CONSTRUCTION OF WETLANDS TO REDUCE NITRATE AND PESTICIDE CONTAMINATION IN AGRICULTURAL BASINS

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Abstract

Construction of constructed wetlands and other green infrastructure can help minimise agricultural pollution in drainage systems (CWs). According to academic evaluations, CWs remove nitrate and pesticides from agricultural runoff more effectively than conventional methods. Pesticides have an average efficacy of 20% to 90%, while nitrates have an average efficacy of 40% to 90%. When dealing with microbiological activities, it's crucial to keep in mind the importance of hydraulic residence time. In order to properly deploy a wetland system, water flow and pollutant transport at various watershed sizes must be evaluated. Contaminants are transported and altered according to specific seasonal patterns when nitrates and pesticides are applied (only after application periods). Based on field tests, we have developed two ways for intercepting signals. Free water surface (FWS) CWs can be instantly installed on streams or ditches as part of a "on-stream" plan and all drainage flows are intercepted. The "off-stream" method targets the cleanest water, whereas interception only targets the most polluted water, such as that following pesticide application. The building of the FWS CW would benefit from geotechnical analysis, consideration of topography, and eco-engineering strategies. The following size ranges have been suggested for consideration: Assuming a maximum depth of water of 0.8 metres, the total volume of water removed from the upstream area is roughly 76,000 cubic metres (m3) per hectare (ha). Therefore, CWs must be viewed as an additional tool for transfer reduction and as part of a larger effort to reduce pollution loading at the plot scale.

Keywords:"Artificial wetland Buffer zone Catchment Design recommendations Non-point source pollution Removal efficiency tile drainage"

1Introduction

Agricultural non-point source contamination of water can be dealt with in a variety of methods to meet the Water Framework Directive standards of pollution. Fertilisers and pesticides are two examples of chemical inputs that might cause non-point source contamination. Reducing pesticide and nitrate use is the first step to reducing pollution in aquatic ecosystems **(Stehle et al., 2011).**Over the next ten years, pesticide use in France will be reduced by half compared to 2008, according to the Eco-Phyto Plan. This means that some of these chemicals will enter aquatic environments as long as fertilisers and pesticides are still being utilised. If pesticide use is reduced, it may be necessary to implement other safeguards, such as buffer zones between agricultural areas and the ecosystems they serve. Many studies have been done on grass strips as buffer zonesprotecting the water from contamination by creating a saline buffer between the field and the water's surface (runoff, spray drift). With their high infiltration capacity, grass strips can help reduce agricultural pollution. Restricted infiltration or if flow to be treated is diverted and does not diffuse across the grass strip have a negative impact on their effectiveness. As a result of water management from tile drainage, grass strips are less effective. Using a tile drainage system, it is possible to concentrate all of the water from a farm or watershed into a single place to put it another way.**(Passeport et al., 2014)**

It is therefore possible to use artificial wetlands (AWs) to improve the water quality of water drained from agricultural land**(Forbes et al., 2004).**Natural wetland biofiltration is replicated in man-made wetlands, known as constructed wetlands. Using ecological engineering principles, wetland ecosystems can be re-engineered to perform better naturally while also reducing water pollution. No legal basis exists for the term "manufactured wetlands," and no legal basis exists for the grass strips that line waterways. However, its role as a "buffer" or "retention" in the watershed is provided by its function. Hydraulic functions can be used to differentiate between different types of built wetlands **(Fonder & Headley, 2010)**according on their classification. System types include everything from intermittent runoff marshes ("if the water course crosses a porous filter") to lagoons ("if the water stream does not cross a porous filter") ("permanent runoff"). Using the phrase "constructed wetlands" above will make it easier to grasp and conform to conventional terminology (CWs).As most agricultural watershed runoff is polluted by runoff from FWS CWs, the following material focuses on this type of filter:

(1) Data from existing studies as well as our own study into the losses of nitrate and pesticides from runoff from drained agricultural watersheds utilising FWS CWs is reviewed and synthesised.;

(2) Develop FWS CW design standards based on our field experiments and propose solutions for intercepting polluted flow.

2Material and methods

We selected a plot (46 ha) in the "Indre and Loire" sub basins and watersheds for one of three experimental fields, each with its own specific dimensions (4000 ha, Seine-et-Marne), 750 millimetres of rain per year, hydromorphic soil crop rotation ("*mainly winter wheat, rape, and barley"*), and a large share of subsurface drainage systems (>80 percent) imply similar drainage characteristics in these locations ("*perforated buried PVC pipe every 10 m space at 80 cm in deep due to more clayed layer below"*). The methods used to monitor water quality at all three scales were the same: weekly flow weight sampling. **(Blanchoud et al., 2020)**A subcontractor, CARSO, tested pesticides and nitrate in all water samples IRSTEA tested for nitrate and CARSO tested for pesticides.

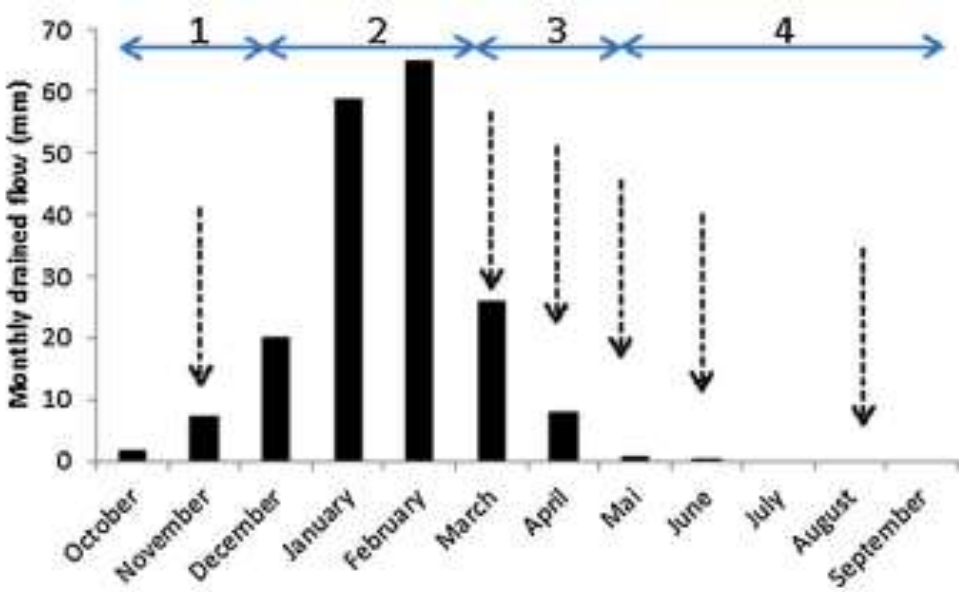

Figure 1 Based on a yearly rainfall of 693 millimetres, this is the average monthly drainage flow, the beginning of drainage, the heavy rains and spring flooding that follow, the irregular spring events, and the lack of any flow throughout periods 1 through 4. Arrows with dashed lines indicate the time of year when pesticides are applied on winter and spring cereal crops **(Tallec et al., 2015)**

3. Farming basins with tile-drained drainage systems

3.1. Hydrology

Knowledge of watershed-scale water channels and flows is needed to develop and implement ecological engineering principles that optimise the purifying function of CWs. Before adopting a CW, a quantitative and qualitative assessment of the watershed's output must be conducted. Drainage runoff is strongly dependent on the rainfall regime as a result of this inter- and intra-annual variation. Depending on the amount of rain that falls each year, the interannual volatility may be "*explained by the alternating wet, dry, and intermediate years*" Events such as precipitation and the water-holding capacity of the soil in a watershed's outlet can have a significant impact on the flow, causing peak discharges and subsequent drops in the drainage discharge. Three different seasons can be observed at watersheds in north western Europe, regardless of the year's weather patterns (Fig. 1). During the "first phase of drainage," which lasts for several months in the early winter, relatively little rainfall infiltrates the ground and is sent back into the environment via drains. It's also called the "strong drainage season," and it lasts until the winter, when a lot of rain returns. New rainfall is diverted to the drain's outlet flow because the earth is so close to hydric saturation. The soil becomes less saturated as the plant grows and the evapotranspiration demand increases (spring to the beginning of fall). There is a lot of water based on the average annual runoff in northern France (180 millimetres, standard deviation 100 millimetres) **(Voltz, n.d.)**

3.2. Nitrogen and pesticide runoff

Nitrate is the primary source of nitrogen losses from agricultural plots. Other agricultural regions have had similarly high percentages. To find nitrates in agricultural water, you need to look for the highly soluble ions. However, nitrogen periodicity is demonstrated by the location of elevated nitrate stock in the surface soil at the time of the monsoon season. There are three ways that nitrate can be transported from the agricultural drainage network: Low-level drainage runoffs in the fall have very high concentrations of NO3 –N (>100 mg/L). When nitrate leaches from the soil to a drain in early winter, it causes this. It is not uncommon for the mean content of NO3 nitrate to fluctuate between 13 and 14 mg NO3 nitrate/L during an active drainage season. Due to the large drainage flow, this period accounts for more than 60% of annual exports. There are also seasonal spikes in concentration in the spring, which are linked to agricultural operations (fertilization).These high spots represent a "typical leaching process from the soil surface to the drain". If agricultural plots are not drained, water runoff and leftover nitrogen in the soil at the onset of winter are two factors that affect interannual nitrate fluxes ("*related to agricultural practices"*). On the basis of data from three experimental fields, **Figure 2** depicts the "same concentration ranges (3–20 mg NO3-N/L)" throughout all spatial scales, from agricultural plots to sub catchments and watersheds (as shown)**(AkDOĞAN et al., 2015)**

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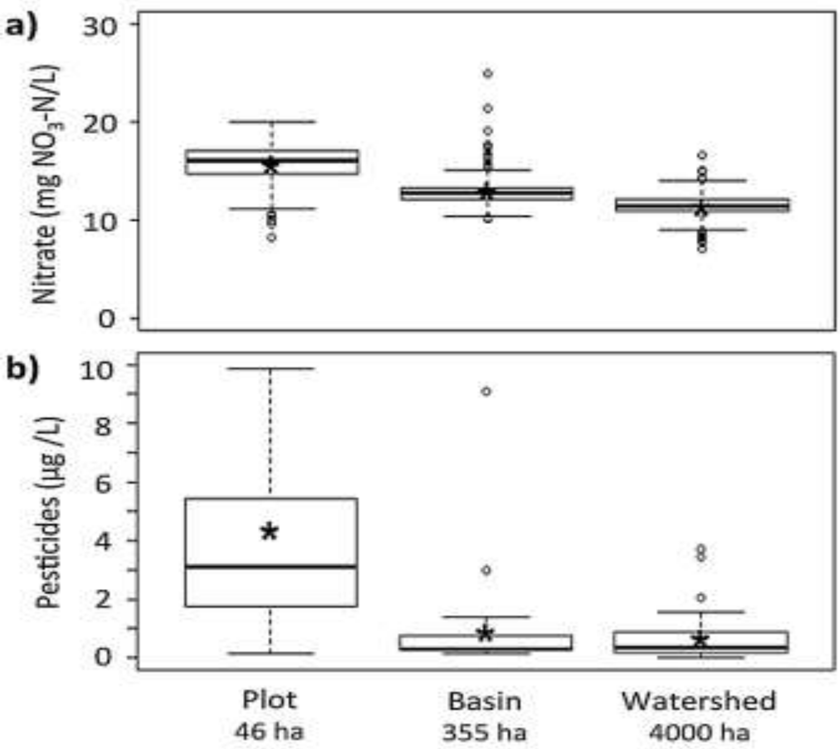

Fig. 2Experiments found that "nitrate and pesticide concentrations in the outflow of three IRSTEA" experiments had a similar land use pattern (more than 80% agricultural usage). Nitrate, (a) and 26 different pesticides, (b) Average, median, 25 and 75 percent quantile, and minimum/maximum values (asterix, bold lines) (whiskers)**(Tournebize et al., 2015)**

Only a small fraction of the total pesticide dose is exported via agricultural drainage, usually less than 5% of the sprayed amount. In comparison to the amount of nitrate exported, the amount of pesticides shipped per hectare each year is a few grams, or three orders of magnitude less. Pesticide transfer is most likely to occur during the first few high-flow events that occur shortly after application. It is possible to detect significant pesticide concentrations in the water even after lengthy durations since the last application, even if flows have resumed. This means that some flows provide no risk of pesticide transfer in the immediate aftermath of application ("*except for remnant persistent pesticides such as Atrazine*"). Pesticides in the soil play a role in exports when the area is drained. Over-the-drain pesticides are more readily washed away than inter-drain insecticides in the soil. There is no correlation between pesticide concentrations and spatial scale like there is with nitrate levels. Upstream, the concentrations are significantly higher (>1 g/L) than the lower course area of the watershed (Fig. 2). Farmers' agricultural practises differ greatly, which has a diluting effect across the board. Even when flow rates remain constant, concentrations are reduced. A thorough hydrological study and knowledge of transfer routes and seasonality are a requirement for any consideration of water conservation (in this case, agricultural drainage). Because of what we've learned about non-point source nitrate pollution in the context of tile drainage, we can say that:

(1) No matter how large or small the intervention, all flows export nitrate in similar concentrations.

(2) Only flows following pesticide application pose a significant risk of transmission, with the largest concentrations occurring at the farm's exit.

4. Development of wetlands to remove agricultural pollution

4.1 Dissipation processes

Several studies have looked into the nitrogen cycle of CWs and the efficacy of CWs in treating wastewater, industrial waste water, and agricultural waste water (Fig. 3). It is becoming increasingly common to incorporate ecological engineering concepts into the design of CWs. A variety of filtering mediums can be utilised to push flow into the system, but outputs can be located at a height that makes the installation of varied oxygenation conditions easier**(Kadlec & Wallace, 2008)**

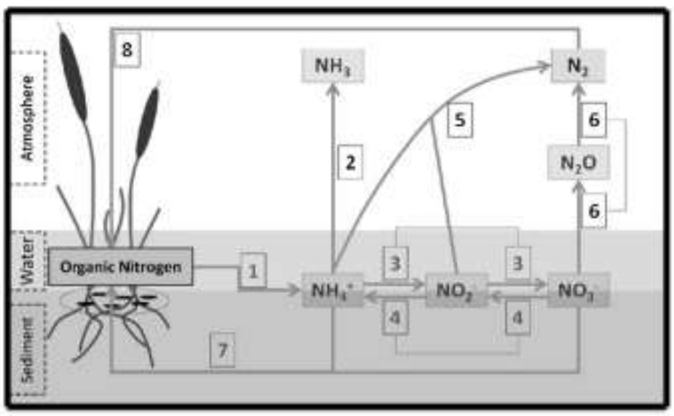

Fig. 3Wetlands' role in the nitrogen cycle Volatilization, nitrification, and ammonification make up the first three steps in the process conversion of nitrate to ammonia by dissimilative means (DNRA), Denitrification, assimilation, and N2 fixation are all steps in the anaerobic ammonia oxidation (ANAMMOX) process**(Priebe et al., 2005)**

4.2 Intercepting flows:

Intercepting a stream on or off the water's surface A watershed's agricultural drainage collector must be taken into consideration while determining whether to use on-stream or off-stream interception for CW insertion. For nitrates or pesticides, one of these methods is better suited than the other for transmission**(Moorman et al., 2015)**

5. Multifunctionality of CWs

Provisioning and maintenance, habitat and enjoyment, as well as economic and social benefits, are all possible in most CWs. Maintaining habitat and biodiversity is another well-known CW service, as is biomass production and the regulation of water quality and runoff, as well as greenhouse gas emissions. Nutrient retention and biodiversity have been discovered to be fundamentally affected by area, depth, and shoreline complexity, sometimes in conflict with one another**(Moorman et al., 2015)**

6. Conclusions

Pesticides and agricultural pollutants like nitrate could be reduced by using CWs. Farms benefit greatly from using green infrastructures, which reduce pollution transfer. A 50 percent target can be accomplished by allocating "*1% of the upstream contributing surface area to CWs*". A large on-stream FWSCW CW should be used to prevent losses of nitrates from drainage basins, according to our recommendation. In small upstream catchments, pesticide runoff has been greatly decreased, hence several off-stream FWS CWs in upstream areas is the ideal option. Hydraulic residence time in CWs is crucial to the water treatment process. For the best results, it must be governed by the end-users. Aside from these stimulants, microbial purifying processes are naturally assisted by the other components. Season, hydrology, and contaminants' properties will all influence how successful they are. To reduce agricultural pollution, the use of CWs is essential, but should not be exploited as a pretext to pollute more. Research on FWS CW emissions and fluxes of N2O is important to safeguard the environment. Much emphasis is placed on the N2/N2O ratio. Additional research on pesticide metabolites or binding residues in CWs is needed to avoid the ticking time bomb effect.

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