CODE OF GOOD AGRICULTURAL PRACTICE FOR LATVIA

JELGAVA, 1999

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Publisher: Latvia University of Agriculture
Printed by «Jelgavas tipogrāfija» Ltd.
Translated and published at the expense of Danish Environmental Protection Agency.

ISBN 9984-596-24-9

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INTRODUCTION

The Code of Good Agricultural Practice (GAP) was prepared by the Danish-Latvian joint project with the participation of Swedish experts. The Danish Environmental Protection Agency, the Ministry of Agriculture of Latvia and the Latvian Environmental Protection Fond financed the project. The responsible **executor institutions** are the Danish Agricultural Advisory Centre and Latvia University of Agriculture. A large number of Latvian experts from research institutions, associations of farmers, advisory services as well as other governmental and non-governmental organisations were involved in the development and evaluation of GAP Code.

The Code of GAP has been elaborated to comply with the requirements of the EU Nitrate Directive, which Latvia has obliged itself to implement during the process of preparation for EU membership. At the same time The Code of GAP contains various recommendations of the Helsinki Commission.

It is important to note that the Code of GAP also provides several concrete recommendations for good agricultural practices. Only codes written in shadowed text boxes are compulsory as they refer to the existing Latvian legislation.

Code of GAP for Latvia has been endorsed by the Ministry of the Agriculture (June 1, 1999), and the Ministry of Environmental Protection and Regional Development (June 8, 1999) of the Republic of Latvia.

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The Code of GAP is not a complete document, it will be periodically supplemented to include new ideas and opinions, to balance the economy of agricultural production with social and environmental conditions, and to establish gradually a model of sustainable development. Authors would be very grateful for every proposal and evaluation that is sent to the following address:

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The Code of Good Agricultural Practice contains legislation obligations, recommendations and practical advice envisaged for farmers, horticulturists, individual growers, agriculture service employees and for everyone who is involved in agricultural production and preservation of rural environment. The aims of the Good Agriculture Practice (GAP) are to decrease the negative influence of farming on the environment and to prevent the impoverishment and irrational use of the main nature resources - soil, water, plants, animals, and landscape. It is recommended to follow the rules accepted in Europe and in other developed countries, so that Latvian goods would not meet barriers in international markets and our rural environment would remain attractive for tourists. GAP comprises main spheres of agricultural activities that are critical in causing water, air, and soil pollution. It gives advice for the prevention or at least for the decrease of pollution. A successful implementation of GAP has to be based on three integrated basic principles: economically viable, environmentally friendly, and socially acceptable.

A determined introduction of a correct farming today can ensure a growing financial support both from Latvia and the European Union.

The society in general as a consumer regards countryside not only as a source of qualitative and healthy food, but also as an acceptable space for living and multifarious recreation possibilities with growing interest how to save the natural environment.

The goal to establish GAP Code for each country is determined by the Nitrate Directive of the European Union (EEC/91/676). It is therefore important that this work is accomplished on Latvia's way towards full membership in the EU. The Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM) calls for a prompt action in Latvia that would decrease the negative influence of agriculture on the environment. Thus, the development of GAP Code is a part of the harmonisation of the Latvian legislation with both the EU legislation and HELCOM recommendations.

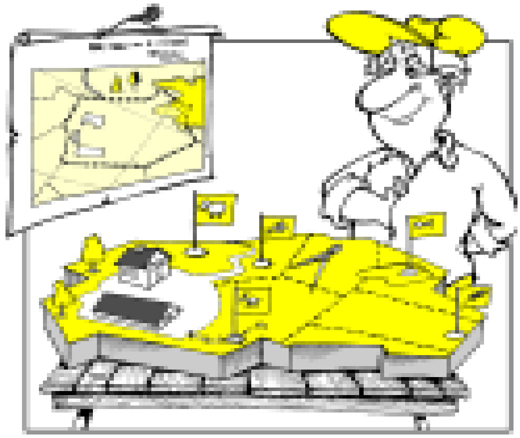
Similar Codes are developed and followed in the farming practice in all of the EU countries. In European context GAP Code is acknowledged as a statement of goodwill of each memberstate to follow the situation and development of its agriculture, to give priority to the preservation of the environment, and to cause no ecologically adverse consequences on national, regional, and global scale today and in future.

GAP Code contains requirements of three levels:

- existing legislation and regulations of the Republic of Latvia that are compulsory (**written in shadowed boxes**);
- regulations implemented in the nearest future (EU Directives, HELCOM Recommendations) that relate to actual agro-environmental problems;
- future aspects and visions that implemented today would give income in future.

GAP Code will be voluntary implemented by farmers based on the goodwill, the understanding and the desire to see their native country beautiful and prosperous today as well as in future.

1. CROPS, SOILS AND FERTILIZERS



1.1. PRODUCTION PROFILE AND LAND USE

Agricultural land is an important component of the environment and the natural landscape. Therefore, society has the right to monitor land use and conservation for the sake of the whole community. Law on Land Use and Land Use Planning (21.06.1991) is mandatory for all land users, including the farmers. Law demands responsibility for rational use of land in order to prevent its degradation and decrease in fertility.

1. The farming profile should be selected according to the soil and climate conditions for the specific area. It is a prerequisite for the economical development and reduction of the environmental risk.

Practical guidelines

In the process of the development of rational land use model for a farm it is necessary to consider the dominating relief, agroclimatic zone, soil cover, farm orientation against the watercourses, infrastructure elements, protective zones and zones of limited production activity as well as other natural landscape components. The land use planning should be based on the aforementioned information (same as previous). The planning includes the delineation of the fields and the assessment of suitability, e.g. for field crops, orchards, grasslands, pastures, forest, etc.

Special attention is required in the use of peatlands. Intent to include new peatland areas in agricultural production their drainage and cultivation probably is no more reasonable from the ecological point of view respecting wetland role in ecosystem as well as from economic considerations due to the necessity of substantial investment for that. In some cases exception could be made for high-decomposed muck soils. Protective measures should be applied in the cultivation of organic soils already used in agriculture to limit peat mineralization and structure breakdown. The main measures include a moderate use of mineral fertilizers (especially fertilizers containing nitrogen) and lime. It is as well important to cultivate perennial crops instead of annual ones. The best way for peatland use – cultivation of perennial grasses.

2. The production type, the farm layout, the development of infrastructure, and land use type shall be selected in accordance with the National Planning Strategy of Latvia and regulations on territory planning[1].

[1] Law on Territory Planning

The Territory Planning[2] is a State launched program that determines the territory zoning in accordance to accepted land use restrictions. It defines for what purposes and activities the specific territory is allowed (planned) to be used in future. Land and soil are essential factors that should be considered in the process of territory planning for setting objectives of a feasible use. Therefore, it is important to harmonise the interests of the individual land user and society to ensure a sustainable and balanced development of the country and its regions, as well as an integration of production activities with the protection and development of natural and cultural heritage.

3. Changes in the land use type shall be done with respect to interests of other land users to avoid negative impact on neighbours as well as on the whole ecosystem[3].

The transformation of land use means a substitution of one land use type by another. It should be based on the considerations of ecological and natural landscape, not only on economic objectives. The land use in one farm shall not limit or restrict the neighbors from the use of their land:[4]

- construction of water ponds could stimulate the waterlogging of the surrounding areas that belong to other persons;
- a new forest plantation in a tile-drained field could damage the water management system and could create water-logging problems on large areas belonging to or being dependent on the specific drainage basin;
- defective water management systems can hinder drainage of neighboring fields.

Prime agricultural lands should be recognized to restrict their transformation in other land use types. These include high fertility and well cultivated areas where considerable state investment is made and areas that due to their location are particularly suitable for cultivation of some specific crops.

4. The basis for a sustainable cropping system is a well-developed crop rotation. The crop rotation should be planned to combine crops suitable for the specific soil type and should include considerations to minimize the risk for diseases.

Practical guidelines

Long term cultivation of crops without rotation (monoculture) results in the yield decrease, in the spread of weeds, pests, diseases, and in the depletion of soil productivity. Therefore, agronomically well-motivated crop rotation is an important factor in realization of economically and ecologically sound production. Despite this classical rule there is a growing tendency to use cash crops for a longer time during the last decade in Latvia.

Positive factors of the use of crop rotations in the context of production and environment protection:

- natural soil fertility is used more efficiently, need for less fertilizers;
- smaller pesticide requirement;
- elimination of the risk of soil erosion as well as of other possibilities of degradation;
- smaller possibility for nutrient leaching.

Some proportions between crops should be maintained, and succession of crops which promote the renewal of soil with others – wich stimulates some depletion. In average these proportions should not

[2] Regulations of Council of Ministers No. 62 on Territory Planning
[3] Regulations of Council of Ministers about Permits for Land Use Type Transformation
[4] Codex of Civil Law of Latvia

exceed the following values:

sugar beet, fodder beet, potatoes	25 %
legumes, flax	20 – 25 %
rape	25 %
wheat	33 %
cereals, total	65 – 75 %

A crop rotation plan should be elaborated for every farm over 10 ha.

5. Crops or post-harvested residues should cover at least 50 % of the cultivated area to avoid or reduce the plant nutrient leaching and to minimise the risk for soil erosion.

Practical guidelines

For elimination of nutrient leaching (especially $N\text{-}NO_3$) and erosion control it is important to keep a part of land covered by crops or plant residues in the late fall – winter period. The proportion of the so-called "green areas" and/or catch crops should be in a flat topography – at least 50 % of the cultivated land, but in a rolling topography where susceptibility to soil erosion is evident –60 –70 %. Crops that provide the functions of "the green cover" are following:

- winter cereals (wheat, rye, barley, triticale);
- winter rape;
- perennial grasses;
- perennial vegetables;
- fruit trees and scrubs, strawberry plantations.
- Crops that are harvested late can in some cases also fulfill the functions of "the green cover":
- sugar beet;
- late harvested potatoes;
- corn for silage;
- late harvested vegetables (beet, carrots, cabbage, etc.).

Reduced leaching of plant nutrients can also be achieved if plant residues are left on the fields without incorporation into the soil, e.g. stubble, catch crop cover and sugar beet tops that are spread out evenly. However, the positive effect to avoid the leaching of plant nutrients is about only half as large in the case of "the green cover" crops and catch crops.

6. To avoid or reduce the plant nutrient leaching inter-crops are very recommended, especially on sandy soils, in the fields bordering with waters, in the case of intensive fertilizer use, and/or if the crop rotation is limited.

Practical guidelines

Catch crops are crops sown under the main crop or sown after harvesting of the main crop (stubble or winter after-crops) are used for forage or as a green manure for soil improvement. Thus, land can is used more intensively, the period of land covered by plants is extended, and the production of valuable forage or green manure is introduced. The plant nutrients left after the main crop are well used by catch crops and therefore leaching risk is prevented. It is very important to avoid the nitrate losses.

Table 1. **Plants used as catch crop**

Variation of catch crops		
Winter	Spring	
	undersown	stubble or winter aftercrops
Winter rye	Winter vetch	Winter and spring rape
Winter wheat	Annual ryegrass	Winter-cress
Winter triticale	Annual lupine	Oilseed rape
Winter vetch	Spring vetch	White mustard
Winter rape	Seradella	Phacelia
Perko	Sweet clover	Fodder lupine
	Clover	Annual ryegrass
		Leguminous and cruciferous plant mixture
		Seradella + annual ryegrass

Leguminous crops require that the following crop should be established very soon to avoid a loss of nitrogen due to leaching.

7. Soil degradation should be avoided and previously degraded land should be gradually recovered.

Soil degradation – human induced decrease of soil properties.

Rehabilitation measures of degraded soils are always much more complicated and expensive than preventive measures.

Practical guidelines

- Perform the soil cultivation in a way to reduce the risk of water erosion, e.g. by driving across the hillsides (slopes).
- Windbreaks (belts) should be planted in vulnerable areas.
- Choose a crop rotation plan that can minimise the risk for water and wind erosion in vulnerable areas. If erosion risk is large use overwintering crops.
- Make sure that pH is optimal for the specific soil type.
- Make sure the soil is dry enough to minimise the risk of damage from the heavy farm machinery.
- Make sure no pollution of chemicals occurs.

8. It is recommended for every commercial farm to elaborate a Project of Crop organization – a professional scheme of crop production in the farm that is based on detailed analysis of the specific site and conditions.

Every commercial farm (fertilized area more than 10 ha) should annually elaborate the Project of Crop organisation. It includes a professional assessment of local conditions and a compilation of a working plan for crop production.

Table 2. **The main types of soil degradation**

Type of degradation	Expression	Conductive factors	Prevention measures
Erosion, water	Translocation of soil particles by water. Fertile soil surface is removed, rills and gullies of different size are developed. At the same time outwash buries soil in other places. Pollution of waterbodies by soil particles and biogenic elements.	Land inclination, rainfall amount and intensity, soil type and texture, type of plant cover, soil tillage methods.	Afforestation of slopes if inclination > 20 % (12°), crop rotations of perennial grasses dominating, special methods of soil tillage, fields covered by crops or stubble in the winter.
Erosion, wind	Translocation of soil particles by wind. Fertile soil surface is blown away. At the same time transported particles bury soil in other places. Pollution of waterbodies by soil particles and biogenic elements.	Soil texture (peat, sand), open landscape without natural barriers, type of plant cover, dominating direction and intensity of wind.	Shelterbelts, crop rotations of perennial grasses dominating, special methods of soil tillage, fields covered by crops or stubble in winter time.
Acidification	Lowering of soil reaction below the plant optimum.	Soil type, high concentration of certain compounds in precipitation, fertilizer use, low intensity of soil liming.	Soil liming.
Compaction	Compaction of soil surface and subsurface. Unfavorable conditions for plant growth and low water filtration.	Use of heavy farm machinery when soil is wet, heavy textured soils low organic matter content, inadequate soil tillage, weak soil structure, intensive and unbalanced use of fertilizers.	Crop rotation, selection of soil tillage methods, liming and use of organic fertilizers for strengthening of soil structure, subsoiling.
Pollution	Accumulation of chemical compounds in soil harmful for plants, animals, humans.	Emissions from industry and transport, unauthorized use of sewage sludge, fertilizers, and pesticides.	Technology development for the reduction of emissions, use of sludge, fertilizers, and pesticides according to recommendations.

1.2. SOIL FERTILITY

Soil fertility is the scope of soil properties that ensure favourable growing conditions for plants. Important fertility parameters are factors such as soil type, texture and water regime, chemical (reaction, content of organic matter and plant available nutrients) and microbiological properties. It is possible to monitor all of these parameters and express them quantitatively. It is also possible to manage and achieve their improvement.

Following are some important practical guidelines for soil fertility control and management:

- it is a long and a time-consuming process to form favourable soil properties, therefore soil management is necessary to plan in a way that ensure gradual increase and stabilization of these soil properties. Soil depletion and the loss of fertility should be avoided;
- in the process of fertility management excessive and incompetent actions should be avoided to prevent a negative effect and environment pollution risk;
- some fertility parameters such as soil reaction and organic matter content are also of great ecological importance, therefore their optimisation is significant from the viewpoint of the environmental protection.

It is recommended to give priority to biological methods of soil fertility management such as:

- cultivation of catch crops, use of green manure;
- cultivation of leguminous crops;
- incorporation of straw;
- use of well prepared composts;
- soil liming.

Soil fertility is of important economical, ecological, and social concern. Only fertile soil is able to support a specific biodiversity of plant and animal species. It can be as a natural buffer and prevent plants from uptake of pollutants and limit their leaching in water. Fertile soil is essential for productive agriculture and sufficient income from farming as well as for maintenance of sustainable and balanced rural development.

Soil fertility is characterised and determined by several parameters. Most important parameters can be divided into three main groups:

- ***soil physical properties.*** Bulk density, structure, and soil moisture regime. These parameters are largely derived from the soil type, texture, and depth of groundwater as well as from soil tillage. These parameters are important to ensure formation of favourable water and air conditions in soil. They substantially affect other fertility factors.
- ***agrochemical parameters.*** Organic matter in soil, soil reaction, plant available nutrient status, cation exchange capacity, etc. These parameters determine other parameters and di-

rectly influence plant nutrient uptake. Although these parameters are partly derived from soil type and texture, they are more substantially influenced by soil management practice (soil liming, fertilizer use).

- ***soil biological activity*** depends on living organisms in soil (earthworms, worms, etc.), microorganisms (bacteria, fungi, etc.), and their activity. These organisms are able to affect the soil nutrient status and plant nutrient uptake. They facilitate breakdown of plant residues, mineralization of soil organic matter. They are responsible for synthesis and breakdown of harmful compounds, production of carbon dioxide (CO_2), etc. It is possible to manage the processes of microbiologic activity in agronomically favourable direction to some extent by means of the formation of other soil properties as well as by the use of fertilizers, especially organic ones.

9. The soil fertility should be maintained or improved by selection of suitable cultivation methods.

Practical guidelines

- pH should be maintained on the optimum level for the specific soil type. *(See the table below)*.
- The content of nutrients in soil should be kept at the optimum level for the specific soil type. *(See the table below)*.
- The biological activity should be considered as well as suitable crop rotation, fertilizing, etc.
- Pollution created through expedient practices should be avoided.
- The bulk density of mineral soil should be suitable. *(See the table below)*.

10. Soil testing is recommended at least once in 5 years in order to obtain a reliable information about soil fertility status and necessary improvements.

Practical guidelines

The basic soil agrochemical parameters are soil reaction, organic matter content, plant available phosphorous, potassium, and magnesium content in soil. In general these parameters give the necessary information about the productivity of the arable land, orchards, pastures, and grasslands. On the basis of these parameters it is possible to plan soil liming, fertilizer use and other soil improvements. Several other soil parameters should be also assessed only if some specific crops will be cultivated. For example, vegetables, oil crops, potatoes and other crops with high calcium, sulfur, and micronutrient requirement. Such analyses are quite expensive, and an experienced expert is only able to provide interpretations of the obtained results. Therefore, it is reasonable to contact your adviser and discuss the necessity for parameters and the possible use of the results before ordering an analysis from the laboratory.

The soil testing process should be divided in three stages to obtain the high quality results. All of them are very important and should be completed accurately:

- delineation of expected soil sampling places on the field, sampling, sample preparation and sending to the laboratory;
- analytical procedures to assess the necessary parameters;
- data interpretation and planning of soil improvements.

Soil sampling should be done preferably in fall or early spring, when fields are not sown and not recently limed or fertilized. At that time it is possible to mach the soil differences more accurately and to avoid liming and fertilization interference. The results will be already available for the coming farming season. It is recommended to do the soil sampling at the same spots and during the same season as it was done previously.

The optimal plant nutrient concentrations in soil, soil reaction as well as other physical and chemical properties that are important to provide the best possible growing conditions for crops and minimal environmental risk depend on soil type and textural class.

The values of optimal soil parameters can be found in the professional literature (reference books, normatives, etc.). Some aspects of the positive influence of organic matter content on soil's agroecological status

- stabilization of soil moisture status, soil structure;
- reduction of bulk density;
- reduction of plant nutrient leaching from the root zone;
- stimulation of soil's biological activity that facilitate the plant nutrient uptake and the breakdown of used pesticides;
- reduction of harmful compound (heavy metals, pesticide residues, etc.) mobility in soil.

Some examples of the positive influence of soil reaction (optimum – around neutral) on its agroecological status

- stimulation of well developed plant cover;
- stimulation of agronomically desirable soil structure development;
- intensification of soils' microbiological activity;
- reduction of harmful compound (heavy metals, pesticide residues, etc.) mobility in soil, etc.

Excessive plant nutrient concentrations in soil should be avoided. Otherwise, nutrient loss and environment pollution risk increases. Especially it is important in the case of mineral nitrogen concentration in soil after harvesting of crops in fall, because mineral nitrogen could be easily leached out. Therefore, it is recommended to carry out soil sampling periodically to avoid development of such unfavorable situations, and to adjust the nutrient status in the soil according to the crop plant nutrient requirements.

The following table gives an example of optimal agrochemical parameters for soils of arable land, pastures and grasslands. These values are different for several specific crops like vegetables, ornamentals, orchards, and plants cultivated in greenhouses.

***Table 3.* Optimal soil fertility parameters**
Author: RAZIBA

Parameter	Organic matter content, %								
	< 5,1				5,1 – 20,0				> 20,0
	Soil texture								
	C	L	SL	S	C	L	SL	S	P*
pH KCl	6,6–7,3	6,4–7,0	5,9–6,5	5,6–6,1	6,3–7,2	6,0–6,7	5,7–6,3	5,4–5,9	5,1–5,6
P_2O_5, mg/kg	160–220	130– 190	120–180	100–160	200–260	190–250	180–240	160–220	320–380
K_2O, mg/kg	200–260	180–240	160–200	100–150	300–360	280–340	260–320	200–250	440–480
Org. matter, %	3,0–3,5	2,5–3,0	2,0–2,5	1,5–2,0	No values for these soils				

**Soil texture: C – clay, L – loam, SL – sandy loam, S – sand, P – peat*

Table 4. **Parameters of bulk density of mineral soil (OM < 5 %)**
Authors: A. Vucans, I. Gemste

Interpretation	Bulk density, t/m³	
	surface layer	subsurface layer
Suitable	< 1,40	< 1,60
Partly compacted	1,41 – 1,50	1,61 – 1,70
Critical	> 1,50	> 1,70

Overliming of soil should also be avoided, especially in the case of organic soils and peatlands. It accelerates the mineralization of organic matter and has a negative impact on some soil properties as well as on availability of several nutrients, especially micronutrients, for plants.

11. Fixation of atmospheric nitrogen by soil microorganisms is considered a desirable and facilitated process in agriculture. However, accumulation of great amount of nitrogen rich and readily mineralised organic compounds increase environmental risk due to the potential leaching of released mineral nitrogen compounds.

Practical guidelines

Leguminous crop cultivation improves soil's physical properties and has a positive effect on soil's microbiological activity. Due to a symbiosis between legumes and microorganisms a considerable amount of atmospheric nitrogen is fixed. Fixed nitrogen is consumed by legumes and is also left in soil for the following crop. However, compounds containing nitrogen are mineralized quite fast in soil after extermination of leguminous crop cover, e.g. after plowing. Thus, a considerable amount of nitrogen can be lost due to the leaching if the following crop is not planted immediately. Therefore, the time period between soil plowing and planting of the next crop should be as short as possible. It is especially important for sandy soils.

1.3. SOIL TILLAGE

Soil tillage is one of the basic activities in crop cultivation and is usually combined with the incorporation of post-harvest plant residues, organic and mineral fertilizers and sometimes also of pesticide into soil. It is important to consider sequence and interaction in the planning of soil tillage methods for certain crop cultivation. In other words, it is necessary to consider what activities have been already carried out in the cultivation of previous crops, what are expected actions in the cultivation of the following crop, what agrotechnics will be used, and what are other soil conditions (weeds, phytosanitary situation, etc.) all together.

It is important that the soil tillage planning should have a future oriented perspective considering at least next 2 – 3 years. Soil tillage affects soil physical parameters and has an important influence on the soil environment in general including the plant nutrient bioavailability, processes of nitrogen turnover in soil (amonification, nitrification, denitrification), microorganisms responsible for plant diseases, etc.

> **12.** Soil tillage should provide the optimal conditions for crop growth. It should be carried out as often as necessary, and simultaneously its intensity should be as little as possible.

Soil tillage – mechanical manipulations performed by means of different tools and implements. Thus, there is a close relationship between soil tillage and other practices used in crop cultivation, that provide and optimize the appropriate conditions for plant growth, maintain and improve soil fertility, control weeds and diseases, economizes resources in crop production as well as retain the quality of the environment.

Practical guidelines

Carry out ploughing and harrowing when the conditions are optimal, i.e. when the soil humidity is appropriate to achieve good results:

- after ploughing plant residues and weeds should be covered;
- ploughing should be done thoroughly. Thus, you spare unnecessary harrowing to prepare a good seed bed;
- the harrowing should not be deeper than necessary to get a good seed bed.

> **13.** Soil tillage should ensure an economy of energy, costs, and resources as well as preservation of soil and nature.

Practical guidelines

There are several soil tillage methods. Each of them has its own specific main objective: plowing, cultivation, harrowing, dragging, stubble plowing, rotary tillage, and rolling. The following factors are considered in the selection of the most suitable tillage method:

- field conditions after harvesting of the forecrop;
- soil type, texture, and physical properties;
- requirements of the succeeding plants;
- soil tillage equipment to be used;
- weather conditions;
- length of the period between forecrop harvest and optimal date for sowing (planting) of the succeeding crop;
- field topography, stoniness, etc.

Additionally, soil tillage methods should be adjusted according to what is protected or prevented, e.g. certain weed control, the destruction of soil crust, the soil water accumulation, the soil loosening or packing, etc. It is also important to adjust the tillage operation span with the power of the tractor used. It is recommended to combine different tillage operations and to use complex agricultural machinery that provides soil tillage and plant seeding simultaneously.

The basic method of soil tillage is plowing with share plough. The use of this implement ensures turning and mixing of plant residues, mineral and organic fertilizers with the soil. The following aspects should be considered for better results:

- the best plowing tool is a reversible plough that leaves no furrows on the field;
- plowing course depends on the field relief (*see erosion*) and on the way the crops would be sown (across the plowing direction). It is recommended to do plowing across the direction of the drainage lines not parallel to them;
- the plowing depth should be adjusted according to the depth of arable (organic) soil horizon and crops expected to be grown. The plowing depth can be classified as follows
  - stubble plowing – up to 10 cm,
  - shallow plowing –10 – 20 cm,
  - regular plowing – 20 – 25 cm,
  - deep plowing (subsoiling) – more than 25 cm;
- the effect of the plowing depends on the shape of the mouldboard, soil humidity, and on the width and speed of the tillage operation. It is very important to do plowing at optimum soil humidity;
- it is recommended to change the plowing depth periodically to avoid the formation of compacted soil layer – plough pan. It limits water movement and root growth. Deep plowing (subsoiling) should be combined with the use of organic fertilizers;
- frequent plowing speeds up mineralization of soil organic matter, reduce the humus content, and can therefore induce decline in the physical, chemical and biological properties of soil;
- undesirable effects of plowing can be avoided by a use of tools that do not turn around the soil, such as cultivators, dicks, rotation harrows, as well as special non-turning plows.

If the soil is too loose, it is necessary to compact it on the surface or subsurface. Different kinds of rollers are used for this purpose such as flat and crumble ring rollers, roller tillers, and subsoil plotters. If possible, the number and the depth of agricultural treatments should be limited by combination of tools, so that they would not overcrush the soil.

14. Soil tillage practices should be realised in definite agronomically well-grounded succession. The best effect is reached if the practices complement each other. It is called the soil tillage system that properly selected and realized is an essential prerequisite for sustainable development of crop production.

There is no particular soil tillage method that would be the best for all circumstances. In crop rotation with sequence of plants it is always necessary to choose the most appropriate method, to fix the tillage depth and other parameters depending on the particular requirements of each crop. Every single soil tillage treatment is not able to provide the appropriate growing conditions for crops, therefore a soil tillage system should be elaborated. Soil tillage systems can be classified according to crops they are recommended for (spring cereals, winter cereals, potatoes, etc.) and as systems for some specific aim (for eroded and susceptible of erosion soils, for peatlands, for irrigated land, conservation tillage, minimum tillage, etc.).

15. The time of soil tillage is an important factor for the formation of good soil properties, as well as to ensure the necessary work quality and soil conservation. The tillage conducted too early, or on the opposite, too late (particularly in clayey soils) could cause rather negative after-effect on the further work and plant growth.

The soil tillage should be performed when soil is ready, i.e. when it has optimum humidity, crushes easily, does not stick to tillage tools, and tillage operation can be performed with minimum force. Soil humidity is a main factor affecting these properties. The optimum humidity depends on soil texture and could be as following: for heavy textured soils (clay, loam) 50 – 60 %, coarse textured (sandy loam, sand) 40 – 70 % of the full water capacity. The negative effects of soil tillage done in the wrong time are compaction, overcrushing, and structure degradation.

Practical guidelines

Soil readiness for tillage can be checked using the following simple method. Take a clump of soil, roll it between your hands, and let it to fall down. The soil is ready for tillage, if the clump breaks down in fragments. The soil is too wet, if it keeps together. The soil is too dry, if it is impossible to form a compact clump by hands.

16. Soil erosion – the process of degradation, translocation and deposition of surface soil particles. It is caused and accelerated by an improper land use. Therefore, the farming practice should be in compliance with measures that provide gradual recovery of degraded soils instead of stimulating erosion.

Soil erosion – translocation of soil surface particles as a result of water, wind or, in many cases, of the human activities.

Water erosion. Water erosion causes deterioration of both soil surface and its deeper horizons, and it stimulates leaching of plant nutrients into the surface waters. If it is very intensive, the characteristic pattern of sheet, ridge, and gully erosion develops. As a result water is polluted by biogenic elements, and a particularly negative effect is caused by nitrogen and phosphorus.

***Table 5.* Classification of soil affected by water erosion**

Erosion class	Slope (degrees)	Characteristic pattern
No erosion	0 – 5°	No significant movement of topsoil by water action.
Slight to medium	6 – 10°	Some loss of A horizon and part of the B horizon is mixed by plowing.
Medium to strong	11 – 18°	Loss of A and partly B horizons, C horizon is partly mixed by plowing.
Strong	< 18°	All genetic soil horizons are lost. C horizon is exposed.

The amount and intensity of precipitation, depth of snow cover and its melting intensity, land inclination, soil type and texture, plant cover are the main factors responsible for the development of soil erosion and its intensity. On the farm level main erosion control measures include appropriate crop rotation, soil tillage methods as well as other anti-erosion practices.

***Table 6.* Soil susceptibility to water erosion**

Susceptibility class	Characteristic pattern
Highly susceptible	Silty soil material, loess
Very susceptible	Loose fine sand, rendzina
Medium susceptible	Gravel, medium sandy
Low susceptible	Coarse texture, including sandy loam
Resistant	Loam, soil rich with coarse fragments

17. Crop production pattern and tillage system should be selected according to the local conditions to keep down water erosion of soil.

Practical guidelines

Normal crop rotations are used in the fields with inclination of up to 6°. In the fields with inclination 7-14° special anti-erosion measures should be undertaken: appropriate crop rotations and tillage operations, etc. The row crops are recommended for cultivation in the fields whith inclination not exceeding 10°, and rows should be across the slope. If fields have inclination of 15-20°, permanent plant cover (sod) should be kept or afforestation performed. Fields with inclination exceeding 20° should be afforestated. Anti-erosion crop rotations must consist mainly of leguminous plants, their mixtures with grasses, and winter crops. Winter rye, wheat, rape, and triticale are highly recommended, because they form a compact cover in the fall.

In crop rotations with the forecrop harvested early and the next crop introduced in spring, it is important to cultivate stubble or winter aftercrops. Stubble crops remain plowless for winter forming mulch. Unsown areas should be covered for winter with different mulching materials such as straw, stalks, and leaves.

All agricultural treatments including sowing or planting should be done across the slope. Use of reversible plough is recommended because it turns the ridge to the top of the slope. Such operation can be performed with the regular plough if inclination of slope does not exceed 5 – 8°.

All kinds of soil located on steep slopes must not be plowed. They should be tilled without turning the soil. Special wide spike-tooth (duckfoot) cultivators could be used. Presowing tillage with passive tool set consisting of harrow or cultivator with cage or subsurface roller could be also used. Cultivation of cereals and leguminous crops by using direct sowing with special drill is recommended in appropriate conditions.

Special anti-erosion treatments should be applied on soils very susceptible to erosion, e.g. furrowing, mole draining, subsoiling, dibbling, etc. Furrowing consists of digging or ridging either continuous or breaked furrows across the slope. Furrows are supposed to scatter and limit water run-off and to increase retention of water in soil. Mole draining includes drilling under the soil surface in the depth of 40 – 50 cm. It creates a system of continuous or breaked canals of approximately 5 – 10 cm in diameter and directed across the slope. Mole drains are made by a special tool – mole plough. It increases soil water retention and reduce the amount of water flowing down the slope.

Subsoiling includes soil vertical cutting for the increase of water retention and water soaking into soil's deeper layers. It is done by a special tool – subsoil plough or regular ploughs if the mouldboard is removed.

Land of rather flat slopes inclined up to 6° is less susceptible and affected by water erosion especially if slopes are long. However, it is advisable to cultivate across the slope. Gullies on the fields should be leveled out in order to prevent their further development.

18. Several regions of Latvia with open landscape, large fields and sandy soils dominating are affected by wind erosion. This factor should be considered in the selection of soil tillage system.

Wind erosion. Wind erosion is especially harmful to the surface layer of the soil (it is blown away), to the plants (mechanical damage), to the root system (it is uncovered), and also to the environment in general (dust pollution).

Intensity of wind erosion depends on soil conditions (texture, moisture regime), wind speed and periods of its appearance, field size and landscape diversity, and plant cover. Wind erosion causes the greatest damage agricultural areas with plain and open landscape, if soil is dry, soil's texture is sand or peat, and large fields dominate with no natural barriers like forests, trees, etc. Crop damage occurs most frequently in early spring.

***Table* 7. Soil susceptibility to wind erosion**

Susceptibility class	Characteristic pattern
Highly susceptible	Loose sand, peatlad under cultivation
Very susceptible	Consolidated sand, loess
Medium susceptible	Sandy loam, light silt loam
Low susceptible	Silt loam
Resistant	Loam, clay

Practical guidelines

Obviously, the most effective treatments to prevent soil from wind erosion are shelterbelts consisting of trees and bushes, and fields kept with plant cover as long as possible. Crop rotations should mostly consist, if possible, of perennial grasses and winter crops (cereals and rape) because they form good and stable plant cover already in the early fall.

It is advisable to include some aftercrops in the crop rotation of winter cereals – spring cereals or to leave some mulch (straw, stubble, and leaves) for the winter period. In areas heavily threatened by wind erosion soil tillage should be done without turning soil, and plants ought to be sown directly into the stubble of the previous crop. Trees should be planted on sand dunes created by wind in the farmland.

1.4. FERTILIZER USE

Use of organic and mineral fertilizers is an effective tool for soil fertility management and crop production. The agriculture as a whole and crop production particularly depends on fertilizers. Fertilization is also important for economic considerations of agriculture as well as for the formation of high quality agricultural products. Like other agrotechnical treatments fertilization should follow certain rules and criteria. All excessive and agronomically not motivated actions must be avoided. Otherwise fertilization could cause only losses not only for the farmer but also for the environment and the whole society (economic and ecological).

19. Production of a high yield of good quality should be reached through a use of a balanced and sufficient fertilization with organic as well as mineral fertilizers. The fertilization should correspond to the nutrient requirements of crops and sustain an optimal soil fertility with a minimum pollution of the environment.

The influence of fertilizers on the environment can be characterized from two aspects:

- **positive effect** – due to fertilization crop yields increase and quality improves, thus stimulating the well being of society. Photosynthetic intensity raises. Absorption of CO_2 and refinement of atmosphere from other harmful compounds increases;
- **negative effect** – environment pollution with biochemically active compounds, disturbance of natural equilibrium in ecosystems that eventually unfavorably affects their further functioning.

Environment pollution risk mostly exists due to neglect of agronomic rules, careless actions, lack of knowledge, etc. Some examples how the undesirable impact of fertilization is caused:

- if rules of transportation, storage, and application of fertilizers are neglected;
- plant nutrient losses from soil due to leaching, erosion and surface run-off, emissions into atmosphere. Plant nutrient leaching from soil root zone is very influenced by soil's reaction. Leaching is more intensive if soil is acid, therefore soil liming also has an ecological importance. Heavy metals and radionuclides are also more mobile in acid soils, therefore their uptake by plants could increase;
- environment pollution with elements that are contained in fertilizers – Cl, Cd, Pb, As, U, etc. For example, phosphorus fertilizers contain 0.5 – 5.0 % fluorine. Fluorine compounds are able to move around in the soil profile and to accumulate in plants, especially potatoes. Phosphorus fertilizers also contain a particular amount of cadmium and strontium. Use of communal and industrial wastes as fertilizers that contain undesirable elements;
- concentration of some compounds in crop products that could be harmful for product consumers – humans and farm animals: nitrates, nitrites, potassium, etc.

20. All of the produced organic fertilizers, e.g. farmyard manure, slurry, animal urine etc., should be used as fertilizers on the fields. Spreading should be done to ensure the highest possible utilization of plant nutrients and the least possible loss to the environment.

Farm animals use and retain in their body for physiological requirements, including the production of milk, meet, wool, eggs, etc., only a small part of nutrients taken in with forage. The main amount of consumed feed, approximately 50 % of dry matter, 70 – 80 % of nitrogen, 80 % phosphorous and 95 % potassium are excreted from organism with urine and faeces. Thus, this amount is contained in manure. If animal urine and feces are collected, litter added, stored, and returned back on the fields, a considerable amount of plant nutrients will be reverted in soil. Thus, economic benefit for farm is achieved. If such actions are not undertaken, animal production becomes a serious source of environment pollution. It is because a huge amount of chemically and biologically active compounds concentrate around the animal housing units, and leakage to surface or groundwater, wells and other places would always happen. It will cause anti-sanitary conditions around the area; especially if manure storage does not correspond to the environment protection requirements.

The positive effects of manure, except aforementioned, are manifold:

- manure is active in soil humus formation;
- intensification of soil microbiological activity;
- production of carbon dioxide, biologically active compounds, enzymes, vitamins;
- improvement of soil physical properties.

It is necessary to consider particular specifics of manure in the planning of its use. In manure plant nutrients are mainly in the organic compounds and therefore available for plant uptake after their mineralisation. Rate of mineralization varies for different kinds of manure, for example:

- urine, slurry – very fast mineralization, quick effect on plant growth, however the influence on soil humus formation is weak;
- straw, manure with straw litter – slow mineralization and plant nutrient release, nevertheless an important role in the soil humus formation.

Rational accumulation and use of organic fertilizers are important for all farms notwithstanding of their specialization. Agronomically recommended intensity of organic fertilizer use is 15 t/ha annually, if calculation is based on farmyard manure with 20 % of dry matter. Mainly it depends on balance between crop production and animal farming in the farm. If the animal production is dominating, the problems with ecologically safe manure utilization will exist. If the plant production is dominating, it will be difficult to keep a positive humus balance in soil. Therefore, the optimum between the two farming branches should be about one animal unit per hectare of cultivated land, not exceeding 1.7 per hectare. It could slightly differ depending on crop rotations

In general the number of different kinds of organic fertilizers is quite large. In Latvia the most often used fertilizers are following: farmyard manure, slurry (liquid manure), urine, poultry manure, composts, communal and industry wastes, sewage sludge, green manure, straw, sapropel, and other organic materials.

21. The amount of organic fertilizers that could be produced in a farm depends on several factors. It is important to know and consider different possibilities before decision making and planning of future activities.

The amount of possible manure accumulation in a farm depends on the following:
- kind of animals and their age;
- forage and feed used;
- duration of period when animals are in barn;
- animal housing system, technology used for manure collection;
- litter used in barn (kind and quantity);
- water added to remove liquid manure;
- manure storage duration and conditions, i.e. the amount of manure left after storage.

22. Application rates should be based on plant nutrient content in manure. Therefore, determination of chemical composition of manure produced in a farm is essential precondition for its agronomically and economically sound use. The total amount of nitrogen applied with farmyard manure, slurry or animal urine must not exceed 170 kg/ha annually.

Chemical composition of manure (plant nutrient content) depends on the following:
- kind of animals;
- forage and feed used, feeding system;
- duration and conditions of manure storage;
- litter added to manure;
- water added to liquid manure.

Practical guidelines

It is recommended to take samples and send them for analysis periodically to ensure the quality of manure (plant nutrient content) accumulated in farm. If analytical data is not available, special normatives should be used that determine the average data.

Application rates for farmyard manure and slurry (liquid manure) must be fixed based on ***nitrogen*** and ***phosphorous*** content and their utilization intensity. It is not allowed to exceed the application rates behind the agronomically and environmentally grounded limits.

The amount of manure available for fertilizing is calculated for the whole year (365 days). Some animals might be kept outside the barn. In this case manure accumulation as shown in this table should be corrected taking into the consideration so called indoor period. Commonly, it is as following (days):

milking cows	220
heifers	220
beef cattle	180
horses	180
sheep	210

Other kinds of livestock usually are indoors over the whole year.

Data about the amount and chemical composition of manure in farm might differ from those listed in normatives depending on particular feeding system, litter used, technology of manure handling, duration and conditions of storage. Manure analysis is recommended to adjust these differences periodically.

Farmyard manure should be used as a fertilizer sufficiently soon after it is produced. It should not be stored for several years on fields or in storage places before spreading.

Table 8. **Draft manure normatives for Latvia***
(per one animal after storage)

Housing system	Manure type	Tons per year	Dry matter, %	Content, kg per ton of manure N	P_2O_5	K_2O
Sow with 18 piglets to 20 kg weight						
Solid floor	Solid manure	4,6	28	4,6	3,5	3,6
Slaughter pig, 20 – 100 kg live weight						
	Slurry					
Slotted floor	•washing	8,7	3	1,2	0,6	1,0
	•periodical flush	3,4	6	2,7	1,6	3,8
Solid floor	Slurry	3,6	6	3,3	1,6	2,8
	Solid manure	2,6	20	5,7	3,2	6,0
Dairy cow, milk yield 3500 – 5000 kg per year						
Tie up, solid floor	Solid manure	13,0	22	4,8	1,9	4,0
	Slurry	22,0	7	2,3	0,9	1,9
Dairy cow, milk yield 5000 – 7000 kg per year						
Tie up, solid floor	Solid manure	15,5	22	5,4	2,2	4,2
	Slurry	27,0	7	2,4	1,2	2,2
Dairy cow, milk yield above 7000 kg per year						
Tie up, solid floor	Solid manure	17,5	22	5,5	2,3	4,4
	Slurry	30,0	8	2,6	1,4	2,4
Young stock (cattle), up to 6 month old						
Tie up, solid floor	Solid manure	2,6	21	5,5	2,1	4,5
	Slurry	6,0	7	1,9	0,8	1,5
Tie up, deep litter	Solid manure	4,0	25	4,5	1,9	3,8
Heifer, 6 to 24 month						
Tie up, solid floor	Solid manure	6,7	21	5,5	2,1	4,5
	Slurry	15,0	7	2,2	0,9	1,8
Tie up, deep litter	Solid manure	9,0	25	4,6	1,9	4,1
Bull, from 6 months up to 450 kg live weight (26 months)						
Tie up, solid floor	Solid manure	11,1	21	4,7	1,9	4,2
	Slurry	20,5	7	2,2	0,9	1,8
Slotted floor	Slurry	20,5	7	2,2	0,9	1,8
Free, deep litter	Solid manure	15,0	25	4,2	1,8	4,6
Horse						
Solid floor	Solid manure	8,0	31	5,2	3,6	7,5
Sheep						
Deep litter	Solid manure	0,9	29	7,8	4,7	10,5
Hens						
Deep litter	Solid manure	0,1	44	17,2	12,4	8,2
Battery	Slurry	0,1	15	10,6	7,2	3,8

**The figures in Table 8 are based on qualified estimates. On basis of this data the calculation of fertilizer plans, manure storage capacity and livestock units could be performed. Further research will provide redefined and validated figures, and an updated manure standard.*

23. Manure should be spread on fields in periods that correspond to the maximum nutrient need by crops. Uniformity of application should be ensured, and manure incorporation in soil should be as fast as possible.

Plant nutrients in farmyard manure, slurry, and urine form soluble compounds. Nitrogen can easily evaporate in the form of ammonia. Therefore, considerable nutrient losses can happen that reduce the manure fertilizer value and lead to serious environment pollution. It should be used for the crops that utilize the nutrients most efficiently. Manure, slurry, and urine should be used in periods when crops can intensively uptake nitrogen. Only farmyard manure rich in litter and used only on heavy textured soils (clay, loam) is allowed to be spread out in the fall for crops sown in the next spring.

24. Farmyard manure, slurry and animal urine must not be used in winter time and early spring between October 15 and March 15, when their incorporation in the soil is impossible. Besides, it is prohibited on the frozen, water saturated, flooded, and snow covered soil.

Practical guidelines

Some recommendations important for manure use.

- Manure, slurry, and urine after their application should be incorporated into the soil to avoid the nitrogen losses. Incorporation should be done as soon as possible but not latter than following: for farmyard manure – on the day of application, for slurry and urine – within 5 hours after application.
- Organic fertilizers for grasslands and pastures should be applied in early spring when the weather is chilly and humid. It is advisable to do grassland harrowing after the fertilizer application.
- Slurry and urine can also be spread out on the growing plants. If so fertilizer incorporation in soil should be provided or, alternatively, fertilizers should be placed directly on the soil surface in a form of concentrated bands or shallow ridges between the crop rows. In this case a trailing hose system or injection system should be used.
- The best way of urine utilization is its use in compost preparation, thus to avoid the plant nutrient losses.

25. Farmyard manure, slurry, and animal urine should be used in fields with slope exceeding 10° only if the fields are covered by plants or if fertilizers are directly incorporated into soil.

Farmyard manure, slurry, urine must not be applied closer than 10 meters from the coastline of waters (lakes, rivers, pounds), drainage channels, wells and other sources of water.

26. All available sources of organic manure should be used in a farm to sustain soil fertility, recycling of plant nutrients, and utilization of production and household wastes. It should be in accordance with sanitary requirements and environmental regulations, and it must not have a harmful effect on the quality of the environment.

Practical guidelines

Characterisation of most common organic fertilizers used in Latvia.

- **farmyard manure** – excreta from farm animals (cattle, pigs, horses, sheep, etc.) together with bedding material (straw, peat, and sawmill dust);
- **slurry (liquid manure)** – excreta from cattle or pigs, that are removed from manure channels by water and therefore diluted to some extent and containing no litter;
- **urine** – liquid excreta from cattle or pigs;
- **poultry manure** – accumulated with litter or in the liquid form (slurry). Contains more plant nutrients compared with the manure from other kind of animals;
- **composts** – organic material admixture of different origin (manure, urine, peat, wastes, plant residues, etc.) that has been biologically treated in the process of composting. In the process of composting different materials that can not be used as fertilizers directly or that contain some harmful compounds are biologically converted into the valuable plant nutrient source. For example, communal and industry wastes, sawmill dust, straw, etc;
- **green manure** – crops grown for use of soil improvement;
- **straw** – after harvesting of crops the straw is left on the field, chopped, added some extra nitrogen (20 – 30 kg/ha or 10 kg per ton of straw), and incorporated into the soil;
- **sapropel** – fresh water sediments (lakes, ponds). Used directly or after composting;
- **wood industry wastes** – sawmill dust, wood processing wastes, etc. Chemical composition differs greatly, however generally low in nitrogen. Considerable part of organic matter in a form of hard degradable compounds: cellulose, lignin, resins, etc. Requires long composting that exceeds one year. Compost components might be slurry, urine, poultry manure, communal wastes, industry wastes and other materials rich in nitrogen, as well as nitrogen fertilizers. It should be noted that composts not yet ready may contain compounds harmful for plants;
- **other organic materials** – sugar beet tops, leaves, plant residues, seaweeds, etc.
- **communal and industry wastes, wastewater** – wastes from communal sewage units, food industry (fermentation, sugar refinery, starch, meet processing, dairy, fish, fruit, vegetables processing plants), hydrolysis, pharmacy, textile, leather industries. These wastes that could be used for soil improvement, might be classified as follows
  - wastes that could be used but only after control of harmful substances in them;
  - wastes that should be composted before use;
  - wastes that should be plowed down some period beforehand the crops are grown;
  - wastes that should be used without any special limitations.

Composting must be done for wastes that could contain sources of infection, helminthes, plant pests or diseases. Such kinds of wastes come from slaughterhouses, feather and fur processing plants as well as from vegetable and fruit processing. Wastes containing low amount of easily available nitrogen and plenty of carbon should be used some period before crop growth. For example, wool and flax fibber processing wastes, because some time is necessary for microorganisms to start the process of decomposition. No special limitations are necessary for the use of wastes that mineralisation in soil is fast and that contain no dangerous organisms. This group includes some wastes from food industry, wastes from fish processing, dried meat and blood meal, hoof and horn meal, tobacco dust, wastes from alcohol distilleries, starch production etc. Wastes from alcohol distilleries contain more dry matter and depending on composition they could be used on the fields without crops, they could be used diluted for crop top-dressing or to make composts after separation of the solid phase. In some cases if wastes are not suitable for agriculture, they are acceptable for forest fertilization.

Before use of aforementioned wastes as soil conditioners or fertilizers special attention should be paid to possible requirements and limitations that are included in different legislative documents. Particularly it is important in the use of sewage sludge (*see hereafter*).

27. Mineral fertilizers are highly active materials. Their rational use gives possibility for fast increase in crops' yield and quality, build-up of soil fertility and, finally, farm economy in general. However, incorrect use causes undesirable effect on soil and crops as well as environmental pollution.

The use of mineral fertilizers is an essential prerequisite for high yield production because there are not enough plant nutrients in Latvian soils to provide crops within the rather short plant-growing period. Rather high investments are needed for fertilization for quite a long period. Therefore, sound economic assessment is necessary before decisions are taken, and all activities should be done considering agronomical conditions. It should be emphasised that non-renewable natural resources (phosphate, potassium-containing minerals, natural gas, energy) are used in the production of mineral fertilizers, and their deposits on the earth are limited. Improper use of fertilizers can create serious environment pollution because well soluble, biochemically active (biogenic) compounds can reach the surface and groundwater. Therefore, rational use of fertilizers is important for both agronomic and environmental aspects.

28. The most appropriate kind of fertilizers should be selected for the specific situation. It gives the possibility to reach the maximum positive response with minimum undesirable by-effects.

Practical guidelines

Nowadays assortment of fertilizers is very multifarious. The following main considerations might be used in the decision making about the best kind of fertilizers in the specific situation:

- production conditions (soil, weather within the growing season, agrotechnics used, kinds of crops and purpose of their growth, etc.). The excessive use of nutrients should be avoided, that is particularly probable when multinutrient fertilizers are applied;
- undesirable elements could be contained in the fertilizers. It is necessary to evaluate the response of plants on their presence. For example, chlorine in potassium fertilizers and ammonium chloride, excess sodium in sodium nitrate, as well as smaller amounts of other elements. Phosphorous fertilizers contain a small amount of cadmium as well as other heavy metals;
- economical considerations. In the given situation not only the most suitable but also the cheapest kind of fertilizers should be selected and applied using the best available technology.

29. Fertilizers should be kept in original packages and in conditions that are required for their storage.

Practical guidelines

There exist special guidelines and regulations for fertilizer storage and handling that take into account physical and chemical properties of fertilizers, their possible negative impact on the environment, hazard risk. One group of regulations is managerial, the other is technical regarding buildings and equipment used for fertilizer handling. The main principles that should be considered in fertilizer storage are as follows:

- orientation of fertilizer warehouses respecting other buildings and constructions;
- prevention of storage places from moisture;
- fire-safety regulations;
- fertilizer loading height;
- fertilizer batch, identification, labelling;
- storage capacities for liquid fertilizers:
  - allowed load and volume for vassals,
  - leak and pressure proof,
  - marking of vassals,
  - pressure gauges,
  - earthwork that twines the storage;
- allowed period of storage;
- corrosion prevention;
- environment protection rules.

30. Fertilizer application rate should be determined based on plant nutrient requirements to achieve the estimated yield level, and adjusted according to the plant available nutrient content in soil and organic fertilizers applied.

Practical guidelines

Determination of fertilization rates is very responsible and quite complicated task.

- Fertilizer rate should be agronomically well-grounded. If low it is hard to achieve planned (feasible) crop yield. If too high – an undesirable effect might be caused (environment pollution, crop lodging, loss of yield quality, etc.). Therefore, soil should be tested periodically to adjust the fertilizer rate.
- Plant nutrients in fertilizers should be well balanced. Deficiency or excess of a certain plant nutrient will cause a negative effect.
- The followed practices should be focussed on a goal to facilitate mobilization of plant nutrients in soil in an easily available form when their uptake by plants reaches maximum. It is particularly important for nitrogen because of its high mobility in a soil. Excess nitrogen not used by plants can easily be leached out from the root zone. Therefore, it is common to split and apply the total nitrogen necessary in several treatments.
- Fertilizers can never cover mistakes and inaccuracies that are made in other operations during crop growing. Reasonable crop rotation, high quality soil tillage, healthy seed, weed and disease control, optimum soil moisture regime, soil reaction, rational use of organic fertilizers, etc.

– all together are a necessary background for excellent fertilizer performance.

- The plant nutrient diagnosis is a special tool that, might be very useful for adjustment of fixed fertilizer rates and time depending on actual crops nutrient supply and availability.

The special normative tables are used for determination of fertilizer rates, or it is done by a professional agronomist. The requirement for plant nutrient is characterised by calculated plant nutrient removal in expected (planned) yield. Special tables are used for estimation of plant nutrient removal. In such calculations it is very important to make a real yield goal estimate, because many factors can influence it. Some of these factors that considerably affect the yield are quite difficult to forecast, e.g. weather conditions. Soil analysis and professionally made interpretations are information sources about soil's capacity to supply plants with nutrients. Plant nutrient content in organic fertilizers and its utilization coefficient characterises the importance of this source for plant nutrition. For example, utilization rate for nitrogen in slurry could be 60 % and more in the first year after application, but only 20 – 30 % from the farmyard manure rich in straw.

An orientation about the nutrient requirement of different crops (in case of medium yield level) and therefore about the necessary fertilizer rates can be obtained from plant nutrient removal data. Usually data is expressed in kg of nutrients per one ton of the main yield considering how the byproducts are managed, i.e. whether they are removed from fields as well or they are left on the fields and plowed down in soil.

***Table 9.* Plant nutrient removal by crops, kg/t**

Data collection made by A. Vucans and I. Gemste

Crops	Byproducts removed			Byproducts plowed down		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Winter rye	23,7	10,2	22,3	16,6	7,1	5,6
Winter wheat	24,8	8,5	21,1	17,4	5,9	5,3
Spring wheat	24,7	10,2	19,8	17,3	7,1	4,9
Spring barley	24,7	10,2	19,8	17,3	7,1	4,9
Oats	26,3	10,9	31,4	18,4	7,6	7,8
Peas	51,4	13,0	25,1	36,0	9,1	6,3
Lupine	77,3	19,1	38,8	54,1	13,4	9,7
Cereal – pea (vetch) mix for grain	31,3	11,3	30,1	21,9	7,9	7,5
Barley – oats mix for grain	25,5	10,6	25,6	17,8	7,4	6,4
Corn, green forage	2,6	1,0	4,4	–	–	–
Mix for green forage	4,3	1,8	5,5	–	–	–
Winter rye for green forage	5,5	2,3	5,2	–	–	–
Lupine for green forage	18,2	4,5	9,1	–	–	–
Potatoes (early varieties)	2,8	0,9	5,0	1,8	0,7	3,2
Potatoes (late varieties)	3,0	1,1	6,2	1,9	0,8	4,0
Sugar beet	5,1	1,7	7,5	1,5	0,7	1,5
Sugar beets for forage	4,3	1,6	6,8	2,1	1,0	3,4
Fodder beet	3,6	1,1	5,1	1,8	0,7	2,5
Fodder carrot	3,3	1,2	4,2	1,6	0,7	2,1
Fodder cabbage	3,9	1,6	5,3	–	–	–
Flax, culms + seeds	10,5	3,4	10,0	–	–	–
Clover > 50 % + grasses, 1st year	21,0	5,5	22,0	–	–	–
Clover > 50 % + grasses, 2nd year	18,0	5,0	19,0	–	–	–
Clover < 50 % + grasses, 1st year	16,5	4,8	18,0	–	–	–
Clover < 50 % + grasses, 2nd year	16,0	4,5	17,5	–	–	–
Clover hay, 1st year	22,0	7,0	23,0	–	–	–

Clover hay, 2rd year	19,0	6,0	20,0	–	–	–
Alfalfa + grasses hay, 1st year	18,0	5,0	23,0	–	–	–
Alfalfa + grasses hay, 2rd year	17,0	4,8	21,5	–	–	–
Alfalfa hay, 1st year	22,0	7,0	23,0	–	–	–
Alfalfa hay, 2rd year	19,0	6,0	20,0	–	–	–
Clover and alfalfa for green forage	8,0	2,5	7,0	–	–	–
Grass hay	16,0	4,5	18,0	–	–	–
Meadows cultivated, hay	16,0	5,0	22,0	–	–	–
Pasture grass with legumes	4,0	1,2	3,5	–	–	–
Pasture grass without legumes	3,0	1,0	2,7	–	–	–
Clover seed + culms	24,5	5,5	22,0	–	–	–
Clover seed	580,0	130,0	525,0	–	–	–
Grass seed + culms	16,0	4,5	18,0	–	–	–
Grass seed	180,0	50,0	200,0	–	–	–
Rape seed	50,0	25,0	45,0	–	–	–
Rape green forage	3,5	1,2	6,0	–	–	–

Table 10. **Plant nutrient removal by vegetable crops, kg/ha**
Data collection made by A. Vucans and I. Gemste

Vegetable	Yield, t/ha	N	P_2O_5	K_2O
Cabbage, late	400 – 500	180 – 200	75 – 80	200 – 250
Cabbage, early	300 – 350	100 – 120	30 – 40	100 – 120
Cauliflower	120 – 150	80 – 100	25 – 30	100 – 120
Carrots, parsley	350 – 400	80 – 100	40 – 50	100 – 120
Celery	200 – 250	150 – 160	60 – 65	200 – 250
Red beet	400 – 450	110 – 120	35 – 40	200 – 220
Radish	180 – 200	100 – 110	35 – 40	100 – 110
Black radish	280 – 300	175 – 180	60 – 65	150 – 160
Turnips	280 – 300	100 – 120	50 – 60	130 – 140
Swede	450 – 500	160 – 170	65 – 70	130 – 140
Cucumbers (open field)	180 – 200	50 – 60	30 – 35	60 – 70
Tomatoes (open field)	~ 100	70 – 80	20 – 25	100 – 115
Lettuce, leaves	80 – 100	20 – 25	7 – 10	45 – 50
Lettuce, heads	120 – 150	45 – 50	25 – 30	75 – 80
Green peas	70 – 80	75 – 80	45 – 50	30 – 50
Horse beans	120 – 150	125 – 130	35 – 60	80 – 90
French beans	75 – 80	75 – 80	25 – 30	45 – 50
Horse radish	100 – 120	60 – 70	30 – 35	45 – 50
Rhubarbs	300 – 400	200 – 220	80 – 100	150 – 180
Onions	120 – 150	45 – 60	25 – 35	60 – 70
Average all vegetables				
• medium yield level	–	110	45	115
• high yield level	–	130	54	138
Average fruits and berries (kg/t)	–	5,0	3,0	6,0

31. Fertilizer (organic, mineral) use should facilitate the improvement of yield quality. Its application must not enforce accumulation of compounds harmful for human or animal health.

Practical guidelines

Fertilizer use is an essential factor in the formation of yield with certain quality parameters. Depending on fertilizer rate and plant nutrient ratio, accumulation of different organic compounds could be facilitated in plant products, e.g. proteins, sugar, starch, oil, etc. These compounds are important for using crop products as food, for processing, for forage and feed. Fertilizers also considerably affect the taste of products, their processing and storage properties. Excess and unbalanced fertilization can stimulate the accumulation of undesirable compounds in yield. It can lead to serious physiological disbalances for the consumers of products. For example, high potassium in forage, especially in the pasture grasses, is a result of abundant potassium fertilization. High nitrogen contents in a form of nitrates in vegetables and forage are due to high and unbalanced application of nitrogen containing fertilizer.

Do not use more nitrogen than recommended to keep the crop products healthy for the consumers.

Table 11. **Maximal recommended concentrations of nitrogen in the form of nitrates in crop products**

mg per kg of natural (moist) products

Crops	Allowed concentration of nitrates, mg/kg	
	grown in open field	grown in greenhouses
Potatoes, early (harvested before 01.09.)	200	–
Potatoes, late (harvested after 01.09.)	140	–
Cabbage, early	700	–
Cabbage, late	500	–
Carrots, early	300	–
Carrots, late	200	–
Tomatoes	50	100
Cucumbers	150	300
Onion leek	400	600
Lettuce	1200	2500
Dill, parleys, celeries, sorrel, spinach, beet leaves	1000	2000
Marrow, pumpkins, sweet pepper	200	400
Aubergines, cauliflower	300	–
Swede, turnips	500	–
Radish, black radish	1500	–
Red beets	1400	–
Onions	80	–
Rhubarbs	800	–

32. Commercial growers (fertilizer area more than 10 ha) should provide annual calculations of plant nutrient balance for the farm.

Plant nutrient balance (N, P, K, Ca, Mg, etc.) calculation shows the efficiency of the nutrients and risk for pollution of the environment. It is a difference between their input and output expressed on a certain area (field) or on a farm, region, state. If the input is higher than output, the balance will be positive, and vice versa – negative, if the output is higher than input.

Importance of plant nutrient balance calculations

- resources planning and its rational use in agriculture;
- soil fertility management;
- prognosis of plant nutrient status in soil, their dynamics and change;
- assessment of fertilizer requirements;
- assessment of actions and measures for environment policy and protection.

Intensity of plant nutrient balance is an input/output ratio expressed as a percentage. It is used to evaluate the plant nutrient flux in a fixed time interval, e.g. one year. Usually it should be 100 – 120 % for nitrogen, or 120 – 150 % if the yield level is above 5 t/ha (in grain units). Pollution risk increases if the values exceed aforementioned. The recommended balance intensity for phosphorus could be 160 – 200 %, for potassium – 120 – 150 %, depending on PK level in soil.

Practical guidelines

Farmers should strive to reach the balance that is lower or normal for the specific farms under certain conditions.

33. Mineral fertilizers should be applied shortly before the maximum plant nutrient uptake. Application is not allowed if essential nutrient losses are feasible due to emission, surface run-off or leaching. It is prohibited to use the nitrogen containing fertilizers in the fall for crops planted or seeded only in the next spring.

Practical guidelines

It is necessary to limit the time interval between the application of easily soluble mineral fertilizers and period when plants are able to uptake the nutrients most intensively. Spring application of mineral fertilizers is strongly recommended for annual crops instead of their use in fall of previous year. The aim is to reduce the risk of plant nutrient leaching or its transformation in less available form. It is prohibited to apply the fertilizers in the following circumstances

- on frozen or snow covered soil;
- if flooding risk of fertilized field exists;
- if soil is water saturated in such extent that infiltration can happen.

The split application should be performed for crops requiring high fertilizer amounts.

34. Special precaution should be followed in fertilizer use in vulnerable and high-risk areas or conditions to prevent migration of nutrients into waters and water intakes.

Practical guidelines

The following vulnerable and high-risk areas or conditions could be pointed out that require special precautions in fertilizer use:

- **rolling topography.** Fertilizers should be incorporated in soil just after application. No incorporation is only allowed if plant cover is well developed;
- **areas that could be flooded in the certain period of a year.** Fertilizers should be used only as the period of possible flooding is over;
- **areas where groundwater level reaches soil surface.** Fertilizers could be used only when groundwater level goes down and field are dried;
- **areas that border with waters.** It is not allowed to use the fertilizers close to the coastline of rivers, channels, lakes, ponds, and water intake places. The cleaning of fertilizer application equipment and other machinery is prohibited in this zone. Surface waters and their inhabitants are very sensitive to the presence even if small amounts of fertilizers. Fertilizer use is prohibited within the 10-meter zone of coastline[5];
- **sandy soils with** low organic matter content and acid. Lower rates of fertilizers should be used and split application is recommended.

35. If plant protection compounds (pesticides) are included in fertilizers all regulations concerning pesticide use must be followed[6].

Some fertilizers, particularly liquid ones, can be used in the mixture with plant protection agents – herbicides or fungicides. In this case all regulations mandatory to the pesticide use should be followed.

36. The best available technology should be used for fertilizer handling and used in a way to provide the maximum effectiveness with the minimal negative side effect on crops and environment.

Practical guidelines

Technology of fertilizer use includes several important steps: organisation, selection of machinery, its adjustment, and quality control. In order to obtain the best possible performance, the main aspects to consider are as follows:

- the selection of fertilizer application method that should meet the agronomic, economic and ecological requirements. Priority should be given to the methods that provide incorporation of the fertilizers directly into soil or the plant root zone;
- the best possible pattern should be followed to obtain an even application. If the incorporation in

[5] Law of Protection Belts
[6] Law of Plant Protection

soil is performed, fertilizers should be placed so that plant roots can easily reach them. For example, undesirable results like heterogeneous harvest ripening, crop lodging, etc. are due to the unevenness of fertilizer application, especially nitrogen. The amount of fertilizers applied must not differ more than ±10 % from the calculated (recommended) quantity;
- application pattern of fertilizers depends on many factors: type of applicator (spreading equipment), its adjustment, quality of fertilizers (physical properties), field conditions, methods of application, qualifications of operator, etc. All these factors should be known and considered to obtain good fertilizer application quality;
- Fertilizer application quality should be checked periodically, and necessary adjustments should be performed.

37. Commercial growers (fertilizer area more than 10 ha) should compile a crop fertilizer plan and field history annually.

Practical guidelines

Fertilizer plan – professionally made document of recommended actions and measurements for fertilizer use, that is based on assessment of relevant farm conditions. It includes fertilizer recommendations as well as managerial and technical guidelines that are based on resources available in the farm. The main factors that should be considered in composition of a fertilizer plan are following:
- kinds of crops cultivated and estimated yield goal;
- soil conditions (topography, type, texture, plant nutrient status, and water conditions);
- climatic conditions;
- land uses type, agrotechnics used, farming intensity, crop rotations;
- other sources of plant nutrient, their contribution (manure, green manure, straw, leguminous plants);
- fertilizers that are more suitable for the specific situation, their price;
- equipment, machinery available on farm.

It is strongly advisable that fertilizer plan is worked out by an experienced professional, i.e. agronomist. It is an important document from agronomic, economic and ecological aspects. The final result to a large extent depends on the plan's logistics, quality and realisation sequence.

Field history – document that contains regular records about soil improvements, agrotechnics used, the use of fertilizers, pesticides, obtained yield, different observations, etc. The field history records show specifics of crop growth conditions for every single field in the farm and accumulate experience for possible future use to avoid repeating mistakes. It is useful for experience and knowledge transmission to the next generations. It gives information that is essential for preparation of recommendations. Therefore, close relationship exists between good field history documentation and well-prepared fertilizer recommendations.

Fertilizer planning should be based on the newest available soil fertility data. Therefore, soil fertility survey should be done periodically (at least once per 5 years). Especially, mineral nitrogen content in soil should be tested before the nitrogen fertilizer use in farms with very intensive crop production and fertilizer use. The plant nutrient balance should be also calculated annually.

The principles in fertilizer planning suggest that firstly the required amount of applied plant nutrients should be determined according to the needs. Next, it should be decided what share of the norm can be covered by animal manure of a certain type. Finally, types and amounts of mineral fertilizer to cover the remaining needs should be determined. See an example in the Table12. An empty form for use your use in preparation of a fertilizer plan for a field is provided in Appendix 1.

***Table 12.* Example of a fertilizer plan for a 4,5 ha field with winter wheat with an expected yield of 6,5 ton per ha**

The need is roughly assessed according to Table 9. The amount of manure and plant nutrients in it is assessed according to Table 8.

	Calculation	Amount	Plant nutrients, kg		
			N	P_2O_5	K_2O
1	Norm* (need) per ha (Table 9.)		161	55	137
2	Norm (need) per 4,5 ha (line 1 x 4,5)		725	248	617
3	Manure from 12 dairy cows, tons (Table 8.)	112	605	246	470
4	Effective fertilizing value of the manure, % (estimate dependent on application time and technique, etc.)		35	40	40
5	Effective fertilizing value of the manure, kg (line 3 x line 4 / 100)		212	98	188
6	Difference to be applied as mineral fertilizer (line 2 – line 5)		513	150	429
7	Plant nutrient content in used fertilisers (ammonia nitrate, superfosphate and potassium chloride)		34	20	60
8	Ammonia nitrate to comply with the rest of need (line 6 / line 7x100), kg	1509	513		
9	Superphosphate to comply with the rest of need (line 6 / line 7x100), kg	750		150	
10	Potassium chloride to comply with the rest of need (line 6 / line 7x100), kg	715			429

**The norm is determined from the standard normative (Table 9.), adjusted for the field's history (under the fertilizing effect of the previous crop), pH of the soil, soil type, soil analyses (under N_{min} analyses), and for the climate in the region.*

38. Special regulations must be followed if sewage sludge is used for soil improvement or fertilization. Harmful compounds (mainly heavy metals) may be present in sludge and, therefore potential risk for human health and environment exists[7].

[7] Regulations of Council of Ministers of Latvia "Use of sewage sludge for soil improvement".

The following rules should be considered in use of sewage sludge for soil improvement:

- the maximum allowed concentrations of heavy metals and PCBs must be considered;
- soil reaction must be higher than pH_{KCl} 5,0 and heavy metal content in soil must not exceed the limits set up for every soil textural group;
- the limits for sewage sludge application that are set up based on nitrogen and phosphorus content must not be exceeded. Attention should be paid to decide the crops to be grown, their rotation, and other agrotechnical characteristics.

2. ANIMAL HUSBANDRY

2.1. INTRODUCTION

Animal Husbandry is a branch of agricultural production dealing with animal produce output and satisfaction of people hobbies or other special interests. It is also the science of animals, their feeding and nutrition, breeding, management.

Specialisation of Animal Husbandry depends on food industry requirements for specific raw materials, on natural circumstances and on market demands. Two different methods, extensive and intensive, are characteristic in Animal Husbandry.

The extensive animal keeping method rather is a historical category. However, given the concern with animal welfare, biological agriculture, and unpolluted produce output this method is being used to a certain extent.

Intensive Animal Husbandry is based on well - developed cultivation of plants. It is characterised by a rapid increase of animal productivity and of the number of animals in a fixed territory.

We have to be conscious of the harmful and even hostile influence of the intensive animal husbandry on the environment. It pertains to low ilizion of ingested feed nitrogen compounds for animal protein as well as low utilization of phosphorus. Usually, faeces and urine excrete more than 60% of feed nitrogen. The amount of excreted nitrogen in some places is so large that the natural nitrogen cycling processes is no longer possible.

In conformity with Latvia's legislation, EU Directives and HELCOM references the issues of great importance on the state level and for every farm are following: **density of livestock, control of the microclimate of livestock buildings, decrease of ammonia emission from manure by the improvement of nutrition, storage of forage, disposal of animal carcasses, animal welfare and health status as the base of qualitative manufacturing of animal produce.**

The majority of issues in Animal Husbandry chapters of the Good Agricultural Practice have a status of recommendations. However, in the nearest future they should be prescribed by law.

2.2. DENSITY OF LIVESTOCK

39. In livestock buildings conditions for keeping animals have be to secure and corresponding to zoo-hygienic requirements. The livestock recording has to be carried out according to the legislation of the Republic of Latvia.[1]

40. The number of animals and the agricultural land area used for manure application should be kept in balance. Livestock unit is used as an index to describe the number of animals per area.

[8] Pedigree record normative documents. 1.volume. Ministry of Agriculture of Latvia Republic, Riga, 1998

Practical guidelines

Livestock Units (LU) is determined as the number of animals that produce an amount of manure equivalent to 100 kilo N ex storage. The amount of manure produced by different animals in different housing systems, bedding types and productivity level is shown in Table 8 of Chapter 1. Table 13 shows the number of Livestock Units per animal and the number of animal per one LU, and is calculated from Table 8.

An empty form for calculation of Livestock Units and livestock density in your own farm is provided in Appendix 2.

***Table 13.* Livestock Units (LU)**

Housing system	Manure type	LU per animal	Animal per LU
	Sow with 18 piglets to 20 kg weight		
Solid floor	Solid manure	0,21	5,0
	Slaughter pig, 20 – 100 kg live weight		
Slotted floor	Slurry washing	0,10	10,0
	Periodical flush	0,09	11,0
Solid floor	Slurry	0,12	8,0
	Solid manure	0,15	7,0
	Dairy cow, milk yield 3500 – 5000 kg per year		
Tie up, solid floor	Solid manure	0,6	1,6
	Slurry		0,5 2,0
	Dairy cow, milk yield 5000 – 7000 kg per year		
Tie up, solid floor	Solid manure	0,8	1,2
	Slurry		0,6 1,5
	Dairy cow, milk yield above 7000 kg per year		
Tie up, solid floor	Solid manure	1,0	1,0
	Slurry	0,8	1,3
	Young stock (cattle), up to 6 month old		
Tie up, solid floor	Solid manure	0,14	7,0
	Slurry	0,11	9,0
Tie up, deep litter	Solid manure	0,18	6,0
	Heifer, 6 to 24 month		
Tie up, solid floor	Solid manure	0,37	3,0
	Slurry	0,33	3,0
Tie up, deep litter	Solid manure	0,41	2,0
	Bull, from 6 months up to 450 kg live weight (26 months)		
Tie up, solid floor	Solid manure	0,52	2,0
	Slurry	0,45	2,0
Slotted floor	Slurry	0,45	2,0
Free, deep litter	Solid manure	0,63	2,0
	Horse		
Tie up, solid floor	Solid manure	0,4	2,4

continue in page 44

Table 13 Continuing

Housing system	Manure type	LU per animal	Animal per LU
Sheep			
Deep litter	Solid manure	0,07	14,0
Hens			
Deep litter	Solid manure	0,01	100
Battery	Slurry	0,01	100

41. The regulations of intensive animal breeding have to be followed to prevent or decrease the adverse influence of livestock density on the environment. The construction and reconstruction of complexes of intensive animal breeding require an assessment of the impact on the environment.[9]

The law prescribes that the assessment of the influence on the environment is necessary also for other facilities as required by the regional departments of the environmental protection. The most of farm manure and slurry storage facilities do not correspond to the demands of environmental protection in Latvia. Thus, in the farms exceeding 10 Livestock Units it will be necessary either to construct new or reconstruct the old manure and slurry storage facilities and perform an assessment of their influence on the environment[9].

Today the law determines that impact assessment on the environment is required for the building and reconstruction of pig and poultry intensive breeding complexes containing more than:

- 85 000 broilers;
- 60 000 laying hens;
- 3 000 pigs with live weight more than 30 kg;
- 900 sows[9].

2.3. MAINTAINING OF MICROCLIMATE IN LIVESTOCK BUILDINGS

42. Slurry and manure should be frequently removed from the stables.

Livestock production is the major source of the emission of different odours and gases in the atmosphere usually arising from livestock buildings, manure and slurry storage facilities and from the

[9] Law on The Assessment of Influence on the Environment

application of manure and slurry on the farmland. Frequent removal of slurry and manure will help to control the emission of smells and gases from livestock buildings.

Practical guidelines

- In livestock buildings manure and slurry has to be collected and transferred to a suitable storage every day.
- Farm vicinity and manure storage facilities should be kept clean.
- Slurry leakage from manure storage should be prevented.
- Use enough bedding where appropriate to keep animals clean.

Table 14. **Indispensable mass of bedding per one animal**

Group of animals	Form of bedding	Daily normative, kg	
		Collecting slurry separately	Collecting slurry with bedding
Dairy cows	straw	2,5 - 3,0	6,0 - 7,0
	peat	2,0 - 2,5	7,0 - 8,0
Sows	straw	3,0	5,0 - 6,0
	peat	3,0	5,0 - 6,0
Fatteners	straw	1,5	2,5 - 4,0
	peat	1,2	1,5 - 3,0
Sheep	straw	-	0,5 - 1,0
Horse	straw	2,0 - 2,5	4,0 - 5,0
	peat	1,5 - 2,0	5,0 - 6,0
Hens	peat	-	0,015 - 0,030

The indispensable amount of beddings is calculated assuming that the moisture of chopped straw is 20%, and of peat - 40%. If peat moisture reaches 50%, the amount of the used bedding has to be increased 1,25 times. If 60%, it should be increased respectively 1,5 times. The bedding has to be stored in dry places to avoid the formation of mould and dust that diminishes the moisture absorption capacity of the bedding.

Manage drinking systems to avoid overflow and spillage.

If livestock is kept in groups, thoroughly clean and disinfect buildings after each batch or stock is removed:

- dust should be removed accurately from all inner surfaces of farms, particularly, from different wrinkles, ventilation shafts, engine bonnets;
- keeping animal pens clean can diminish odour emission.

Uncleanness and anti-hygienic conditions are the result of different reasons, including unskilled management and farm construction. Increase of animal density, bad ventilation, discrepant construction of animal pens, poor floor surface, bad functioning of feeding and drinking equipment create untidiness in animal pens.

If livestock is kept individually, clean and disinfect individual pens thoroughly when they are empty:

- the pen must have suitable dimensions to keep clean a dairy cow tied to an individual pen. The bedding has to be always clean and unspoiled. It has to be added every day;
- Passages between individual pens have to be cleaned very carefully and daily.

Dairy and parlour buildings need to be washed and cleaned frequently. If disinfectants are used, make sure you have the correct type and quantity of disinfectant and the right volume of washing water. If high-pressure hoses are used, take care to avoid splashing of manure on walls, ceilings, and milking equipment.

Clean out grit and sediment from slurry channels, collection systems and stores. Thick sediments encourage microorganisms to grow and produce bad odorous.

Areas of concrete used by livestock should be cleaned after animals are removed.

Poor ventilation can result in humid conditions that stimulates unpleasant odorous, high levels of ammonia, and poor animal health. Ventilation fans should be maintained, and the farmer has to check whether they function with the correct airflow corresponding to the numbers and weight of animals.

2.4. DECREASE OF AMMONIA EMISSION FROM ANIMALS BY THE ENHANCEMENT OF NUTRITION

43. Animals should be fed according to balanced feed rations in order to minimise emission of ammonia from the animal organism.

Practical guidelines

Cattle use productively about 24% of the ingested feed nitrogen protein, pigs – up to 40%. Faeces and urine excrete the remainder.

To improve the productive use of nitrogen:

- protein rationing has to be used for dairy cows and ruminants in rumen degradable and rumen not degradable fractions;
- the corresponding ideal protein model has to be achieved for pigs of each productivity group by use of synthetic amino acids. The total amino acid requirement has to be stabilized, thus reducing the total nitrogen intake and excretion in faeces and urine;
- the farmer has to consult on these issues with the Latvian Agricultural Advisory experts in Ozolnieki, Jelgava, or with advisors from local district offices or experts of Latvia University of Agriculture. Every farm has to perform chemical analyses of the produced forages.

2.5. STORAGE OF FORAGE

43. A correct storage and utilization of forage should ensure proper animal sanitary conditions in animal buildings and in the production of qualitative and unpolluted animal produce.

Practical guidelines

Finely ground feed and feed remains (in bins and on flours) increase the amount of dust. Odours can be absorbed by dust particles and thus diffused in the air.

To improve the situation:

- try to use new mechanisms for preparation of concentrated feed - grain flaking, high-moisture grain preservation, for pigs - pelleted mixed feed feeding with moisture technology;
- it is preferable to use the mixed concentrated feed in a pelleted form.

Keep food such as milk by-products (whey, skimmed milk), yeast, and molasses, that can produce strong odorous in properly constructed covered tanks or silos. Feed animals very carefully.

Odours from silage clamps sometimes create problems in dairy production. Well-made silage causes less odours than the silage that is not produced qualitatively.

Balled silage has the advantage as it is enclosed until you use it, thus only a small quantity of this product is exposed at any time. Careful use of this technique can help to limit the amount of odours released.

2.6. DISPOSAL OF ANIMAL CARCASES

45. Animals carcasses should be disposed of at a rendering plant[10].

Disposal methods on the farm such as burial or burning in the open may cause water or air pollution.

Practical guidelines

Never dispose of carcasses in or near watercourses. Apart from causing water pollution it involves a serious risk of spreading diseases to animals of neighbouring farms.

You should report any suspicion of a disease that has caused ill health or death of animals to Veterinary Offices at the local Animal Health Agency. Carcasses should be made available for post-mortem examination in such cases.

If no disease is suspected, and no other means for the disposal of carcasses are practical, the carcasses can be buried on the farm as long as the following rules are met:

- the burial site must be at least 250 metres away from any well or spring that supplies water for human consumption or for the use in farm;

[10] Law on Veterinary

- the burial site must be at least 30 metres away from any other spring or watercourse and at least 10 metres away from any field drain;
- the bottom of the buried pit should have at least one metre of subsoil above it, so that the carcass is covered by at least one metre of soil below the topsoil;
- the bottom of the burial pit must be free from standing water.

2.7. ANIMAL WELFARE AND HEALTH STATUS AS THE BASE OF A QUALITATIVE MANUFACTURING OF ANIMAL PRODUCES

43. Manufacturing of animal produces should be done with consideration of animal welfare and health conditions.

Practical guidelines

Animal health conditions and, consequently, consumer health depend on the following factors:

- use of growth promoters and antibiotics;
- unfavourable conditions for animal welfare and threats to animal health;
- use of genetically modified organisms in agriculture.

An intensive use of growth promoters and antibiotics causes serious problems for human and animal health. Moreover, many bacteria develop immunity against antibiotics, and thus undermine prospective efforts in their extermination.

A raise in the intensity of breeding and pedigree record and the improvement of feed quality and keeping conditions as appropriate for each animal species will diminish the necessity for antibiotics.

It is not permitted to use growth stimulators including hormone preparations, because it is not possible to predict their concentration in animal produce.

In order to improve animal health and welfare it is necessary

- to use well balanced feeding rations;
- to avoid long transportation of animals;
- to provide a suitable extra space for exercises.

The quality of animal produce is important for the consumer as well as the producer

- consumer should be able to choose high quality and healthy products;
- information about the production conditions should be available for consumers;
- the quality offers the producer an advantage in the advertisement of his goods.

The use of genetically modified organisms in agriculture increases every year. In animal husbandry it is an ethical problem, and it has to be evaluated as a very risky undertaking.

3. COLLECTION AND STORAGE OF ORGANIC MANURE

3.1. INTRODUCTION

Livestock farms, manure storages and silos are critical sources of dangerous pollutants due to a high concentration of chemical elements (especially nitrogen, phosphorus) and high content of organic matter in the manure and in the run-off. Nitrogen evaporates mainly in the form of ammonia from these buildings to atmosphere. Soil accumulates different chemical compounds and organic matter. However, if such substances are disposed of continuously, possibilities of their leaching from soil will increase. Phosphorus, ammonium nitrogen, and organic matter are usually bound in the topsoil and can reach watercourses in the surface run-off with out-washed soil particles. The nitrate nitrogen is mobile in soil, and its transmigration with run-off stream can pollute the groundwater.

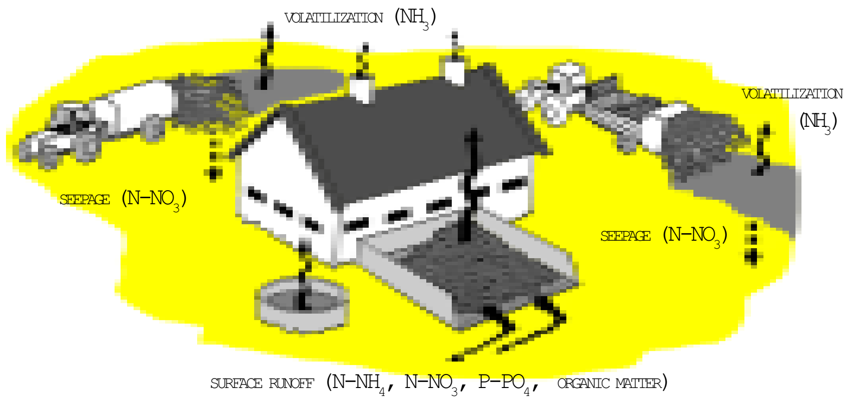


Figure 1. The influence of organic fertilizers on the environment

A rational utilization of plant nutrients and protection of the environment are mutually interconnected processes. Carefully managed and utilized plant nutrients have less pollution impact on the environment and at the same time increase the yield.

3.2. THE LOCATION OF FARMS, MANURE STORAGES AND SILOS

47. Livestock buildings, manure and silos storages should be located in a way to minimise their harmful influence on the environment.

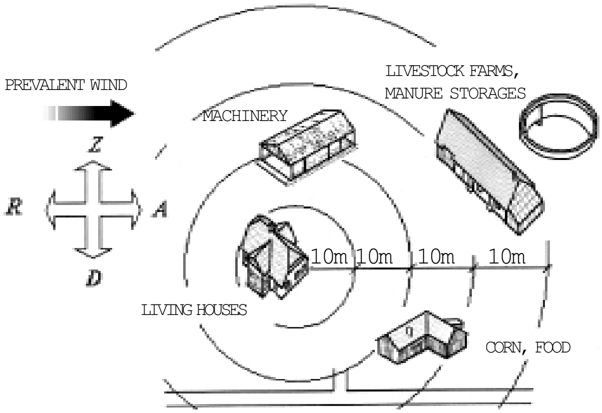


Figure 2. An advisable location of buildings in a territory of a farm

Practical guidelines

The construction of new livestock buildings should take place in an appropriate location against the living houses taking into consideration the prevalent wind direction.

The stable should be located along the north – south direction to improve the lighting and ventilation of the stable. It is useful to locate the manure storage in the eastern side of the barn to limit the diffusion of odours in the rest of the farm's area.

Collection and draining of precipitation from roofs should be implemented to improve the farmyard conditions after rainfalls and to restrict the dissipation of pollution to the environment.

> **48.** It shall be ascertained that there are no restrictions applying in the territory of the construction of livestock barns, manure storages or silos. The minimum distances to the objects of high hazard must be observed.[5; 11; 12]

Additional information

The existing legislation prohibits building of new farms, storages for fertilizers, silos, and enlargement of the existing farms in the following areas:

- shelter belts of the dunes of the Baltic Sea and the Riga Gulf;
- shelter belts of rivers and other watercourses;
- nature reserve areas of strong regime;
- restricted areas of national parks;
- restricted areas of biosphere reserves;
- nature conservancy areas;
- nature parks;
- periodically flooded areas;
- green belts in cities.

Following minimum distances to specific objects should be considered in the location of new

[5] Law on shelter belts
[11] Rules for protection and reclamation on territories of special preservation
[12] Method on designation of shelter belts around the water-supply sources

farms, manure storages, and silos:

- 50 m to watercourses and water streams (including collecting ditches of melioration systems), but not less than the prescribed width of shelter belts (Chapter 5);
- 500 m to water basins used for centralised water-supply systems;
- 1000 m to health resorts, if not stated otherwise;
- 500 m to memorials, if not stated otherwise;
- 200 m to hydro meteorological monitoring stations and stationary monitoring posts of state significance.

Following distances to other objects are recommended to prevent deterioration of the environmental situation:

- 20 m to other ditches of melioration systems (interruption and drainage channels), underground water collection places;
- 30 - 50 m to wells, depending on local conditions;
- no less than 15 m to living houses in farms;
- 200 m to public buildings (living houses, schools etc,);
- 500 m to populated areas, cottage areas, areas of gardeners' associations,
- 20 m to the borders with other land properties;
- 200 m to locations of protected plants, and rare biotas.

An increase of the production is not allowed in the farms located within the aforementioned distances. Their further operation is allowed only after measures to improve the environmental situation are implemented. Manure storages shall be reconstructed if needed to ensure prevention of any seepage, decrease of ammonia evaporation by covering manure storages (especially, nearby populated areas), and prevention of any surface run-off from manure storages.

3.3. NECESSARY MANURE STORING PERIOD AND VOLUME OF STORAGES

49. The volume of storage facilities should be large enough to storage manure during the period when spreading is not allowed. Litter manure storages should provide accumulation of the volume produced during at least 6 months, but slurry tanks – for 8 months period.

Practical guidelines

The typical climate conditions promote the plant nutrient leaching during the whole year in Latvia. However, its quantity depends on the season and local conditions. It is important that the largest amount of leaching occurs in periods with less plant vegetation – in spring, autumn and in winter. The losses of leached plant nutrients can be very considerable during the aforementioned periods due to the high water level in ditches, and intensive operation of drainage systems and rivers.

The spreading of manure before or after vegetation periods significantly increases the losses of plant nutrients. The relative shortage of plants and the elution regime of water seepage promote the leaching of plant nutrients Under climatic conditions of Latvia. Therefore, the spreading of fertilizers is not advisable in winter, in late autumn when the rainfall season has started, and in very early spring when drainage systems operate intensively.

The length of manure accumulation and storage period should be considered in calculations of the volume of manure storages. In Latvia the manure spreading period continues from middle April to middle October, therefore the volume of farmyard manure (FYM) storages should be envisaged for at least a 6 months storage period. The volume of storages should be increased considering 8 months of accumulation, if water is used for manure collection and transportation. It is recommended to collect urine into separate reservoirs intended for 8 months storage period.

An empty form for calculation of the required manure storage capacity of your farm is available in Appendix 3. In principle, the capacity of each type of manure storage should be calculated respectively, i.e. separate calculation for storage of solid manure and for slurry. It is assumed that a ton of manure equals to a volume of 1 m^3. It is approximately correct for most manure types. If manure is mixed with large amounts of bedding material (straw, wood chips or peat), the density is smaller, and it should be considered when converting tonnes to m^3. See Table 15 for converting from tonnes to m^3.

3.4. MANURE ACCUMULATION AND STORAGE

50. Farmyard manure should be accumulated and stored in a way to minimise the losses of plant nutrients, and to avoid the influx of precipitation into storages. The construction of storages should provide for reliable and convenient operation.

Practical guidelines

In order to prevent the urine and manure leaching in groundwater, the floors, manure channels and reservoirs should be impermeable and of a proper mechanical and chemical resistance. The inspection of impermeability and reparation of defects should be performed periodically.

To minimise the volume of precipitation influx in storages:

- areas of access roads and manure storages should be planned as small as possible;
- litter manure should be stacked in heightened piles (2 – 4 m) to facilitate self-compaction of manure.

***Table 15.* The amount of manure (FYM) depending on the height of heaps on 1 m² storage area**

Height of heap m	Amount of manure on 1m² t/m²	Density t/m³
1,0	0,85	0,85
1,5	1,32	0,88
2,0	1,80	0,90
2,5	2,30	0,92

Considering the gradual filling of storages and eventual changes in herd size, it is recommended to section the storage area to provide for convenient collection of manure effluent and rainfall water from the storage's area used for manure unloading.

Walls increase the capacity and facilitate convenient emptying of the storage if erected in 1,0-1,5 m height and in width of at least 0,2 m.

If manure is unloaded near the barn, an empty zone in width of 1,5 – 2,0 m should separate manure and the barn.

The surfaces covered with manure should have a slope of 1-3 % towards the reservoirs to ensure the collection of leached liquids.

Roofs should be provided with waterspouts to carry water outside the storage's area in order to avoid precipitation influx in storages.

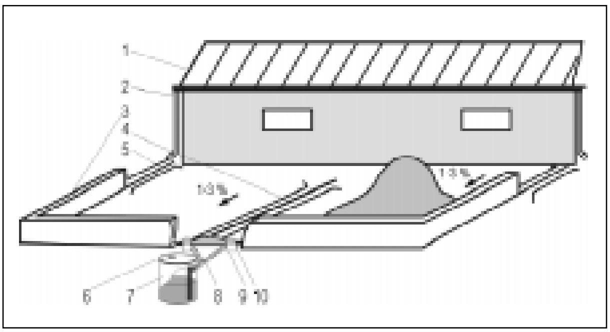


Figure 3. Scheme for the storage of litter manure: *1- stable, 2 – water-spouts, 3 – wall, 4 – elevated storage floor, 5 – elevated edging, 6 – tank, 7 – lid, 8 - pipe, 9 – grid, 10 – pit for sediments.*

Stalk materials in the thickness of 0,3-0,5 m should be used for the underlay of manure piles to absorb the manure effluent and accumulate the rainfall. Heaps should be covered by a layer of peat or chopped straw to minimise the losses of ammonium nitrogen. Piles covered by layers of air insulation (i.e. plastic sheets, rubber, etc.) decrease the composting processes and reduce the losses of plant nutrients.

The amount of manure per area unit of storage can be increased if litter manure is heaped in high piles. Trailers should be placed on solid and impenetrable ground that would drain off leached liquids into the reservoirs.

Storage of manure is not acceptable on the field. Nevertheless, as an exception, field manure storage might be situated in plain and dry sites with little penetrable soil. A layer of peat, straw or other absorptive material of at least 0,5 m should be placed under manure heaps. The compacted manure should be covered with a 0,2 – 0,4 m, deep layer of peat or chopped straw. Field manure storages should not be located in the same places as in previous years.

Slurry storage reservoirs may be of different constructions, however few basic principles should be considered in their construction. A slurry inlet should be provided below the level of liquid in tanks, i.e. via water seal, to avoid the inflow of poisonous gases in the barn. The volume of preparation tanks should ensure accumulation of slurry produced in a period of at least two days. However, for a convenient use of a tractor drive pump for transportation of slurry to the main storage, the preparation tank should provide an accumulation of slurry for 7 – 30 days. The mechanic and chemical characteristics of slurry reservoirs and manure storages should guarantee operation for a period of at least 20 years.

The inlet of slurry should be placed close to the bottom of the storage to minimise the nitrogen losses in the form of ammonia. The losses of nitrogen can be further reduced by covering the slurry surface with a layer limiting the access of air (plastic sheets, seed oils, stable materials) or by an installation of roof over the storage. The slurry should be mixed only before emptying the storage. Equipment of respective power should be used for this purpose (for example, tractor drive mixer).

For safety of humans and animals the uncovered storages must be surrounded with a fence in the height of at least 1,5 m. Warning signs should be placed nearby the slurry tanks.

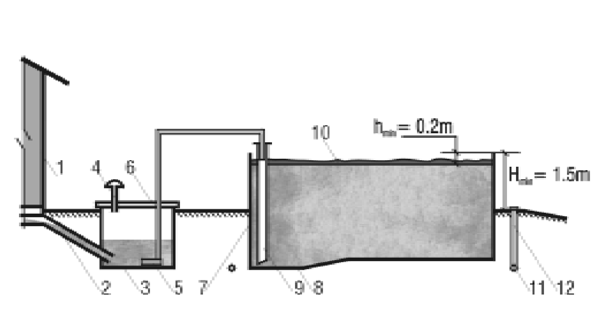


Figure 4. Scheme on slurry collection: *1- stable, 2 – input tray, 3 – preparation tank, input pipe in store, 4 – ventiduct, 5 – pump, 6 – lid for tank, 7 – slurry storage, 8 – socket for emptying, 9 – pipe, 10 – layer for air insulation, 11 – drains, 12 – well for control of water.*

Covered storages should be constructed for accumulation and storage of poultry manure, unless special manure processing or composting technology is used. It is impossible to keep fresh poultry manure in large heaps due to their high water content, and substantial plant nutrient losses occur if manure is stored in small heaps.

> **51.** Manure storages or special constructions should be used for manure composting.

Practical guidelines

The constructions of composting places should have floors of impenetrable materials. Leached liquids should be collected and stored. Plain and never flooded sites have to be chosen in case the composting is done on the field. At least 0,5 m deep layer of peat, straw or other absorptive materials should be placed under heaps.

3.5. CONSTRUCTION OF STORAGES AND MATERIALS

52. According to law storages shall be built from qualitative materials and technologies to ensure their safety[13; 14].

Practical guidelines

The building of storages shall be performed according to the existing building normative and regulations.

The floors of manure storages should be at least 150 mm thick (concrete class B25). The walls of slurry pits and manure stores should be planned at least 150 mm thick, but the supporting walls for manure storages should be constructed 200 – 250 mm thick (depending on their height).

The bed for the floor of storages should be a 150 mm deep layer of sand and gravel. The concrete used in constructions must be of high quality (class B25). The floor should be divided (with wood lathes, iron profiles etc.) in areas up to 35 m^2 in order to prevent the emergence of fissures.

The recommended size of armature net for floors is 150x150x8 mm. The joints of armature are spliced in 300 mm. Special measures to increase impermeability of concrete are not necessary given the physical characteristics of manure.

3.6. MANURE SPREADING

53. The manure spreading should be done qualitatively with special attention to the machinery used.

Practical guidelines

Soil compaction should be avoided during the manure spreading. Soil containing excess moisture is especially sensitive to compaction. Soil compaction is reduced if wide tires of low pressure are used. Spreading of manure should be performed in a way to reduce unnecessary driving on fields. Manure should be spread as evenly as possible. For example, it is advisable to provide the spreading equipment with trailing hoses for slurry spreading. Thus, no slurry reaches leaves of plants, and the losses of nitrogen are minimized.

[13] Construction law

[14] Common normatives for construction

3.7. SILAGE EFFLUENT COLLECTION

54. Silage effluent that is produced during the silage preparation and storaging should be collected. The leaching of silage effluent to the environment must be prevented.

Practical guidelines

The amount of silage effluent makes about 5 – 10% of the volume of herbage dried previously or 20% of the volume of green herbage. A proper use of technology and preservative substances can reduce the excretion of silage effluent. The leakage of silage effluent in watercourses, even in small amounts, can cause death of fish and other water creatures.

Silage effluent can be collected in slurry tanks or in special underground reservoirs. It can be collected and stored in slurry pits if silage effluent is mixed with slurry not to exceed 5% of the total volume.

In order to provide a proper maintenance of constructions, it has to be considered that silage effluent promotes the corrosion of different materials, including steel and concrete.

Silage effluent can be utilized for fertilization in a rate of up to 50 m^3/ha.

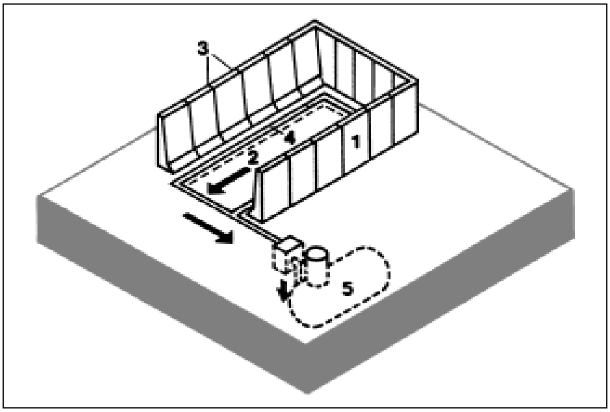


Figure 5. Scheme of the collection of leakage from silo: *1 – silo for ensilage, 2 – concrete, 3 – seals packed with pitch or mastic floor (concrete or bituminous), 4 – tray for the collection of silage effluent, 5 – tank for the storing of the leached silage effluent.*

55. The aforementioned manure regulations are recommended for all farms, and should be strictly observed by farmers that possess more than 5 livestock units.