DETERMINATION OF THE ECONOMICALLY AND TECHNICALLY EFFICIENT DRAINAGE SOLUTIONS FOR THE MAIN TYPES AFFECTED BY MOISTURE EXCESS IN TIMIS, ARAD, BIHOR, MARAMURES AND SATU-MARE COUNTIES

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Abstract
This paper presents the results of the drainage studies carried out in the last 20 years on the main soil types with moisture excess from the western part of Romania. In establishing a drainage study, the following are required: topographical studies (site plans), hydrological and hydrogeological studies (isophreatic), soil studies as well as experimental laboratory research. Soil studies are important for determining the soil texture, the hydraulic conductivity (Ksoil), the mole drains stability index (Idc), the plasticity index (Ip) and the microstructural index (R).
The experimental laboratory research led to the determination of the hydraulic characteristics of the drain tubes, of the filter materials and of the drain tube complex, by using different filtering materials .As a result of this drainage study, in order to it reclaimed some moisture excess areas, optimal solutions – from an economical and a technical point of view – can be obtained by using drain tubes and filtering materials adapted for every single reclamation.

Keywords: studies, soils, moisture excess, drain tubes, filter materials

1. INTRODUCTION

Varied landscape of Romania and hydro-graphic, hydrological, hydrogeological and soil conditions different from one area to another quite problematic land reclamation (irrigation, draining-drainage, soil erosion).
Of the 8 million hectares affected by excess moisture, about 4 million hectares requires direct measures of drainage, the rest in need of drainage measures differentiated (saline, alkaline, with saucers soils, etc..).
To establish the optimal solution for drainage on a particular type of soil is necessary to know the factors that determine drainage solution to be adopted namely: specific drainage flow (q), rule drainage (z), hydraulic conductivity of soil (K), geometric and hydraulic parameters of drainage tubes and filtering material, implementing technology available, etc.
In addition to the technical conditions caused by the drainage study will be taken into account and a minimum consumption of scarce materials, low energy and fuel, reduce manual labor, raising the quality of work, safety in operation for a long time, the usage of the local materials and some industrial waste, etc..

2. MATERIAL AND METHOD

Soil studies relate to soil texture, hydraulic conductivity determined in situ or in laboratory, mole drains stability index, plasticity index and micro index. Determinations were performed according to the Methodology for Development of Pedology Studies of ICPA Bucharest. (e.g. Florea N. [1]).
Laboratory studies and experimental research to determine the hydraulic characteristics of drain tubes, filtering material, respectively complex drain tube with different filtering materials refers to the determination of the coefficient of hydraulic resistance to water entering in the drain tube without filter or in or complex filter drain and to determine the degree of warping in time of the drain tube with filter.
These laboratory experiments were performed according to the methodology known in the literature (e.g. Wehry A. [2], [3]) and were carried out on vertical stands including drain tubes without filter or drain tube complex with different filtering materials (e.g. Man E.[4]) and on horizontally stand has determined the degree of warping in time of drain tube without filter or drain complex with different filtering

materials and the coefficient of hydraulic efficiency.

3. RESULTS AND DISCUSSIONS

The situation works for draining-drainage from the western area of the country is presented in table1.

Results of soil analysis had led to the establishment of measures and work necessary to remove the excess moisture in these areas. Soil analysis were made on 10 soil types characteristic of the five counties studied, and the physical properties of these soils are presented in table 2 .

Table 1.The situation works for draining-drainage in western Romania

Cur issue	County	Potential (ha)		Executed (ha)		Perspectives (ha)	
		draining	drainage	draining	drainage	draining	drainage
1	Timiş	450719	15444	438788	11225	11661	4219
2	Arad	228202	800	221958	654	6244	146
3	Bihor	200207	14841	166698	1499	33509	13342
4	Maramureş	37906	9784	27481	4781	10425	5003
5	Satu Mare	213565	12562	201065	8312	12500	4250
6	TOTAL	1350599	53431	1055990	26471	74339	26960

Table 2.Physical properties of soil.

Area and type of soil	Texture	Hydraulic conductivity K (m / day)	Indices of stability mole drains			Comments
			R	Idc	Ip	
Timiş County						
Margina Alluviosol	LA	0,163	1,02	0,070	13,18	Stability 2-3 months
Făget-Alluviosol	NL	0,355	1,28	0,040	8,18	Stability 1-2 months
Folea-Alluviosol	L 0-50 cm LP 50-100	0,220 0,060	1,07 0,78	0,012 0,034	15,25 16,25	Stability 2-3 months
Lovrin-Chernozem Gleyze	LN 0-50 cm NL 50-100 cm	0,020	0,92 1,23	0,080 0,020	17,40 9,10	Stability 2 months
Arad County						
Felnac-Secusîgiu Alluviosol Gleyze	LL 0-50 cm LP 50-100 cm	0,100 0,160	0,48 0,63	0,170 0,180	26,45 28,12	Stability 1 year
Chişinău –Criş Alkali white a. mollic	LP	0,268	0,21	1,180	36,20	Stability 3-4 years
Bihor County						
Santăul Mare Gleysol	LL	0,050	0,36	0,840	26,29	Stability 2-3 years
Ciumeghiu Gleysol	AL	0,010	0,42	0,131	33,25	Stability 1-2 years
Tileagd Alluviosol	LA 0-50 cm LP 50-100 cm	0,014 0,011	0,29	0,120	30,40	Stability 2-3 years
Fănica-Alluviosol mollic Gleyze	AL 0-50 cm LP 50-100 cm	0,605 0,817	0,29	1,341	41,97	Stability 2-3 years
Valea Lighet Gleysol	LAP 0-50 cm LAP50-100cm	0,168 0,336	0,42	0,430	32,41	Stability 1-2 years

Valea Sînicolau Alluviosol mollic Gleize	L 0-50 cm L 50-100 cm	1,985 3,074	0,36	0,008	11,07	Stability 2-3 years
Maramureş County						
Ulmeni-Vertosols pseudoGleyze	AL 50-100 cm	0,033	0,27	0,390	45,80	Stability 2-3 years
Salsig – Luvosol Gleyze	LP 0-50 cm TP 50-100 cm	0,727 0,197	0,56	0,250	28,90	Stability 3 months - 1 year
Tamaia–Luvosol	TT 0-50 cm AP 50-100 cm	0,662 0,665	0,28	0,590	48,20	Stability 2-3 years
Satu-Lung Eutricambosol mollic Gleyze	AP 50-100 cm	0,146	0,30	0,970	30,50	Stability e 2-3 years
Pribileşti Eutricambosol	AP 50-100 cm	0,031	0,26	1,330	45,80	Stability 3- 4 years
Suciu de Jos Gleysol	LP 50-100 cm	0,049	0,59	0,140	27,30	Stability 3 months - 1 year
Săcălăşeni Eutricambosol Gleyze	TP 0-50 cm LP 50-100 cm	0,175 0,075	0,52	0,206	12,30	Stability 3 months - 1 year
Satu Mare County						
Turulung Luvosol stalled	LL 50-100 cm	2,790	0,54	0,184	26,70	Stability 3 months - 1 year
Doba- Stagnosol luvic- vertic	TP 50-100 cm	0,950	0,29	0,449	31,55	Stability 2-3 years
Carei Tiream Gleysol blaken	TT 50-100 cm	1,560	0,30	0,430	27,50	Stability 2-3 years

The data presented above indicates that all points of Timiş County where they did soil tests resulting that the mole drains are not recommended. In the county of Arad and Bihor mole drains are recommended, they resisting from 1 year to 4 years. In the county of Maramureş and Satu Mare, except the municipalities Salsig, Suciu de Jos, Sacalaseni, Turulung where stability of mole drains is less than 1 year, recommended the implementation of mole drains.

To establish the optimal solution for drainage on a particular type of soil is necessary to know the factors that determine drainage solution to be adopted. Of these the most important are: the specific drainage flow, standard drainage, hydraulic conductivity of soil, geometric and hydraulic parameters of the drainage tube and the filtering material and technology implementation. With these data it can be adopted drainage solution and the distance between drains, on the basis of technical and economic calculation. In determining the drainage solution, in addition to the technical conditions specified by the study of drainage is envisaged the development of variants with minimum consumption of scarce materials, low energy and fuel, reduce manual labor, raising the quality of work, safety in operation for a long time, use priority of the local materials and some industrial waste.

Technical and economic results of the calculation of distance between drains are set centrally in Table 3 (e.g. Man T.E. [5], [6]).

Table 3.Techno-economic calculation of the distance between drains

City and soil type	Types of filtering material	Types of drain tube	The distance betweendrains (m)	Specific investment lei / ha
Timiş County				
Margina	IFS+ ballast 5 cm	Plastic (do 5 cm)	10	18529 (1996)
		Ceramic	10	19959
	Spent poly-propylene	Plastic (do=5 cm)	9	19236

Alluviosol	bags δ=0,6cm	Ceramic	9	19626
	Without filter	Plastic (do=5 cm)	9	19747
		Ceramic	9	19902
Făget Alluviosol	Filtex wrapped around tubeδ=0,6cm	Plastic (do=5 cm)	15	16113
		Ceramic	16	16637
	IFS wrapped on the tube	Plastic (do=5 cm)	15	11996
		Ceramic	15	12225
	Without filter	Plastic (do=5 cm)	15	11239
		Ceramic	16	11623
Folea Şipet Cerna Alluviosol	Spent poly-propylene bags δ=0,6cm	Plastic (do=5 cm)	4	44970
		Ceramic	4	43969
	Without filter	Plastic (do=5 cm)	3,6	46536
		Ceramic	4,1	45023
Lovrin Chernozem Gleyze	Filtex wrapped around tubeδ=0,6cm	Plastic (do=5 cm)	1,34	182174
		Ceramic	1,54	173189
	IFS+sand δ=0,6cm	Plastic (do=5 cm)	1,72	107897
		Ceramic	1,84	112977
	Without filter	Plastic (do=5 cm)	1,26	131526
		Ceramic	1,49	123567
Arad County				
Felnac Secusâgiu Alluviosol Gleyze	Without filter	Plastic (do=5 cm)	5	38219 (1996)
		Ceramic	2	113618
	Filtex wrapped around tubeδ=0,6cm	Plastic (do=5 cm)	6	41488
		Ceramic	4	72098
	IFS + coarse sand	Plastic (do=5 cm)	7	26533
		Ceramic	2	93365
Chişinău Criş Alkali white a. mollic	DPE Φ=50mm Without filter	Plastic (do=5 cm)	4,40	38410
	DPE Φ=50mm Madritex 400	Plastic (do=5 cm)	4,81	54054
	DPE Φ=50mm Madritex 400 înf.+sand	Plastic (do=5 cm)	7,20	34440
	DC Hex Φ=100mm Blanket	Ceramic	5,90	47600
Bihor County				
Tileagd Alluviosol	Without filter	Plastic (do=5 cm)	5,1	327459 (1998)
		Ceramic	6,75	272663
	Filtex wrapped around tubeδ=0,6cm	Plastic (do=5 cm)	5,61	436990
		Ceramic	7,22	369747
	IFS+sand δ=0,6cm	Plastic (do=5 cm)	9,19	203239
		Ceramic	10,67	194991
	Spent poly-propylene bags δ=0,6cm	Plastic (do=5 cm)	5,61	299349
		Ceramic	7,22	256192
Santăul Mare Gleysol	Without filter	PVC (do=6,5 cm)	3,6	48424
		Ceramic	3,9	47528
	Filtex wrapped around tubeδ=0,6cm	PVC (do=5 cm)	3,6	68465
		Ceramic	4,0	67141
	IFS+sand δ=0,6cm	Plastic (do=5 cm)	4,3	43888
		Ceramic	4,6	45558
Ciumeghiu Gleysol	Without filter	Plastic (do=5 cm)	4,43	37651
		Ceramic	4,92	37401
	Filtex wrapped around tubeδ=0,6cm	Plastic (do=5 cm)	4,6	53201
		Ceramic	5,05	53066
	IFS+sand δ=0,51cm	Plastic (do=5 cm)	5,4	34396
		Ceramic	5,04	36839
Maramureş County				

Ulmeni Vertosols pseudogleyze	Without filter	Plastic corrugated 8cm	2	153000 (1999)
	Ballast δ=0,15cm	Plastic corrugated 8cm	3	209667
	Textile Waste + ballast	Plastic corrugated 8cm	3	222667
Salsig Luvosol gleyze	Without filter	Plastic corrugated 8cm	6	510000
	Ballast δ=0,15cm	Plastic corrugated 8cm	7	898500
	Terasin 200 +ballast	Ceramics	7	100000
Tamaia Luvosol	Without filter	Plastic corrugated 8cm	2	153000
	Ballast δ=0,15cm	Plastic corrugated 8cm	3	209666
	Textile Waste + ballast	Plastic corrugated 8cm	3	222666
Satu Lung Eutricambosol mollic gleize	Without filter	Plastic corrugated 8cm	3	102000
	Ballast δ=0,15cm	Plastic corrugated 8cm	5	125800
	Terasin 200 +ballast	Ceramics	5	140000
Pribileşti Gleysol march	Without filter	Plastic corrugated 8cm	1	306000
	Ballast δ=0,15cm	Plastic corrugated 8cm	3	209667
	Terasin 200 +ballast	Ceramics	3	233333
Suciu de Jos Gleysol	Without filter	PVC (do=8 cm)	4	77250
	Ballast δ=0,15cm	PVC (do=8 cm)	5	125800
	Terasin 200 +ballast	Ceramics	5	140000
Săcălăşeni Eutricambosol Gleyze	Without filter	PVC (do=8 cm)	3	120000
	Ballast δ=0,15cm	PVC (do=8 cm)	4	167250
	Textile Waste + ballast	PVC (do=8 cm)	4	167000
Satu Mare County				
Turulung Luvosol stalled	Without filter	PVC (do=8 cm)	11	547250 (2002)
	Madritex wrapped	PVC (do=8 cm)	20	1500000
	Madritex wrapped + coarse sand (5 cm)	PVC (do=8 cm)	22	1980000
Doba Stagnosol luvic vertic	Without filter	PVC (do=8 cm)	-	-
	Madritex wrapped	PVC (do=8 cm)	23	1725000
Carei-Tiream Gleysol blaken	Without filter	PVC (do=5 cm)	3	125250
	Madritex wrapped	PVC (do=5 cm)	20	1375000

Following the analysis of pedological study, results of laboratory studies on hydraulic parameters which characterizing the degree of warping over time of drain tubes without filter, respectively the drain tube complex plus different filtering materials and the results of

Table 4. Drainaje solutions

County	Tipy of soil	The solution adopted
Timiş	Alluviosol	Tubular Drainage
	Chernozem gleyze	Tubular Drainage + geotextile and filter trench (sand, ballast)
Arad	Alluviosol gleyze	Cross Drainage
	Soloneț mollic	Cross Drainage
Bihor	Gleysol	Tubular Drainage+geotextile (wrap or blanket)
	Alluviosol	Tubular Drainage
	Alluviosol mollic gleyze	Tubular Drainage
Maramureş	Vertosols pseudogleyze	Cross Drainage
	Luvosol gleyze	Tubular Drainage + textile waste
	Luvosol	Tubular Drainage + textile waste
	Eutricambosol mollic gleyze	Cross Drainage
	Eutricambosol	Cross Drainage
	Gleysol	Tubular Drainage+geotextile (wrap or blanket)
	Eutricambosol gleyze	Cross Drainage
Satu Mare	Luvosol stalled	Horizontal drainage (DPE Φ 80, without filter, L=11m)
	Stagnosol luvic- vertic	Cross Drainage
	Gleysol blacken	Cross Drainage

technical and economic calculation, were determined drainage solutions for the design work in the areas studied, solutions presented in Table 4 (e.g. Man T.E. [7]).

4. CONCLUSIONS

Drainage efficacy depends on choosing appropriate filtering material, resulting that the nature and drainage composition must be correlated with conditions of soil, groundwater, climate and characteristics of drain tubes.
For each soil type studied was established recommended drainage solution, the distance between drains a calculation based on money, is recommended for design solutions encompassing all their constructive elements and some technological recommendations.
For all drainage facilities heaving heavy soils with k <0.2 m / day, drainage solution is cross drainage, including closed horizontal drainage with plastic tube and drained of graded gravel trenches, mole drainage and raising deep.
At the design of drainage networks have provided the study, analysis and testing different filtering materials for the area, soil type and drainage situation in question, the analysis being done to the following criteria: hydraulic, costs, quantities disponibile, technology, sitting, sustainability over time and specific criteria for various types of filtering materials.
According to these criteria, will choose the filtering materials so as to have the lowest price and to hold lower price than the price of the drain tube. It also will choose the filtering materials found in sufficient quantities in the area and pore analysis of filtering material is in conjunction with curve size drained soil.
Consequently, from the study of drainage made, were obtained optimal solutions in terms of technical and economic for planning of with excess moisture, using drain tubes and filtering materials appropriate arrangements in each hand.

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