Soil Erosion Management Practices in the Prefecture of Kilkis, Northern Greece

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Abstract: Declining yield, as a result of erosion in soils located in the Prefecture of Kilkis, Northern Greece has been observed. An area of about 3.000 hectares has been studied and the majority of the examined soils were mainly formed from the weathering of limestone or acidic material. These soils cover mainly hilly areas, have been classified as *Entisols, Inceptisols or Alfisols*, and are usually cultivated by wheat, maize, cotton, tobacco and sugar beets. They have been developed on tertiary or quaternary deposits and the upper terraces or alluvial fun are very susceptible to erosion. The appearance of high degree of erosion is present in the slopes greater than 6 % and is illustrated in the erosion map. Pronounced differences on soil depth, texture, water holding capacity, and nutrients have been recorded. Available phosphorus was very low in the subsurface layers, whilst potassium ranges in the ploughing layers and magnesium was in normal levels. Nutrient loss is quite severe and nitrogen leaching seems to play a dominant role in the decline of the crop yield, hence on farmers income. Attention should be paid in the water shortage during the dry season, which affect land cover and erosion risk is increased during the rainy season. In particular, it can be argued that in this semi-arid region the following measures and practices may be adopted such as: the policy of subsidies which encourage farmers for rotation or set aside of marginal areas, incentives for reforestration, minimum ploughing and/or ploughing along contour-lines, rational irrigation by means of the extension of drip irrigation systems may be applied, avoidance the burning of plant residues after harvesting and in general adoption of a sustainable land use planning may be introduced.
Keywords: erosion, acidity, micronutrients, nutrient deficiency, irrigation

1 Introduction

An erosion result in severe losses in the productivity of soil resources and it affects the quality of life in larger regions. This phenomenon has become a real threat to the welfare of people in many areas of Greece because large areas are seriously threatened by erosion. The phenomenon is developing slowly and attention should be given to possible changes of the related social and economic factors.

The natural as well as the human factors and causes inducing erosion in Greece are the following: climate, physiography, geology, soil, hydrology and human effects (Yassoglou, N., *et al*., 2001)

Man affects erosion by excessive harvesting of plant biomass, cultivation practices on slopes leaving the surface uncovered during the period of rainfalls. Other factors such as forest, pasture and cereal residue fires, technical works on slopes and sub-surface soil horizons or layers might undergo destruction of their structure, compaction and hardening can increase erosion risk. The objectives of this presentation are to inform the competent authorities and public to undertake active participation for combating of this undesirable phenomenon. Furthermore, cultivation practice and management measures to be addressed in conjunction to the E.U. policy for sustainable agricultural development.

2 Materials and methods

Determination and delineation of the threatened areas in Greece should be addressed based on integrated analysis of the erosion factors and processes. General mapping of threatened areas will be based on the combination of the bio-climatic zones according to Bangoules - Gaussen (Mavromatis, 1980) and soil factors.

Detailed delineation and risk assessment of erosion will take place wherever the general mapping indicates the need for more precise determination of measures and priorities. More specifically, detailed delineation will take place on regional, community or watershed level, wherever the necessary measures are costly and their socio-economic impacts are large.

All the area that has been studied is 120.000 hectares. An area of about 3.000 hectares is very vulnerable has been declined as a result of a erosion. The studied soils represent two regions and have been collected from locations whereas the slope was greater than 6 %.

The collected samples were air-dried and sieved in order determinations to be conducted in the fine earth (<2 mm).

The hydrometer method was used for mechanical analysis (Boyoukos 1951), whilst the pH value was obtained by measuring in 1:1 soil:water suspension (McLean 1982). The organic matter content was measured by a modified wet digestion, (Black. 1965).

The method of ammonium acetate (IN at pH 7) was used for the exchangeable cations (Thomas 1982). The exchangeable form of K^+ and Na^+ were determined in a flamephotometer, whilst Ca^{++} and Mg^{++} were measured with an atomic absorption spectrophotometer of Varian Techtron. The Cation Exchange Capacity was determined by the ammonium acetate method (Rhoades, 1982), whilst the plant available phosphorus was measured by using a modified Bray method (Kuo, 1996).

The plant available form of micronutrients Fe, Cu, Zn and Mn was conducted by extraction with 0.005 M DTPA (Lindsay and Norvell 1969, Lindsay and Norvell 1978). The hydrolytic acidity was estimated by acetate Na and phenolphthalein.

3 Results and conclusions

The presented soils have been developed on hard limestone and gneiss, classified as *Alfisol* and *Entisol*, respectively (Soil Taxonomy, 1999). The intensification of agriculture has an impact on erosion and usually the argilic horizon lies on the surface. In parallel, the ploughing horizon of *Entisols* has been reduced and this has an impact on decreasing of crop yield.

The Cation Exchange Capacity ranges between 16.91—35.28 $cmol_c \cdot Kg^{-1}$ soil, and productivity greatly differs amongst soil types. The values of pH were found between 5.3 to 5.7 and this property is strongly affects on crop yield. The *xero-thermic* regime did not favor the formation of rich organic matter, which is low and ranges between 9.3 to 13.0 mg/kg.

The exchangeable K^+ was found between 0.16 to 0.42 $cmol_c \cdot Kg^{-1}$ soil, whilst the exchangeable Mg^{++} was from 1.8 to 8.6 $cmol_c \cdot Kg^{-1}$ soil, and according to previous Greek experience is in a sufficient level. The available phosphorus in the surface layers was found between 11 to 13 ppm and P application can affect crop productivity.

The micronutrients concentration was found as following: Fe 25.16—42.98 meq/100g, Cu 2.48—2.98 meq/100g and Mn 48.20—57.40 $cmol_c \cdot Kg^{-1}$. These levels are normal for the main crops in terms of efficiency. Zinc content ranges between 1.12 to 1.44 meq/100 g soil and deficiency symptoms were observed in the surface soil layers, mainly in maize, and the concentration of boron was found between 0.23 to 0.62 ppm and deficiency symptoms were revealed in the surface mainly in sugar beet.

In order to prevent erosion the following general measures may be taken into account:

- Detailed determination of threatened areas
- Information and awareness of groups involved
- Appropriate land-use planning and its implementation
- Rehabilitation of the eroded by introducing areas
- Legal and institutional measures
- Immediate banning of grazing in the burnt forests as well as artificial reforestation, in areas where the natural recovery is not possible
- Socio-economic incentives for sustainable development in the eroded areas
- Restoration of the terraces, wherever this is economically feasible, increase of the organic mater in farm lands and improvement of soil nutrient status. The main and most effective

technical measures for the protection of the sloping land in Greece had been the construction of terraces, which are supported by dry stonewalls or nets made from tree or shrub branches.

- The institutional measures refer to application of set aside systems, through EU subsidies, in regions threatened by the erosion. Effective control of soil erosion will be achieved by applying the principles of sustainable Land Use planning.

Effective erosion control measures related to cultivation are those, which ensure land cover of the agricultural land. Some of these measures are:

- Strip crop rotation along the contour lines.
- Use of winter crops.
- Minimum ploughing and ploughing along the contour lines.
- Avoiding spring irrigated crops on sloping land.
- Burning of residues on sloppy areas with a gradient greater than 6% should be avoided.
- Application of subsidised set-aside systems with priority to areas with steep slopes.
- All steep slope areas should be turn into forestland or pasture.

In Greece, the main degradation factor affecting forested areas is man. Generally, land use changes in forests should be allowed only after a precise assessment of the environmental impacts taking into consideration the particular social needs.

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Table 1 Order : alfisol
Suborder : xeralf

Depth Cm	Horizon	Color	Particle Size Distribution S	Si	C	Texture	Struct.	O.M. Mg • kg	pH (1:1)	$CaCo_3$ %	$CaCO_3$ Requirements Kg • ha	Exchangeable cations K^+	Na^+	Ca^{++}	Mg^{++}
												cmol$_c$ • Kg^{-1}			
0—24	Ap	5 YR 3/4	48	14	38	SC	massive	13,0	5,7	-	7.520	0,42	0,07	15,5	8,6
24—61	Bt	5 YR 4/4	48	14	38	SC	3cabk	8,0	6,9	-		0,37	0,17	17,9	11,6
61—80	BC	5 YR 4/6	48	18	34	SCL	3cabk	4,4	7,3	1,32		0,22	0,22	-	12,3
80—104	C_1	7,5 YR 5/6	48	20	32	SCL	2msbk	3,3	8,0	7,92		0,21	0,40	-	12,9
104—150	C_2	7,5 YR 5/6	60	20	20	SCL/SL	1msbk	2,3	8,1	3,96		0,18	0,89	-	14,5

CECmeq/100g	DEPTH cm	Availaple P ppm	Micronutrients (0.005M DTPA) Fe	Cu	Zn	Mn
			ppm			
35,28	0—24	13	25,16	6,40	1,44	48,20
41,98	24—61	4	9,44	2,48	1,92	13,80
41,26	61—80	3	-	-	-	-
40,84	80—104	3	-	-	-	-
40,84	104—150	1	-	-	-	-

Table 2 Order : entisol
Suborder : orthnet

Depth Cm	Horizon	Color	Particle Size Distribution S	Si	C	Texture	Struct.	O.M. Mg • kg	pH (1:1)	$CaCo_3$ %	$CaCO_3$ Requirements Kg • ha	Exchangeable cations K^+	Na^+	Ca^{++}	Mg^{++}
												cmol$_c$ • Kg^{-1}			
0—35	Ap	5 YR 4/4	61	21	18	SL	massive	9,3	5,3	-	11.030	0,16	0,07	9,5	1,8

CECmeq/100g	Depth cm	Availaple P ppm	Micronutrients (0.005M DTPA) Fe	Cu	Zn	Mn
			ppm			
16,91	0—35	11	42,98	2,98	0,23	57,40

Soil map of the kilkis area, Greece

SCALE: 1：350.000