PBL Netherlands Environmental
Assessment Agency

Evaluation of the Manure and Fertilisers Act 2016:
Synthesis Report

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H. van Grinsven & A. Bleeker

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Corresponding author
hans.vangrinsven@pbl.nl

Authors
Hans van Grinsven and Albert Bleeker

Contributions by
Jan van Dam, Frank van Gaalen, Sonja Kruitwagen, Marian van Schijndel, Sietske van der Sluis, Aaldrik Tiktak, Roos den Uyl, Henk Westhoek

Graphics
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George Burggraaf

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Summary

Dutch fertiliser and manure policy stabilises manure problem but offers no solution

The Dutch Manure and Fertilisers Act (*Meststoffenwet*), in part, is the Dutch implementation of the Nitrates Directive. The Manure and Fertilisers Act determines, among other things, how much nitrogen and phosphate, in the form of fertilisers and animal manure, may be applied on grassland and arable land, as well as the application method. Since the introduction of the Dutch nitrogen and phosphate application standards in 2006, environmental quality has improved further. On average, the target of a maximum of 50 milligrams of nitrate per litre of groundwater has been met in nearly every location. Only in the southern sand region, the average nitrate concentration in upper groundwater continues to exceed the target level. However, a solution to the eutrophication problem in regional surface waters strongly influenced by agriculture, is not yet in sight; there, nitrogen and phosphorus targets are still being exceeded, by a substantial margin. Another aspect of the manure problem is the continued, high pressure on the manure market. About half of the manure produced must be disposed of by the livestock farms, of which half outside the Dutch agriculture.

Nitrates target almost met, but in the southern sand region exceedances persist

An important objective of the Nitrates Directive has almost been achieved; over the 2011–2014 period, exceedances of the nitrates target in the upper groundwater of the sand region, on average, were below 5 milligrams per litre. Nitrate concentrations decreased, between 2006 and 2014, but by less than in the period before 2006. Model analysis has revealed that this decrease is mainly the delayed effect of measures during the period before 2006, and caused by slowly declining mineralisation of soil nitrogen. Exceedances in the southern sand region were substantial, with 30 milligrams of nitrate per litre. A considerable part of current exceedances could be the result of manure fraud. Indications of such fraud are exceedances of the legal maximum

application of animal manure, as inferred from regional manure accounting. Compliance monitoring results showed that, on approximately 10% of the so-called high-risk farms, one or more of the legal application standards were being exceeded, and as also indicated by frequently occurring unlikely high phosphate levels in samples of transported manure. Models predict that exceedances in the southern sand region will decrease to 10 milligrams of nitrate per litre by 2027, despite the introduction of lower nitrogen application standards in 2014. Model analysis revealed that the potential decrease in nitrate leaching is largely offset by an increase in the use of nitrogen-rich manure separation products. This allows farms to use more nitrogen from animal manure within legal nitrogen application limits, without exceeding the phosphate application standards.

Current implementation of WFD will hardly reduce eutrophication by 2027

One of the objectives of the Nitrates Directive is to reduce eutrophication of surface waters. The Manure and Fertilisers Act does not include eutrophication targets but these are part of the implementation of the Water Framework Directive (WFD) to attain a good aquatic ecology by 2027. Over the 2011–2014 period, these eutrophication targets for phosphorus and nitrogen were exceeded in about half of the monitored surface water sites that are predominantly influenced by farmland. If agriculture-related sources are to deliver a proportional contribution towards achievement of these targets, the national agricultural load should decrease by approximately 40% for phosphorus and about 20% for nitrogen. With the current implementation of the Manure and Fertilisers Act, by 2027, approximately one third of this WFD task for nitrogen will be realised and approximately 10% of the task for phosphorus. The Manure and Fertilisers Act, therefore, makes a modest contribution to achievement of the eutrophication targets as defined in the Nitrates Directive (prevention and reduction) and the WFD (achievement by 2027).

Around 2014, the current Manure and Fertilisers Act ended the accumulation of phosphates in agricultural soils. Achieving a national balance between phosphate input and output was a target of the Manure and Fertilisers Act set in 1995 for the year 2000. Stricter phosphate application standards since 2010 for phosphate-saturated soils, has results in a reduction in phosphate levels – for grasslands, at an annual rate of more than five kilograms per hectare. Nevertheless, model analysis has indicated that a decrease in phosphate in soils is unlikely to contribute to improved surface water quality until after 2027.

Current policy approach offers few prospects for solution to manure problem

The nutrient loading of surface waters can be reduced by measures to reduce soil nutrient surpluses. Reducing the use of manure and artificial fertiliser by further tightening of the application standards would be most effective. From an agronomics perspective, however, there is little room for a further tightening of nitrogen application standards, as these are already at or just below recommended fertiliser levels.
For phosphate, there may still be some room to do so. As the amount of artificial phosphate fertiliser used on arable land is already low and on grassland is almost none existent, tighter legal standards automatically mean less room for the use of animal manure. This in turn leads directly to higher manure disposal costs for livestock farms and possibly to lower revenues for arable farmers and extensive livestock farmers for taking on manure surplusses. Therefore, measures that prevent nutrients from reaching surface water are more favourable, such as those that prevent surface run-off of nutrients and those that improve soil structure. For farmers, a barrier to taking these measures is often that, in the short term, they lead to additional costs or work. Over the past decade, on a national level, the cost of disposal of livestock manure has been fairly stable, at an annual 250 to 300 million euros. Per farm, manure disposal costs tend to be increasing for pig and dairy businesses, but this is mainly due to the autonomous expansion of these farms. For an average pig farm, the costs amount to 40,000 euros per year, and represent about 5% of total production costs. Many farmers express their concern about further tightening of application standards leading to reduced crop yields and soil fertility. Although these concerns are not supported by measurement data, in combination with increasing manure disposal costs, they add to decreasing support for the Manure and Fertilisers Act among farmers.

Limitations to the size of livestock farms remain necessary

In general, a smaller number of livestock reduces pressure on both the environment and the manure market. However, many livestock farms strive to expand in order to increase economic efficiency and farm income. From the year 2000 onwards, under the Manure and Fertilisers Act, pig and poultry livestock numbers have been capped via a system of tradable manure production quotas. These quotas are fully utilised, and in some regions, quotas are being exceeded by dozens of percents. Indirectly, livestock numbers are also being limited by the legal maximum threshold for manure application. In order to achieve targets for ammonia and greenhouse gas emission levels and water quality, it is therefore important to maintain the quota system for pigs and poultry, and to introduce phosphate production quotas for dairy farms, which are currently planned for 2018, to compensate control of manure production, following the abolishment of the milk quota system in 2015. The use of low-phosphate feed also contributes to reducing current pressures on the manure market.

Increasing dependence on manure exports makes the livestock sector vulnerable

Ever decreasing amounts of manure can be disposed of within the Dutch agricultural sector, due to the gradual tightening of the phosphate application standards. This leads to an unrelenting pressure on the manure market; the costs of manure disposal remain high, and dependence on the export of manure and manure products increases.
The introduction of mandatory manure processing has boosted the manure processing industry but has not reduced pressure on the manure market or reduced disposal costs per tonne of manure. In particular, the export of unprocessed, and sometimes unpasteurised, manure products is not future-proof. There is a risk of exporting pathogens, and Germany, which is the main importer of Dutch manure, is in the process of revising and tightening its manure policy. This makes for a vulnerable future for animal husbandry in general and pig farming in particular, because of the latter's large share in manure exports.

Current approach to tackle manure problem has reached its limits

The current regulatory and generic approach under the Manure and Fertilisers Act seems adequate to achieve the nitrates target for groundwater. However, it is not delivering custom solutions to achieve the nutrient targets in the Water Framework Directive (WFD) in regional surface waters, in large parts of the Netherlands. The nitrates target could be achieved, especially if national and regional authorities, the agricultural sector and the affiliated agro-industry would work together to tackle the issue of manure fraud. However, current conventional agricultural and fertiliser practices – although in accordance with agronomic recommendations and economically optimal crop choices – will not lead to achievement of the WFD nutrient targets in regional surface waters, especially in the Dutch southern sand region and central clay and peat regions. The Manure and Fertilisers Act does not provide positive incentives for farmers to change their current fertiliser practice. A first step for the authorities to improve both farm support and credibility of the Manure and Fertilisers Act would be to reinvest in their communication about the Act's targets and measures and its relationship with targets in Nitrates Directive and the WFD.

Regional solutions offer more perspective to meet the WFD's nutrients objectives

A more regional approach offers a better perspective for achieving the targets of the Nitrates Directive and the WFD, and is in line with WFD implementation through river basin management plans. In regional arrangements, farmers, agro-industry, water management organisations, government authorities, nature conservation organisations, NGOs and inhabitants work together to find economically achievable and accountable targets and packages of measures while integrating goals for water quality with those for other policies (such as nature and climate). In this way, there is more scope for the development of local solutions, with farmers and other stakeholders sharing knowledge and creating synergy advantages. Achievement of targets is improved while negative side effects for farming in the catchment areas can be reduced by improved coordination between farms of land use, crop choices, fertiliser and manure application and intensity, and by improved linkage to local ecosystem sensitivity . Currently, farms are individually held accountable for the proper implementation of the Manure and Fertilisers Act. The proposed regional approach would require experiments with new legal instruments to equalise local exceedances of environmental goals and the costs of measures or yield losses between farms. Coordination of this regional process by national and regional authorities remains necessary to secure that regional environmental targets are achieved and problems are not passed on to neighbouring regions. Moreover, the government is accountable to the European Commission for implementation of common EU directives. Although regional solutions offer a better perspective for achieving the targets, in some regions, the WFD objectives are not reconcilable with the conventional agricultural economy.
The question is whether, and at what cost, these objectives should be achieved everywhere, or if new less productive, extensive forms of agriculture have potential and can be subsidised or financially compensated.

FINDINGS

Evaluation of the Manure and Fertilisers Act 2016: Synthesis Report

Introduction

The Dutch Manure and Fertilisers Act came into force, in 1987, to reduce nitrogen and phosphorus losses, from fertilisation to improve soil, water and air quality. Since 1996, the Manure and Fertilisers Act also represents the Dutch implementation of the EU Nitrates Directive.

The Manure and Fertilisers Act states that the Minister (currently the Minister of Economic Affairs) reports to the Dutch House of Representatives, at least once every five years, about the Act's effectiveness and efficiency. Since 2002, the evaluation of the Act has been in the hands of PBL Netherlands Environmental Assessment Agency (and its predecessors), Wageningen University & Research (WUR) and other institutes, such as the National Institute for Public Health and the Environment (RIVM) and Deltares. The previous evaluation dates from 2012. The main theme of the 2017 evaluation centres on whether groundwater and surface water quality has improved, policy targets have been achieved, and, if so, what the contribution of the Manure and Fertilisers Act has been, in this respect. The evaluation looks back on the period 2006 to 2014 in particular (ex-post evaluation), but also looks to the future, to the 2017–2027 period (ex-ante evaluation). In addition, the costs and benefits for both agricultural businesses and the government in relation to the Manure and Fertilisers Act are also quantified. The related policy efficiency, however, could not be assessed due to a lack of information.

Parallel to the ex-post and ex-ante evaluations, WUR has also conducted a study into farmers' experience with the fertiliser policy, how this affects their support for the policy, as well as how any bottlenecks could be solved. The study was used in an exploration of the perspectives in the agricultural sector in order to improve achievement of the environmental goals. This included elements such as maintaining a balance between supply and demand on the manure market and economic perspectives for the agricultural sector.

Nitrates Directive

The main objective of the EU Nitrates Directive is to improve water quality via reduced agricultural pollution. The directive's introduction states the common interest of 'protecting human health, maintaining and improving terrestrial and aquatic ecosystems, and ensuring the lawful use of water'. The directive's measures and regulations have been elaborated in the Manure and Fertilisers Act. In addition, part of the policy on fertilisers has been incorporated into the Soil Protection Act and the Environmental Activities Decree (Activiteitenbesluit Milieubeheer).

The implementation of the Nitrates Directive is to lead to reduction as well as prevention of nitrate leaching from agriculture and the possible resulting eutrophication. The Nitrates Directive, therefore, prescribes that fertilisation is done according to so-called Good Agricultural Practices, and sets a strict maximum threshold for the use of animal manure, of 170 kilograms of nitrogen per hectares. The Netherlands utilises the option of derogation, which allows a conditional 250 kilograms of nitrogen per hectare for farms with grazing livestock. Derogation is both applied and approved per farm.

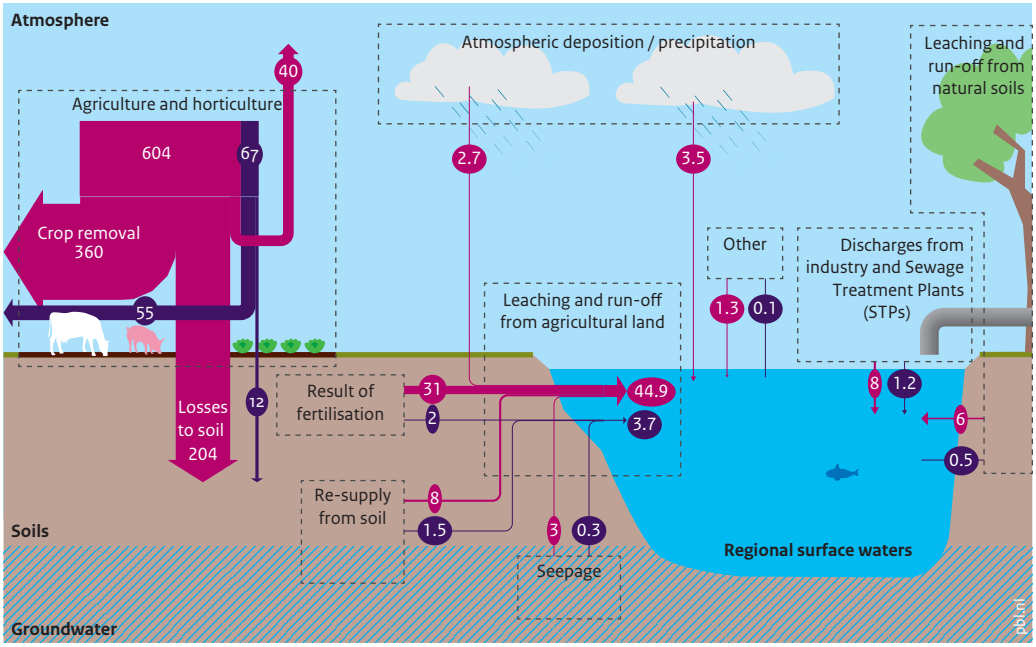
Measures towards improving water quality are formalised in the Nitrates Action Programme (NAP), with four-yearly progress reports being submitted to the European Commission. Every four years, the action programme is reviewed on the basis of the related progress report. In 2016, the fourth NAP progress report was published, and the current, fifth action programme runs from 2014 to the end of 2017.

Demarcation and approach

The ex-post evaluation focuses, in particular, on the 2006–2014 period. The system of nitrogen and phosphate application standards was implemented in 2006; replacing the MINAS system of loss standards. The fourth Nitrates Action Programme ended in 2013, after which the fifth was started. Data for the period before 2006 were also included in this evaluation, when relevant, and, in some cases, data were also available on 2015 and 2016. The ex-ante evaluation's horizon of 2027 was chosen because that is also the horizon used in the EU Water Framework Directive (WFD). The WFD target of achieving a 'good ecological state' by 2027 is closely related to one of the objectives of the Nitrates Directive; namely, that of reducing eutrophication. Fertilisation has led to agricultural soils being the main source of nitrogen[1] and phosphate[2] in regional surface waters (Figure 1). An important difference between the two directives is that the Nitrates Directive mainly prescribes means and methods and mandatory efforts, whereas the FWD contains a result obligation. This leads to divergent opinions among stakeholders about the role of the Manure and Fertilisers Act in achieving the WFD targets.

Figure 1

Nitrogen and phosphorus balances of regional waters, 2010–2013



In million kilograms → Nitrogen (N) → Phosphorus (P)

Source: Wageningen Environmental Research; PBL

The ex-post evaluation centres around measurements, with which the effects can be demonstrated up to and including those of the fourth Nitrates Action Programme (NAP), while the ex-ante evaluation is based mainly on models. Thus, the projected effects of the fifth NAP (2014–2017) are based on model calculations. Because policy adjustments have a delayed impact on water quality, their impact cannot be measured immediately. The evaluation results are intended, among other things, for policy accountability and as building blocks for the design of the sixth NAP (2018–2021).

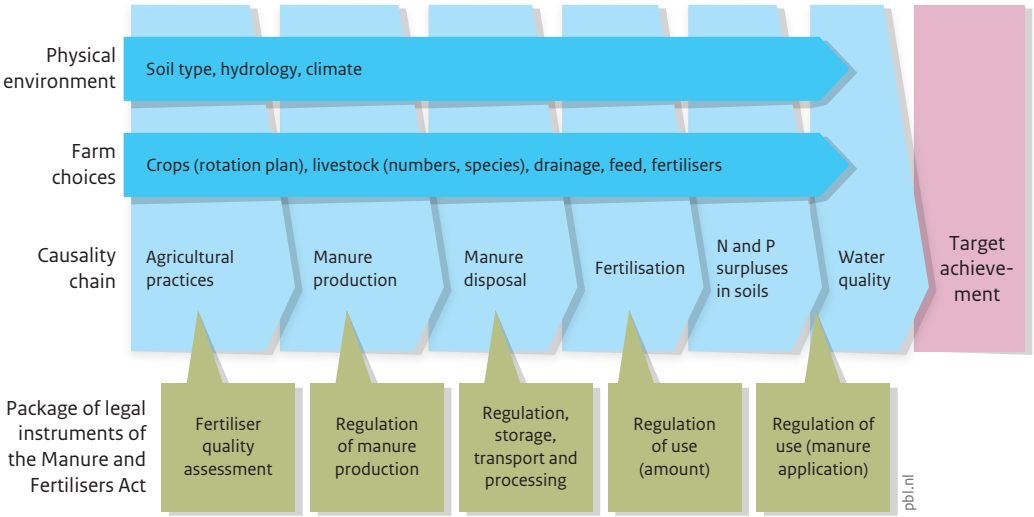
Evaluation questions

The Dutch Ministries of Economic Affairs and of Infrastructure and the Environment have drafted 60 questions for the evaluation, which were answered in the reports concerned (Velthof et al. 2017; Schoumans et al. 2017). For this PBL synthesis, the 60 questions were condensed into 10 overarching questions.

1. What have been the consequences of the Manure and Fertilisers Act for the legal maximum threshold for manure application?
2. To which degree has there been a reduction in the nitrogen and phosphate surpluses on the soil balance for agricultural land? Those surpluses are an indication of environmental pressure on aquatic systems.
3. Wat is the relationship between the eutrophication target in the Nitrates Directive and that in the Water Framework Directive?
4. To which degree is the nitrates target (of 50 mg nitrate per litre) achieved for groundwater below agricultural soil, both currently and in the future? How it this affected by the Manure and Fertilisers Act and by how much is this impact reduced as a result of manure fraud?
5. Is there an improvement in the quality of groundwater and surface water in the agricultural region, concerning nitrogen and phosphorus?
6. To which degree are the nitrogen and phosphorus standards being achieved in regional surface waters, both currently and in the future, to support achievement of the WDF targets by 2027? What is the relationship with loading from agricultural soils and what is the impact of the Manure and Fertilisers Act?
7. To which degree do policy instruments of phosphate production quota, in coherence with the manure accounting system, contribute to achieve equilibrium on the manure market and the management of manure disposal costs? What has been the contribution of private initiatives to reduce manure production via feed measures?
8. What are the effects of the Manure and Fertilisers Act on soil fertility and crop yields?
9. What is the remaining policy task for nitrate in groundwater and nitrogen and phosphate in regional surface waters, currently and after the full impact of the implemented fertiliser policy?
10. What are the perspectives for the agricultural sector and the government to tackle the remaining task to achieve policy objectives? How do farmers experience the implementation of the Manure and Fertilisers Act? What would be the social costs and benefits of a more stringent fertiliser policy? What are the technical options of achieving environmental targets, and what are the barriers and opportunities to apply those options in actual practice?

Figure 2

Intervention points in the Dutch Manure and Fertilisers Act in relation to agricultural activities and water quality



Source: PBL

Finally

The importance of the Manure and Fertilisers Act reaches beyond its impact on water quality and on achieving the targets of the Nitrates Directive and the Water Framework Directive. Implementation of the Manure and Fertilisers Act delimits the total heads of livestock, as well as the use of nutrients. This has important effects on agricultural practices and, indirectly, on the structure of the agricultural sector. This is why fertiliser policy is also important for achieving other policy targets and ambitions, such as for ammonia, greenhouse gases, the efficient use of resources, the circular economy, and sustainability of agriculture – particularly for livestock farming.

Fertilisation and surpluses in the soil

Fertiliser policy: legal space to utilise phosphate reduced by 30% since 2006

Several adjustments have been made to the Manure and Fertilisers Act, over the 2006–2014 period. For example, phosphate application standards were tightened, gradually; the phosphate amount can be utilised in the Netherlands has been reduced by nearly 30%. In addition, a ban has been imposed on the use of artificial phosphate fertiliser on derogation farms. The legal application space for phosphate fertiliser is more limited in the central and southern sand region than it is in the rest of the Netherlands. This is the result of the, since 2010, lower phosphate application standards and the, since 2014, lower nitrogen application standards. Another cause for the reduced legal space to utilise manure in the sand region, is the decreased interest of farmers in derogation. This is related to the additional conditions and demands set for farms that wish to be eligible for derogation. For example, up to 2014, derogation farms had to use at least 70% of their land as grassland (after 2014, this was increased to 80%). Another measure is the implementation of the manure processing obligation in 2014. Livestock farmers who produce more manure than they are allowed to spread across their land must have part of that manure processed. This obligation leads to a processing task for 2017 of 30 million kilograms of manure phosphate. This task is equivalent to half of the phosphate surpluses of livestock farms in the southern, central and eastern sand regions.

Changes in the Manure and Fertilisers Act have hardly decreased the national application space for nitrogen since 2006 (for both nitrogen in manure and total *fertiliser equivalent* nitrogen). The effect of generic lowering of the application standards in the sand and loess regions was partly nullified by the introduction of higher nitrogen application standards in the clay region. However, on farm level, the introduction of application standards for nitrogen in animal manure in 2006 has meant that many dairy farmers, from then on, had to dispose of the excess manure for off-farm processing.

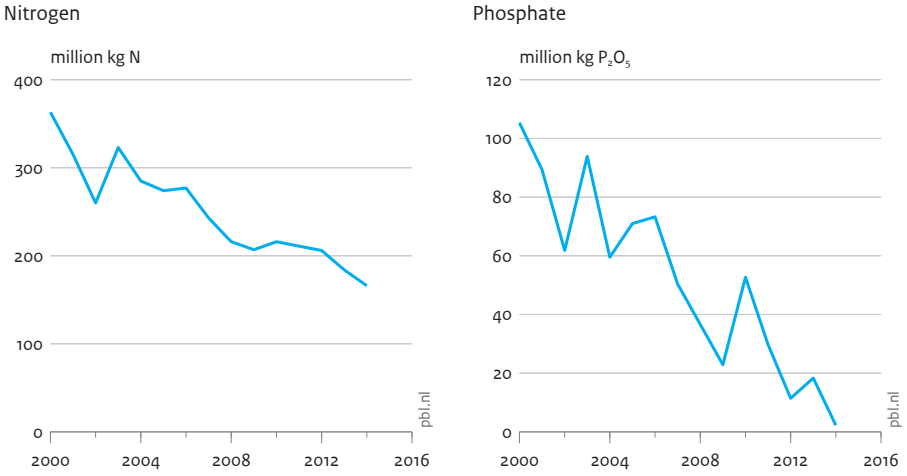
Phosphate surpluses in the soil are decreasing, but nitrogen surpluses are not

The national phosphate surplus in soil has decreased, from nearly 50 million kilograms in 2000 to only a few million in 2014 (Figure 3). From a national perspective, balanced phosphate fertilisation is achieved: soil inputs are close to the amount of phosphate that is removal. In this way, a target of the Manure and Fertilisers Act's set in 1995 for 2000 has been achieved, albeit 15 years later. Achievement of balanced fertilisation is the direct result of the tightening of the phosphate application standards and the ban on artificial phosphate fertiliser at derogation farms. The more stringent standards led to an overall reduction in the use of mineral phosphate fertiliser.

The phosphate surplus in soils is an indicator for the long-term environmental pressure on surface water. On arable farms in the Netherlands, on average, this surplus declined over the 2011–2014 period by about 50%, compared to the period from 2007 to 2010. On dairy farms, this surplus decreased by 90%. Average phosphate surpluses in arable

Figure 3

Nitrogen and phosphate surpluses on the agricultural soil balance



Source: CBS Statline

farming, during 2013 and 2014, were around 15 kilograms per hectare; in dairy farming they were around zero.
However, on a national level, the annual average over the 2011–2014 period still amounted to a surplus of 5 kilograms per hectare for dairy farms and 20 kilograms for crop farms. Over the 2006–2015 period, no statistically significant change was measured in phosphate stocks in soil (based on P-AL –extractable soil P fraction with a pH 3.75, solution of 0.10 N ammonium lactate and 0.40 N Acetic acid).

The average national nitrogen surplus in soils also declined over the period of the fourth Nitrate Action Programme (2011–2014), compared to the third period (2007–2010) (Figure 3), but average soil surpluses at farm level did not decline with statistical significance. Only on arable farms in the sand region, nitrogen surpluses have shown a statistically significant decline, due to reductions in the application of both artificial fertiliser and animal manure.

Effect on nitrate in groundwater

Target for nitrates in southern sand region not within reach

In the sand region, nitrate concentrations in upper groundwater below agricultural land have decreased, significantly (Figure 4). In the southern sand region, the average concentration decreased between 2006 and 2014, from 100 to 75 milligrams of nitrate per litre. In the other sand regions, average concentration levels decreased from around 60 to 40 milligrams per litre. The decreasing trends in the sand regions are usually in line with decreasing trends of nitrogen fertilisation and nitrogen surpluses in the soil.
These decreases are relevant for achieving the targets of the Nitrates Directive, as a reduction in nitrate leaching is one of the main targets, and because the nitrates problem is largest in the sand region.
Despite the decreases, the maximum of 50 milligrams nitrate per litre is being exceeded on 46% of farms in the sand region, and in loess region this is on 64% of farms. In the clay region, this is 7%.
On derogation farms, nitrate concentration levels in the upper groundwater are slightly lower than on average dairy farms in the sand region. Less nitrate is leached, as derogation farms in the sand region, on average, have a larger share of grassland and wet soils.

Under current policy, the decrease in nitrate concentrations in the southern sand region is expected to be insufficient to achieve the nitrates target of 50 milligrams per litre, over the coming two decades. This is indicated by model calculations as well as measurements that show a declining rate of decrease, over the 2012–2014 period.
The consequences of exceedance of the nitrates target in upper/shallow groundwater could be that the quality of the pumped water for the drinking water supply cannot be ascertained; currently, there are around 30 groundwater extraction points for drinking water with water quality problems related to nitrate leaching– but those problems are mainly the result of historical fertilisation practices.

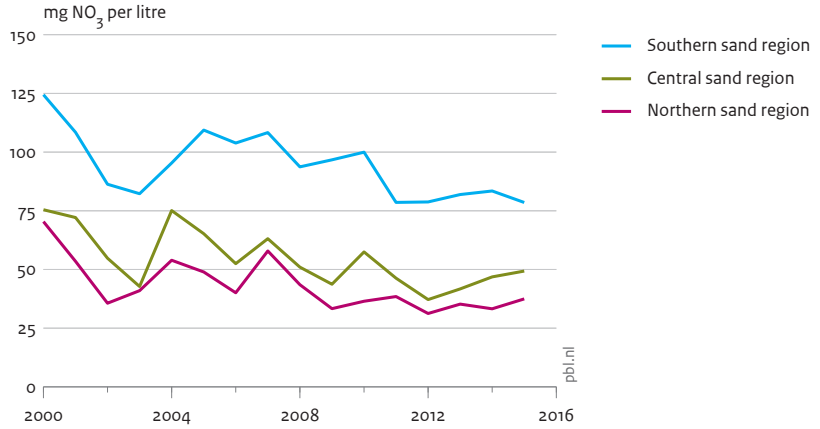
Manure separation products and delayed effect have large impact on nitrate trends

Under implementation of the fifth NAP, by 2027, nitrate concentration levels in the southern sand region would come down to 60 milligrams per litre. This would be a decrease of 15%, compared to 2013. The fifth NAP does not constitute an improvement on the fourth NAP and current policies would be insufficient for achieving targets in both the Nitrates Directive and the Water Framework Directive.

The more stringent conditions under the fifth NAP per 2014 for derogation and the introduction of stricter nitrogen application standards and statutory manure nitrogen efficiencies in the sand region, will only contribute to a limited degree to improving the achievement of the nitrates target. The main reason for this is a strong increase in the application of more manure separation products that, although low in phosphate, are relatively high in nitrogen. Livestock farmers use such products as these allow a higher

Figure 4

Nitrate concentrations in upper groundwater, per sand region



Source: RIVM

utilisation of the legal application standards for nitrogen in manure, while saving on manure disposal costs.

In addition, model calculations show that the former MINAS system (1998–2005) is still having an impact on current and future decreases in nitrate leaching (Figure 5).

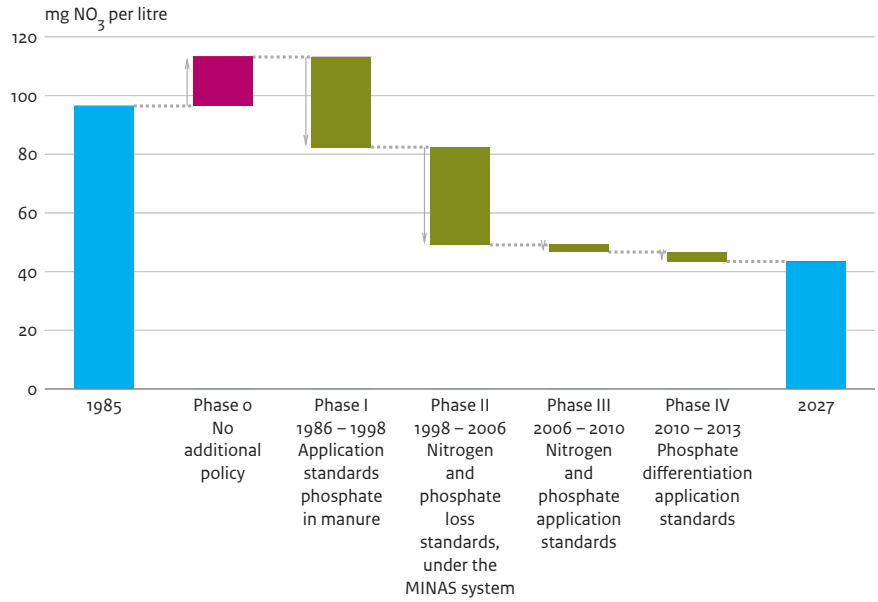
The strong decrease, under MINAS, of nitrogen fertilisation and nitrogen surpluses, caused a decrease in nitrogen mineralisation, which continued after the switch to the system of application standards in 2006. And, without additional policy, this will remain the main reason for the decrease in nitrate leaching after 2016. This effect is strongest in the southern sand region. Up to 2013, the system of application standards hardly reduced nitrogen loading of surface water, because total nitrogen fertilisation and nitrogen surpluses hardly declined, compared to under the MINAS system.

Manure fraud possible explanation for exceedance nitrates target

In the southern sand region, with much intensive livestock farming and where manure supply far exceeds regional demand, more animal manure is being applied than the legal space within the application standards would allow. In other words, the legal space for animal manure is being exceeded in that region. For 2014, the exceedance for nitrogen is estimated at 4% to 28% and for phosphate at 8% to 29%. Under current application levels of manure and use of manure separation products, this exceedance may lead to additional nitrate leaching of 5 to 30 milligrams per litre.

Figure 5

Effect of four implementation phases of the Manure and Fertiliser act on the change in nitrate concentrations in upper groundwater, in sand and loess regions, 1985 – 2027



Source: STONE model of Wageningen Environemental Reseach; adaptation by PBL

This overuse and exceedance of the nitrate standard is an indication of manure fraud, here defined as deliberately disposing of less manure than is legally required and fertilising the land well above the legal application standard. The occurrence of manure fraud is supported by the results from selective compliance monitoring of farms in 2014 by the NVWA (the Netherlands Food and Consumer Product Safety Authority), which showed that, on around 10% of farms, one or more application standards were being exceeded. Another indication of manure fraud is the fact that nitrogen–phosphate ratios in transported animal manure, according to data for the mandatory chemical analysis of manure samples, are substantially lower than those ratios commonly used for applied manure in the fertiliser recommendations. This would imply that, *on paper*, more phosphate is being disposed of by farms than in actual practice.

Effect on nitrogen and phosphorus in surface water

Nitrogen concentration levels in surface water are decreasing

Over the 2006–2014 period, nitrogen concentrations decreased in regional surface waters dominantly influenced by agriculture, not only in the sand region but also in clay and peat regions. The decreasing trends in the sand regions are consistent with trends in nitrogen fertilisation, soil nitrogen surpluses and nitrate leaching.
Despite this decrease, the mean nitrogen concentration in the summer half year exceeded the WFD target[3] for nitrogen in surface water by a factor of nearly two, in the entire sand region, during the 2011–2015 period. As concentrations are levelling off, achieving the WFD target in the coming 10 to 20 years is not expected to be within reach without additional policy.

By 2027, the fifth NAP will achieve a 15% decrease in agriculture-related nitrogen loading of surface waters in the sand region, compared to 2013 levels. This decrease is barely different from the impact of the fourth NAP. The small impact is also due to the before mentioned effect of the increased application of manure separation products. It will hardly bring achievement of the WFD target for nitrogen any closer. Models predict a decline in nitrogen concentrations of fewer than 10 percentage points, and this is particularly due to other measures rather than those in the Manure and Fertilisers Act. In the fifth NAP, nitrogen application standards for clay soils are increased, and will cause an increase in nitrogen loading by 2027; this also contributes to the WFD target for nitrogen not being achieved.

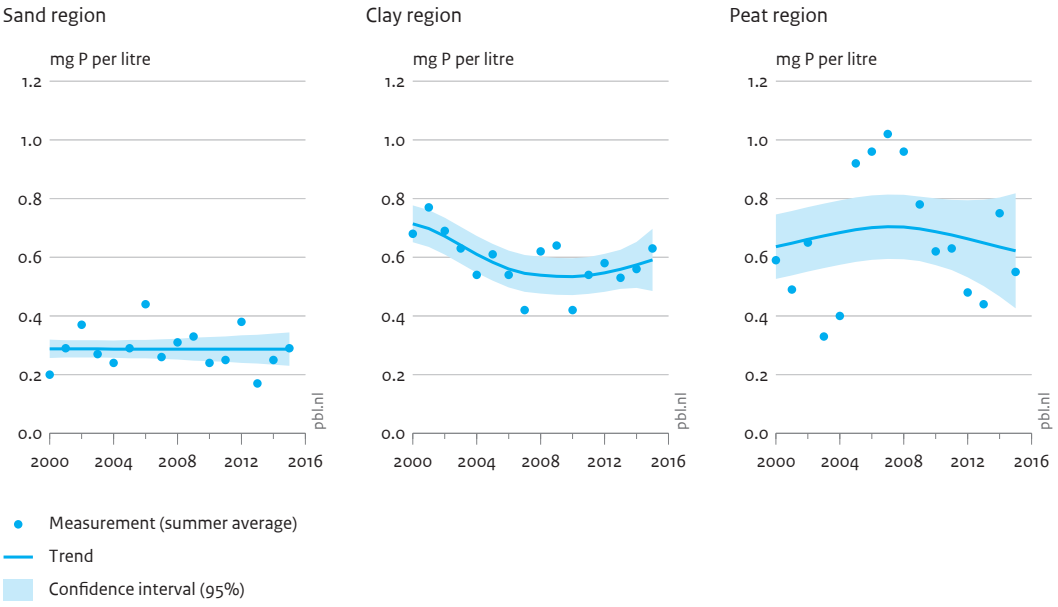
Phosphate policy effective for surface water, but targets not within reach

From 2010 onwards, on average, no statistically significant decrease in summer concentrations of phosphorus in run-off and surface water has been observed in all soil regions (Figure 6). The concentrations in the summer half year are most relevant for the occurrence of eutrophication. Only brooks were found to have a decrease in average summer concentrations of phosphorus.
The Manure and Fertilisers Act, however, has been causing decreases in phosphate fertiliser use and particularly phosphate surpluses in the soil – on average, these surpluses in dairy farming were ‘zero’ in 2015. The reason why phosphorus concentration levels in run-off and regional surface waters are not decreasing is because phosphorus loading of surface water, primarily, is a function of the supply of phosphate from the soil stock and not of actual fertilisation.

The WFD targets for 2027 will not be achieved under current policy; the average phosphorus concentrations in surface water exceed the WFD targets by a factor of two to three. Despite this exceedance of WFD standards for phosphorus in large parts of the country, the implementation of the Manure and Fertilisers Act over the 1987–2016 period can be considered as effective, as it has prevented an increase in the total leaching and run-off of phosphorus from agricultural land. Model calculations show

Figure 6

Phosphate concentrations, specifically in agricultural surface waters



Source: Deltares; adaption by PBL

that, without this policy, the average phosphate loading would have increased from 2.2 kilograms per hectare in 1985, to 3.6 kilograms by 2027. Up to and including the fourth NAP, phosphate loading is expected to decrease by 0.4 kilograms per hectare, per year, up to 2027, to an annual 1.8 kilograms per hectare. Implementation of the fifth NAP is not projected to lead to any significant additional reduction in phosphorus leaching or run-off to surface water, by 2027.

The insufficient achievement of the target for phosphorus in surface water poses a policy dilemma

The lack of additional measures or improvements can be interpreted to mean that implementation of the Manure and Fertilisers Act is insufficient to meet the Nitrates Directive's requirement to reduce eutrophication. The decrease in the supply of phosphate to the soil stock in regions where phosphate application standards are lower than crop removal implies that, in the long term, the contribution from agricultural land to eutrophication will decrease. Whether this will be sufficient to attain the targets of the Nitrates Directive and WFD, from a legal and policy perspective, is difficult to say.

There are deviating views about the obligation to comply with the Nitrates Directive with respect to reducing phosphorus loading, and the degree to which the Water Framework Directive can impose additional measures on the agricultural sector to achieve a 'good ecological status' by 2027.

The model-based translation of the gap between current eutrophication status and targets in the Nitrates Directive and the Water Framework Directive into tasks or specific measures for the agricultural sector contains many uncertainties; for example, regarding the relative contribution of various sources of nutrients and response to measures. A too strict political or legal separation between the implementation of the two directives, however, may hinder the efficient choice between measures to reduce sources of nutrient loading to surface waters. The costs of measures to reduce leaching and run-off from agricultural land could turn out lower per kilogram of nitrogen and phosphate loading than those that address point sources or adjustments in hydromorphological measures (adjusted management and redesign of surface waters and banks).

Effect on manure market

In dairy farming, the manure application limit was exceeded, despite animal feed covenant

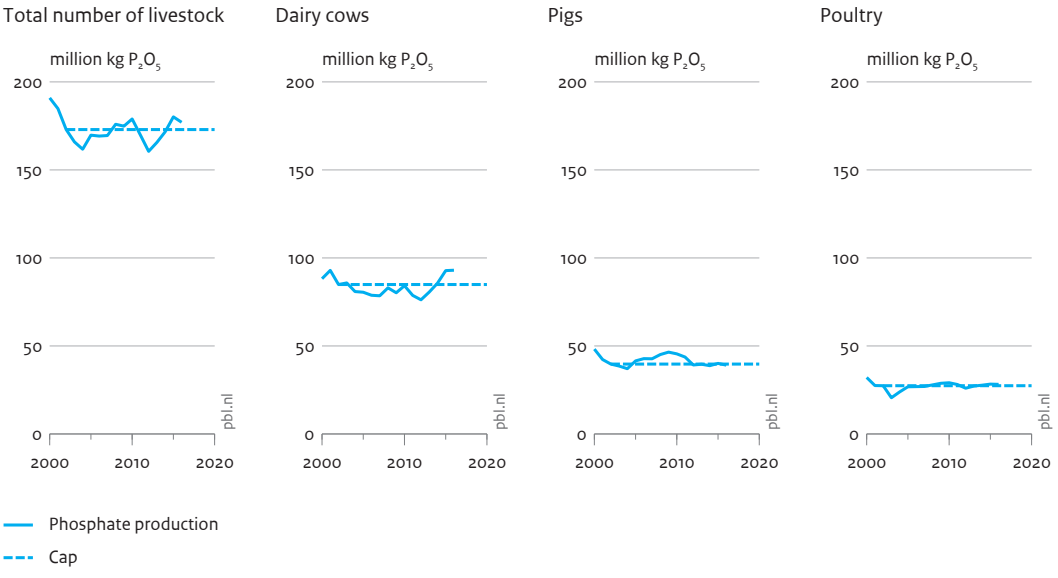
The animal feed covenant in dairy farming could not prevent exceedances of the EU cap on manure production for phosphate by 5 to 7 million kilograms, in 2015 and 2016 respectively. In the 2011 animal feed covenant, farms and feed companies agreed to increase the use of low-phosphate feed. In combination with other corporate initiatives, such as extension of the capacity of manure separation, processing and export, this did prevent an even larger pressure on the manure market that would have occurred due to the increase in the production of dairy manure, from 2012 onwards. Since 2012, phosphate production by dairy cattle has increased substantially, as a result of strong increases in both livestock numbers and milk production in dairy farming, in anticipation of abolition of the milk quota on 1 April 2015. This additional phosphate production disturbed the manure market, as it coincided with a gradual decrease, between 2006 and 2015, in phosphate application standards and the national legal space for the application of phosphate.

Pressure on manure market remains high

Pressures on the manure market continue to be high. Not only due to phosphate, but also because, in 2014, nitrogen policies were tightened in the sand regions. For the derogation, the application standard for nitrogen in dairy manure on dairy farms was limited (from 250 to 230 kg per hectare), nitrogen application standards for some crops were decreased and fertiliser equivalencies for pig manure were increased. In the southern sand and loess region, with the highest manure production level per hectare, the application standard for total effective nitrogen decreased by around 20 kilograms per hectare (nearly 10%), compared to values when the system was introduced in 2006.

Figure 7

Phosphate production and cap in animal manure



Source: CBS Statline

The application standard for phosphate decreased by 30 kilograms per hectare of grassland (nearly 30%) and 45 kilograms per hectare of arable land (nearly 50%). Moreover, over the 2006–2015 period, the legal space for manure application decreased, due to the 6% decrease in agricultural area, such as for the purpose of urban development. The phosphate production by the total heads of livestock increased over that period, by well over 6%. Increasing amounts of manure, therefore, need to be disposed and transported. Between 2005 and 2014, phosphate export from the eastern Brabant region and northern Limburg increased by 60%, from 20 to well over 32 million kilograms.

Manure market increasingly dependent on export

Dutch livestock farms, currently, use nearly half of their manure production (expressed in phosphate) on their own land. The other half needs to be disposed of outside the farm; a quarter goes to arable farms or extensive dairy farms and the remaining quarter ends up outside Dutch agriculture (mostly abroad). Because of the decrease in the legal space for on-farm disposal, the volume of traded manure increased, after 2006, by around 60 million kilograms of phosphate to over 80 million by 2015. Net manure exports increased from 15 to 33 million kilograms. Between 2006 and 2015, increases were seen in the export of, particularly and mainly to Germany, untreated and fully or partly sanitised manure, as well as in the solid manure fractions (of the manure after separation). In addition to increases in the export of manure and manure products, the

incineration of poultry manure also increased, from around 0.3 million kilograms of phosphate to 9.7 million. The combustion ash containing phosphate is no longer a manure product and is traded particularly abroad, among other things to improve soil quality. The increasing dependence on manure export causes the manure market to be vulnerable. Currently, Germany is implementing stricter manure policies (Düngeverordnung) and there is the risk of exports of untreated non-sanitised manure to stagnate if contamination with pathogens should be detected.

Mandatory manure processing is an effective measure, because this secures the supply of manure to processing facilities and stimulates development of processing capacity. In 2015, there was sufficient manure processing capacity, from a national perspective, for mandatory manure processing. On a regional level, there may still be a shortage in capacity in the eastern sand region. When implementation of the fifth NAP is combined with a system of phosphate production quota, there will be sufficient manure processing capacity up to 2020.

High manure disposal costs, particularly in pig farming

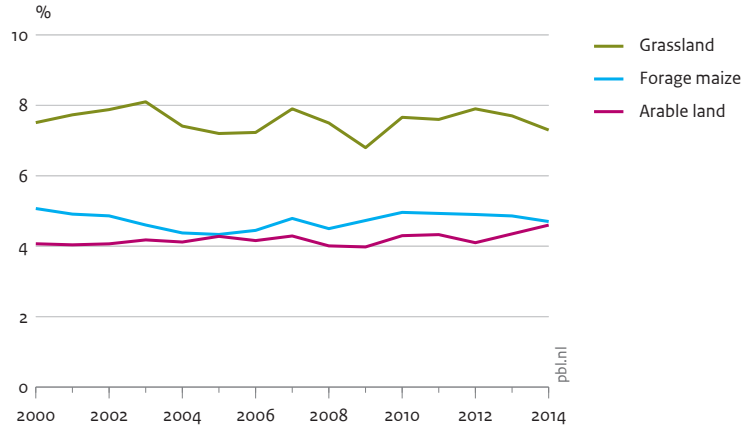
The national annual costs of manure removal hardly increased for the livestock sector, despite increases in manure surpluses, and ranged between 0.25 to 0.30 billion euros annually, over the 2006–2016 period. The manure market is the most positive for the poultry sector, where manure removal has been organised via long-term and sometimes cooperative contracts, and total cost for manure removal shows a decreasing trend. At farm level, manure removal costs did increase, particularly for pig farms. The annual manure removal costs, for an average pig farm, increased from over 15,000 euros in 2000, and less than 10,000 in 2003 and 2004, to over 40,000 euros in 2015. In dairy farming, these costs increased from negligible in 2005 to 6000 euros in 2016. The manure removal costs are sometimes a heavy financial burden on the farmers family income. The increase in manure removal costs per farm is mainly the result of increases in farm size. Over the years, costs per tonne of manure and per animal have remained fairly stable. Manure removal costs in pig farming are 5% of the total production costs, whereas in dairy farming this share is around 1%.

The gross income per 100 kilograms of milk has decreased from 9 euros in 2005 to 2.6 euros in 2016; mostly as a result of low milk prices and high transport costs, rather than higher manure removal costs. Between 2010 and 2016, feed costs increased by 3 to 4 euros per 100 kilograms of milk, and manure removal costs by 0.4 euros per 100 kilograms of milk.

The arable farming sector, on the other hand, profits from the high pressure on the manure market. By accepting animal manure, the sector generated an additional income of around 0.2 billion euros, annually, between 2013 and 2015. Over three-quarters of this additional income consisted of cost savings in lower purchases of artificial fertiliser, and one quarter of reimbursements by the manure supplier (intermediary or livestock farmer).

Figure 8

Organic matter content in the surface layer of agricultural soil



Source: Eurofins Agro

Manure production quota are effective

Manure policy also intends to reduce manure volumes via a system of tradable manure production quota (expressed in phosphate units), which limit the number of animals. Production quota for poultry in 2015 were utilised for around 106%, and for pigs this was nearly 100%. Over the 2012–2015 period, poultry livestock numbers increased by nearly 10%. The full utilisation of the quota points to a trend of expansion, as do the still high prices of pig and poultry quota. Without production quota, the increase in pig and poultry numbers over the 2006–2014 period probably would have been even larger.

Concerns over soil fertility not supported by data

Many farmers have expressed concern about reduced soil fertility. However, this is unsupported by empirical data. On average, the organic matter content of agricultural land is either stable or increasing, except for grassland in marine clay areas in western Netherlands (Figure 8). Measurements also do not indicate a decrease in nitrogen mineralisation, but do show a decrease in the phosphate fraction that is easily available to plants (calcium chloride extractable: P-CaCl2), in about half of the soil samples from arable land and grassland. This decrease can be explained by the reduction in the use of artificial phosphate fertiliser. The variation in the decreases in P-CaCl2 between farms is very large, and it is unclear whether this points to a real deficiency for crops. Up to 2027, the fifth NAP is expected to cause agricultural areas with a high or very high soil phosphate status (phosphate saturated) to acquire a neutral (sufficient) phosphate soil status. The fifth NAP is expected to have little impact on the soil organic matter content. On average, the phosphate content will be sufficient, but on a regional level, phosphate deficiencies may occur. The average P-AL number for grassland in sand and loess

regions is expected to decrease from 53 milligrams per kilogram in 2013 to 47 milligrams in 2027. The grassland area that has a low phosphate content will increase from 0% to 2% on sand and loess, and from 0% to 5% on clay. The average Pw number for arable farming on sand will decrease from 37 to 32 milligrams per litre. Furthermore, up to now, there is no indication that more stringent application standards have led to a reduction in the dry matter yield of crops. Crop yields have increased for grass, forage maize and all common agricultural crops, since 2006, by around 1.6% annually, and this increasing trend appears to be continuing. The more stringent standards also have not led to a decrease in the phosphate content of grass and forage maize, but the nitrogen content of forage maize has decreased.

Remaining policy tasks

Nitrogen in groundwater in southern sand region

In order to achieve the nitrates target for upper groundwater in the southern sand region, nitrogen surpluses need to decrease by 40%; this is the conclusion drawn from the concentration levels that were measured over the 2011–2014 period. This corresponds to a 15% to 20% reduction in nitrogen fertilisation. After accounting for the delayed impact of the fourth NAP up to 2027, a reduction task of 30% will remain for the nitrogen surplus. Implementation of the fifth NAP will result in a remaining reduction task of just over 15% in nitrogen surpluses.

Nitrogen and phosphate in regional surface water

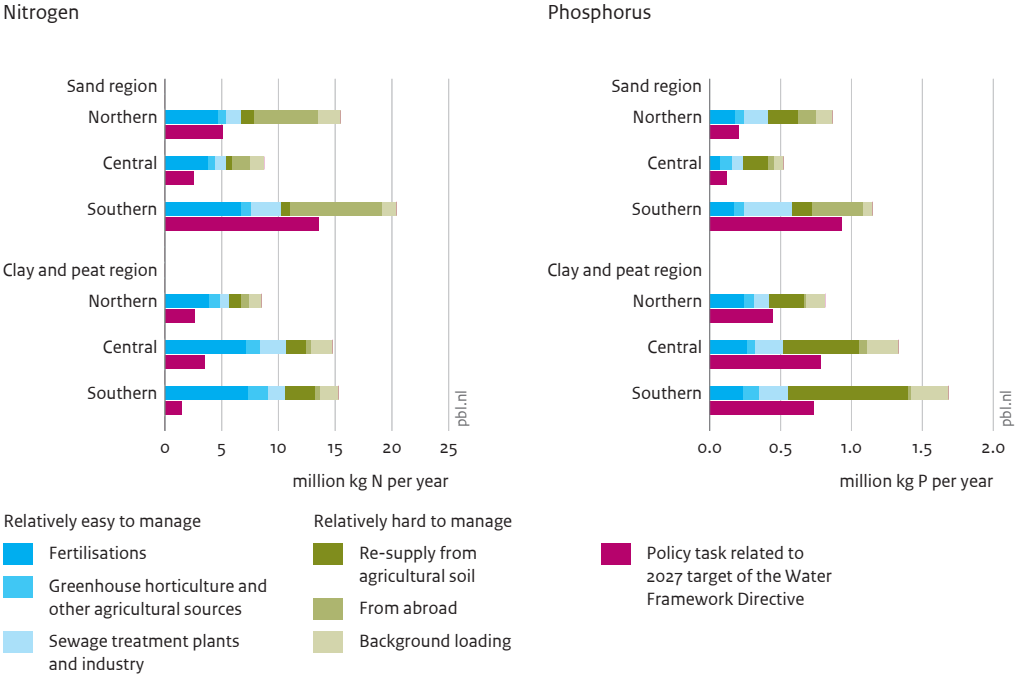
Nutrient loading of surface water must be reduced, for WFD targets to be achievable. The calculated regional, small national task, based on water quality measurements over the 2011–2013 period, for nitrogen will be a reduction of around 35%, and for phosphorus this will be around 50%. This is the reduction task for all nutrient sources combined; in addition to sources related to agricultural activities and land use, this also includes wastewater treatment plants and foreign sources. The calculated tasks for surface water vary considerably per region. For nitrogen and phosphorus, the reduction task is rather large in the southern sand region, where the input must be reduced by two thirds. For phosphorus, the task is also substantial in clay and peat regions, particularly those in central Netherlands (Figure 9).

Nitrogen and phosphate reduction tasks for agriculture are substantial, yet uncertain

Agriculture is responsible for part of the nitrogen and phosphate reduction task regarding regional surface water. The share of agriculture in the WFD task is difficult to determine. It depends on assumptions about retention levels per source and the degree to which surface water loading through fertilisation and soil processes can be influenced. On a national level, reduction tasks for nutrient loadings related to agricultural practices are calculated at around 20% for nitrogen and 40% for phosphorus. These tasks are the most

Figure 9

Nitrogen and phosphorus loading of surface water, per source, 2010 – 2013



Source: Wageningen Environmental Research; adaption by PBL

substantial in the southern sand region, for both nitrogen and phosphorus. For the clay and peat regions, the task is largest in central Netherlands. Implementation of the fourth and fifth NAP will reduce the WFD task for agriculture, by 2027, by about one third. In the clay region, implementation of the fifth NAP will result in a small increase in nitrogen loading by 2027, due to an increase in nitrogen applications standards. Current policies will hardly diminish the WFD task for agriculture for phosphorus in clay and peat regions, whereas the phosphorus reduction task for the sand region will decrease by about one fifth.

Opportunities for policymakers and stakeholders

Options for more effective and efficient fertiliser policy

The search for options for a more effective and efficient manure policy is not a simple one, as objectives and interests of society and individual stakeholders often conflict. It is a balancing act, between protecting the environment and protecting farmers. The Manure and Fertilisers Act primarily focuses on the environment, but there are also

secondary targets for maintaining equilibrium on the manure market and retaining an economic perspective for the agricultural sectors.

This final section outlines a number of possibilities for bringing the targets of the Manure and Fertilisers Act closer within reach. It also shows the field of tension, indicating possible opposition or barriers in the implementation.

Win–win perspectives for a more effective and efficient fertiliser policy

Although a more effective and efficient fertiliser policy is not easy to achieve, there are a number of general process options that may improve the implementation and, thus, also the achievement of targets.

- Improving the communication by the national government and regional authorities about the Manure and Fertilisers Act, thus increasing public support for the policy and improving government credibility;
- Increased involvement and responsibility of large stakeholders in the agro-food chain with the development and implementation of measures. These are the enterprises that ensure the supply of basic resources and services, and the processing of agricultural products;
- Increased transparency about the coherence between means and objectives of the Manure and Fertilisers Act on the one hand, and the WFD implementation on the other – in view of more efficient solutions to water quality issues;
- Better coupling of targets and effects of the Manure and Fertilisers Act with those related to circular economy policy (lower import levels of animal feed and artificial phosphate fertiliser), climate policy (less nitrous oxide, methane and artificial nitrogen fertiliser), sustainable soil management (retaining and utilising nutrients), and sustainable livestock farming (maitaining grazing-bazed dairy systems);
- Developing knowledge about a more efficient use of nutrients in feed and fertilisers, and better utilisation of that knowledge in arrangements of farmers, consultants and contract workers, and independent research.

Balancing environmental and agricultural interests

The search for perspectives for a more effective and efficient manure policy, as stated above, means balancing the protection of both the environment and socio-economic needs of the farmers. The remaining environmental task, which mostly concerns surface water, implies the need of reducing nutrient loading. This means adjusting agricultural practices. Here, four pathways can be distinguished: (1) ensuring that good agricultural practices are applied everywhere, using current insights into efficient fertilisation and feeding practices; (2) improving agricultural practice, with frontrunner farms setting the standard; (3) retaining the main function of agriculture on current agricultural land, but with fertilisation, high livestock densities, feed rations or drainage being sub-optimal choices, from an agri-economic perspective; and (4) the main function of agriculture being abandoned, and the area of agricultural nature being expanded. Pathways 1 and 2 centre around conventional agriculture and there are no large changes in land use or livestock. Pathways 3 and 4 are forms of extensification.

Society benefits from stricter manure policy

The societal benefits of the Manure and Fertilisers Act are considerable. However, quantification and monetisation of those benefits is uncertain. Total annual benefits related to the Manure and Fertilisers Act in 2008, compared to the year 2000, were estimated at 0.4 to 2.5 billion euros. The annual benefits to ecosystems were projected at 0.3 to 2 billion euros, as a result of reduced leaching and run-off of nitrogen and reduced ammonia emissions and deposition. The benefits to human health, due to reduced ambient levels of ammonia aerosols and, to a much smaller extent, by reduced nitrate in drinking water, were estimated to be between 0.1 and 0.3 billion euros.
The costs mostly relate to manure disposal and storage which, in 2008, amounted to approximately 0.4 billion euros, and have not significantly increased since the year 2000. These costs are lower than the lower bound of the societal benefits and indicate that stricter manure policies will also provide net benefits to society. The question, however, is whether farmers should bear the additional future costs of cleaner water, when their fertilising practice is in accordance with agronomic recommendations and complies with legal rules and regulations. In recent years, there has been an increase in the tension between legal application standards and rules for the use of fertilisers on the one hand, and conventional crop rotations and associated fertilisation recommendations, on the other. Especially in the sand region, arable farmers are not always allowed to apply recommended levels of nitrogen fertiliser. This is one of the reasons why farmers are losing faith in the government and in the merits of the Manure and Fertilisers Act. There is diminishing understanding for the water quality objectives and statutory measures, and farmers consider policy to be too complex and too costly. This attitude can compromise compliance with and effectiveness of the Manure and Fertilisers Act.

Abolishing derogation more effective than reducing livestock herds for reducing nitrate leaching

Three scenarios to deal with the remaining reduction tasks have been explored: (1) implementation of the most stringent application standards in good agricultural practice; (2) no derogation; and (3) decreasing the total number of dairy cattle by 20% and pig and poultry numbers by 50%. Scenario 1 hardly improves the likelihood of achieving environmental targets by 2027. The nitrate standard will not be achieved in the southern sand region, and the amount of pig manure that needs to be disposed of from agriculture will increase by 20 million kilograms of phosphate. Under Scenario 2 (no derogation), the costs of the removal of additional amounts of manure and of the purchase of additional artificial fertiliser will rise by about 200 million euros, annually. Replacing animal manure with artificial nitrogen fertiliser will reduce nitrate leaching in the sand region by around 10% and means that the nitrates target will be met. Under Scenario 3, the level of nitrate leaching is higher than under Scenarios 1 and 2, as 0.2 million hectares of grassland will become available to be converted into arable land. However, under Scenario 3, ammonia emissions from arable farming will decrease by about one quarter.

Nitrates target within reach in southern sand region, by more efficient fertilisation

The nitrates target of 50 milligrams per litre could be achieved in the southern sand region by combining more efficient fertilisation, better soil management and more effective application of catch crops. This perspective would fit current regulations. Addressing manure fraud will also contribute, exceedance of legal nitrogen application standards is one of the possible explanations for the current exceedance of the nitrates target. These measures may be included in good agricultural practices, in the long term, and, thus, can be implemented by farms at no additional costs. For arable farming on sandy soils, achieving the nitrates target cannot be combined with following the recommended level of fertilisation. Moreover, 'average' achievement means that the nitrate standard will still be exceeded on 30% to 40% of the agricultural area. Whether this achievement percentage will prove to be sufficient is as yet uncertain. The Water Framework Directive, for example, uses an operational policy target of exceedances at a maximum of 20% of measurement locations.

Full achievement WFD calls for far-reaching changes in agriculture in certain regions

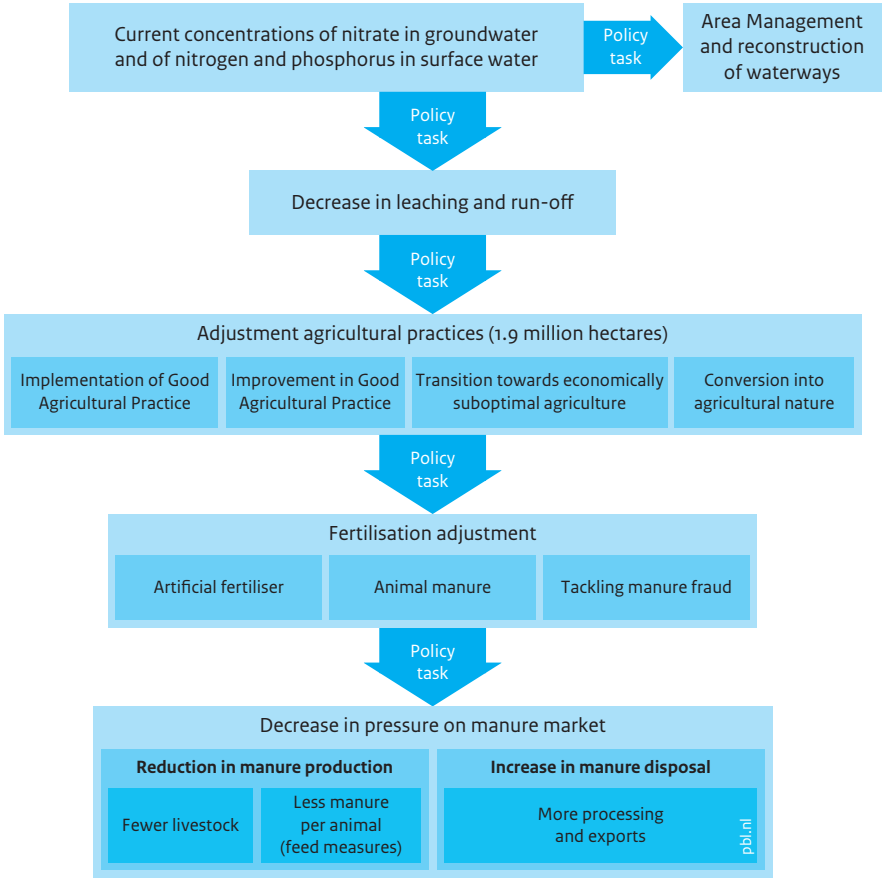
In large parts of the sand region, full achievement of the WFD targets for phosphorus and nitrogen will not be possible without far-reaching measures, such as fertilisation at levels below agricultural recommendations, adjustment of the cultivation plan, and mining of the currently high soil phosphate stock. This also applies to the WFD target for phosphorus in large parts of the clay and peat region, where hydrological measures, such as controlled drainage and raising the water level may be additional measures. There may be substantial reduction in surface water loading, due to improvements in good agricultural practice, particularly when supplemented by measures to reduce surface run-off. However, even under such additional measures, achieving the target by 2027 will not be feasible, due to the delayed response in phosphate leaching and run-off from agricultural soils. Financial compensation or additional income will be needed to cover the costs related to fertilisation and drainage below recommended levels, and for changing to less profitable cultivation plans. Compensation to farmers could be viewed as reimbursement for supplying a service to society. The feasibility and affordability need to be weighed against the legitimacy (the societal benefits, the polluter pays principle, competition) and the option of negotiating less ambitious water quality targets (using the WFD's disproportionality principle).

Less pressure on manure market via feed measures rather than manure exports

As long as application standards remain too high to achieve the environmental targets, there are only limited possibilities to reduce the pressure on the manure market as well as the manure removal costs for livestock farmers. Expansion of manure exports may reduce this pressure, but the opportunities to do so are very limited, as long as the price–performance ratio of products from pig and cattle manure processing cannot compete with that of artificial fertilisers, and while there is a chance of decreasing export possibilities for all such products other than manure pellets. The production of renewable energy from manure fermentation could generate additional income to

Figure 10

Options for nutrient policy with greater environmental impact without increased pressure on manure market



Source: PBL

contribute to lower manure removal costs, but not to lowering the reduction task for manure processing. The application of low-phosphate feed offers more perspective for reducing the pressure on the manure market. This feed may reduce the amount of phosphate, on a national level, by 10 to 20 million kilograms (10% of the manure production). Most of which could be realised in dairy farming and via farm-specific implementation and improved knowledge. Manure removal costs will only decrease, substantially, if the combination of manure export and changes in the type of feed will lead to a situation where the legal space for manure application per region is more in accordance with the regional supply of manure. This would also increase the opportunity for a further tightening of application standards in order to come closer to achieving the quality objectives for groundwater and surface water.

Lower manure disposal costs due to fewer heads of livestock

In the longer term, the pig farming and cattle sectors will benefit from measures that would lead to a structural reduction in the pressure on the manure market and to lower manure removal costs. Further use of low-phosphate feed and a focus on manure processing is an important precondition. Should these two options not yield any results, reduction in livestock numbers through one-time buy-outs is another option. Nitrogen surpluses and leaching will not decrease, unless feed measures and manure processing or reduced livestock numbers lead to less use of nitrogen from animal manure, even if the decrease is compensated by increased use of artificial nitrogen fertiliser. This is due to the lower legal fertiliser equivalence (60% to 80%) of nitrogen in animal manure, compared to that of artificial fertiliser. There are few environmental risks in allowing nitrogen-rich manure separation products (mineral concentrates) as replacement of artificial fertiliser (applying it in levels above the application standard for animal manure) if the legal fertiliser equivalence is set at 100%. Many measures that lead to improved utilisation and reductions in nutrient losses involve less use of animal manure. This generally will be met with protest, because, in the short term, it means both higher manure removal costs for farmers and lower revenues for the manure processing companies and arable farmers accepting manure.

Regional arrangements in addition to generic policies and standards

In order to achieve WFD targets, in some regions, application standards must be further lowered and alternative management and reconstruction of water systems is needed. Regionally specific arrangements may help, in the search for feasible and affordable ways of achieving these objectives. The chances of success of such arrangements increase when (a) there is only one arrangement and one contact point per region; (b) all relevant stakeholders and actors are involved, including the national government; (c) environmental and other public objectives are negotiable, and multiple policy dossiers are taken into account; (d) economic perspectives are created both for livestock farmers who wish to continue farming as well as those who decide to cease farming; and (e) instruments will be available to hold individual farms accountable.

The advantages would be that, compared to a more generic approach, there is greater support among farmers, as there would be more opportunities for them to shape the content of the arrangement, for collaboration and individual considerations, and because there would be advantages from agreements on exchanging land or crops between farms, and because there could also be opportunities for levelling out any exceedances of environmental standards with results from farms that stay below environmental standards, both between regions and years.

However, regional arrangements cannot prevent that, for many farms, there is insufficient economic perspective.

Notes

1 Nitrate is a nitrogen compound. With regard to groundwater, concentrations and standards mostly refer to nitrate, and in surface water to total nitrogen (N-total).

2 In the context of agriculture and fertilisers, this generally is expressed as phosphate, and in context of water pollution as phosphorus.

3 National nutrient targets to support achievement of a good ecological status by 2027, as required under the Water Framework Directive.

PBL Netherlands Environmental Assessment Agency

Mailing address
PO Box 30314
2500 GH The Hague
The Netherlands

Visiting address
Bezuidenhoutseweg 30
2594 AV The Hague
T +31 (0)70 3288700

www.pbl.nl/en

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