THE MALFUNCTIONS OF FINNISH SUBSURFACE DRAINAGE

Aarne Pehkonen
Univ. of Helsinki
Dept. of Agr. Engineering

Abstract

In Finland underdrainage malfunctions, either permanent or temporarly appear in about 5 % of the arable land. The reasons behind the malfunctions are in most cases related to the compaction of the topsoil and to such risks due to the topography, location, and peat soils that are difficult to drain, iron ochre and tendency of siltation which cannot be solved in a underdrainage project of average capital costs.

1. Introduction

The deficient function of the underdrainage system can be easily discovered when the malfunction is severe. As a whole malfunctions are on the contrary very difficult to inspect. The appearance of the malfunctions depend greatly on the momentarily climate especially precipitation, cultivated crop and the cultivation method. Thus the malfunction term is very relative. The same technical deficiency can cause in different situations varying drainage problems.

This paper is based on the study done by M.Sc. Markku Puustinen and the undersigned at the Dept. of Agr. Engineering. In this paper the drainage malfunction has been regarded as a situation where according to the farmer dysplasia or carrying capacity problems in different cultivation phases haveappeared due to wetness. On these premises it has been estimated that in Finland appr. 5 % of the underdrained arable land have either temporary or permanent drainage problems.

The malfunctions in subsurface drainage came into highlight in the rainy summers of the early 80's. At that moment there was no system in the country for clearing the reasons behind the malfunctions nor for solving the discovered problems. At the same time a new underdrainage system, trenchless drainplough, was introduced and the marketing of the coated, so called filter pipes increased rapidly. Thus farmers confidence in Finnish underdrainage systems started to falter. During this situation a research was started at the Dept. of Agr. Engineering, Univ. of Helsinki, in order to verify the reasons behind the malfunctions in the planned subsurface drainage and trough this develop the possibility to solve the discovered malfunctions and to prevent them.

2. The sample of the study

The farms of this study were chosen from the fault reports that the technicians of the Salaojakeskus had received. These 92 farms represented different pipe materials and underdrainage areas in relation to the fault reports. Thus the study had 51 clayware pipe, 31 plastic pipe and 10 drainage systems made of board pipes or different materials together. The material was gathered during 1982 and 1983 and thus the malfunctions (all but one) that appeared represented the traditional underdrainage method. The drainage systems had been laid by continuous trenchers except for 9 older systems dug by hand and had gravel as permeable fill.

The way the problem was approached can be compared to that of a doctor trying to find out what is wrong with the patient, in this case the ineffective drainage system and what has caused the problem. In the study the farmers were intervieved to verify the history of the drainage system and the cultivation methods that could have caused the drainageproblem. In the field study one main drain and one minor drain were dug open. In the test holes the soil structure, drain depth, pipe gradients, percolation rate, pipe size, size and condition of perforation or joints and condition of of the gravel fill were stated. The factors which could have caused problems to the drainage system were estimated on the basis of the trench structure and observations of the surrounding area.

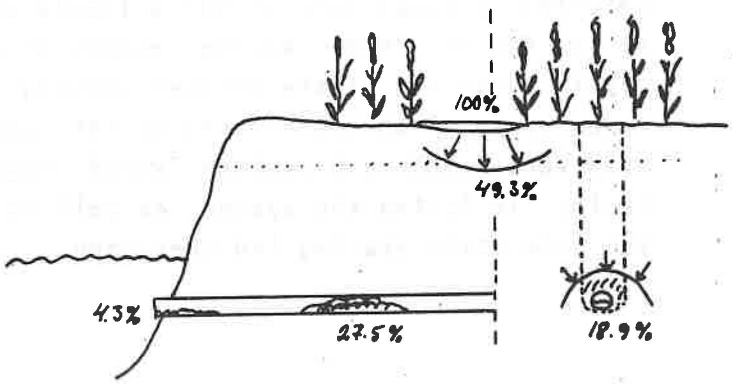
The oldest drainage system had been laid in 1939 and the latest in the previous year. A system with drainage problems was in average 11 years old. The average field size was 4.8 hectars varying from 0.6 to 35 ha. The actual problem area varied as well from a fraction to the whole of the field. In some cases the drainage system has worked effectively and the malfunctions appeared after several years. In other cases the system never worked the way it was planned.

3. The common deficiencies in subsurface drains

Of the 92 drainage systems 459 such faults or deficiencies were found which alone or together cause a malfucntion. On the average 5.0 deficiencies per system were discovered. Thus an inefficient drainage system is a typical consequence of many unfavorable coincidences, a certain kind of multihandicap patient.

When these deficiencies are examined by their influence (Fig.1) it can be discovered that in about half of the cases the underdrainage as a technical system has been in good shape. In these cases the malfunction has been mainly caused by the compaction and the water has not been able to reach the drains fast enough. Wide spacings between the drains and small distance between soil surface and groundwater level are associated to this problem. Thus the topsoil of the field is wet when cultivated and the risk of compaction increases.

Figure 1. The discovered faults and deficiencies grouped by water movements.



The majority of the causes of faults and deficiencies were related to the materials; pipes and gravel filling (Table 1). Typical problems were siltation in the pipes and plugging of the gravel filling, pipe joints or perforation. Breakages of pipes were found only in drainage systems made of boardpipes.

Table 1. The discovered faults and deficiencies gruoped by their appearance

Fault is associated to	Number of faults n	%
Laying the system	109	23,7
Materials	171	37,2
Cultivation	76	16,6
Field	83	18,1
Field location	20	4,4
In total	459	100,0
Faults or deficiencies in average 5,0 per system		

The most typical mistakes made during different phases of drain laying were those associated with the trench structure or the leading of surface water. The lack of backfill of topsoil and or gravel were the most typical faults in the trench. This was mostly due to extremely difficult laying conditions where the trench had collapsed before the backfilling of topsoil or even before the backfilling of gravel.

The main reasons of the problems with the surface water were either a total lack of blind inlets of gravel or there were too few of them. Another essential problem was the deficient levelling of the ditches causing surface flow into the lower spots. Problems related to the gradient and the pipe size were found in 9 systems which equals appr. 10 % of the faults in laying the system. As well in 10 cases a clearly too wide drain spacing had been used.

About 65 % of the problems associated to the field involved soil texture. More than half of these were either raw or poorly humificated peat soils to which is characteristic a poor carrying capacity. On peat soils the ground water caused in 9 systems special problems locally. Topographic problems of the field appeared in slope bends or in vast low spots.

The problems associated with the location of the field are mainly caused by the fact that due to the high surroundings or high water level in the nearby waterway the main drain and the outlet have remained too low. Thus the distance between soil surface and groundwater level has remained too small or the water has been unable to discharge through the outlet at all times.

About 3/4 of the problems with the cultivation were related to soil compaction. This problem appeared both on mineral and peat soils. On mineral soils the compaction involves especially clay. On these soils the worst compacted layer was usually immediately beneath the topsoil in the top layer of the subsoil. On peat soils the problem appeared mainly as poor infiltration. Also wrong ploughing direction caused in certain cases (5 %) problems with the water reaching the subsurface drains.4. The reasons behind malfunctions

If the underdrainage is regarded along with other construction activities as a result of human labor input the faults and deficiencies causing malfunctions are also due to mistakes and neglects in different phases. Approaching the problem in this way in appr. half of the cases (51.2 %) the factors causing malfunction derive from planning. Although actual planning mistakes appear rarely. In appr. 16 % of the malfunction cases different degree planning mistakes had been made. In other words actual planning mistakes occur in less than
1 % of the whole underdrained area. On the contrary a much more serious problem is the lack of knowledge during the planning phase. Of the deficiencies in the drainage systems about 35 % involved such situation. The system has been planned according to standard methods although it has not been

proven that a drainage system laid by it would work in exceptional situation.

Of the faults and deficiencies causing malfuntion appr. 1/4 (27 %) is associated with mistakes made in different phases of laying the drainage system and appr. 1/5 (22 %) is associated with the cultivation. In this respect the compaction is an essential problem as mentioned before but deficiencies occurred also in the maintenance of the underdrained area. Underdrainage is thus a simillar technical system as other corresponding structures. It also demands maintenance. According to the results of this study the significance of the maintenance has not been fully understood.

As a whole the result of this study emphasizes clearly how important planning is. The planner has to receive adequate information of the site to be underdrained. The research must be able to give to the planning also solutions for difficult conditions such as compacting peat soils, heavy clay with poor percolation rate or areas with iron ochre. This will be clearly emphasized during next few years in our country as laying underdrainage systems will move towards east and north, to areas where previously mentioned exceptional conditions occur more frequently than in the traditionalunderdrainage areas.

According to the results of this study no functional differences between the pipe materials cannot be shown. If there is a tendency of siltation blockages, they will occur as well in clayware pipes, plastic pipes and pipes made of boards although blockages differ in shape. In clayware pipes the siltation is usually at the bottom and in joints of pipes. In plastic pipes it covers the whole inner surface of the pipe. Instead the results indicate that gravel on top of the pipe is not sufficient in all situations. Even in a pipe with proper backfilling of gravel can occur siltation due to the incoming material from underneath. On certain areas filtering materials seem to be necessary even under the pipe.

According to the results no clear relationship was verified between the malfunctions and cultivation methods on the farm. If such connections occurred they could be explained by factor of local conditions and soil texture. The results can be explained so that different ways of normal arable farming (grain crops, grassland etc.) do not set such different demands on drainage system which would make it necessary to plan a system for a particular rotation or on the contrary would restrict the rotation and cultivation methods according to the drainage system. Situations clearly different from normal arable farming such as intensive root crop growing seem on the other hand to set demands on the drainage system that normal a drainage system for normal arable farming does not always fulfill.

The basic reasons of the malfunctions are mainly associated to the location and the topography of the area to be drained, to the poor percolation rate of the soil, to soil texture that is difficult to drain and to certain local problems. The most significant of those are iron ochre and pressurised groundwater.

The greater number of these risk factors exist simultaneously on the area to be drained, the greater the probability of malfunctions seems to be. As mentioned before the planning has not always had possibilities to take these special demands into consideration. The climate has a definite effect on the malfunctions. In rainy summers there appeared clearly more malfunction cases especially if the rainfalls occurred at times when machinery had to be used on the fields. Climatic factors seem to have an effect also on the success of the drain laying. If the drainage system was laid in poor conditions the malfunctions seem to be more frequent because all phases cannot be done carefully enough.

5. The malfunctions can be solved and prevented

Possible methods of solving the afore mentioned malfunctions has been preliminarily studied during the past couple years. For the most common malfunctions fairly simple remedies can be found. Disadvantages of compaction can be prevented by lowering the stress on the soil for example with dual wheels. Adding blind inlets of gravel has also proved to be an effective way of solving surface water problems. Siltation can be removed by rinsing. These are relatively inexpensive choices. An expensive redrainage seems to be necessary only seldom as an solving method. Even in severe cases adding new minor drains seems to be adequate. In order to bring back farmers confidence into underdrainage in Finland a quality-guarantee system has been created. According to it the planner,material suppliers and the contractors guarantee together that drainage system actually performs as desired and these participants agree to solve the malfunctions which appear within guaranteed time. It has been looked forward that this system will prevent malfunctions as laying subsurface drainage in Finland moves to new difficult areas.