BACKGROUND PAPER ON MEASURES AND RECOMMENDATIONS TO REDUCE ENTRIES OF NITROGEN, PHOSPHAT AND PESTICIDES INTO WATER IN THE DANUBE RIVER BASIN

Prepared for ICPDR Workshop November 5/6th on measures to implement WFD and PoM

Manfred Roettele *, Better Decisions, D- 48249 Dülmen, Germany
E- mail: Manfred.Roettele@BetterDecisions.de

A. Introduction

According to projections from FAO, the world population will increase from 6,5 bio people in 2005 to 9.1 bio people in 2050. The estimated additional need for food is 70% higher than the current production. Population growth will lead to more urbanisation, further economic development in Asia and to higher consumptions of meat. Increased investments in agriculture land and technology can already be observed as a general trend. These developments will have impacts on Europe and answers how to tackle these issues need to be given. One answer will be that agriculture will need to realize higher productivity in areas where this is possible and at the same time to meet these needs in a sustainable way.

The Danube countries have the potential to increase their agricultural productivity as expressed in a recent series of articles published in the DLG – journal under the headline: Danube Countries – the IOWA of Europe (5). Some regions in these countries represent best arable production areas. Due to the agricultural production in the past times (e.g. Romania), characterized by limited availability of resources, the fertility of soils has decreased. Reports indicate that rising inputs especially of Phosphates and Potassium and improving the acidity of the soils may double the yields (6). Especially countries which have joined the EU, experience more foreign investments into agriculture. If the Danube countries manage to develop further their structural and legal framework for investments the productivity of agriculture will surely increase. This means that the inputs for seed, fertilizers and pesticides, which are generally lower compared to countries in Western Europe until now will go up. We therefore can expect higher pressures on water and aquatic organisms from Nitrogen and Phosphate entries from agriculture. These nutrients are known to cause the eutrophication of water stimulating growth of water plants. Degradation processes of the water plants lead to a reduction of the oxygen content in the water, which negatively impacts the development of water organisms. High levels of Nitrate in drinking water are considered unhealthy and require big efforts for water treatments.

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* Manfred Roettele is an independent consultant and is project manager of the TOPPS projects. TOPPS – projects started 2005 with the 3 year funded project from Life and ECPA to reduce losses of Plant Protection Products (PPP) to water from point sources. The follow up 3 year project TOPPS prowadis funded by ECPA, contributes to reduce PPP losses from diffuse sources (spray drift and field runoff / erosion). TOPPS projects develop and recommend Best Management Practices (BMPs) with European experts and stakeholders. Intensive dissemination through information, training and demonstration is conducted in European countries to create awareness and help to implement better water protection. **TOPPS** stands for: **T**rain **O**perators to **P**romote **P**ractices & **S**ustainability
www.TOPPS-life.org

B. Key pollutants from Agriculture

Key pollutants currently widely discussed in the River Basin Management Plans are the main plant nutrients Nitrogen and Phosphate and also some Pesticides.
Most plant nutrients are native and originate from the substrate below the soil layers from alteration. Further sources for nutrients to the soil are inputs from fertilizers, atmosphere and groundwater. These nutrients occur mainly in the soil in the form of their salts, adsorbed to organic or anorganic sorbents, especially clay minerals and humic acids (1).

1. Nitrogen

Nitrogen is exceptional (1) because it is

- hardly provided through the bedrock,
- it is subject to many biological / chemical modifications in the soil,
- Nitrogen needs are highest compared to other plant nutrients,
- In the soils of Europe Nitrogen determines mostly the yield (e.g German soil classification system is based on the fertility of the black soils – Tschernosem, a soil which stores a lot of Nitrogen in the accumulated organic matter).

Plants can only uptake Nitrogen if it is desorbed and in the liquid soil solution available (mainly as Nitrate NO3). In this phase it also can be transferred easily by water.

a) Atmospheric Nitrogen sources
The atmosphere contains the chemically rather stable Nitrogen gas - N2 (78%). Lightning and precipitation can provide Nitrogen inputs of 10 to 30 kg /ha N. We also can assume that some Nitrogen losses from agriculture activities, industry and traffic will return to the soil with the rain. Measurements in the USA (fig.1) show that higher atmospheric deposits can be seen in densely populated areas (East coast, great lakes) but also in the intensive agricultural Midwest states Iowa, Illinois and Indiana (Corn, Soybean)(2)

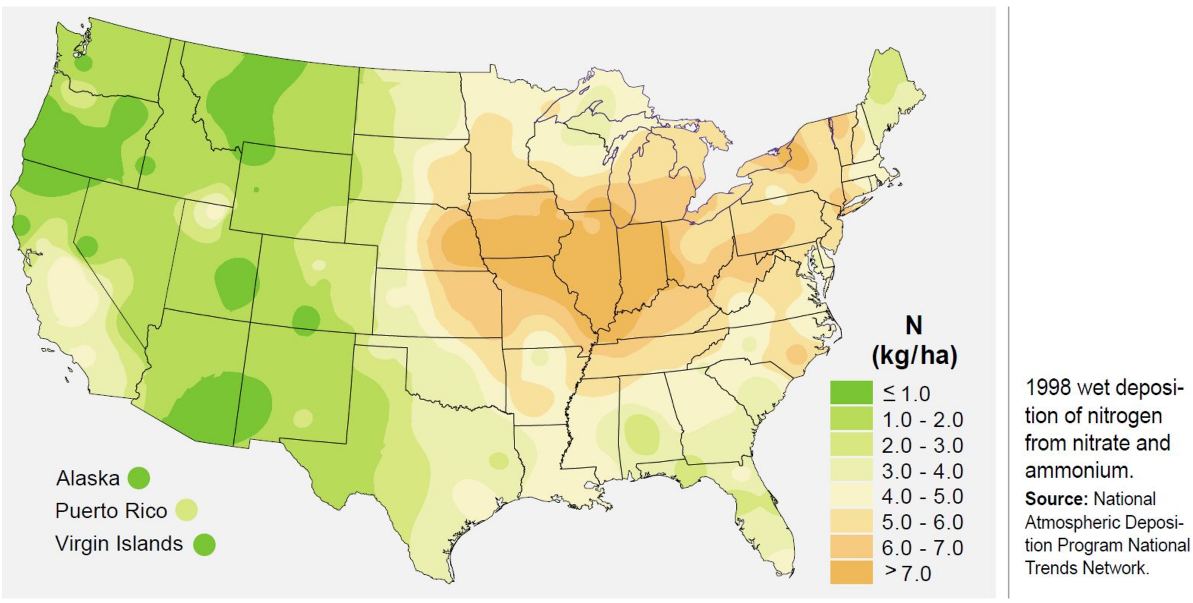

Figure. 1: Atmospheric deposits of Nitrogen / ha per year in the United States of America

b) Organic bound Nitrogen in the soil

Under middle European conditions soils store in the topsoil (< 100 cm) organic matter of about 1000 to 2000 dt / ha in Black soils 3000 dt/ha. As a rule of thumb this organic matter can mobilize about 0,1 % as Nitrogen in a season (100 to 200 kg/ha (1)) through mineralization (NO3 and NH4). Some of this Nitrogen may be used by microorganisms to incorporate it in their metabolism.
Mineralization of Nitrogen depends on microbial activity mainly by the aerobe bacteria of Nitrosomas and Nitrobacter. The rate of Nitrogen mineralization therefore depends mainly on factors influencing the microbiological activity in the soil (pH, Temperature, Humidity and Air).
Mineralization of Nitrogen stops below temperatures of 0 to 2 degrees Celsius. The rate of mineralization from the organic matter depends mainly among others on the ratio between Carbon / Nitrogen.

Microorganisms in symbiotic cooperation with legumes can capture and accumulate atmospheric Nitrogen of about 60 to 90 kg/N/ ha. Legumes in the crop rotation need to be considered in the Nitrogen balances as an additional Nitrogen source. Nitrate leaching from clover was 10 to 20 % higher than from grass (1).

c) Nitrogen from organic fertilizers
Organic fertilizers are different kinds of manure from animal production (dung, slurry, liquid manure), compost, sewage sludge and others (Tab.1). These organic materials differ in their composition and in their ratio of C/N. Straw have a C/N ratio of 50 to 100 and will fix Nitrogen before it can be mineralized. Well dilapidated dung has a C/N ratio of 15/20 and will deliver about 50% of its Nitrogen content by mineralization, while strawy dung has a C/N ratio of 20 to 30 and will only deliver about 25% of its nitrogen content in the first year. Mineralization of organic bound Nitrogen can be influenced by practices of farming e.g: Application timing and volume of manure distributed on the field. The method of tillage influences the temperature and aeration of soils. Crop rotation influences the input of organic substance from crop residues, growing legumes will increase the nitrogen fixation and due to a favourable C / N ratio also the N-availability for the following crops, irrigation directly influences microbiological activity.

Table 1: Nitrogen produced by animals (Nitrogen Balance; Excel Program LEL, Schwäbisch Gemünd

Animal / slurry	N – brut kg	N – net kg
1 Milk cow 6000 to 7000 kg milk	100	70
1 Pig (breeding)	37	22
1 Pig (meat production)	14	8
100 hens	69	34

www.LEL.bw.de (3)

According to the Nitrate Directive a maximum amount of 170 kg N / ha with organic fertilizer can be applied on arable fields and 230 kg N/ ha on permanent very productive grassland.

d) Nitrogen from mineral fertilizers
Nitrogen fertilizers are produced by transferring N2 gas from the atmosphere to Nitrate or Ammonium. About 50 to 60% of the applied mineral fertilizer is used by the plants in the respective vegetation period (1) the rest is bound by microorganisms, adsorbed in the topsoil or can be transferred by water. Big advantages of the mineral fertilizers are that they can be applied at times when plants can utilize it. In practice this is done by splitting applications.

e) Nitrate transfer with water

Nitrate can be transferred through the soil to the ground water and via runoff, erosion and drainage to the surface water (fig.2). For Germany the UBA estimates Nitrate entries in groundwater to be about 46% (3). It seems very difficult to assign reliable shares to different entry routes as surface and ground water are not so easy to distinguish. Nitrate entries into water are generally defined as diffuse sources but it might be worthwhile to investigate if not significant entries originate also from point sources too. Point sources are related to activities on the farm. These are evaporation of ammonia and could be e.g. leaking manure storage or pipes, spills from filling and cleaning the manure spreaders and others. In the TOPPS-life project focussed on reducing pesticides in surface water, point sources were identified as the main entry route (> 50%).

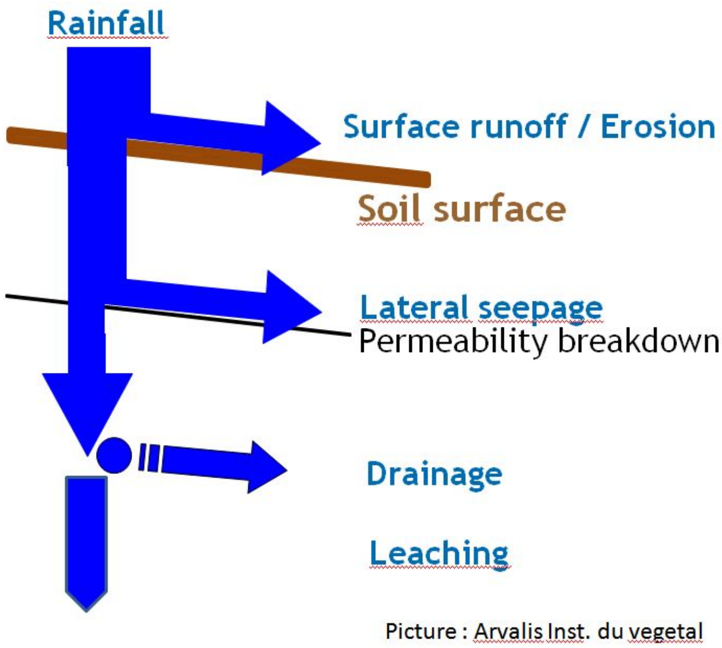

Figure 2: Water pathways for Nitrogen

f) Nitrogen Balance

Farmers in some EU countries are obliged to prepare a Nitrogen Balance once a year. Respective advice and web based tools for helping farmers are available in these countries. The balance addresses the Nitrogen inputs (fertilizer / mineralization), losses to the atmosphere and Nitrogen leaving the field with the harvest. These balances are linked to payments related to CAP for these EU countries (Cross Compliance). Targets are set for the Nitrogen surplus / year in 2012 at 60 kg / ha (e.g. Germany). Currently these targets have not been achieved e.g in Germany, where the average surplus is estimated by the UBA with 80 kg / ha for 2010. Biggest problems to reach the targets exist in areas with intensive animal production. Also late harvests due to bad weather conditions or reseeding of crops after frost damage can easily change the predictions of the available Nitrogen in the soil and therefore influences the surplus.

g) Leaching to ground water

Under European climatic conditions Nitrogen and other water soluble weak absorbing pollutants (PPP) can be transferred to the ground water mainly during the time of ground water recharge. This is when soils tends to be water saturated and where no vegetation or little vegetation can utilize water (late autumn to early spring). Transfer in the soil depends very much on the substrate of the soil (karstic structures vs. layers of loess / clay) and the distance between the surface and the groundwater table. Depending on the conditions it can take very long time until leachates are reaching groundwater.

As can be seen in the figure 3, the farmer has basically two main challenges in minimizing the risk of Nitrogen transfer to the ground water

a) Determine the correct amount and application timing of Nitrogen to keep the remaining available Nitrogen after harvest to a minimum. (This is a prediction based on soil testing, correct assumption on nutrients contents in the organic fertilizers, the development and Nitrogen needs of the crop and the availability of mineralized Nitrogen during the vegetation period, the weather, other factors and farmer experience.)

b) Trap the remaining Nitrogen, if water availability is sufficient by an intermediate crop.

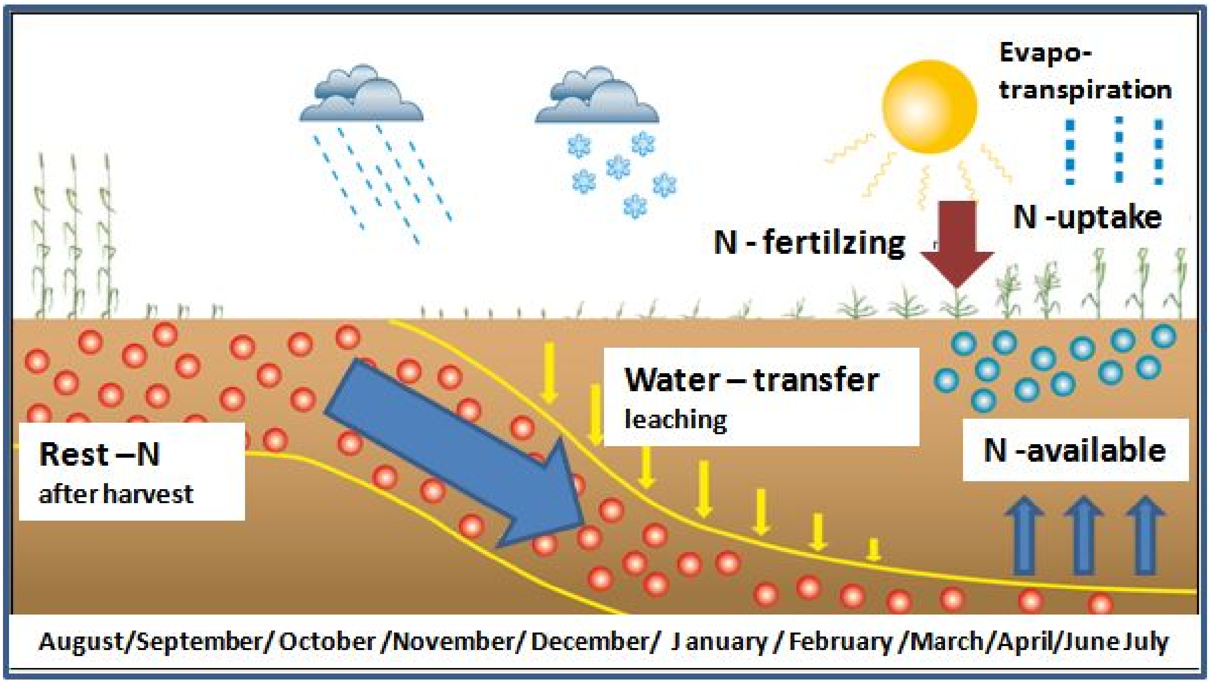

Figure 3: Nitrate movement in the soil during the year for a spring sown crop without an intermediate crop (picture: Yara changed)

2. Phosphate

a) General information

The P – content in the soils varies between 0,02 to 0,08 % (1% P = 2,29 P2O5; average content in the earth crust 0,05%). P is bound in the soil in inorganic and organic forms. The organic bound fraction varies in arable topsoil between 25 to 65% of total P. (About 60 to 120 kg of P / ha is bound in microorganisms: assumption 3000 kg / ha dry mater with 2 to 4% P (1)).

There is only a weak correlation between soil carbon content and P content (C/P ratio). It varies between a ratio C/P of 1000 to 100. Fertile black soils are at a ratio of about 100. Well dilapidated dung has a C/P ratio of 150 to 250 (1).

b) P – fertilizer and plants uptake

Organic fertilizer

Based on assumption for the required annual P - balance (e.g Germany) P2O5 contents in animal manure are listed in table 2 for orientation.

Table 2 : P2O5 produced by animals (P- Balance; Excel Program LEL, Schwäbisch Gemünd

Animal / slurry	P2O5 – kg
1 Milk cow 6000 to 7000 kg milk	38
1 Pig (breeding)	18
1 Pig (meat production)	6
100 hens	42

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The P2O5 surplus per year should not exceed 20 kg / ha P2O5 (based on a 6 year average). The uptake of P from crops varies according to the yield and crop type, but can be estimated between 20 to 45 kg / ha (1).

Mineral P- fertilizers show a higher solubility than soil born P, but it is quickly bound in the soil. It is estimated that only 20 % of the P applied is utilized by plants in the same year. The different fertilizers can be distinguished by their solubility: Superphosphate (Ca - phosphate + Sulphuric acid) > Thomas-phosphat (byproduct from steel production > raw phosphate).

c) P transfer to water

Leaching of phosphates to the ground water is very unlikely. Certain risks exist on sandy soils with high ground water tables, where sorption capacities are low.

As Phosphate is mainly bound to soil particles the main entry routes from agriculture into water are transfers due to runoff / erosion from the fields and wind erosion. Entries of phosphates from outside agriculture can be significant especially if still detergence containing Phosphates are used or not sufficient sewage treatment is performed (daily discharge from a person is 3 g P).

P can be desorbed to water from sediments under anaerobe conditions (the more anaerobic the more phosphate can be released)(1).

3. Conclusion for Nitrogen and Phosphate

Nitrogen and phosphates behave very differently as their risk to be transferred to water is concerned. Main difference is their availability (solubility) in water, which is high for Nitrogen (mainly Nitrate) and low for Phosphates. Mitigation measures therefore need to consider for Nitrogen ground water and surface water, while the main focus for phosphate is the surface water.

According to the UBA in Germany (4) the nitrogen entries into surface water have decreased by 45% between 1985 to 2005 and 77% of the current load is estimated to originate from agriculture. Main reductions were achieved through better sewage treatments and less pollution from industrial sources.

P – entries were reduced in the same time by 71% mainly attributed to the replacement of P in detergence and better sewage plants. The reduction achieved from agricultural sources is estimated low with about 1%. It seems that reductions in agriculture are much more difficult to achieve.

4. Pesticide

The Water Framework Directive (WFD) and the Directive on sustainable use of pesticides (SUD) gave a stronger focus on the use phase of Plant Protection Products (PPP). This resulted in the development of multi-stakeholder projects (TOPPS) supported mainly by ECPA and the EU-commission (Life) across EU member states. Target is to develop Best Management Practices (BMPs) recommendations to mitigate unintended losses of PPP to water and disseminate these to advisers, farmers and stakeholders.

As the properties of the pesticides are very different, mitigation measures need to focus at the same time on substances which have a higher solubility in water and also on substances which are adsorbed to organic matter or soil particles. Mitigation measures relevant to avoid PPP losses to water are similar to those which are needed to reduce Nitrogen and Phosphate entries into water from agriculture.

5. TOPPS - Mitigation concepts and structure

For PPP we distinguish between point sources and diffuse sources. Point source are connected with all activities on farm like the cleaning and filling of sprayers and the management of contaminated liquids. Diffuse sources are those which are connected with the application in the field (spray drift) and transfer of PPP via water and soil (runoff / erosion).
In the case of Nitrogen and Phosphate it should be considered whether such separation could also be helpful. Leaking of manure storage or pipes, cleaning and filling of fertilizer spreaders for example might be sources, which should be addressed. Point sources as defined, require specific mitigation measures and can result in fast reductions, as most critical factors can be controlled directly by the operator (e.g. not weather depended, focus is on the farm).

The approach to mitigate diffuse sources is more complex. TOPPS adapted a diagnosis method, (based on French experience) which starts at catchment and at field level. This diagnosis results in the determination of the main water pathways and classifies fields in risk classes for runoff / erosion. These risk classes are linked to the description of local relevant situations. The local advisers need to select out of a toolbox of mitigation measures those, which best fit into the specific agricultural context. A set of measures need to be discussed with the farmers and an implementation plan (focus is on all farmers operating in a catchment and individuals operating on specific fields) need to be agreed. It is possible to apply the same method also to mitigate Nitrogen or Phosphate entries into surface water.

The BMPs developed focus on three main pillars

- Correct behavior of the operator
- Improvement of technologies / equipment
- Improvement of infrastructure

6. Diagnosis method

The diagnosis focusses first on the water pathways in the catchment and fields. Depending on the maps available a lot of the catchment diagnosis can be done at the office desk: Hydrologic network, topography, weather data for the area, times of soil saturations, soil maps, field maps and other information.

Then a field evaluation follows to verify information and to close knowledge gaps. Maps are often not precise enough to capture relevant changes in the field. A good understanding of the soil and substrate is necessary to make judgements of the water transfer in the soil and to estimate runoff and erosion risks. The field observation should record mitigation measures or infrastructure, which are already implemented (e.g. buffer strips, hedges, drainage, pipes passing streets), agricultural production and practices. (see figure 4). During the field audit signs for runoff / erosion should be noted. (Sediments, rills, gully etc.)

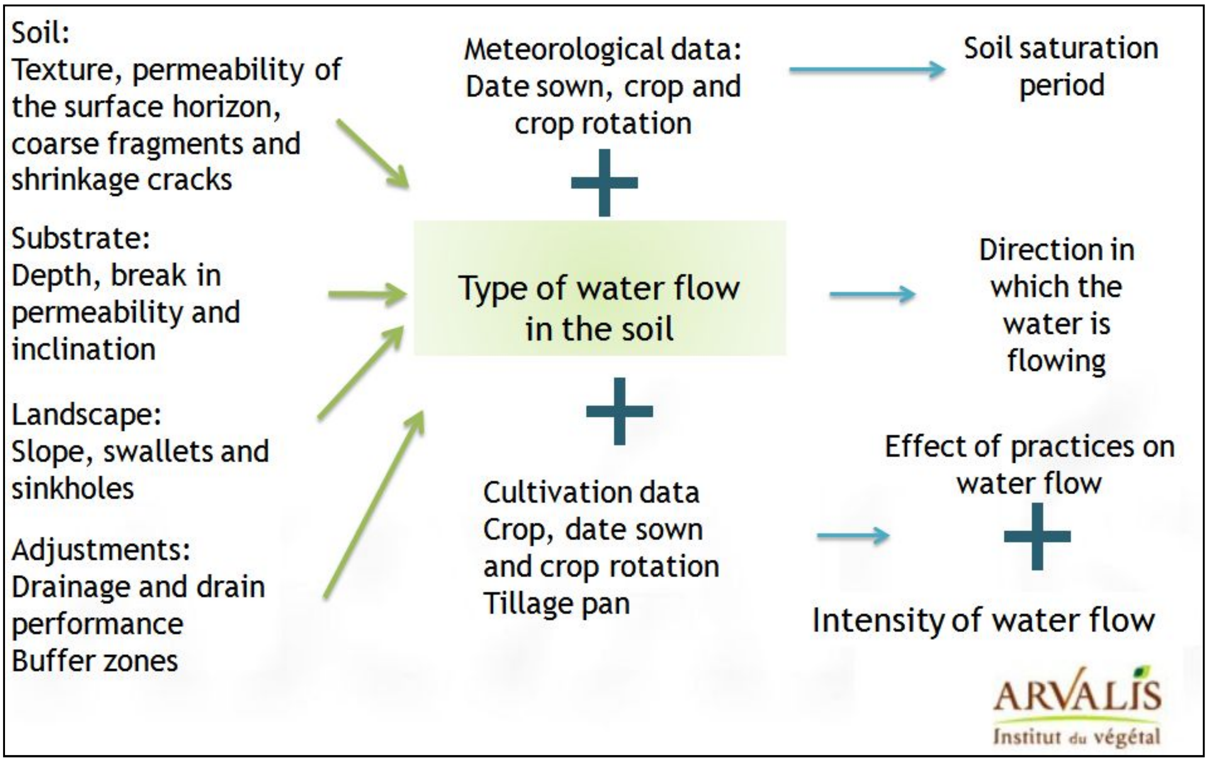
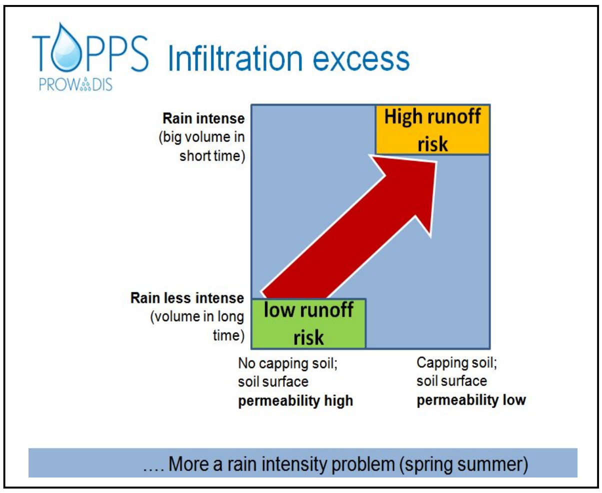
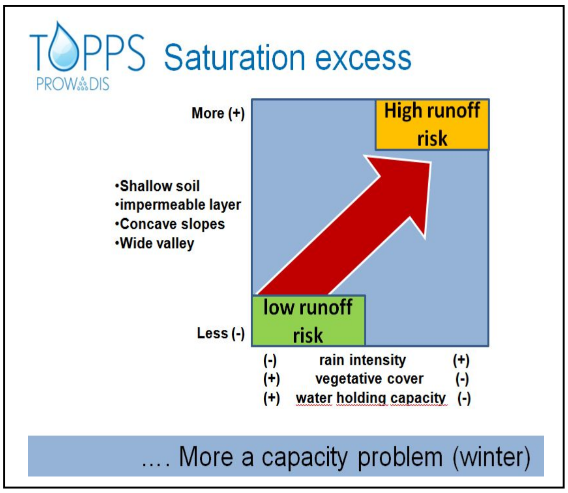


Figure 4: Information needs for catchment and field diagnosis (source: Arvalis Institut du vegetal)

Dashboards / decision trees have been developed to support advicers in the diagnosis and decision process in order to reduce complexity and to ensure correct decisions. Two dashboards were developed (see Example Figure 5 for Infiltration restriction).

a) Runoff / erosion from saturation excess (mainly situation during winter where soils are water saturated (bucket is full)
b) Runoff / erosion from infiltration restriction (mainly for situations with intensive rain events, impermeable soil layers, drainage etc.)





The adviser needs to work with two dashboards to also cover situations where both runoff situations occur. He has to work through three decision levels.
Level 1: Proximity to water
Proximity to water is not just defined by the distance to a water body, also the time needed for runoff water to reach a water body needs to be considered (pipes, roads, short cuts). Also for groundwater protection the proximity to the water is a key factor to determine the risk factor (karstic substrate, cracks, others). The proximity to water is the first risk factor which needs a decision

Level 2: Is there water transferred from outside the field or how is the permeability of the topsoil for water. Factors to be decided depend on decisions from level 1

Level 3: Does runoff water reach the water body ? or how steep is the slope in the field.
Often also the slope length is mentioned as a factor. In our TOPPS discussions we saw the slope length as an important factor, but this can be changed by mitigation measures like in field buffers or changing the size of fields. Therefore this aspect is more related to the aspect of mitigation measures.

<table>
<tr><th colspan="13">Dashboard 1: Determine Runoff risk levels due to Infiltration restriction (D1)</th></tr>
<tr><td>Level 1</td><td colspan="3">Field not adjacent to water body</td><td colspan="9">Field adjacent to water body</td></tr>
<tr><td>Level 2</td><td colspan="3">Transfer of runoff water to field downhill?</td><td colspan="9">Permeability of the topsoil</td></tr>
<tr><td></td><td rowspan="3">No</td><td colspan="2">Yes</td><td colspan="3">High
- no capping soil AND
- sandy and sandy loam soil (<20% clay, >65% sand) OR high gravel contents (>50%) OR
- loamy and silty soils (sand + silt >65%) with good aggregate structure and high organic matter content (>3%) OR
- no swelling clays (<20%)</td><td colspan="3">Medium
- no capping soil AND
- other soil textures</td><td colspan="3">Low
- capping soil OR
- clayey and loamy soils (>30% clay, <30% sand) OR
- swelling clays >25%</td></tr>
<tr><td>Level 3</td><td colspan="2">Runoff reaches water body?</td><td colspan="3">Steepness of the slope</td><td colspan="3">Steepness of the slope</td><td colspan="3">Steepness of the slope</td></tr>
<tr><td></td><td>No</td><td>Yes</td><td>shallow (0 to <2%)</td><td>medium (2 to 5%)</td><td>steep (>5%)</td><td>shallow (0 to <2%)</td><td>medium (2 to 5%)</td><td>steep (>5%)</td><td>shallow (0 to <2%)</td><td>medium (2 to 5%)</td><td>steep (>5%)</td></tr>
<tr><td>Risk class</td><td>Very low</td><td>Very low</td><td>High</td><td>Very low</td><td>low</td><td>medium</td><td>low</td><td>medium</td><td>high</td><td>medium</td><td>high</td><td>high</td></tr>
<tr><td>Scenario</td><td>T1</td><td>T2</td><td>T3</td><td>I1</td><td>I2</td><td>I3</td><td>I2</td><td>I3</td><td>I4</td><td>I5</td><td>I6</td><td>I7</td></tr>
<tr><td colspan="13">Dashboard based on Arvalis decision tree, Syngenta advisory concept and contribution of TOPPS prowadis partners</td></tr>
</table>

Figure 5: Dashboard to determine the runoff / erosion risk of a field. (TOPPS-prowadis project)

Risk classes determined are connected to scenario descriptions, which mention in a general way the measures needed to mitigate the water pollution risk and direct the adviser to the toolbox of mitigation measures.

7. Toolbox of mitigation measures

For ground water protection it is necessary to know the leaching risk in the field for water soluble substances. First mitigation measure is to make a correct Nitrogen balance, which also takes into account realistic Nitrogen losses and to determine the fertilizers needs and application timing accordingly. Experience and advice structures supporting the Nitrogen balance concept are available in EU countries (big variations in the rules ?). A further important mitigation measure is that mineralization of N from soil is not stimulated when it cannot be utilized by plants (reduce tillage). Very efficient mitigation measure is the cultivation of intermediate crops, which can trap available Nitrogen and prevent transfer to the ground water. In very vulnerable areas permanent grassland and restrictions of fertilizer use may be the only way to keep the ground water protected. Measurements in NL showed that N- leaching under grassland was about 1/10 of arable land (referenced in 1).

TOPPS – Prowadis developed the toolbox of mitigation measures with a main focus on the protection of surface water. In the toolbox measures are summarized under 5 main mitigation areas (figure 6). Within these main areas specific measures are explained on how they work, how they should be implemented, how efficient they are and if there are constraints to be considered for implementation.

Figure 6: Mitigation measures toolbox (source: Topps prowadis project)

Soil management	• Reduce tillage intensity • Manage tramlines • Prepare rough seedbed • Establish in-field bunds	• Manage surface soil compaction • Manage subsoil compaction • Do contour tilling/disking
Cropping practices	• Use Crop rotation • Do strip cropping • Enlarge headlands	• Use annual cover crops • Use perennial cover crops • Double sowing
Vegetative buffers	• Use in-field buffers • Establish talweg buffers • Use riparian buffers • Use edge-of-field buffers	• Manage field access areas • Establish hedges • Establish/maintain woodlands
Retention structures	• Use edge-of-field bunds • Establish veget. ditches	• Establish artificial wetlands/ponds • Build fascines
Correct use of fertilizer & pesticides	• Adapt application timing • Optimize seasonal timing	• Adapt product and rate selection

Mitigation measures can be distinguished in measures targeted to avoid runoff at source (keep the water in the field) and measures "outside the source" (out of the field). Measures at source can be executed mainly by the farmer in his field, measures outside the field are often related to more than one farmer and concern the whole catchment.

a) Soil management measures

These measures are mainly targeted to mitigate runoff in the field. Main aspect are to slow down the water flow (cloddy seedbed, field bunds, contour tilling) and to increase the infiltration capacity of the soil (reduce tillage, manage surface and subsoil compaction). The intensity of the soil management has also an influence on the mineralization of Nitrogen by aerating and warming the soil.

b) Cropping practices

A very important mitigation measure is an optimized crop rotation. Fields with different crops alternating in a landscape can act as buffers in the catchment (winter-, spring crops; row crops vs broadcast crops). This measure should be organised in a catchment to avoid that certain crops are overly concentrated in a catchment area. Strip cropping is a technique which is recommended if the fields are very big and long slopes are present. It is a way to slow down water flow and to increase the infiltration capacity of the soil. This technique may require compromises between environmental requirements and economic pressures (time to complete work).
Enlargement of headlands and double sowing techniques are attempts to create vegetative buffers in the field by a planted crop. In fields with slopes sometimes it is not possible to cultivate the field across the slope due to its steepness. The field bottom often allows sowing across the slope. The area which can be sown across the slope should be extended as much as possible by extending the headland. Annual cover crops are sown before or after the harvest of the main crop. Main purpose of the cover crop is to protect the soil surface (soil structure) and to capture the available nutrients in the soil after the main crop, mainly Nitrate. The vegetative matter of the cover crop will be mostly incorporated into the soil before sowing the following main crop. This improves the organic matter content and soil structure and increases the infiltration capacity for water, adsorption sites for nutrients and PPP. Permanent cover crops are mainly established in perennial crops like orchards or vine. These crops, mainly grassy strips, slow down water, trap sediments, preserve a good soil structure supporting water infiltration and protect the soil from too strong soil compaction from heavy machines. Cover crops need to fit into the production system, especially the aspect of sufficient water availability needs to be considered.

c) Vegetative buffers

Vegetative buffers can be considered as infrastructure measures (established for several years) in a catchment or field. The functions of buffers are to provide infiltration areas for water, slow down water flow, trap sediments (most important mitigation for Phosphate entries) and to provide habitat to increase biodiversity. Buffers in the fields should prevent water leaving the field and should avoid the build up of concentrated flow. (see CORPEN brochure: English reference (www.TOPPS-life.org)
The right positioning of the buffer in the catchment is usually more important for its efficiency to reduce runoff, than its width. A buffer aiming to stop primarily eroded soil particles can be smaller (e.g. 5 to 10 m) than one with the aim to intercept runoff water and its dissolved pollutants (e.g. 10 to 20 m). Parameters such as soil permeability, soil saturation, slope length and slope of the runoff area also have to be considered. In areas and at times when soils are water logged (or flooded) the efficiency of a grassed buffer zone is generally low, because buffers with saturated soil cannot capture runoff water by infiltration (mainly relevant to mitigate Nitrate and PPP entries). This effect needs to be especially considered for riparian buffers, which are potentially more prone to water logging than upslope buffers. A diagnosis of current buffer structures on their effectivity and for new proposed buffers is necessary to design optimized mitigation structures.

Different buffer types are required to match different runoff scenarios:

- In-field or edge-of-field grassed buffers are needed to intercept diffuse runoff on or near the plot.

- Alongside riparian areas, grass filter strips are essential to prevent runoff water from fields to enter directly into the surface water. Protection of surface water bodies by riparian buffers is especially important and effective in the upstream part of the catchment, as well as in the vicinity of water springs in chalk aquifer areas.
- Establishment of grassed talweg buffers can be necessary to enhance infiltration of concentrated runoff water in natural water flow pathways/hollows on hillsides. Roads alongside fields often act as a concentrated flow pathway collecting runoff water: Therefore establishing buffer zones alongside roads (edge of field buffers) protect these potential linear pathways from runoff water.
- Natural water infiltration zones (e.g. dry valleys, sinkholes) in karstic areas should be protected from runoff in the same way as surface water bodies, as these areas provide a direct link from the soil surface to groundwater.

Figure 7: Examples for buffer positioning in a catchment (source Corpen, Irstea modified)

1: In-field buffer, used to break up a long slope inside a cultivated field

2: Edge of field buffer zone, protecting a road (potential water pathway).

3: Edge of field buffer zone in downslope corner of a field, where water is concentrating.

4: Grassed talweg, to reduce concentrated water flow

5: Large grassed buffer zone (i.e. meadow), used to intercept, disperse and infiltrate concentrated water flow exiting from the upslope talweg.

6: Riparian Buffer: Grassed buffer strip between edge of field and a surface water body, to intercept diffuse runoff from the upslope field

Different types of vegetative buffers can be established:

- Grassed buffers,
- Hedges,
- Combination of hedges and grass,
- Woodland,

- Meadow

Water infiltration is better in buffer zones planted with woody and ligneous vegetation due to the more extensive root system. Dense grass vegetation is more efficient to slow down surface water flow and thus enhances trapping of eroded soil particles. Combinations of both systems enable to realize advantages of both types of vegetation. As a side effect, dense vegetation on buffers also enhances the adsorption of nutrients and PPP. Due to the build-up of organic matter which stimulate microbial activity, soils have better buffering capacities (degradation). Selection of plant species for vegetated buffer strips needs to consider local requirements and cannot be generalized. Species selection may also be influenced by other buffer functions, such as providing bee forage or habitats for selected plants or animals.

Buffers need to be maintained and managed to remain functional.

Good surface roughness in the vegetated buffer zones is important to trap soil particles transported in runoff water. For grassed buffers a regular mowing of the grass is necessary. The average height of the grass should be around 10 cm and the maximum height should not exceed 25 cm to maintain erect grass leaves. If grass is allowed to grow higher, it will be pressed down by runoff water and the buffer will have a reduced efficiency for slowing down runoff water and trapping soil sediment. As a minimum, one mowing per year is necessary, respecting the breeding periods of birds as well as flowering / seeding periods of forage plants. Mowing machines should be equipped with warning systems to protect wildlife.

Essential for buffer zone functioning is also to avoid all processes that decrease water infiltration into the soil. Therefore soil compaction needs to be avoided, by limiting the traffic of machinery to a minimum possible. Use of buffer zones as animal pasture might be possible, but grazing with large animals can also cause soil compaction. In this respect also the contamination of surface water with additional nutrients and pathogenic microbes from animal faeces needs to be considered.

Buffer infiltration efficiency is also reduced by soil sediment accumulating on the buffer, causing a clogging of soil pores as well as leading to concentration of water flow in the buffer. Therefore a regular sediment removal or spreading out of sediment on vegetated buffers is needed. Soft tillage may be used to level the soil surface.
Buffer zones shouldn’t be fertilized or sprayed with PPP, unless it is essential for the establishment of dense vegetation: This is especially true for riparian buffers, where a quick transfer of runoff to adjacent surface water bodies is possible.

d) Retention and dispersion structures

Retention structures are needed if the runoff water and eroded soil is leaving the fields (also from drainage). These structures keep runoff water in the catchment and collect potentially polluted runoff water and sediment. In general all farming persons in a catchment and also authorities are directly involved as the mitigation measures mean infrastructure investments.
The efficacy of retention structures depend on the length of time water can be detained (the longer the better). Vegetation and microorganisms will use and degrade the pollutants nutrients and PPP. Retention structures are especially useful to capture sediments and therefore phosphates. As sediments accumulate in the retention structures these need to be removed after some time and spread in the fields. Retention structures normally do not contain water the whole year.
Retention structures: Examples

a) Artificial wetlands
b) Natural wetlands
c) Vegetated ditches
d) Bounding at the edge of the field

A further measure to mitigate concentrated flow of water (erosion) is the attempt to redistribute the water by dispersion structures e.g. fascines or dam constructions. These measures slow down the water flow and due to the dispersion of the water increase the possible infiltration area.

Constraint: (may be legally unclear)
Constructed wetlands are anthropogenic, infrastructural installations such as dams, which are constructed to retain and clean runoff water from sediments, nutrients, and PPP. Therefore, any regulation regarding protection of wetlands or surface water bodies, may potentially interfere with the functionality of the retention structure. It should be discussed before the establishment of the structures, what happens e.g. if endangered species occur in the retention structure and how the original purpose of the structure can be maintained. Especially for artificial constructions, it should be pointed out that the habitat only exists because of the original purpose of management of runoff or drainage discharge to surface water.

e) Correct use of fertilizer and PPP

For the application of Fertilizers certain legal requirements have been set (rules may be locally different) determining the maximum N volume from organic fertilizers per year on arable land of, 170 kg N/ha and on permanent grassland of 230 kg N/ha) . The application of fertilizers is not allowed between 1st November to 31st January for arable and 15 November to 31st January for grassland. After harvest of the main crop the amount of N applied to the stubble or cover crop is restricted to 80 kg N/ha (Example: Germany / Düngemittelverordnung)
The amount of Fertilizers to be applied need to be based on the Nitrogen and Phosphate balance which needs to be done and documented by the farmers every year (Area balance in Germany and some other countries, global balance in other countries, rules are not always comparable among countries). Nitrogen and phosphate maximum surplus targets are set after harvest (N = 60 kg/ha; P2o5 20 kg/ha).
Application of PPP is regulated in the registration process and times of applications are listed on the PPP label. PPP and fertilizers should not be applied on frozen soils and during times of water saturation. Best Management Practices must be taken into account additional to the legal obligations.

9. Analysis and summary of measures reported in ICDPR - project team (29th April 2012 – Annex 4)

a) Manure storage capacity
Most countries propose under their code of good agricultural practice storage capacity of about 6 months for the slurry from animal production. In RO storage capacities are defined by local administration and vary between 0,5 months and 6 months.

b) Restriction for fertilizer application
Most countries report restrictions on the application timing of fertilizers. Generally there are restrictions in winter differing by countries. Most countries have restrictions between beginning of November and mid February.

c) Application volumes of fertilizers (organic / mineral) and area approach of Nitrate Directive

Most countries report maximum Nitrogen application volumes for organic fertilizers as experessed in the Nitrate Directive with 170 kg N / ha. The descriptions do not always differentiate between organic and total nitrogen. SI determines the maximum amounts depending on crops 60 to 320 kg N/ha. MD and UA mention maximum volume of manures in t/ha between 10 to 15t/ha and 20 to 60t/ha. (The kind of manure is not defined but Nitrogen content can vary a lot between animals)

One key requirement should be to balance the Nitrogen and phosphate on the basis of inputs and outputs. This is a basis to estimate the Nitrogen surplus, which should be minimized.
Countries follow different approaches:
i. Full area approach (DE, AT, SI)
ii. Nitrate Vulnerable Zone (NVZ) approach: CZ 50%, SK 60%, RO 60% of agricultural land, HU 2,5 mio ha, other countries have not yet defined their approach. In the survey provided it is not clear how and who is performing Nitrogen and Phosphate balances and which level of obligation exist. It might be worthwhile to investigate these aspects deeper.

d) Erosion / runoff minimising measures

Measures mentioned refer mainly to vegetative buffers with recommendations of buffer widths to waterbodies. Main differentiating factors are the type of waterbodies and the slope of the fields adjacent to the water (Tab. 3). As understood all buffers proposed are "riparian" buffers. For farmers the buffer size is a very important factor as it can directly affect his production area. It is therefore important to verify to the farmer that the buffer strip is effective and also compensations for buffers should be considered. Buffer regulations differ a lot between countries. In order to develop trust among farmers across countries for the recommendations, reasons for the differences should be given and explained (Level of harmonisation in EU is low).

Tab.3 Measures against erosion/ Nitrate entry: buffer stripes

	Situation	Measure
DE	Soil water saturated Soil frozen snow covered	No application of fertilizer
	Field along water body	3 m Buffer ; Precision equipment 1 m
	slope > 10%	0 - 3 m no fertilizer application
		3 - 10 m direct incorporation
		10 - 20 m incorporation or developed intermediate crop
AT	along river	5m Buffer
	along river and slope >10%	10m Buffer
	stagnant water	20 m Buffer
	if precise equipment	Buffer can be reduced 50% (not for grassland)
SI	River 1st order	15 m Buffer
	River 2nd order	5 m Buffer
HU	Slurry can be applied	25 m Buffer to well
		20 m Buffer to Lake
		5 m Buffer to other water body
RO	Slope < 12 %	1 m Buffer

	Slope > 12 %	3 m Buffer
BG	National Standard ?	5 to 10 m Buffer
UA	Small streams	2,5 m Buffer
	Middle streams	50 m Buffer
	Big streams	100 m Buffer
Source: Annex 4 : ICDPR workshop 29th April 2012		

e) Wetlands

From the survey in the countries it seems that the focus on wetlands is low and the possible mitigation effects are probably underestimated. Especially in situations where runoff / erosion leaves the field wetlands or similar structures should be considered.

10. Implementation of Best Management Practice

a) Farm structures impact productivity, competitiveness and investments.
If we consider the share of the working population employed in Agriculture we can assume a West to East gradient: Germany about 3% to Romania / Bulgaria of about 20%. Romania still has about 4 million farms with an average size of about 3 ha. We can assume strong economic pressures to adapt farm structures for more competitiveness which will enable farmers to invest. The number of farms decreased between 2003 and 2007 in Bulgaria by 26% , Hungary by 20% and in Romania by 13% (Eurostat). Statistics show a trend to bigger farms but the speed of this process depends on the general economic development. In the Danube River Basin we have big numbers of small family farms and big agricultural holdings which farm very big areas and cover a big share of the agricultural land. Surveys from the TOPPS project indicated that current advisory services reach about 30 to 60% of the farmers. Big challenge for any implementation strategy for BMPs is how well farmers can be reached with advice.

b. Structure for advice and farmer education system is key for BMP implementation
Structures of advice in EU countries are very divers. Generally there exist public (state) and private advisory services for farmers. In the public advisory services their roles are not always very clear and sometimes they focus more on administration and controls than on practical advice. Private advisory services are provided by consultants, input industry and distribution. Currently it is assumed that most of their advice is oriented towards increasing the productivity of the farm operation and have not yet a specific focus on advice related to environmental aspects.
In the TOPPS project we found that ongoing training and information of persons advising farmers on environmental topics needs to be improved. Especially in situations where the number of farmers to be reached is very big the prime focus to implement Best Management Practices to protect water needs to be based on structures which can provide advice. Implementation of the SUD (Directive on save use of pesticides) will require certified advisers for pesticides. It is not known if similar schemes are required for advice given for fertilizers. Such certification schemes would mean that BMPs need to be developed and should be in place for respective information and training.

Best Management Practices on water protection should be a defined topic for the different education levels in agriculture to create awareness and to transfer knowledge. These activities should be addressed to every farmer / adviser.

c. Scope and focus
For Nitrogen different approaches are used in countries: Full area and NVZ – approach (NVZ= Nitrate Vulnerable Zone).

c1. Focus on problem areas
Implementation of Best Management Practices to protect water should first concentrate on the problem areas. Especially in countries where the accessibility of farmers is a problem (big numbers). More intensive monitoring as required by the WFD, will help to identify the problem areas and to draw respective maps.

c2. Mobilize and train all potential advice capacity in a problem area
Advisory services and farmers can be much more intensively served if there is a specific area focus. All persons, which can provide advice should be part of the advisory schemes: Public and privat advisers. Private advice should also include distribution / retail of agriculture inputs like fertilizers and PPP.

c3. Develop incentive schemes to support that advice on water protection BMPs is directly requested by farmers.
Farmers need to be convinced to change practices in problem areas. Some measures, which will be proposed require investments (infrastructure, equipment, land) for implementation. Farms with lower productivity will have not the means to compromise on short term returns. Attractive incentive programs are necessary.
Advisers should make documented implementation plans with agreed measures and timelines as a basis for any incentives. The plans could be used to check success over time.

c4. Check significance of point sources
Point source problems should be checked (Manure storage, infrastructure on farm, and equipment) on their importance for Nitrate and Phosphate entries into water. If they are significant first focus can also be given to reduce point sources, which could mean faster wins.

11. Key implementation perspectives

In the TOPPS projects BMPs were developed along three main perspectives: Correct behaviour of the operator, improvement of equipment/technique and improvement of infrastructure. Most important perspective is the correct behaviour of the farmer / operator (fig.8).

We have reached consensus within our multinational project teams, that these three perspectives could be a good help to develop also a consistent implementation strategy for the Best Management Practices. Measures and incentives need to be adapted to the local needs and resources.

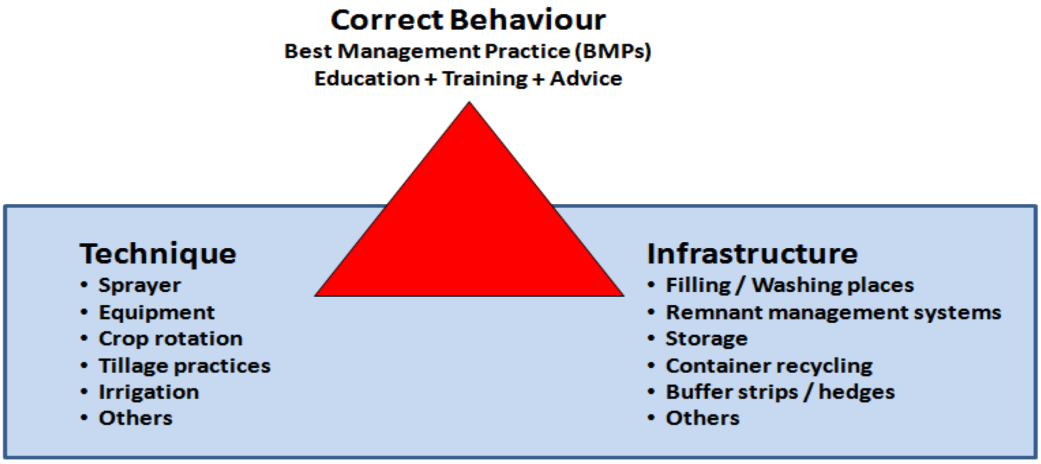


Figure 8: Key perspective for BMPs development and implementation (source: TOPPS)

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Further references are made in the text. Best Management Practice information is based on results from the TOPPS life project 2005 to 2008 and results from TOPPS-prowadis 2011 to 2014. www.TOPPS-life.org