusion

Eliminating water erosion of soil is an important element in the system of measures aimed at protecting and shaping land. Anti-erosional measures, which belong to the domain of technical sciences (environmental engineering) and agricultural sciences (environmental protection and shaping), help to implement the policies of sustainable development referring to the surface of land through space use rationalisation, taking into consideration the requirements of sozology.

Over the past several years, we could observe a diminishing activity concerning the realisation of projects aimed at agricultural land sanation, while we could observe intensified afforestation, which is in compliance with trends popular in the EU, due to food overproduction and the need to improve the natural environment conditions.

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