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Report on the prototype constructions of the EquineLife project

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Abstract

In this project equine constructions with different use were tested. At the Equine College Ltd (Ypäjä) we tested a paddock surface construction and a free running stable. At the Icelandic Horse Competence Center, Kuuma we tested an oval racetrack surface construction and paddock surface constructions. In both these Kuuma areas we used chemicals for reduction of phosphorus load. At MTT experimental farm, Ypäjä we tested a weather shelter construction. We also constructed and tested a weather shelter at the College Ltd (Ypäjä). For assessment of the nutrient status in the equine areas surface soil samples (0 – 2 cm) were taken for soil analysis.

The test paddock constructed with a layer of chopped car tyres at the Equine College Ltd (Ypäjä) has been dry throughout the test period (two years) compared to the sand paddocks with mud problems. Also in periods with slippy conditions this type of paddock construction with its elastic surface seems to be superior in comparison with the sand paddocks. One disadvantage with this construction has been that pieces of the chopped car tyres with their nasty steel wires has been dug out to the top layer by the horses and these pieces had to be taken away occasionally.

The free running stable was constructed for sixteen horses with three paddock areas. One paddock area can be used by the two groups of horses thus making it easier to clean the paddock not in use. The outdoor areas with the most intensive use proved to be highest in phosphorus load status. Constructed areas especially equipped with bedding material attracted the horses to defecate in these areas and thus making the cleaning work easier.

At Kuuma we tested two different chemical treatment of the oval track surface. No increase in the iron content could be noted in the easily extractable soil contents, although the addition of iron sulphate chemicals (ferric and ferrous sulphate). The increase in the extractable sulphur level was only modest. The extractable phosphorus content in soil decreased after the treatment.

At Kuuma an improvement of a muddy paddock area of 3800 m^2 was carried out. This work included drainage pipe constructions with a distance of 9,5 m between pipes. The area was divided into four paddocks where two different chemicals in the woodchips layer or woodchips/sand layers were tested. The phosphorus content in the drainage water from the ferric sulphate treated paddocks was about 60 % lower than the contents in the drainage water from the paddocks treated with calcium hydroxide. The Kuuma stable personnel has been pleased with no mud problems.

The tested weather sheds in Kuuma and Ypäjä were both cost effective. Both construction types (wood and clay/straw) can be recommended. The weather shelter in Ypäjä was well suited for its purpose. Of the tested bed material inside and around the shelter the woodchip areas were more attractive than the sandbed for the horses as sleeping areas. Between the tested windbreak wooden materials (birch, Scots pine, larch, Norway spruce and aspen) we did not observe any difference during the test period. The drainage pipes build to take away the water from the weather shelter area were in some places dug up by the horses. This was not awaited as the drainage pipes in the Kuuma paddock test area at the same depth were not dug up. One explanation could be that Kuuma paddocks were filled up with wood chips.

Of the tested different constructed prototypes we can especially recommend the woodchip use as this clearly is a win-win case. The horses will not eat sand, and we save our eskers.

Index words: equine, horse, phosphorus load, paddocks, chemical treatment, run-in stable, weather shelters, weather sheds

Introduction

Horses are social animals and prefer to live in close contact with conspecifics. Horses are adapted to moving over long distances every day and to spend most of their time on food consumption. These natural behaviour patterns need to be considered in order to optimise welfare in stabling systems for domestic horses. Although the ways in which horses are used differ considerably, all horses have the same basic needs regarding locomotion, social contact and comfort behaviour. Søndergaard et al. (2004) recommend that horses spend at least 3-4 hours per day in paddock, but if the horse is exercised, the time in paddock can be reduced. The daily time in paddocks should, however, never be less than one hour, since there are other aspects of being released in paddocks which cannot be met by forced exercise, i.e. the freedom of movement and access to physical contact with other horses (Søndergaard et.al., 2004).

In an English survey concerning abnormal behaviour, McGreevy et al. (1995) found that horses are less likely to develop abnormal behaviour the less time they spend in the stable.

Schatzmann (1998) found that horses do not prefer to stay outside if the entire outdoor area is muddy. Thus, it is important to make sure that this is not the case.

In a study on policy recommendations for sustainable equine industry Vihinen (2005) has pointed out that in the studied countries: Finland, the Netherlands and Sweden a significant number of horses and ponies are not registered. The main reasons are the price of registration and the fact that some horse owners do not recognised the relevance or possible use (Vihinen, 2005). Due to this we do not know the exact number of horses in Finland. This make also the work on environmental load from this sector difficult as the exact problem scale can not be seen.

In the official registers the number of horses in Finland is 66 000 (Suomen Hippos, 2007). The number of horses in this register has increased rapidly during the last years. Thus an increase by more than 2000 horses has been reported from the year 2005 to 2006.

In 1995 Pietiläinen reported that phosphorus is the major nutrient limiting algae growth in Finnish lakes. Also globally phosphorus has been reported as limiting factor in the majority of cases (Ongley, 1996).

In the past a reduction of both phosphorus and nitrogen was considered to be needed to reduce algae growth in the Baltic Sea. However during last years increasingly the opinion has been presented that the expensive measures against nitrogen output (for example in agriculture), imposed by authorities in order to diminish eutrophication in the coastal waters, are doomed to failure as evidently phosphorus is initially the limiting nutrient (e.g. Söderström, 1996).

Those species of blue-green algae that usually form the blooming in the Baltic Sea, the toxic Nodularia and the non-toxic Aphanizomenon, satisfy their nitrogen need by fixing dissolved atmospheric nitrogen from water. The growth of these species is thus dependent on the availability of phosphorus in the water. The concentration of plant-available phosphorus is thus a crucial factor that determines the extent of blue-green algae blooming in summer (SYKE, 2004).

The authorities in European countries like Finland, Sweden, Russia, Estonia, Latvia, Lithuania, Poland, Belarus, Denmark and Germany in which large areas situate in the badly polluted Baltic Sea catchment area know quite well the need for a reduction in agricultural phosphorus load. Still they do not necessarily know that within the agricultural sector you find critically high phosphorus source areas like equine areas (Jansson et., al, 2000).

A study on soils from areas of different equine use (Jansson et al., 2005) showed that the highest phosphorus contents in the surface layer (0 – 2 cm) could be found in areas where horses most frequently defecate or are given hay or silage. The lowest contents were found in areas with a low frequency or short history of equine use. In steep areas this method probably underestimates the load. Also in paddocks, where there is a throughflow of water the topsoil phosphorus content may underestimate the phosphorus load. The extractable phosphorus contents in surface soil samples (0 – 2 cm) in comparison to deeper soil samples (0 – 20 cm) were on the average three times higher in the surface soil samples. The deep (0 – 100 cm) sampling showed that the highest extractable soil phosphorus in equine areas would be find in the surface soil.

When comparing the extractable phosphorus content from the paddock surface soil with the dissolved reactive phosphorus contents from the rain simulation it could be seen that the correlation coefficient was high (r^2 = 0,85). This means that in equine areas the low cost analyses of extractable phosphorus contents of the topsoil is a good indicator in predicting phosphorus load (Jansson et al., 2005).

Paddocks and weather sheds

The number of horses has earlier been much higher. In 1950 the number of horses in Finland was as high as 408 800. In those days horses were used in agricultural and forestry work and were not kept year-round in paddocks.

In our EquineLife survey from 70 horse stables from South Western Finland (Pikkarainen, 2005) we got information regarding 828 horses. This data represents about one percent of the whole horse population in Finland. According to this study the horses were kept in paddocks for 7,2 hours on the average. On the average the size of these horse paddocks were 1100m^2. The paddocks had been in use for 5,4 years on the average.

From the same report it can be seen that on the average in the same paddock there were kept 1.9 horses. In most of the cases there were no weather sheds (68%). When these figures are applied to whole Finland it can be estimated that we have about 37 000 horse paddocks. As our increase in horse number has been as high as more than 2000 horses in the last registered increase from the year 2005 to 2006 (Suomen Hippos, 2007) these horses need 1000 additional paddocks.

In Sweden the amount of phosphorus in faeces and urine from a horse is reported to vary from 8 to 16 kg phosphorus per year (Steineck et. al, 2000). With varying diets van Doorn et al. (2004) found wide varying but relatively low (0 to 1 g/day) urinary P excretion by mature trotters. The faecal excretion varied from 18 to 37 g/day.

In a study on faecal phosphorus excretion from yearling geldings Hainze et. al (2004) found water-soluble phosphorus contents varying from 3,0 to 7,9 g/day. Faecal output of total P, water-soluble P and insoluble P was 8.4, 3.0 and 5.4 g/day, 10.1, 3.9 and 6.9 g/day, 14.9,5.3 and 9.6 g/day, and 19.0, 7.9 and 11.1 g/day, respectively for diets containing whole oats, alfalfa cubes, sweet feed and pelleted concentrate (Hainze et. al., 2004). The water-soluble P thus varies between 36 to 42 % of the total P in the faeces.

From the above figures it can be calculated that the inputs of phosphorus into our paddocks is 3 kg of phosphorous in faeces during one year per horse. As on the average two horses use the same paddock we will get an input of 6 kg phosphorus/paddock/year and about 60 kg phosphorus per hectare. As reported by Pikkarainen (2005) the surfaces in paddocks are changed every third year and this will make our paddocks surfaces on the average 1,5 years old and in this period the average AAAc extractable phosphorus has risen to over 50 mg P/l soil as reported earlier (Jansson et al. 2005). This corresponds approximately to a phosphorus content in surface water content of 1 mg dissolved reactive P/l. Thus the dissolved reactive phosphorus load from a horse paddock areas are as high as eight times as those from our field areas.

Mud problem has been defined as a serious problem for especially small acreage horse landholders. It has been noted that: most people realise that rainwater plus exposed soils equals mud. What many people do not realise, however, is that this combination can also lead to water pollution (Blickle et al., 2003). When soil and manure has mixed with water to make mud, it can easily be carried into nearby streams or lakes. Sediment can smother trout and salmon eggs, destroy habitat for insects (a food source for fish) and cover prime spawning areas (Blickle et al., 2003). In high-traffic areas (such as paddocks or stall entryways), horse hooves loosen topsoil and compact the soil below. As the soil becomes more and more compacted with the constant pounding of heavy horse hooves, rainwater is not able to percolate through the soil and instead pools on top, mixing with the loose topsoil to create mud (Blickle et al., 2003). The hoofs of a 1200-pound horse generates about 100 psi (100 pounds per square inch). At a walk, trotting or cantering horses can increase the psi even more (Backhaus, 2005). Also in Finland the problem with high traffic domestic animal areas has been noted. In a trial with different stage of cattle trampling Pietola et., al (2003) measured an infiltration rate decrease from 7 cm h^{1} to 1 cm h^{1} in a trampled area. On a sandy soil the same figure was a decrease from 15 cm h^{1} to 3 cm h^{1}.

Accumulation of horse dung in exercise areas (paddocks) is a problem, especially in countries with snowy winters. The phosphorus concentration in surface water from a paddock area, which was cleaned daily, was compared to water from an uncleaned paddock area by Airaksinen et al. (2006). They found that the cleaning of paddocks lowers the phosphorus content, especially during the summer, when horses were not kept in the paddocks but a residual effect remained. In their trial they collected the dung from the paddock of three adult horses during 8.5 winter months. The horses spent 6 hours per day (on average) in their paddocks. The total content of phosphorus in the dung collected from the cleaned paddock amounted to eight kilograms. As pointed out in their report these nutrients would be usable for crop production after composting (Airaksinen et al. 2006, Airaksinen et al. 2001).

Pastures and weather shelters

Pikkarainen (2005) made a survey study from 70 stables in South Western Finland (Häme). In her survey out of 70 stables at 57 at least some of the horses were pastured and in less than 50% the horses had some kind of protection against bad weather. Out of these 28 stables with some kind of protection 12 stables had a weather shelter and 21 of the stables had forest areas as protection against bad weather for their horses. As much as 80 % of the horses are kept on pasture in summer (Pikkarainen, 2005).

In a study on nutrient loads from pastures Jansson and Tuhkanen (2003) compared runoff concentrations in artificial rain from different critical source areas of phosphorus load on pastures and other field areas to soil extractable contents. The extractable phosphorus in uppermost layer (0-2 cm) proved to be a good indicator of the critical source area. The pastures in Sweden are also reported as a source of phosphorus. If horses are kept all year around on pasture the pastures receive more nutrients than the uptake by pastures (Steineck et al. 2000).

In the USA the problems on environment problems on horse farms are well known and horse farms are advised in the best management practices in horse keeping on farm level (Stephenson et al., 2003). The best manage practices include mud management, the use of buffer strips, and installing rain gutters.

Tracks

Liddle and Chitty (1981) when testing the nutrient budget of horse tracks on an English lowland heath observed that the track soil had more phosphorus than the control area. This was the case in the path area of a vegetation dominated by *Calluna vulgari*, but not in the path area vegetation dominated by *Pteridiurn aquilinum.* In a greenhouse trial they observed that there were more seedlings and a greater biomass was produced when the plants were grown in soils from tracks than when they were grown in soil from the control areas. Närvänen et al. (2007) tested soils from different equine areas for their easily soluble phosphorus contents. In their study a trotting course, a dressage arena and a driving course were lower in phosphorus than Finnish field areas (Mäkelä-Kurtto et al., 2002). The soil phosphorus levels were low compared to other equine areas like paddocks.

Run-in stables

Jansson and Närvänen (2005) tested a promising chemical treatment using ferric sulphate to water from a horse stable area. When using an amount of 0,06 mg/l of ferric sulphate solution (11.5 w/w iron) they measured a reduction of 95 % in dissolved reactive phosphorus in the settled solution. Närvänen et. al (2006) reported a full scale treatment of the surface run-off waters from an equine paddock area with ferric sulphate. In their tests the reductions of dissolved phosphorus, total phosphorus and total nitrogen after the treatment were 95%, 81% and 60%, respectively.

Material and methods

In this project different equine constructions are tested ecologically and for their suitability for equine use. At Kuuma we tested two different chemical treatment of the oval track surface and also an improvement of a muddy paddock area of 3800 m^2. At Kuuma and in Ypäjä we tested weather sheds. At Kuuma two wooden weather sheds for the horses using the above 3800 m^2 paddock area were tested. In Ypäjä we tested both a shed made of clay and straw and a weather shelter constructed of different wooden materials, straw bales and recycled materials.

The first meeting for planning of different construction works in this project was held in December 2004. In this meeting the places for demonstrating a low phosphorus load paddock surface area and other construction areas were discussed with the staff members at the Equine College Ldt (Ypäjä) and the MTT Equine Research (MTT/HET) in Ypäjä. Preliminarily the area between two central buildings in Ypäjä (Ypäjä hall and College hall) was chosen for demonstration. Later it was decided that the paddock area for demonstration purpose will be the paddock area south of the stable building IV.

In the following meetings different alternatives were discussed. Especially regarding the question where to build the shelters there were many different opinions. It was could be seen that to promote equine welfare and at the same time minimise harmful effect on the environment is a large task and it requires much creativity. As the weather shelter would be situated in a culturally important landscape (Loimijoki river valley). The riverside planning and landscape management was important. Ari Väisänen from equine College, Ypäjä planned the weather shed constructed in Ypäjä and planned and was in charge of the work on the run-in stable constructed in Ypäjä. He also planned the plans on the weather shelter in Ypäjä and was in charge of the construction work.

Helena Jansson and Susanna Särkijärvi from MTT/HET visited with M.Sc. Arch Teuvo Ranki **(**www.kolumbus.fi/teuvo.ranki**)** as a guide in Turku a clay horse stable and a clay sheep stable, in Merimasku a 100 year old clay horse stable and in Parainen they visited a bungalow building site **(**www.steamcastle.com**)**. This bungalow is constructed using the clay building technique. M.Sc. Arch Teuvo Ranki is specialised on clay building technique and promised to consult us in the planning. Helena Jansson and Susanna Särkijärvi visited 13.9.2005 three free running stables Kylämäki in Marttila (http://www.unki.net/pihatto.htm), Hessi talli in Urjala (http://www.hessitalli.fi/wiki/doku.php/alku) and Laukko Estate in Vesilahti (http://www.laukko.com/).

Paddocks and weather sheds

At the Equine College Ltd (Ypäjä), testing of a paddock constructed with a layer of chopped car tyres and a free running stable were carried out.

Chopped tyres (see fig. 1.) were applied as a 30 to 40 cm layer on the surface of a paddock in a southern slope 15,8 x 44,8 m in size, witch has been in paddock use for twenty years. During these years the paddock surface has been replaced three times and at the same time also refenced. Eight years had passed since the last time. The paddock has no subsurface drainage. The work at this test paddock site was carried out in October 2005 and it could be taken into use at the end of October 2005. The upper layer of the paddock was removed exposing the layer with stones and crushed stones. On this a 300 mm layer of chopped car tyres was applied. This layer was covered by a textile fiber cloth. On this a 200 mm layer of 0 – 16 mm crushed stone was spread. For the first face of the work (removing the old layer and applying the chopped car tyres) it was needed two days of work, another two days was needed to apply the textile fibre cloth and the crushed stone layer and one day was used for restoring the fences. In this paddock horses have been kept very intensively as already the first one to three horses are taken out into the paddock at six o'clock in the morning for one and a half hour. The next turnout (one to three horses) is between 8 to 12 a. m. and the last turnouts (one to three horses) are from 1 to 8 p. m. Often the adult students bring their horses to this paddock even later. . The faeces have been collected from the paddock twice a week when the temperature has been above 0°C. When there are minus degrees it is not possible to do this collection work.

This paddock has been used has been dry all through the winter and spring 2007. During the winter this paddock did not become frozen and hard as other paddocks. It remained soft and elastic also during the time snow was melting and during rainfall periods. Pieces of chopped car tyres have still come up from paddock base and these pieces need to be taken away as these pieces contain steel wires, which can be harmful to horses.

Fig 1. Chopped car tyres used for constructing the elastic paddock surface.

A clay-straw weather shed was constructed at the Equine College Ltd, Ypäjä in autumn 2005. As bearing construction was round wood. This is a low cost material and can also be find as recycled. As the bearing construction a round pillar construction was chosen as it is a low cost material. The pillars were placed three meters from each other. As roof construction a pitched roof was chosen.

The pillars were placed in holes to a dept where the frost will not affect them. The upper reaches were applied and fasten after an equalization cut of the upper tops of the pillars. Under the tin roof reaches planks (50 mm x 125 mm) and boards (32 mm x 100 mm) were used (Fig 1). It was obvious that to make the building insensitive to wind the clay-straw would not be enough. Thus crosswise steel bars were applied within the clay walls.

The base construction was made of pressure treated 50 x 200 wood plank and 32 x 100 board (Fig. 2).

The plywood forms for the wall construction were filled with a mixture of 10 % (weight) straw, 20 % water and 70 % clay. The walls are 40 cm wide. This construction work took 108 hours. The horses have eaten some holes into the walls.

The stable managers Anna-Leena Laakso and Eva Suvanto and stable manager student Mari Hämäläinen have made the every day observations about the paddock use.

Fig. 2. The clay-straw weather shed built at the Equine College Ltd, Ypäjä in summer 2007 (photo Helena Jansson).

The plans for renewing four paddock surface areas at the Icelandic Horse Competence center (Alivio) were prepared by Aaro Närvänen. As the upper layer in two of the paddocks were used wood chips (200 mm) and in two paddocks 150 mm of sand and on the top 100 mm of wood chips. The size of the paddock area is 3800 m^2 and each paddock is 950 m^2. Before applying the surface materials in the paddocks two drainage pipes were applied to each paddock to a depth of half a meter. To test the influence on the run off water quality of two different chemicals an amount of 80 kg Ferix-3 was applied to two paddocks and the same amount of hydrated lime was applied to two paddocks.

The digging work was carried out by Jouko Norri ltd. Jari Kauha assisted in the paddock work and built the two (5 x 4 m) weather sheds and established the fences. For construction of the weather sheds recycled wood was used. These weather sheds are divided into two parts 10 m^2 each and are used by horses from two paddocks (fig 3). Aaro Närvänen and Jari Kauha were the work leaders in the paddock renewing work.

The plans for the paddocks and the weather sheds as well as pictures from the different work phases are available on the internet at the Equine Life project internet website: http://www.equinelife.fi/files/tarhan_piirrokset_web.ppt and http://www.equinelife.fi/files/kuuman_tarhaa.ppt

Fig. 3. Weather shed built at Kuuma. In the foreground the paddock area with wood chips can be seen. Note the chrushed stone powder area in the front of the shelter (photo Aaro Närvänen).

At the Kuuma Icelandic Horse Competence Center (Alivio) the renewing of the oval course was planned by Sirpa Brumpton. MTT assisted in the GPS measurements (Aaro Närvänen and Ilkka Sarikka). As surface was used stone powder.

Pastures and the weather shelter

MTT/Equine Research weather shelter was built in a culturally important landscape. The riverside planning and landscape management was important. Jokioinen Experimental Farm is responsible for the pastures used by MTT/Equine Research. The weather shelter will be used by the mares with foals but during 2007 it has been used by young (2 years old) mares. When planning the weather shelter environmental and cultivation aspects were taken into account. The building is not situated too close to the area of Viloila defined not suitable for building (ancient, stone age settlement) by the National Board of Antiquities.

The constructing work was started in July 2006 with measuring and digging work. The MTT/Animal research Services team transported the soil to from the building area. The MTT/forest service has brought the needed wooden materiel from their forest and 500 m^3 of wooden (aspen) chips has been made. This aspen wood chips material was used for the area around the whether shelter. This area was underdrainaged and the water will be chemically treated in a sandbed. The pasture is divided into four blocks and these into three sections and the horses are moved from one section to another to avoid overgrassing. In the middle of August the frame work of the building could be started. This frame was constructed of wooden material from the forest of MTT. Only one side of the logs was sawed. The vertical logs were attached to the foundation by abutment iron elements. The ridge beams and the supporting pillars were attended by notching. The frame construction was completed at the end of September 2006.

As the clay builder did not turn up to make the clay wall the use of an alternative building construction needed to be considered. As the contract with the clay builder Timo Lehtonen on the construction of the clay walls did not hold, it was rescinded. The drainage pipes for drying out the area around the weather shelter were laid in June 2007. The drainage pipes were placed at 0.5 m depth. The ditches were filled with sand. As we assume that the horses will stay for long periods in the area close to the shelter we constructed a chemical water treatment system with a dosage system and a sand filter. The supervisor of this work was Sami Uusitalo, MTT, Field Service Unit. In August 2007 the building was taken into use. The shelter was used by two-year-old mares.

Tracks

At the Kuuma Icelandic Horse Competence Center (Alivio) the renewing of the oval course was planned by Sirpa Brumpton. MTT assisted in the GPS measurements (Aaro Närvänen and Ilkka Sarikka). The levelling work was completed during autumn 2005. Stone powder will be used as surface. This layer was applied in summer 2006.

At Kuuma we tested two chemicals for lowering of the phosphorus load from the oval track build. In fig. 4. the water suspension of ferric sulphate is spread to the straight part of the oval course, which is closer to the buildings (http://www.kuumanhevoset.fi/). In addition ferrous sulphate suspension is spread to the surface of the other straight part of the course. For comparison the curves are not treated. The applied amount of ferrous sulphate was 40 kg as well as the amount of ferric sulphate.

Fig 4. Spreading ferric sulphate solution on the Kuuma oval track (photo Aaro Närvänen).

Run-in stable

The work on the run-in stable at Ypäjä was started in May 2006. The contractor is Alastaron Rakentajat Oy and prefabricated units come from FM-Haus Oy.

To this loose housing system belong two separate lying areas where horses have also drinkers and mangers. Hayracks are outside in the paddock. There are also three paddocks for the horses. Horses use free running stable and three paddocks during autumn, winter and spring about nine months in a year. They have free access to laying area (inside) and to paddock. During summer months horses are on different pastures.

Two groups of horses use the three paddocks in terms so that always one paddock is empty. At that time the paddock is cleaned and the surface is resting. We test if it is possible to reduce the erosion and compaction of the paddock surface. Due to the arrangements with two paddocks in use and one resting paddock, stallions and mares can use the same areas although not at the same time. This makes the herd behaviour possible for the horses without keeping them together.

A water sample from the pond constructed in the area has been taken in November 2006 to see the background nutrient level before the horses will take the free running stable building into use.

The paddocks in connection to the run in stable are established at a very sheltered site. When using the paddocks there is a possibility to change the paddocks using two paddocks of three and one paddock can rest for restoration. This gives possibilities for the two foal herds (stallions and mares) to sniff and check on interesting smells. This gives us possibilities to test our hypothesis in horse behaviour. For treating the surface flow waters from the paddock areas a ferric sulphate dozer was constructed in spring 2007.

The free running stable was introduced in January 2007. The young stallions (eight) use the left side of the building and the eastern paddock. The young mares (eight) use the right part of the building and the western paddock. In addition these horse groups use in turns the southern paddock, where they get more physical exercise. The eastern paddock was covered with wood chips. This surface material worked well during the low temperature periods in the winter and also during the period when snow was melting. This paddock was neither slippery nor wet. As this paddock material was elastic it was not frozen hard at any time during the winter. In the other paddocks the surface is uneven because of roots. The soil is course mineral soil with minor organic soil areas. In the paddock most of the trees are still alive although the horses have eaten the bark of many of the trees badly. One possible explanation to this behaviour could be lack of essential trace elements like copper in their diet (see. http://www.abc.net.au/canberra/stories/s1424265.htm).

In all three paddocks a 16 m2 (4x4m) defecating area was constructed. The defecating area of the young mares was bedded with peat and the defecating area of the stallions first with saw dust and later with wood chips. In the largest paddock the bedding material was saw dust. The defecating area was enclosed with logs. The horses used this area for defecation until the area was covered with frozen hard droppings. These frozen droppings were difficult to collect. In the paddock area of the mares their defecation area developed close to the hey feeder and the gate. The feeder was moved away from the gate area. In the paddock area of the stallions the hey feeder area was not used for defecation but instead they had a restrict area, where they defecated. Both groups used as defecation areas the paths to the free running stable building. The stallions had also a restrict area in the paddock area, where they defecated. The mares used many areas in the paddock area for defecation. The paddock areas have been cleaned some times during the stabling period. The horses ate the bark of the trees in their paddocks. In the eastern paddock the storm cut down trees on two occasions. The stallions ate the bark of some spruce trees and other spruce trees were left in peace. The mares ate the bark of aspen trees and small spruce trees. Branches of trees were also given for these mares.

The drainage of the area was improved by digging ditches around the area and it worked out well. In the paddocks there were no muddy places although much water streamed to the area from the hillside. The water from the area was led into a constructed sedimentation pond. The water from this pond was analysed for its phosphorus content before the horses came into the free running stable. A treatment system for chemical cleaning of the water before the pond was constructed in June 2007. In the gates there are no wire netting and the horses put their heads through the openings, which may be dangerous for them. A wire netting would be needed and small gates for the people moving through. In the sleeping area of the free running stable there is a solid floor. On this floor a bedding layer was applied before the horses came. As the first layer a 10 cm of peat was applied. On this layer a 10 cm of straw and upon this layer another 10 cm of peat was applied. On the top a layer of 10 cm of straw was applied. Every day the sleeping areas were raked and the droppings were covered with dry straw. Bedding material was added twice a week. Twice a week a clean-up was made, the drinking and feeding cups were cleaned, the wire nettings were brushed and scrubbed, the doors were cleaned and the cobwebs were brushed away. As the horses were taken to the free running stable during the winter with its low temperatures, the bedding layer did not immediately start warming up (due to lack of microbiological activity). In March when the weather warmed up also the bedding warmed up. The ventilation system was not good enough during that period.

The plastic plank has proved to be a good solution (recycled plastic made plank k600). The horses are not gnawing it. The water bowls (three in each department) have worked well although one of these froze during the lowest temperature periods. The water to these bowls comes heated from a container (+18 0 C) before it comes to the water bowl. The adjustable feeder for concentrated feed has worked well. During the test period there was no need for adjustment as the bedding area did not rise much as the horses came into the building not before January. The sharp-edged joints of the feeders were repaired and holders chains have got a plastic cover on. At the southern wall a water post has been constructed to make it possible to get water to the horses in the southern paddock. There have been a number of other improvements to be done.

Soil and water sampling

Soil sampling was carried out at the oval track constructed at Kuuma and from different paddocks at Kuuma, from the sediments in the ditch behind the rubber paddock and in paddock areas of the constructed run-in stable. The samples were taken to a depth of 0-2 cm. Water sampling was carried out at the prototype paddock constructions at Kuuma. During the test period ten sample pairs were taken.

Soil and water analyses

For assessment of the phosphorus load in the studied areas the soil was extracted using the soil test method in use in Finland (Vuorinen and Mäkitie, 1955) using a soil AAAc-extraction (0.5 M ammonium acetate, 0.5 M acetic acid, pH 4.65). In addition to soil extractable phosphorus (AAAc-P) also other soil properties were determined as soil pH, electrical conductivity and extractable calcium, magnesium and potassium. The hot water soluble soil boron was determined by a modified Berger and Troug (1944) method (Sippola and Erviö, 1977). Iron was extracted from the soil samples using an acetate-EDTA solution (Lakanen and Erviö, 1971). Sulphur was extracted using the same method and the concentration was determined by plasma emission spectroscopy. For water analysis the flow water was collected into bottles. The water samples were analysed for dissolved reactive and total phosphorus as described by Uusi-Kämppä and Yläranta (1996).

Results and discussion

In equine areas with high phosphorus status also the soil pH was high (fig 5), but compared to the Finnish average contents for field areas the pH in this study is of a normal Finnish level (Sippola and Tares, 1978 Mäkelä-Kurtto et al., 2002).

The average hot water soluble boron contents (Appendix 1) in this study was slightly higher than reported by Sillanpää (1982) for Finnish field areas but when compared to his international country study the level is the same.

The highest soil AAAc-extractable soil phosphorus was measured from a small paddock sampled for background purpose (Appendix 1), but also defecating areas in paddocks constructed during this project were high in phosphorus as well as the surface of the constructed wood chips paddocks are according to the field interpretation of results alarmingly high in phosphorus (Viljavuuspalvelu, 2000).

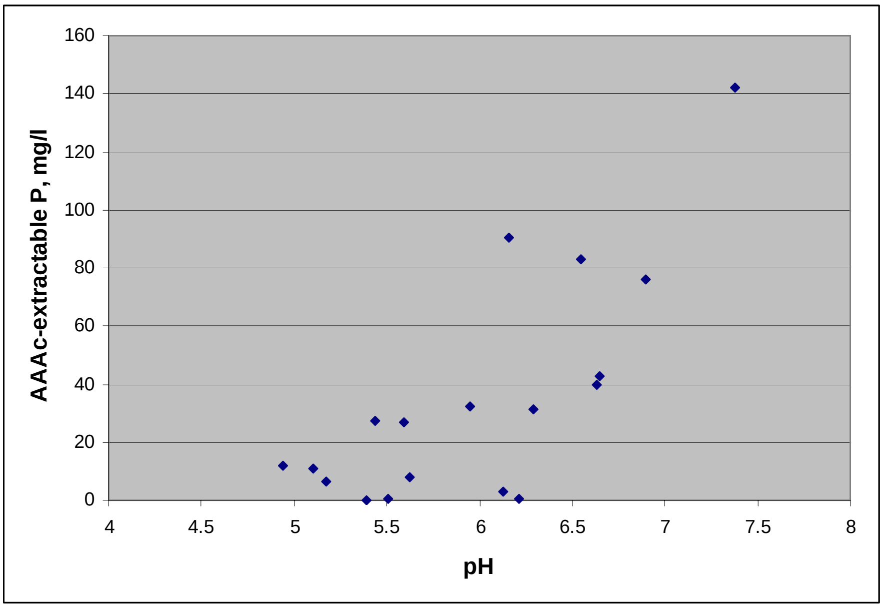

Fig. 5. Regression of AAAc-extractable phosphorus on soil on pH in different equine areas.

The sulphur soil status in this study compared to the international sulphur soil status is generally low (Jansson, 1995). In some areas more frequently used by the horses the contents are higher but only of a medium international status. Also the soils in the areas treated with ferrous or ferric sulphate were of this medium international sulphur status.

As can be seen in Fig. 6 the electrical conductivity in soil is a very good indicator of the soil AAAc-extractable contents. However when a track surface is treated with ferrous or ferric sulphate the electrical conductivity is much higher compared with the untreated (the third lowest dot in the figure).

In this study we found a dissolved reactive phosphorus content of 2.91 mg/l P only (see Appendix 2). The highest water phosphorus content we have earlier sampled from a puddle in an equine area is 17,3 mg/l dissolved reactive phosphorus. This area was a paddock area, where no change of surface paddock surface material had been carried out for more than twenty years. This content is more than hundred fold the contents reported from Finnish field waters (Rekolainen, 1993).

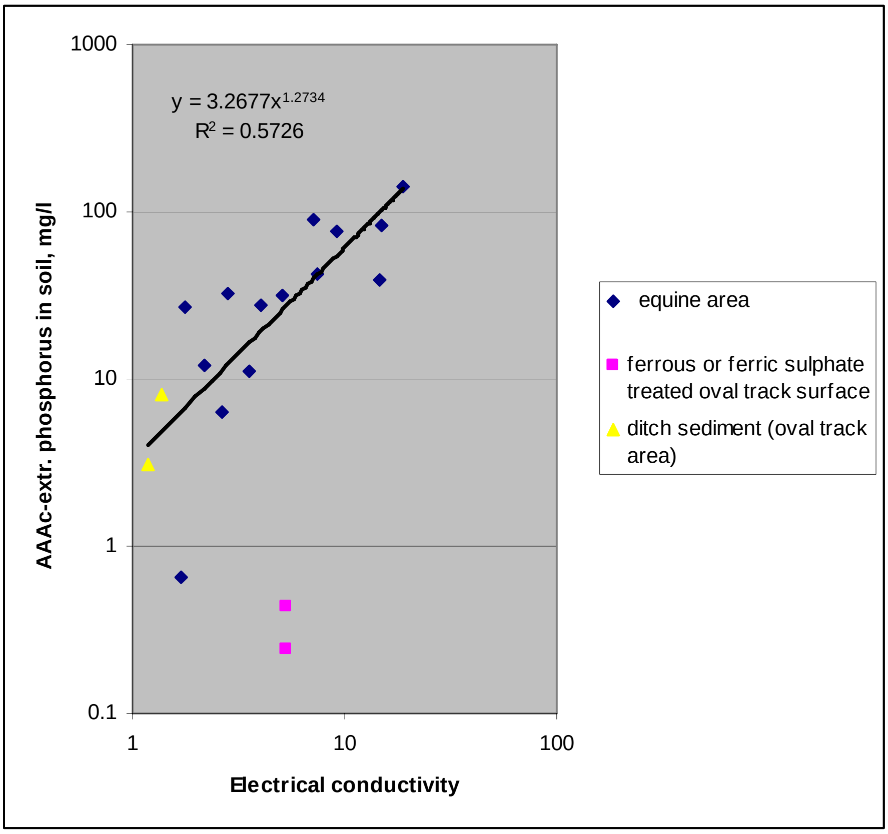

Fig. 6. Regression of electrical conductivity (10^{-4} S/cm) on AAAc-extractable phosphorus in different equine areas. The ferrous or ferric treated soils and the ditch sediment samples are not included in the equation.

Paddocks and weather sheds

In unfrozen periods the horses dug up some big holes in the tested paddock at the Equine College Ltd (Ypäjä). Even the textile cloth was exposed and squeezed. The biggest holes were done close to the gate. This problem was cured by adding gravel. A larger problem was that the new surface should have been established to some larger width also in the area outside the fenced area. As the fences are not electrified the horses are also digging close to and under the fences and as the surface in the paddock is higher than the neighbourhood the surface stone powder has escaped and exposed the chopped car tyre material under the fences and also inside the fences. We collected two wheelbarrows of tyre material before the snow cover period. The wires in the car tyre material were very sharp and can be a danger to horses and humans (when collecting). These problems may decrease when the ground settled with time. The faeces have been collected from the paddock twice a week when the temperature has been above 0°C. When there are minus degrees it is not possible to make this collection work. We have the impression that the horses ”love” this paddock surface because it is elastic. At first the horses did wonder about the surface but got used to it quickly.

The tested weather sheds in Kuuma and Ypäjä were both cost effective and both wood and clay wall constructions can be recommended.

When comparing the test results from the Kuuma paddocks treated with hydrated lime or ferric sulphate it can be seen that the dissolved reactive phosphorus was much lower in the water from the ferric sulphate treated paddocks compared to the hydrated lime treated paddocks (Fig. 7). On the average the dissolved reactive phosphorus in the water from ferric sulphate treated paddocks was 61 % lower compared to water from the hydrated lime treated paddocks (Appendix 2). This same difference can be seen in the total phosphorus contents. The difference is not however as pronounced as in case of dissolved reactive phosphorus (Fig. 8).

The horses have used these paddocks from the beginning of September, 2005 and the stable managers have observed that the horses seem to be happy with their woodchips paddocks. The horses love to roll and rest on the woodchips surface. The surface of the paddocks has remained dry also during a longer wet periods. The horses' legs have stayed dry and clean and therefore there has not been any need to wash them when the horses are taken into the stable. A part of the horses do not use the shelters but are standing beside the shelter wall. The horses have also defecated outside the shed beside the wall ("toilet area").

The horses have dug and looked for something to eat among the woodchips material especially in paddock number three. In this paddock there was twigs and leaves in the woodchips. Peaces of woodchips have been stuck in the sole of the hoof but this trouble has decreased. As the temperature turned below 0°C the woodchip surface became a bit slippery.

The paddocks has been cleaned twice a week. The woodchips and the stone powder around the shelters slow down and complicate the cleaning work. As the woodchip material is consired a drawback mixed together with the peat bedding manure the dropping material from the paddocks has been collected separately. The feeders have worked well. The fence poles and wires constructions have stayed in good shape. The Kuuma stable personnel has been pleased with no mud problems in the woodchip paddocks.

The soluble iron content was lower in the water from the ferric sulphate treated paddock area compared to the hydrated lime treated area. This was not expected but a lowering in the content of soluble iron in the water from ferric sulphate treated field ditch water compared to untreated water has also been observed (Närvänen and Jansson, 2007).

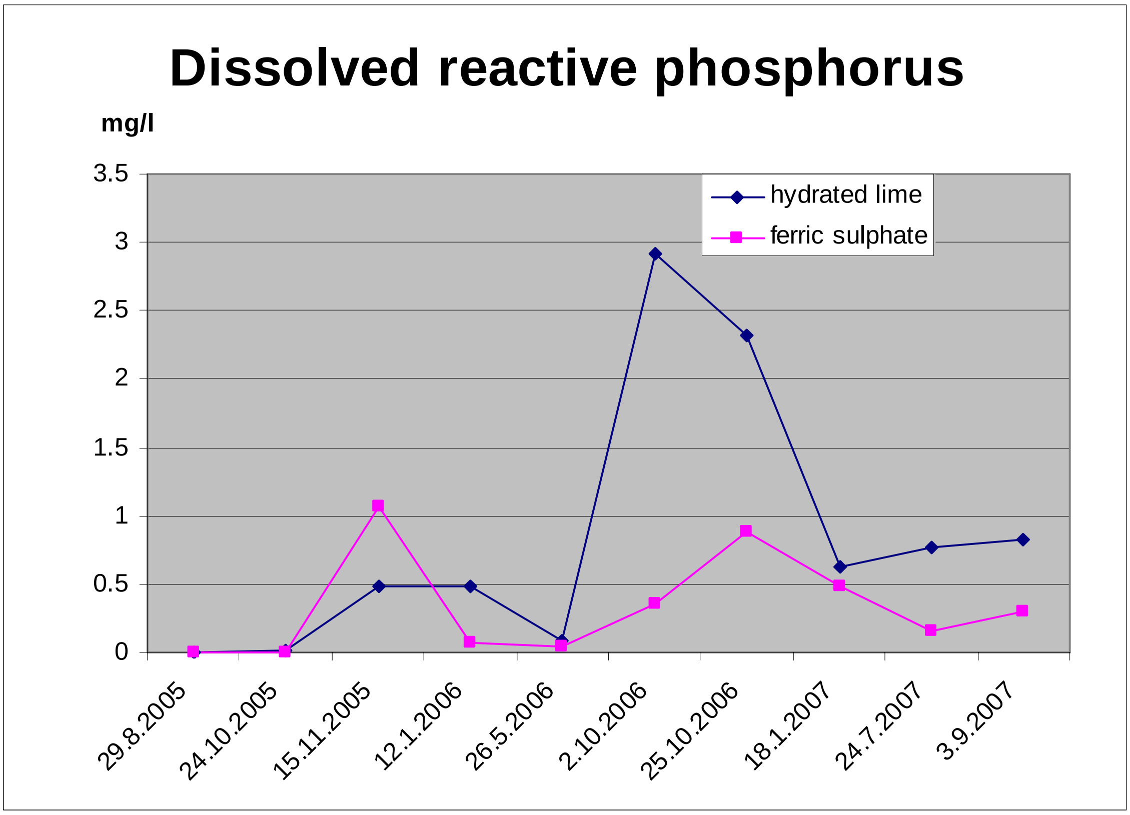

Fig 7. Contents of dissolved reactive phosphorus in runoff water from the Kuuma paddocks treated with hydrated lime or ferric sulphate.

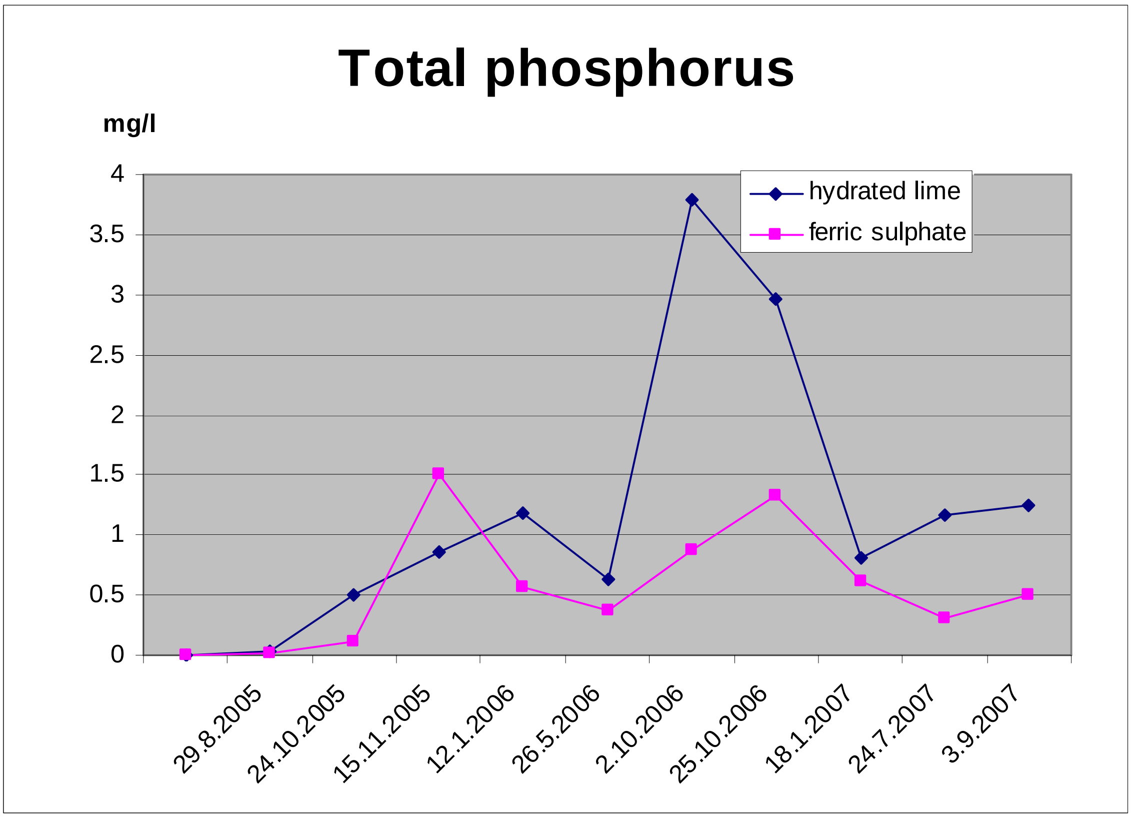

Fig 8. Contents of total phosphorus in runoff water from the Kuuma paddocks treated with hydrated lime or ferric sulphate.

Pastures and weather shelter

The weather shelter was used by young mares in late summer 2007. The weather shelter in Ypäjä was well suited for its purpose. Of the tested bed material inside and around the shelter the woodchip areas were more attractive than the sandbed for the horses as sleeping areas. Also the observed droppings were almost all from the (aspen) wood chips area. Between the tested windbreak wooden materials (birch, Scotch pine, larch, Norway spruce and aspen) we did not observe any difference as these has not been gnawed at by the horses at all during the test period. The drainage pipes build to take away the water from the weather shelter area were dug up by the horses. This was not awaited as the drainage pipes in the Kuuma paddock test area at the same depth were not dug up. One explanation could be that Kuuma paddocks were filled up with wood chips and not with sand as in the Ypäjä weather shelter area.

Tracks

As can be seen the soil tests made from the track area in Kuuma show low phosphorus contents. The lowest contents are found from the ferrous and ferric sulphate treated surface of the track (Appendix 1). The measured electrical conductivities from these ferrous and ferric sulphate treated were much higher than the untreated areas. Compared to the international contents of AAAc-EDTA soluble sulphur reported from Finnish field soils by Jansson (1995) the contents in the ferrous and ferric treated track surface soils are higher. However the average

AAAc-EDTA soluble contents in soils from Syria and Iraq were higher than the maximum measured content measured in this study.

As can be seen in Fig. 7 there is a close relationship between the soil extractable potassium and phosphorus. In the Kuuma oval track area the sampled surface soils treated with ferrous or ferric sulphate as well as the ditch sediments from ditches below the treated track area are in a low position in Fig. 9 i.e. it seems that the chemicals reduce the AAAc-extractable phosphorus. The ditch sediment AAAc extractable phosphorus contents are very low compared to the contents in ditch sediment s from equine areas reported by Jansson et al. (2000). As the sediment phosphorus contents are in good correlation with the phosphorus in the water flowing in the ditch this means that we have low phosphorus load ditches beside the tracks (Jansson et al., 2000).

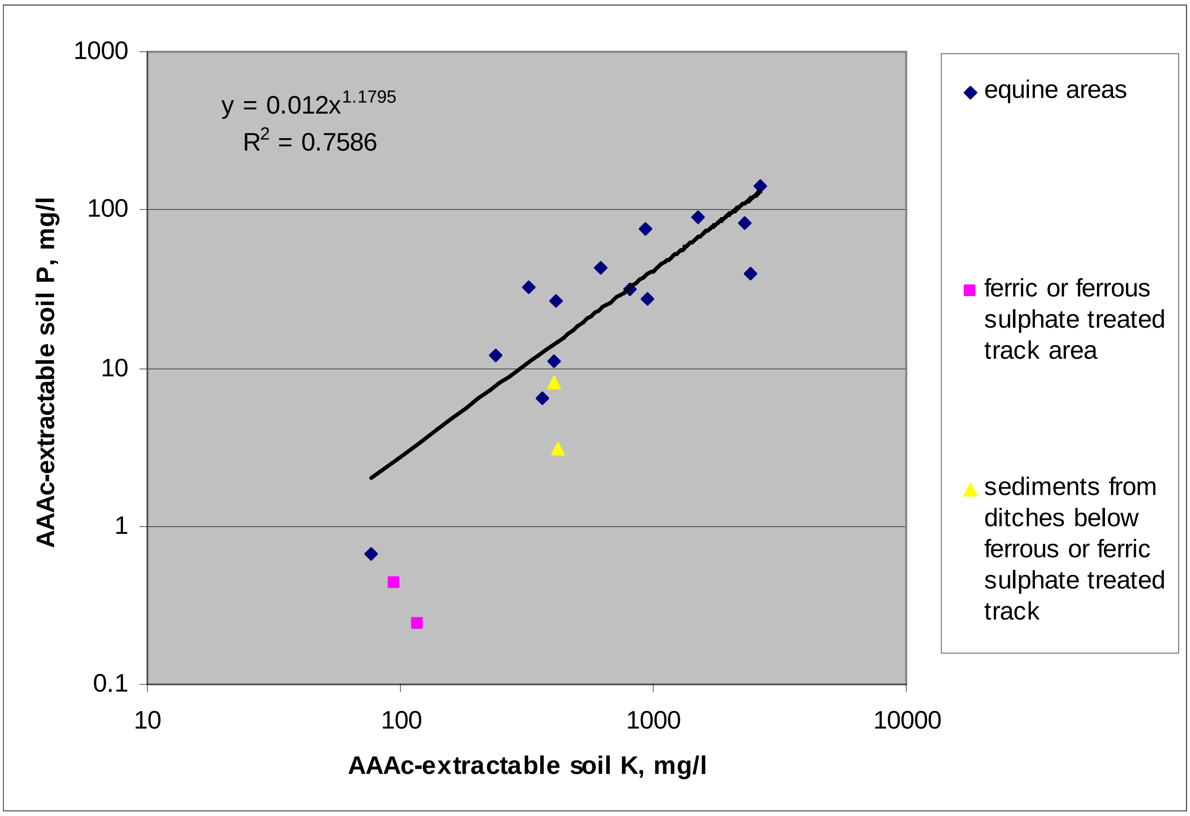

Fig. 9. The Regression of AAAc extractable potassium (mg/l soil) on AAAc-extractable phosphorus in different equine areas. The ferrous or ferric treated soils and the ditch sediment samples are not included in the equation.

Run-in stable

The water bowls (three in each department) have worked well although one of these froze during the lowest temperature periods. The water to these bowls comes as heated in a container (+18 ^{0} C) before it comes to the water bowl. The adjustable feeder for concentrated feed has worked well. During the test period there was no need for adjustment as the bedding area did not rise much as the horses came into the building not before January 2007. The sharp-edged joints of the feeders were repaired and holders chains have get a plastic cover on.

The plastic plank has proved to be a good solution (recycled plastic made plank k600). The horse are not gnawed it.

Appendix 1 shows that the lowest soil pH areas were found in the paddock areas of the constructed run-in-stable. The lowest pH was measured in the largest paddock. Our earlier study on paddocks (Jansson et al., 2005) showed much higher pH levels. The explanation to these relatively low pH levels in certain parts of the paddock areas is probably that these areas have been in use for a relatively short period. The sampled defecating areas had a much higher pH (Appendix 1). Also the phosphorus contents in these areas were high compared to the “clean” areas and the area of the southern larger paddock. The measured phosphorus contents were low in the incoming water of the chemical water treatment. The treated water was low in pH (Appendix 3). This together with the increased soluble iron content indicate a successful treatment of the water. Also the phosphorus content was lower than in the incoming water. In a low phosphorus content water the ferric sulphate treatment of has not been as successful however as it is in a high phosphorus content water as the needed ferric sulphate amount needed for a reduction of the same amount of phosphorus has increased with decreasing content of phosphorus in ditch water. This observation has recently been made in treatment tests of field ditch water by Närvänen and Jansson (2007).

Conclusions

In Finland the growing horse population is to a high rate situated in the Baltic Sea Proper catchment area. Also in the other countries with land areas in the catchment area this will be a problem as a fast developing economy will increase the horse population. We can see this growth in the equine industry very clear in a country like Sweden. In Sweden the economy has steadily been growing for a long time and more and more people are interested in equine sports and Sweden has now the highest amount of horses per inhabitants of all EU-countries. Swedish horse population declined from about 720,000 to approximately 84,000. Since then the number has risen again, reaching 220 000 horses in 2000 (Brasch et al., 2002) and in 2004 it is estimated to be 300 000 horses in Sweden (Swedish tourist office, 2004). As equine paddock use in these two countries is probably the same the phosphorus load from equine areas in Sweden is more than four times the load in Finland. However in Finland we have already areas where the amount of horses per inhabitants is almost as high as in Sweden (see Åland, 2005, Ålands Landskapsregering, 2006)

According to the EU Water framework directive we should have a good biological and chemical status in our waterbodies in 2015. This should make us cut down our phosphorus load. The water from equine areas is high in phosphorus and these areas are an increasing problem with our increasing horse population. A reduction in phosphorus contents using chemical treatment has been shown to be cost effective especially in surface waters from these equine areas with high phosphorus contents. Therefore in our Finnish Agri-environment Programme and also in the separate programme for Åland, chemical treatment of waters from equine areas should be included. Also the stables outside the Agri-environment Programme should be subsidised by the Finnish Government to make it possible for the stable owners to carry out these measures.

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Appendix 1.

The general soil properties and soluble nutrient content in areas of different equine use.

Area	B water soluble mg/l soil	25 ml:n air dry soil g	S AAAc-EDTA mg/l soil	Cu AAAc-EDTA mg/l soil	Fe AAAc-EDTA mg/l soil	Mn AAAc-EDTA mg/l soil	Zn AAAc-EDTA mg/l soil	pH H2O 1:2,5	El. cond. 10 -4 S/cm	Ca AAAc mg/l soil	K AAAc mg/l soil	Mg AAAc mg/l soil	P AAAc mg/l soil	S AAAc mg/l soil	Fe AAAc mg/l soil
Ditch sediment (ferric)	0.56	22.58	31.9	10.07	606.1	133.6	2	6.13	1.18	3032	417.7	901.2	3.06	30	72.2
Oval track, ferric	0.29	38.78	159.7	1.62	489	9.8	1.35	5.51	5.3	526.4	95.62	55.12	0.44	154	189.3
Oval track, untreated	0.25	38.41	84.2	1.27	552.7	13.2	1.18	6.21	1.69	386.1	76.28	30.68	0.66	68.1	193.4
Ditch sediment, ferrous	0.82	19.03	33.4	7.69	1160	80.9	2.8	5.62	1.38	2135	405.3	385.5	8.05	25.4	140.7
Oval track (ferrous)	0.3	38.96	266.9	1.62	421.1	11.8	1.17	5.39	5.32	578.9	118.2	53.07	0.24	240.4	222.9
Small paddock	1.25	12.58	113.5	2.69	538.5	58.6	13.78	7.38	18.8	2635	2643	513.9	141.87	111.9	60.2
Wood chips paddock	0.77	5.59	40.1	1.67	343.8	30.5	6.35	6.9	9.2	1194	935.2	249.9	76.05	31.4	27.2
Wood chips paddock	0.68	6.18	20	1.26	172.8	27.4	9.19	6.65	7.44	1043	621.1	199.2	42.63	19.4	19.9
Sacrifice area	1.22	14.35	122.5	7.82	1568	111.9	6.89	6.63	14.6	2128	2440	590.9	39.55	103.9	107.3
D. sed., chopped tyres	0.87	10.06	40.8	9.62	1771	60.9	15.67	5.59	1.78	893.7	412.6	253	26.65	29.6	302.3
D. sed., sand paddock	0.72	5.96	15.4	4.4	559.7	41.2	9.87	5.95	2.84	881.9	321.4	274.2	32.2	11.3	32.4
Below the feeding area	0.66	9.2	24.8	1.66	776.7	53.5	9.63	6.29	5.14	953.6	815.3	243.6	31.37	22.3	88.6
Beneath the hey feeder	0.99	12.97	38.1	3.9	726.6	141.8	20.03	5.44	3.99	1376	944	317.3	27.31	26.2	20.7
Defecating area	0.95	10.9	25.4	1.42	429.4	121.9	11.16	6.16	7.13	1039	1498	355.9	90.21	20.9	34.8
Clean area, right	0.76	18.39	41.8	2.69	887.5	321.1	8.47	5.17	2.67	1060	366.5	233.3	6.4	31.6	101.5
Clean area, left	1.2	13.14	25.1	1.45	750.9	129.9	13.03	5.1	3.57	1481	403.3	290	11.07	17	30.3
Defecating area	0.76	4.26	65.5	0.45	159.9	15	4.48	6.55	14.8	594.4	2317	262.9	82.78	61	8
Paddock, south	0.53	9.49	41	1.33	543.8	71.6	10.6	4.94	2.18	530.5	239	133.8	12.12	29.1	67
Average	0.75	16.2	66.1	3.48	692	79.7	8.2	5.98	6.06	1248	837	297	35.2	57.4	95.5

Appendix 2.

Flow water quality from the Kuuma wood chips paddocks treated with hydrated lime or ferric sulphate.

Nr	pH	soluble P mg/l	Tot. P mg/l	NH4-N mg/l	NO3 -N mg/l	Tot. N mg/l	soluble Fe mg/l	COD_{Cr} mg/l
Hydrated lime treated								
58399	7.11	0	0.04	0.04	3.05	3.46		
58402	6.81	0.01	0.51	1.63	0.1	1.85		681
58406	7.12	0.49	0.86	1.44	0.08	2.82		
58410	6.78	0.49	1.18	2.65	0.14	5.13		
58445	7.31	0.08	0.63	14.1	0	22.3		
58452	7.04	2.91	3.79	2.55	3.65	10.1		
58460	6.98	2.32	2.97	4.74	1.19	9.23		
58496	6.9	0.63	0.81	1.77	4.15	7.07	2.2	
58555	6.93	0.77	1.17	2.45	6.93	14.3	2.75	729
58575	7.15	0.83	1.25	2.42	4.83	9.85		
	7.01	**0.85**	**1.38**	**3.38**	**2.41**	**8.61**	**2.48**	**705**
Ferric sulphate treated								
58400	6.87	0	0.02	0.02	1.3	1.51		
58403	6.66	0	0.12	0.55	0.61	2.11		258
58407	6.61	1.06	1.51	1.24	0.33	3.03		
58411	6.59	0.07	0.57	1.41	0.59	3.04		
58446	7.140	0.04	0.38	6.08	0	10.65		
58452	6.83	0.35	0.87	1.48	3.24	9.26		
58461	6.67	0.88	1.33	0.38	0.94	4.74		
58497	6.96	0.49	0.61	2.95	5.67	9.66	0.96	
58556	6.45	0.15	0.31	0.78	18.45	22	1.63	291
58576	6.75	0.3	0.5	0.26	10.34	12.92		
	6.75	**0.33**	**0.62**	**1.52**	**4.15**	**7.89**	**1.30**	**275**

Appendix 3.

Flow water quality of the untreated and ferric sulphate treated water from the area of the free-running stable in Ypäjä.

Year/date	sample	COD tot.	Fe	pH	Soluble P	Tot. P	NH4-N	NO3 -N	Tot. N
		mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l
2006	untreated		4.85	6.45	0.02	0.21	0.05	3.08	4.02
18.1.2007	untreated			6.95	0.04	0.34	0.07	4.05	5.14
2007									
24.7.	incoming	33	4.75	6.69	0.01	0.2	0.43	0.56	1.31
1.8.	incoming		4.04	7.11	0.1	0.57	0.28	2.75	6.35
average			**4.40**	**6.80**	**0.06**	**0.39**	**0.36**	**1.61**	**3.83**
	outgoing								
24.7.		19	1.3	3.37	0.01	0.03	0.09	0.81	0.99
25.7,		27	7.44	3.27	0.01	0.02	0.18	1.57	1.77
1.8.			7.02	5.72	0.05	0.37	0.08	0.92	1.87
average			**5.25**	**4.12**	**0.02**	**0.14**	**0.12**	**1.10**	**1.54**