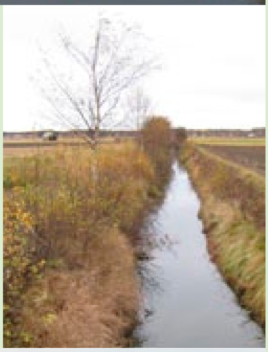
Guidelines for mitigating the adverse effects of acid sulphate soils in Finland until 2020



Ministry of Agriculture and Forestry
Ministry of the Environment

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Photo Eeva Nuotio

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Julkaisun nimi:
Guidelines for mitigating the adverse effects of acid sulphate
soils in Finland until 2020

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Summary

Finland has the largest surface area of acid sulphate soils in Europe. The acidity and metal loading flowing from acid sulphate soils weakens the status of natural waters and causes damage especially to fisheries. According to the River Basin Management Plans adopted by the Finnish Government in December 2009, reaching a good status of waters especially in Ostrobothnia calls for actions to reduce the adverse effects caused by acid sulphate soils. The purpose of the strategy on mitigating the adverse effects of acid sulphate soils is to promote and support the implementation of the River Basin Management Plans.

The strategy work on acid sulphate soils is focused, in particular, on advance prevention of negative effects, combating damages, and mapping and classification of acid sulphate soils. The strategy emphasises the need to increase advice and communication on acid sulphate soils and to take them into account in legislation, programmes, land use planning and support systems. The aim of the strategy is to influence the decision-making by operators, municipalities, Regional Councils and public authorities.

Preface

Finland has the largest surface area of acid sulphate soils in Europe. Adverse effects from the soils arise at the onset of acidification when soil layers containing sulphate rise above the groundwater level. Problems in waters are the most severe after rains, when harmful substances dissolved from the soil are carried to waters. This loading has significantly weakened the ecological and chemical status of surface waters along the western coast, with fish mortality at times as the most visible damage.

Because of the nature of the acidification process, the drainage of lands for agriculture and forestry and certain other purposes is among the main factors in aggravating the acidification problems. This is why it is important to take acid sulphate soils into account in the use and maintenance of drainage systems and other land use, and to base land use planning on sufficient information on acid sulphate soils and the risks they cause.

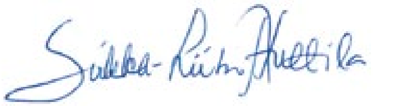
The first six-year period of the implementation of the Water Framework Directive is now under way in the EU. In Finland the problems and needs for measures relating to acid sulphate soils have received a great deal of emphasis in the River Basin Management Plans for the western and south-western coastal regions. Exceptional weather conditions and water situations in recent years have further highlighted the need to intensify actions to mitigate the adverse effects caused by acid sulphate soils.
The strategy establishes the main objectives and measures to efficiently reduce the adverse effects caused by acid sulphate soils. Outlines for actions are presented for developing both the legislation and the support schemes. It is also important to take acid sulphate soils better into account in various national and regional programmes, as well as in guidelines, recommendations and advisory work.

Knowledge and information on the effects and damages caused by acid sulphate soils should be improved. Climate change leads to growing frequency of extreme hydrological events, which is expected to increase the environmental load from acid sulphate soils. Research on this is important in order to improve the ability to adapt the land use of acid sulphate soils and water protection to the changing climate.

In the efforts to mitigate the adverse effects of acidification the focus should be on cost-efficient, advance prevention, but the development of actions to combat the damages must be continued as well. Systematic mapping of acid sulphate soils is important as it lays the foundation for the targeting of the actions to reduce the negative impacts as efficiently as possible to areas where the problems are the most severe.

The aim of the strategy is to reinforce and outline the key actions to mitigate the adverse effects caused by acid sulphate soils. The strategy has been drawn up in collaboration between the Ministry of Agriculture and Forestry and Ministry of the Environment. The preparation took place in a project launched by the Ministry of Agriculture and Forestry, where the expertise and views of the different stakeholders could be widely utilised for the strategy work.

Helsinki 18 March 2011



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Content

1 INTRODUCTION

Finland has the largest surface area of acid sulphate soils in Europe. Most of these are located along the western and south-western coast between the rivers Temmesjoki and Mynäjoki. For the most part they were created during the Litorina Sea stage of the Baltic Sea. Adverse effects of acid sulphate soils on the environment arise at the onset of acidification, when soil layers containing sulphate rise above the groundwater level. The problems in natural waters are the most severe after rains, when substances dissolved from the soil that are harmful to living organisms are carried to them.

For a long time acid sulphate soils were considered as a problem for agricultural production, in particular. Later it has become evident that they also have significant impacts on fisheries, biodiversity, water supply, forestry, peat mining, and the status of surface waters and groundwater. The acidity and metal loading resulting from the drainage of acid sulphate soils has led to a clear degradation in the ecological and chemical status of surface waters along the western coast, with fish mortality at times as the most visible damage.

Because of the nature of the acidification process, the drainage of lands for agriculture, forestry and certain other purposes is a central factor in creating the acidification problems. Earthmoving and banking in acid sulphate soils may also cause significant damage. This is why it is important to take acid sulphate soils into account in all kind of land use, and to base land use planning on sufficient information on acid sulphate soils and the risks they involve.
This strategy establishes the main objectives and measures to efficiently reduce the adverse effects caused by acid sulphate soils. It is also important to take acid sulphate soils into account better than at present in various national and regional programmes and in guidelines, recommendations and advisory work. The strategy proposes the actions to be taken for developing the legislation, support schemes and their application.

Knowledge and information on the impacts and damages caused by acid sulphate soils should be improved. Climate change leads to growing frequency of extreme hydrological events, which is expected to increase the environmental load from acid sulphate soils. Research on this is vital to improve the adaptation of land use and water protection in acid sulphate soils to the changing climate. The topics that are studied quite little so far which would deserve more attention include the socio-economic aspects of the adverse effects caused by acidification.

In the efforts to mitigate the adverse effects of acidification the focus should be on cost-efficient advance prevention, but the development of actions to combat the damages must be continued as well. Important actions include keeping the groundwater level high enough so that the soil layers which contain sulphide stay saturated with water for as much of the time as possible. Usually this can and should be done in a way that causes no damage to the cultivation and plants, and without any increase in, for example, the greenhouse gas emissions.

Appropriately targeted and timed liming of natural waters may have significant impact, even if in many cases the impacts of extensive water liming projects have proven quite small relative to their costs.

Systematic mapping of acid sulphate soils is important, as it lays the foundation for the targeting of the actions to reduce the negative impacts as efficiently as possible to areas where the problems are the most severe. This is why mapping is an important strategic objective. Adverse effects of acidification can, however, be efficiently reduced on the grounds of the current knowledge, which means that the actions to mitigate such effects should be intensified even before the more comprehensive mapping work has been completed.

The purpose of the strategy for mitigating the adverse effects of acid sulphate soils is also to contribute to and support the implementation of the River Basin Management Plans adopted by the Finnish Government in December 2009 and their revision in the next planning round. Further actions to reach the objectives set for the status of waters are needed especially in the river basin management areas of the river Kokemäenjoki – Bothnian Sea - Archipelago Sea and river Oulujoki - river Iijoki. The outlines of the strategy must be comprehensively taken into account in all land use, legislative work, and development of support schemes and steering of actions.

Photo: Ministry of Agriculture and Forestry / Photo archive

2 BACKGROUND OF THE STRATEGY

2.1 Acid sulphate soils and their adverse effects

In the Baltic Sea region acid sulphate soils were created mainly during the Litorina Sea stage 7500 – 4000 year ago, when the seawater was warmer than today, and the salt content was higher. Microbes reduced the sulphate in seawater into sulphide using organic matter as a source of carbon and energy in the oxygen deficient or anoxic bottom sediment. In this process the sulphide was precipitated as poorly soluble iron sulphide into the water-saturated sediment. As a result of land uplift, drainage and flood protection works the sulphide layers which used to be saturated with water have come in contact with oxygen causing them to start producing sulphuric acid (H_2SO_4). Most of the known sulphate soils are in the western and south-western coast less than 60 metres above the sea level. Of the acid sulphate soils 70% are in the area between the towns of Kristiinankaupunki and Oulu. In addition to the Litorina sediment, there are small areas of sulphate in the black schist areas in Eastern Finland and Kainuu, as well as Häme and North Ostrobothnia.

Acidification of acid sulphate soils takes place mainly in the summer. In areas with subsurface drainage and dry weather conditions it may go as deep as 2 - 3 metres. During low flows the water moves slowly through the deeper soil layers where it is neutralised, thus creating well-buffered water. During high flows the groundwater level in the soil rises so that the pores of the deeper soil layers are filled with water. The sulphuric acid created in the unsaturated, i.e. oxidised, soil layer is thus rapidly transported with water to ditches and further to natural waters, along with other metals dissolved from the suspended material. The acidity of waters is usually the highest during the autumn and spring runoff when the rains and melting waters wash the soil and carry the acidity created as a result of the preceding dry period to watercourses.

The acid sulphate soils have been known for a long time, but until the 1970s they were primarily seen as a problem for agricultural production. To improve the conditions on acid farmlands, intensive liming and efficient drainage of the tillage layer have been recommended since the 1930s, while spreading sulphuric soil from ditches on arable lands should be avoided. This has neutralised the tillage layer and washed the acidity created in the deeper soil layers into waters.

The land uplift resulting from the Ice Age leads to a gradual increase in the depth of acidification in the land profile. Because of the subsurface drainage and sufficient drainage depth required by modern cultivation techniques, as well as land uplift, the acidification risk of drainage waters in acid sulphate soils is the greatest in the farming areas along the Ostrobothnian coast. In forestry and peat mining sites the risk is smaller due to the different type of drainage need and techniques, but these areas may also be a source of loading that causes acidification of waters. In peat mining, the risk of loading is usually the greatest in connection with the after-use and drainage extending to the mineral soil at the bottom of the peatland.

Draining of acid sulphate soils impacts both the chemical and ecological status of waters. In Ostrobothnia, in particular, the ecological status of river basins located below the depth contour of 60 metres is no more than satisfactory, largely as a consequence of the drainage of acid sulphate soils. Among the specific problems are the so-called acidity peaks caused by the drainage of acid sulphate soils which at worst may cause extensive fish mortality and long-term negative changes in the ecological status of waters.

The classification of waters according to their chemical status is based on the concentration of hazardous substances, so-called "priority substances" which have adverse impacts on the environment. The chemical status is considered good if the environmental quality standards for priority substances are complied with. In the River Basin Management Plans the status of waters has for the most part been estimated as less than good only in waters with a lot of acid sulphate soils in their catchment area. Often the main reason for failing to comply with the environmental quality standards is the high cadmium levels in waters.

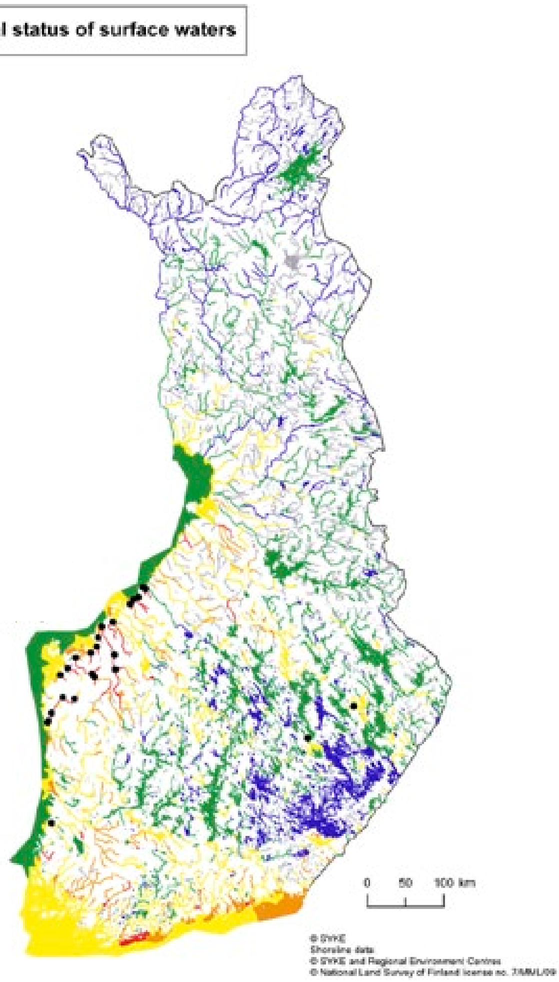
Figure 1. Acid sulphate soils in arable areas in Finland (Puustinen et al. 1994)

In the River Basin Management Plans adopted in 2009, it was estimated that about 30 of the river systems discharging into the Gulf of Bothnia and the adjacent sea areas suffer from serious acidity problems caused by the drainage of acid sulphate soils (Figure 2). Acidity is natural in some of these waters, but the problems have escalated because of human actions and land uplift. The acidity of waters and especially the metals dissolved in them have led to fish mortality and other toxicity-related consequences in the living organisms, and thus impacted on the ecological status of surface waters and biological diversity of aquatic ecosystems.

The drainage of acid sulphate soils has destroyed or seriously weakened many locally or regionally important fish populations. The most sensitive species such as salmonids, pikeperch, burbot, roach, shelled molluscs, gastropods and crayfish, suffer from acidity. These species usually breed and their young hatch at the time when the acidity level of the water is the highest.

Besides rivers and coastal waters the drainage of acid sulphate soils causes problems in dammed sea bays, fladas and glo-lakes. These are important spawning and breeding grounds, but due to fish mortality caused by acidity they may lose their significance for fisheries for several decades.

The acidification caused by drainage may also have adverse effects on groundwater. If the tight layers at the margins of groundwater areas are punctured when digging ditches, the ditch water gets absorbed into the ridge. Groundwater abstraction may also lead to release of metals as the groundwater level drops. Acidification of surface waters and the other quality issues this causes may cause problems for communities using surface waters as the raw water source. The varying and at times high metal concentrations in waters due to drainage waters from acid sulphate soils may cause problems in the treatments processes at water supply plants.



Class	Colour
High	
Good	
Moderate	
Poor	
Bad	

* Chemical status less than good

Data:
Regional Environment Centres and Finnish Environment Institute SYKE

SYKE
Shoreline data:
SYKE and Regional Environment Centres
National Land Survey of Finland permit number 7/MML/09

Figure 2. Ecological and chemical status of surface waters in Finland (Finnish Environment Institute, 2009)

2.2 Current legislation, support systems, land use guidance and information actions

Legislation: Water and environmental legislation and legislation concerning agriculture and forestry make no specific reference to acid sulphate soils, and how these should be taken into account in the planning and implementation of projects and measures. According to the current legislation, drainage may be done on the lands of the so-called passive owner who opposes the works, but water protection constructions such as wetlands may not be established on such lands.

No notification to the environmental authority or permit procedure is required for the drainage of acid sulphate soils. When considering the need for a permit the combined impact of the projects is not always sufficiently taken into account.

The legislative proposal for amending the Water Act lays down a general obligation to notify the regional environmental authority of drainage works that are not to be considered minor. The purpose of notifying of drainage is to improve the preconditions for advance control and to harmonise the current, varying practices. The Centre for Economic Development, Transport and the Environment examines the potential contaminating effects and, where necessary, requires a permit to be applied for. The proposed new threshold for dredging extends the permit procedure to smaller dredging projects than at present.

Support systems: The conditions relating to the aid for drainage, land consolidation and Act on the Financing of Sustainable Forestry do not include acid sulphate soils and specific water protection actions that these might need.

The agricultural investment aid (2010), included in the Rural Development Programme, does not contain any measures specifically targeted to acid sulphate soils. The special features of acid sulphate soils have not been taken into account in the special measures of the agri-environmental support scheme concerning controlled subsurface drainage and controlled irrigation. At the moment there are no support payments that could be targeted to changing the uses of arable lands in the most affected areas, or the cultivation of plants requiring a shallower drainage depth. On the positive side, the regional delimitation of non-productive investments and aid for wetlands has been changed as from 2010 so that the catchment areas discharging into the Kvarken and Bothnian Bay are covered by the aid in the same way as other agriculture-dominated catchment areas.

The measures concerning acid sulphate soils should be targeted to the most seriously affected, so-called "hot spot" areas, but no systematic mapping of these has been carried out yet. However, because of the climate change, measures should also be targeted to valuable waters where the effects of acidification have so far remained smaller. The support schemes do not sufficiently take account of the costs incurred from determining the areas with acid sulphate soils by, for example, soil drilling and pH measurements.

Land use guidance: Land use and water protection on acid sulphate soils can be steered through spatial planning and national and regional programmes. In the present national programmes, acid sulphate soils are usually not dealt with separately, and in the regional programmes they are also not taken into account the way they should be.

Information actions and communication: Training and farm-specific advisory services for farmers and forest owners do not deal systematically with soil acidity caused by oxidation of sulphides, but make only casual reference to these. Recognising acid sulphate soils and water protection measures needed in such areas are not systematically included in the training of planners. Spatial planners, planners of drainage works, forestry measures, roads and repartitioning, digging machine operators and other actors in areas with sulphate soils do not necessarily recognise acid sulphate soils or know about the measures that should be taken to minimise the adverse effects they cause. Information material on acidity caused by sulphate soils is unsystematic and scattered. In most cases similar measures are proposed for sites causing acidity loading in a large and small scale.

2.3 Advance prevention and combating of acidification

Land drainage is the most significant human action causing acidification of waters in areas with sulphate soils. Annex 1 gives a brief description of the methods for advance prevention and combating of acidification. The methods have been described in depth in the report of the Ministry of Agriculture and Forestry (2009) "Better Management of Acid Sulphate Soils".

Acidity and metal loading from acid sulphate soils could be efficiently reduced through changes in land use and the related changes in drainage methods. The direct costs of such methods are usually quite small, but they may still have significant indirect impacts on the whole agriculture sector and individual farmers. This is why more extensive use of these measures should be considered only in the most seriously affected areas. In other areas cultivation of plants that require a shallower drainage depth, like grasses, should be considered. This causes less harm to the farming business.

When properly implemented, controlled subsurface drainage, controlled irrigation and recycling of drainage waters are efficient means of controlling acidity in most arable land areas with acid sul-

Table 1. Estimated effect of measures to control acidity caused by sulphate soils

Measure	**Main target**	**Implementation costs**	**Adverse social impact**	**Effectiveness in preventing acidity**	**Recommended for use in preventing acidity in waters**
Controlled subsurface drainage	Agriculture	Quite costly	Small	Quite effective, partly uncertain 1)	Recommended
Controlled irrigation and recycling of drainage water	Agriculture	Quite costly	Small	Quite effective, partly uncertain 1)	Recommended
Bottom dams, wetlands and water protection structures in ditching	Agriculture Forestry	Quite costly	Very small	Effective	Recommended
Arrangements for watercourse regulation and pumping stations	Agriculture Waters	Quite low cost	Small	Quite effective 2)	Recommended for specific sites
Change in drainage method, avoiding increase in drainage depth	Forestry	Low cost 3)	Great	Very effective	Recommended
Change in cultivated plants and reduced drainage depth	Agriculture	Low cost 3)	Really great	Very effective, partly uncertain	Recommended
Lime filter drainage	Agriculture	Costly	Small	Quite effective, partly uncertain 4)	More information needed
Lime filter drainage combined with controlled subsurface drainage	Agriculture	Costly	Small	Quite effective, partly uncertain 4)	More information needed
Liming of tillage layer	Agriculture	Low cost	Small	Ineffective 5)	Not recommended
Lime chip dams and bottoms	Forestry Waters	Quite costly	Small	Uncertain	More information needed
Anaerobic bottom dams	Agriculture	Very costly	Small	Uncertain	Not recommended
Treatment of excavation masses	Excavation work	Quite low cost	Small	Quite effective	Recommended
Liming of waters	Waters/ Small water bodies	Very costly	Small	Quite effective 4)	Recommended for specific sites

1) on lands with sulphide layers at a considerable depth
2) applicable on only few sites
3) significant expenses may incur to individual operators
4) short-term impact
5) needed for plant production but little impact on runoff water

Picture: Rainer Rosendahl

phate soils. Open ditches are also a good solution for controlling acidity, and in most cases it is thus not necessary to construct subsurface drainage in such fields to reduce the adverse effects of acidification. However, modern cultivation techniques usually require subsurface drainage in Finland.

In forestry, soil acidity problems can be reduced by avoiding ditch cleaning and supplementary ditching, especially if this involves increased drainage depth in problem areas. Bottom or pipe dam solutions in the basic drainage channels and, possibly, the use of lime chip dams may reduce the problems in agriculture and forestry areas. In farming areas bottom dam solutions in the basic drainage channels may be needed to secure the benefits from controlled subsurface drainage.

Adverse effects caused by acid sulphate soils cannot be significantly reduced through abundant liming of arable lands, because liming of the topsoil does not reduce acidity which derives from below the tillage layer. Extensive liming of waters is very expensive, and it may lead to harmful lime and metal sediments. Locally, and on a case-by-case basis, liming of drainage waters may be useful for preventing acidification of small water bodies with significant nature value, and in small channels with a valuable fish stock. Liming has some significance in treating the symptoms, but it does not remove the actual cause of the problem. Changes in the arrangements for the release of water and use of pumping plants, where possible, may also prevent the acidification problems from escalating.

Several other methods have been designed to control the adverse effects of acid sulphate soils, but further information is needed on their efficiency before they can be used. Information on the impacts of methods to control acidity is still quite scattered, and the effectiveness of many of the methods are not known. This is why in Table 1 only verbal descriptions are given on the impacts of the measures.

3 MAIN OBJECTIVES AND VISION IN MITIGATING THE ADVERSE EFFECTS OF ACIDIFICATION

3.1 Main objectives

The objective of the strategy for acid sulphate soils is to promote the development of means for controlling soil acidity, sustainable land use and drainage solutions. The aim is to find practices and tools for reducing the acidity and metal loading caused by acid sulphate soils to the extent that a good ecological and chemical status of waters can be reached as soon as possible. In the River Basin Management Plans, it has been estimated that in waters which suffer from acidity problems a good status of the water will be reached by 2027, provided that the measures proposed in the plan are implemented. Acid sulphate soils should be reckoned with in all land use, and land use planning should be based on sufficient information on the location and quality of acid sulphate soils and the risk they cause (Figure 3). The objective of steering the placement of new activities is to prevent an increased need for drainage, especially in the most problematic areas.

3.2 Vision 2020

Specific needs due to acid sulphate soils have been incorporated in the legislation and support schemes in a way that the risks caused by acid sulphate soils are taken into account in land use guidance, and requirements are set for measures and support activities. Actors operating on acid sulphate soils are aware of the specific features of the areas and the necessary, cost-efficient measures. Actions to reduce the adverse effects of acidification are effective, their impact has been proven and the actions are targeted to problem areas on the basis of sufficiently reliable mapping information.

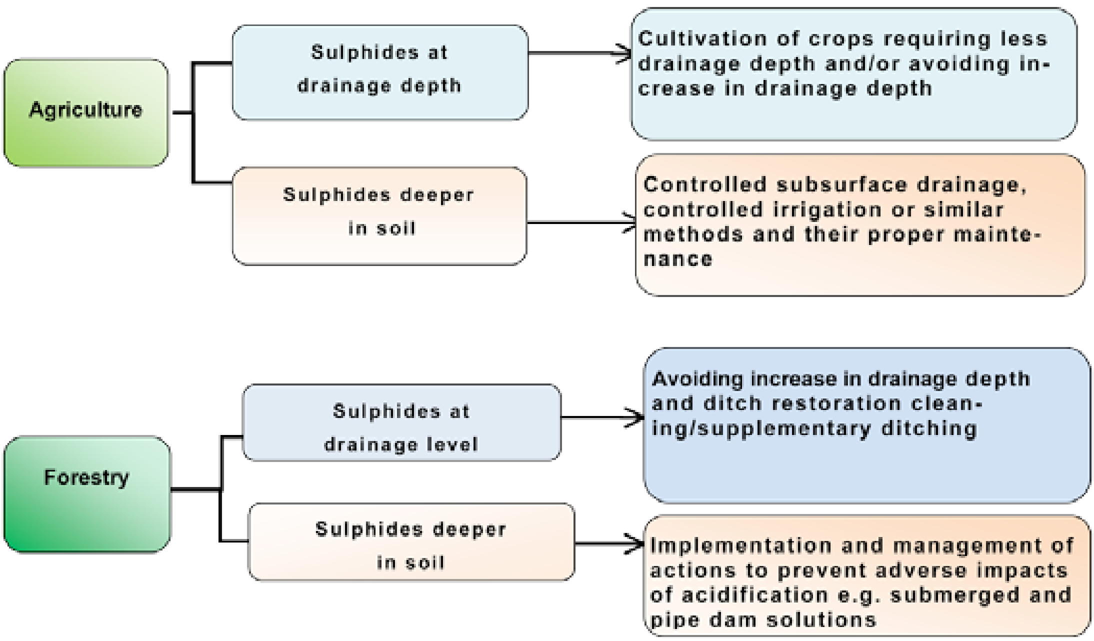


Figure 3. Proposal for taking soil acidity into account in agriculture and forestry

4 KEY ACTIONS

4.1 Acid sulphate soils are reckoned with in legislative work

Through changes to the legislation and developing the guidelines we can ensure that the prohibitions to pollute surface waters and groundwater (under the Water Act and Environmental Protection Act) are to a sufficient degree taken into account in the permit procedures concerning drainage in acid sulphate soils, conditions for such permits and their control.

Examining the possibility to add citation of soil acidity caused by sulphate soils as a factor to be taken into account in project planning - for example, to the Water Decree and legislation on agriculture, forestry and land use - should be carried out.

Extensive projects that impact on the drainage status of sulphate soils should be notifiable to the environmental authority. The Government proposal for amending the Water Act includes the notification of the regional authority of drainage and dredging, which contributes to giving due account for acid sulphate soils.

The possibility of establishing wetlands and other water protection structures easily on lands owned by passive users should be investigated.

The Ministry of Agriculture and Forestry, Ministry of the Environment and Ministry of Justice are responsible for the further preparation of these issues.

4.2 Incorporation of acid sulphate soils and their effects in national and regional programmes

Acid sulphate soils and their effects are specifically taken into account in national and regional programmes that impact on the status of waters or drainage status of lands. Such programmes include the national target programme for water protection, regional river basin management plans, forest programmes, rural development programmes and national drainage programmes. Acid sulphate soils are also taken into account in regional land use planning.

The parties preparing the national and regional programmes are responsible for taking the proposal into account in the programmes. The Regional Councils and municipalities are responsible for taking acid sulphate soils into account in zoning.

4.3 More efficient reduction of the adverse effects of acidification through better support schemes

Water protection measures in acid sulphate soils are incorporated in the support schemes of agriculture, forestry, basic drainage and land consolidation in more comprehensive and diverse ways than at present. Support for water protection of agriculture on acid sulphate soils is diversified. Possibility to obtain support from the Water Framework Directive referred to in Article 38 of Council Regulation (EC) on Support for Rural Development by the European Agricultural Fund for Rural Development is examined. The conditions of support for basic drainage should include an approved acidity management plan.

Measures to improve the management of acid sulphate soils will be included in the new Rural Development Programme to be implemented as from 2014. To mitigate the adverse effects of sulphate soils it is particularly important to target the support to cultivation of grasses and other plants requiring a shallower drainage depth, as well as to controlled subsurface drainage and irrigation on arable lands located in areas with acid sulphate soils.

The support payments for measures to promote the management of acidity are targeted primarily to proven problem areas. Because comprehensive mapping of such areas has not been done yet, ways to finance the survey and analysis of acid sulphate soils during application for support needs to be examined. The possibility to use existing information needs to be inspected so that, for example, support will be allocated to water bodies where acidity is a serious problem or there is a risk that it may become such, and where arable farming or forestry is a significant form of land use. In order to be eligible, the area concerned must be located on acid sulphate soil.

The revised Act on the Financing of Sustainable Forestry allows higher support payments for planning and implementation of several water protection measures fully from the State funds on demanding sites. In the implementation of the Act the planning and implementation done on acid sulphate soils will be considered more demanding than normal actions.

Land consolidation is improved so that environmental and water protection perspectives are taken into account in the related drainage operations in the same way as in drainage for agricultural and forestry purposes, especially in areas with acid sulphate soil.

The responsibility for developing the support schemes rests with the Ministry of Agriculture and Forestry together with the Ministry of the Environment.

4.4 Supplementing and updating the special characteristics of acid sulphate soils in guidelines and recommendations

The guidelines and recommendations concerning basic drainage, land consolidation, agriculture, forestry and peat mining will be complemented to include concrete instructions for identification of acid sulphate soils, advance prevention of adverse effects of acidity, and information on measures to combat these. The procedures and good practices relating to the compliance with and control of the Water Act and permit decisions issued under it are clarified in drainage and dredging projects in acid sulphate soils. Recommendations are made for the banking and after-treatment of acid sulphate sediments.

The closer the sulphide layers are to the surface, the less the land should be drained. Areas where there most likely are sulphides close to the soil surface include sulphate soils close to the seashore or other lowland areas such as lake formations and embankments, and after-use areas of mires used for peat mining. On the other hand, there is no strict need to regulate drainage in sulphate soils located higher, or where cultivation has been going on a long time, and thus the oxidizing sulphide layers are often deeper.

The responsibility for updating the guidelines and guidebooks rests with the research institutes, regional authorities, municipalities and advisory organisations. The Ministry of Agriculture and Forestry and Ministry of the Environment are responsible for providing the preconditions for this work.

4.5 Reinforcing research, communication and advisory work

Various kinds of methods have been developed to combat and prevent problems relating to acid sulphate soils. Right now, however, there is not enough information on the effectiveness of these methods and their combined impact. The knowledge base needs to be reinforced, but the lack of information as such is not an obstacle for taking action, as significant progress can be made in reducing the adverse effects based on the knowledge we have right know.

In the future the new potential sulphate soils resulting from land uplift must also be taken into account in the planning. The impacts of climate change on the management of the soil acidity problem have to be assessed. Climate change is very likely going to worsen the adverse effects caused by the drainage of acid sulphate soils, as it increases the frequency of extreme weather events, such as long droughts and exceptional flooding.

Communication and guidance concerning acid sulphate soils should be considerably increased. Further information is needed, in particular, by people engaged in agriculture and forestry, planners and implementers of projects or land consolidation operations that impact the drainage status of the land, public authorities, educational establishments and problems related to acidity caused by the oxidation of sulphides in the subsoil, and regular acidification of the topsoil, call for quite different kinds of solutions. These should therefore be presented as separate entities in the advisory material. The aim is to set up a communication network to ensure efficient flow of information regarding acidity problems. The Rural Development Programmes and Rural Network are utilized in the communication and advisory work.

The responsibility for developing research, communication and advisory work rests with the Ministry of Agriculture and Forestry, Ministry of the Environment, research institutes, regional authorities, municipalities and advisory organisations. Part of the development work can be done through project activities.

4.6 Sufficiently comprehensive mapping of acid sulphate soils

Efforts will be made to map the most significant areas with acid sulphate soils and the risk of loading they cause on waters using harmonised methods by 2015. The common methods and classification criteria to be used in Finland were established in 2011. Acid topsoils are classified according to the loading they cause on waters, using their potential adverse effect on the acidity loading of waters as the criterion. The mapping of acid sulphate soils will be included in measures that are eligible for financial support until the national mapping has been completed. Sufficient funding is allocated to the mapping operation.

Comprehensive mapping is necessary because the acid sulphate soils may differ considerably from each other in their specific properties. The closer the sulphide layers are to the soil surface, the easier they come in contact with oxygen, and the greater the risk is that acidity, aluminium, iron and heavy metals are released in harmful quantities. This is why the depth of the sulphide layers must be taken into account when classifying acid sulphate soils based on the potential environmental risk they could cause.

The mapping results are used to compile a spatial data set which can be utilised by all actors, from land owners to public authorities. Based on the mapping data it should be possible to collect follow-up data on the impact of different water protection measures on acidity. Farm-specific mapping and further studies will also be necessary after the national project has been completed due to, for example, the uneven and fragmented occurrence of sulphate soils, which makes it very difficult to produce an accurate map.

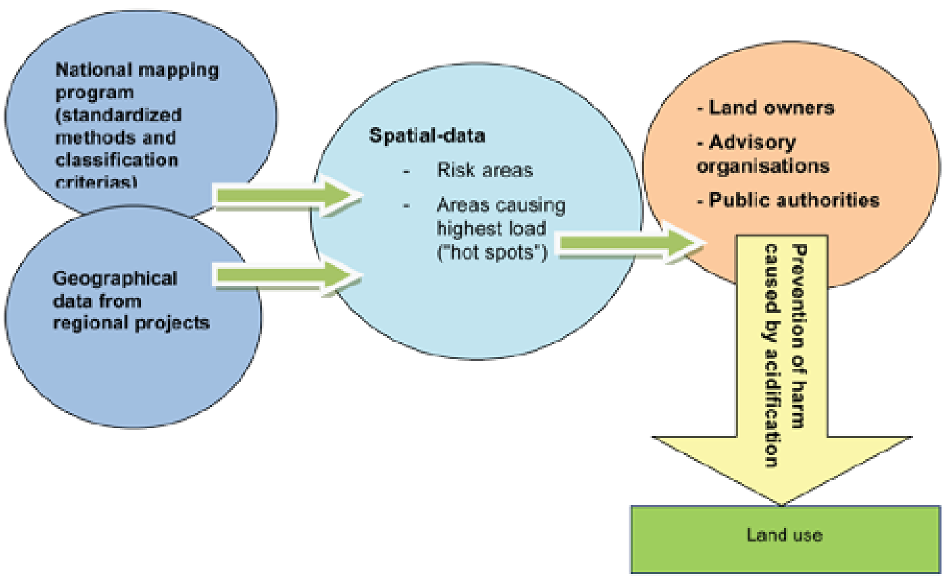


Figure 4. Objectives of the mapping of acid sulphate soils

The main responsibility for the national mapping of acid sulphate soils rests with the Geological Survey of Finland. Certain parts of the mapping work can be done through project activities (Figure 4). The mapping work should be prioritised in a way that ensures rapid mapping of the most problematic areas. Actors who plan drainage projects in potential sulphate soil areas are responsible for investigating the location of sulphate soils in the area concerned.

4.7 Further studies on adverse effects to obtain a comprehensive picture

Further studies are needed on the adverse effects that the acidity from sulphate soils is having on fisheries, water supply, agriculture, forestry and peat mining. Acidity should also be duly taken into account in monitoring the state of the environment. The typology of river basins in acid sulphate soils will be revised, and the need for indentifying the types of watercourses in acid sulphate soils will be examined so that these can be taken into account in the next round of river basin management planning.

Additional inputs are needed to study the economic and social impacts of acid sulphate soils, mitigating the problems they cause, and for developing methods to support the decision-making. Participatory planning processes relating to the matter will be launched, and an action programme will be prepared to examine the economic, social and ecological impacts of fish mortality.

The Ministry of Agriculture and Forestry promotes the study of the impact of acid sulphate soils together with the Ministry of the Environment and advisory organisations. The most important research institutes conducting the studies are the Finnish Game and Fisheries Research Institute (RKTL), Finnish Environment Institute (SYKE), Agrifood Research Finland (MTT), Finnish Forest Research Institute (Metla) and Geological Survey of Finland (GTK). Of the Finnish universities at least the Åbo Akademi University, University of Helsinki and University of Oulu will be involved. Part of the proposed studies can be conducted through the Catermass Life+ project concerning soil acidity and climate change (2010 - 2012), and other project activities.

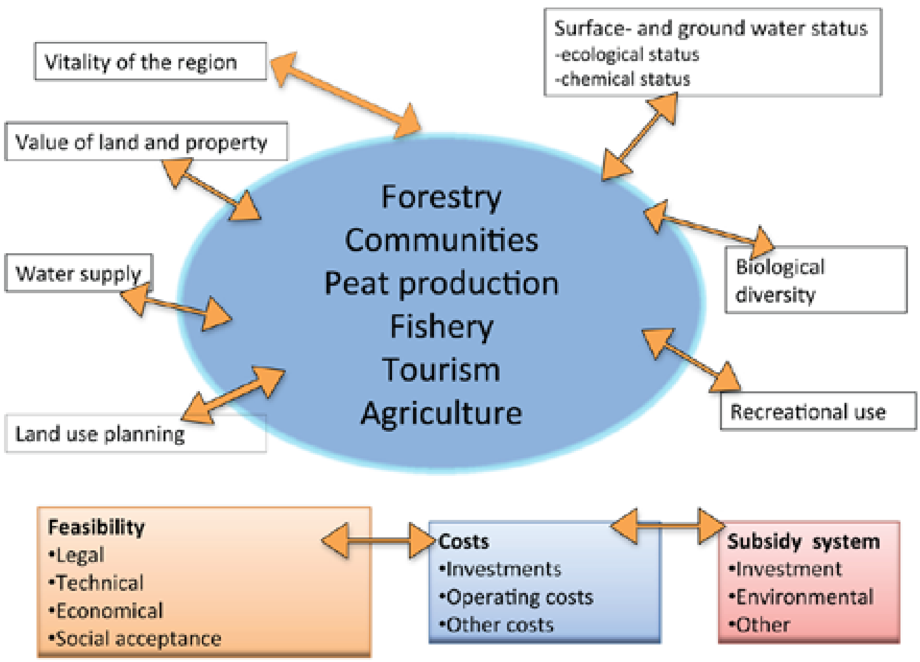


Figure 5. Factors influencing the socio-economic impacts of acid sulphate soils.

4.8 Acid sulphate soils are reckoned with in land use planning and building

Land use planning: Acid sulphate soils are taken into account in all land use. Efforts are made to have enough information on acid sulphate soils and the risks they cause in land use planning. This requires national mapping, project-specific studies and guidelines.

The placement of new activities is steered properly to avoid major drainage measures in the most problematic areas. In the permit procedures sufficient measures to prevent and minimise loading must be defined for the projects.

Civil engineering: Special requirements due to acid sulphate soils are taken into account in the planning and execution of measures to be implemented in acid sulphate soils. Rules concerning, for example, contaminated sediments and soil may need to be complied with in the placement and after-treatment of dredging and surplus masses. Information on acid sulphate soils and how these have to be accounted for should be coupled with notifications and applications concerning dredging projects.

Sulphides and metals accumulated from sulphate soils to the bottom sediment of river basins are taken into account when assessing the need for dredging in the areas concerned, and the placement and after-treatment of the dredging masses. The dredging plan is based on chemical analyses of the material being dredged. The need for chemical analyses and potential harmful impacts of dredging can also be assessed by mapping the bottom macroinvertebrates (lack of living organisms, deformities).

Particular caution is needed in the dredging of acid sulphate soils and acid sediments. In peat mining sulphuric soil is taken into account also when planning the after-treatment and -use of peat mining areas.

The main responsibility for taking acid sulphate soils into account in land use planning, and planning and implementation of measures which impact on the drainage status rests with the operators, but the public authorities are responsible for developing the planning practices.

4.9 More efficient prevention of adverse effects of acid sulphate soils

Further information is needed on the methods of preventing the adverse effects caused by acid sulphate soils. Methods such as controlled sub-surface drainage/irrigation, bottom dams and insulating films need to be investigated. Experiences from other countries should also be considered in developing new methods of preventing the adverse effects.

Plans for specific catchment areas, including assessments of the cost-efficiency and environmental impacts of the different measures, have to be prepared in case very problematic situations. A local action plan is drawn up on the better utilisation of watercourse regulation and pumping as well as the needs and possibilities for liming of waters for all watercourses where such measures may come into consideration. Such watercourses include the entity comprised of the river Ähtävänjoki and lake Luodon-Öjanjärvi as well as the rivers Kyrönjoki, Lapuanjoki and Perhonjoki.

The responsibility for the preparation of plans for specific catchment areas rests with the regional authorities together with the other actors in the region.

5 IMPLEMENTATION AND FOLLOW-UP OF THE STRATEGY

5.1 Implementation of the strategy

The Ministry of Agriculture and Forestry and Ministry of the Environment are responsible for the general steering of the strategy work and implementation of measures by the ministries. The strategy is executed as part of the legislative preparation, operative and financial planning and performance guidance.

The strategy is put to practice in river basin planning work by taking account of the main proposals of the strategy in the River Basin Management Plans and their implementation. On a national level the implementation of the strategy is matched with the implementation of the Government Resolution on Water Protection Policy Outlines to 2015.

The implementation of the strategy also depends on the sectoral support schemes and their financial and programming periods, which determine when special consideration and revision of the strategic outlines may be necessary.

5.2 Follow-up of the strategy

The implementation of the strategy is followed as a part of the performance guidance procedures between the Ministry of Agriculture and Forestry, Ministry of the Environment and the agencies and institutes in their administrative sectors.

Follow-up of the strategy implementation is also monitored as part of the follow-up relating to the water protection targets until 2015, and the follow-up and reporting of the implementation of the River Basin Management Plans.

Specific impact assessments and evaluations will be conducted if necessary, and the implementation of the strategy may also be reviewed together with stakeholders representing the NGOs.

5.3 Impacts of the strategy

The proposed measured should make it possible to reach a good chemical and ecological status of waters in a significant share of the waters located in acid sulphate soils. Besides improving the status of waters, a reduction in the adverse effects of acid sulphate soils has a positive effect on the terrestrial and aquatic organism, the soil and climate change adaptation. The drainage of acid sulphate soils has a negative effect on the use of waters, especially fishing and fisheries, so this is also where implementations of the strategy can be seen as beneficial.

The implementation of the proposed measures causes costs both to the operators and to the public sector. The polluter-pays principle is considered when allocating the costs from the measures. If, however, the costs of the measures could be considered unreasonable, sufficient support payments should be targeted to their implementation. Other measures brought on the public sector will be implemented, where possible, by reallocating funds within the available funding framework to these measures.

To improve the efficiency of the agri-environmental support, measures should be targeted to areas with the highest risk to a greater extent than before. The targeting of measures should be based on criteria relating to water protection and status of waters. On a farm level, too, measures must be targeted to parcels that cause the greatest loading. When revising the environmental support it is ensured that sufficient compensations are paid for efficient water protection measures so that the farmers are willing to commit to these.

Through the good status of waters and with a better image, economic benefits can be gained from the management of acidity. The beneficiaries from the improvements include fisheries, recreational users and the water supply. Indirect beneficiaries are various nature and wildlife service enterprises, and other tourism. The implementation of the measures creates jobs, while the development of environmental expertise in the regions and further processing of innovations may have positive impacts on exports as well.

In the long term, climate change and other changes in the operating environment may increase the adverse effects caused by acid sulphate soils, or at least slow down the decreasing trend in these. The decrease in adverse effects has a positive impact on human health, living conditions, quality of life and well-being, and community structures. Measures proposed in the strategy offer an incentive to various sectors and public authorities to take action and increase collaboration between them.

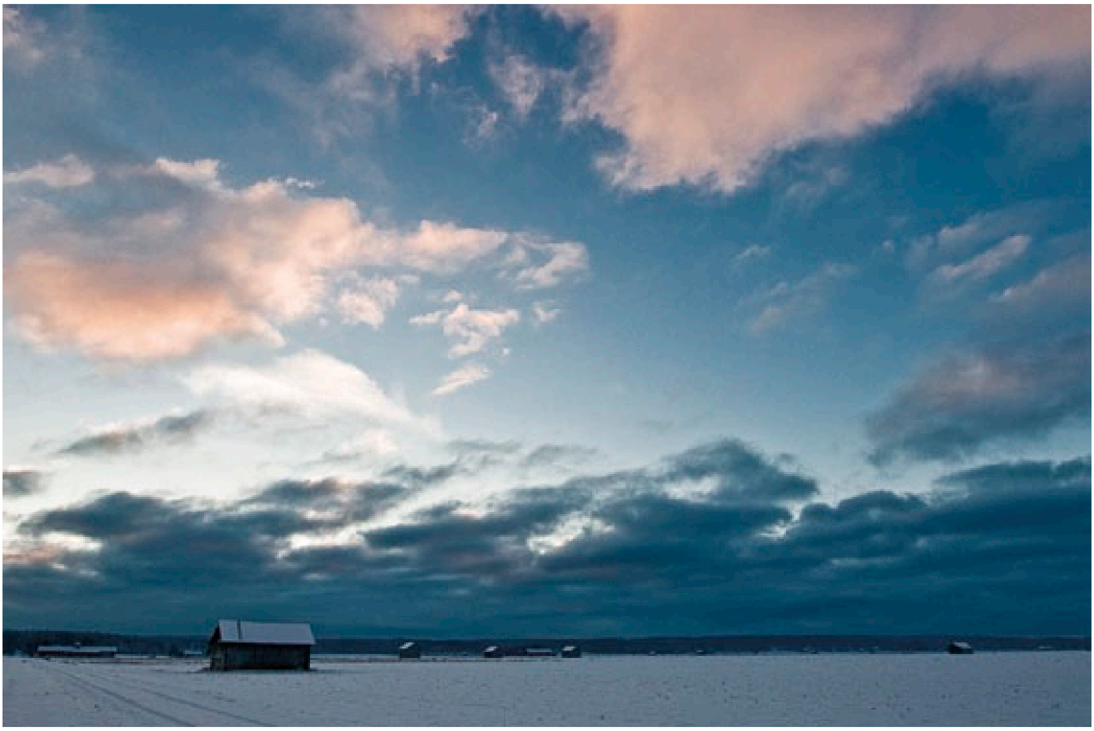


Photo Vincent Westberg

ANNEX 1. Main methods for mitigating the adverse effects of soil acidity

Land use and drainage

Because of the short growing season, snow melt and uneven distribution of precipitation, as well as soil properties, the practising of agriculture and peat land forestry in Finland calls for efficient land drainage. In farming areas, local drainage is usually done by means of subsurface drainage and feeder drains. For local drainage the drainage waters must be conducted away from the area through main ditches or other basic drainage methods. In forestry areas land drainage is done with open ditches. Besides the local drainage of acid sulphate soils, the intensified basic drainage increases considerably the acidity problem in waters.

Dredging may be necessary at river mouths because of the accumulation of erosion material and the land uplift. In areas with extensive sulphate soils the bottom sediments of rivers and their estuaries are often sulphuric with high levels of harmful metals, which may be further increased by loading caused by land use in the upstream area. The metals might get released in dredging, causing a threat to the coastal ecosystems. In dredging, the excavation operations as such may not cause the leaching of acidic compounds, but it usually happens after oxidation and a dissolving process. The acidifying effect is often the greatest 2 – 3 years after the excavation. Efficient liming of the excavation masses after the banking may prevent or at least reduce acidification.

The flood protection works in Ostrobothnia, especially the embankments in lowland estuaries and the related drainage operations, have caused problems with acidification. A lot of sulphuric sediment has accumulated in lowland estuaries, and the sulphuric layers may be very close to the soil surface. When drained, especially by means of subsurface drainage, such lands cause very high acidity loading. It has been estimated that no drainage should be done at all in areas where the sulphide layer is close to the soil surface to achieve a significant reduction in acidity loading.

Peat mining requires the drainage of peatlands that are suitable for this purpose. The after-treatment and -use of peat mining areas may also require drainage operations, which involve a risk of further increasing the acidity loading.

Road building, drainage of settlement areas and other changes to the drainage state may also increase the acidity loading of waters.

Drainage method and depth

The modern commercial cultivation techniques usually require local drainage to be done by means of subsurface drainage. Most of the utilised agricultural area in Finland is already covered by the subsurface drainage system. In most cases subsurface drainage reduces the solid matter and phosphorus loading compared to open ditches, but in acid sulphate soils it may increase the acidity and metal loading from these lands. According to different estimates, the sulphate levels in subsurface drainage waters from sulphate soils are 1.5 – 10 times the levels in open ditches.

On forestry lands the impact of drainage does not usually go as deep in the ground as in agricultural lands, because only open ditches are used for land drainage. Based on studies on arable farming it can be assumed that the acidification risk caused by drainage waters is smaller in forestry areas than in farmlands with subsurface drainage. In exceptional cases the drainage in forestry lands may impact deeper soil layers if a slightly sloped area requires deeper ditches than normally to conduct the drainage waters, or if, for example, the ditches have been considerably eroded after the actual drainage operation.

Waters from outside the peat mining areas are conducted past the mining fields. Drainage waters from the mining areas are conducted away from the area through water protection constructions. The surrounding ditches as well as the outlet ditches from the mining fields often go as deep as the mineral soil. The drainage effect of the feeder drains in the mining fields usually extends to the lower mineral soil only in the final stages of mining. The drainage effect of the ditching arrangements in the after-use may go even deeper into the subsoil, which increases the acidity loading risks in areas with sulphide sediments.

Water protection measures in drainage

The most common water protection measures in forestry are sludge pits and digging breaks in feeder drains, sedimentation ponds dug in collector drains and outlet ditches, and overland flow fields. When placed in sulphate soil, the sludge pits and sedimentation ponds may also cause acidity loading. The River Basin Management Plans propose a wider use of measures to improve the standard of water protection, including overland flow fields, wetlands and bottom and pipe dams. Wetlands and flow regulation using, for example, dams may reduce acidity loading from drainage in forestry lands, but as of yet there is no practical experience or guidelines on this.

Some of the water protection methods in peat mining are the same as those used in forestry. Sludge hollows and retention pipes are used in feeder drains in peat mining areas. In isolation ditches the solid matter loading is reduced by sedimentation ponds. Sedimentation ponds are the basic method for the purification of water in the mining field. Intensified water treatment methods include surface flow fields, flow regulation, vegetation fields and chemical purification of water. There are no guidelines on the applicability of the methods for reducing acidity loading. In new projects the main issues for preventing acidity loading are the mapping of sulphuric soils and planning of drainage and production with due account for the mapping results. Re-paludification and the watering down of peat mining areas may be good after-treatment methods when there is a risk of acidification, but as yet there is very little information on how effective they are.

Controlled subsurface drainage, controlled irrigation and recycling of drainage water

The objective of the controlled subsurface drainage used in Finland is that whenever cultivation techniques allow it, the water level in subsurface drainage wells is allowed to rise above the ditching depth. This is how the sulphides in the subsoil should stay saturated with water for a longer time. However, there are occasionally prolonged periods of drought in the middle of the summer, when abundant use of water by the plants may cause the groundwater level to fall considerably below the subsurface drains if no additional irrigation water is used. This has led to the conclusion that, without the possibility to conduct additional water, controlled subsurface drainage may prevent the oxidation of sulphides when these are quite deep in the soil profile, but controlled subsurface drainage alone cannot prevent the sulphuric layers close to the soil surface from oxidising because in arable lands with subsurface drainage periods of drought may inevitably cause the groundwater level to fall deeper than this. It seems that the positive impact of controlled subsurface drainage takes years to materialise. In addition, constructing controlled subsurface drainage alone does not reduce the problems in acid sulphate soils, but it must also be properly managed.

Controlled irrigation and recycling of drainage water may slow down the drop in the groundwater level in land with subsurface drainage. So far, the main target in taking these measures has been to reduce nutrient leaching and irrigate the plants, but they also contribute to controlling acidity. One problem that may arise is that in dry periods there might not be enough supplementary water available, and there are also costs involved if water has to be pumped to the drains. In lowland embankment areas, some of which are quite problematic sulphate soils (hot spot areas), this kind of regulation of the water economy may succeed without unreasonable costs. It should also be possible to use brackish water for this purpose.

The soil type and slope may restrict the use of these methods. The soil of the area must be sufficiently permeable by water, which is why special support for controlled subsurface drainage, controlled irrigation and recycling of drainage water is granted only to arable lands with sand, fine sand or gyttja clay. A maximum slope suited for the control measures is also required.

Bottom dams and wetlands

Bottom dams and wetlands may slow down the drop of the groundwater level in arable areas. They may also be used to regulate the water level in the drains, lengthen water retention and prevent, for example, erosion caused by drainage by damming the water in the drains or on land. The impacts of bulkhead gates and pipe dams are the same as that of bottom dams, i.e. they regulate the water level. In periods of extreme drought, the amount of water coming to the ditches may be so low that even the dams cannot prevent the water level from dropping to soil layers below the drains.

Liming of the soil

Surface liming of arable lands has been a traditional way to allow cultivation on acid sulphate soils. Liming can be used to neutralise the tillage layer to which the lime is mixed, but it has quite little impact on the quality of the runoff waters coming through the subsurface drains. If the aim is only to reduce the adverse effects of acidification in waters, liming of arable lands is rarely cost-efficient. Even larger quantities of lime applied in the highest soil layer do not reduce the leaching of acidifying material to waters. In order for the added lime to have any significant impacts on the acidity loading into waters, it should be placed to soil layers deeper in the ground where the oxidisation takes place. This, however, is not possible, except for the soil in subsurface drainage excavation sites.

Liming of waters

The liming of waters has proven to be costly and difficult to implement. Acidity problems should primarily be prevented in places where they are created. Liming of waters may be recommended as a rapid remedial action in case of a significant acidification problem in particularly sensitive areas. Direct liming of waters may come to question only in exceptional cases, because this method has significant negative impacts as well. Liming stations with dispensers for both dry and wet lime are in use. Their construction costs and especially operating costs are very high. They may be suited to waters that are heavily influenced by sulphate soil and/or low water flow. The method may be applicable for rescuing small water bodies, for example, if the survival of fish depends directly on preventing acidification.

Anaerobic bottom dams, lime chip dams and -bottoms, lime filter ditches

Anaerobic bottom dams occupy less space than large wetlands, and they may function as a producer of alkalinity. The neutralisation of drainage waters included in the anaerobic bottom dam system is based on microbial reduction and related rise in the pH level. The purpose of the method is to neutralise the acidity of the water and precipitate the metals contained in it. Anaerobic bottom dams have been tested in the river Kyrönjoki, with quite poor results.

Lime chip dams have been used in the restoration of small brooks for fishery purposes, where the aim has been to both raise the water level and slightly increase the pH level. There are no research results on wider use of this method in sulphate soils.
Lime filter ditch is a subsurface drain with 3 – 10% of burned lime (CaO) mixed into the soil used to fill in the pit. This creates an alkaline zone in the soil layer through which most of the drainage water is transported to the subsurface drain, which neutralises the acid waters. The lime mixture improves the water permeability of the drainage pit, and the drainage waters are filtered through the alkaline soil material with good soil structure. The neutralised

water is led through the subsurface drainage pipe to the discharge water body. The effectiveness of lime filter ditching weakens considerably in just a few years, but the period of utilisation may be extended when combined with controlled subsurface drainage.

Watercourse regulation and pumping plants

Regulating the water flow in watercourses where the regulation of discharge / water levels is applied may reduce the adverse effects of acidity in certain exceptional cases. In areas drained by pumps, acidity peaks may be reduced by adjusting the pumping of acid waters step-by-step, or waters may be led to areas where they cause the least damage. The surface area of embankments represents a very small share of acid sulphate soils in Finland. Usually the drainage status before the embanking was weak, which means that quite little acidity has been leached from them. This is why the water pumped from such areas may be very acid and efficient pumping may lead to serious acidity problems locally.

Mapping

Efficient and appropriate application of the methods described above requires mapping information at different levels of detail. A general national map on sulphate soils is needed for the classification of areas based on the acidity risk involved. Site-specific mapping is needed in connection with project implementation as the basis for planning the individual methods and measures.

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