Approaches to determine the nutrient retention value of wetlands

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Introduction

The "CircuLar Economy Approach in River pollution by Agricultural Nutrients with use of Carbon-storing Ecosystems" (CLEARENCE) project aims at the development of an integrated landscape-ecological, socio-economic and policy framework for using wetland buffer zones (WBZ) in circular economies of water purification and nutrient re-use in agriculturally used catchments (www.moorwissen.de). CLEARANCE aims to deliver: (1) assessment of synergies and constraints between nutrient removal in WBZ and biomass utilization; (2) analysis of market and non-market values of rivers and river ecosystem services (as co-benefits of WBZ); (3) quantification and upscaling of costs and benefits of WBZ at the catchment scale; (4) policy and social network analysis concerning feasibility of using WBZ in circular economies as a solution to agricultural nutrients pollution; (5) market assessment of commodification options of WBZ-related ecosystem services, including nutrient removal and biomass production (KOTOWSKI et al., 2017).

The part of the University of Kiel in this project is to look for worldwide approaches for marketing wetlands as a nutrient sink and to discuss the findings for their usability for European transboundary watercourses. In general, abiotic and biotic elements, structures and processes of an ecosystem that contribute directly or indirectly to human well-being are referred to as ecosystem services, whereby a social and economic value is attached to nature. This is the basis of Payments for Ecosystem Services (PES) reasoning (MATZDORF et al., 2014). Marketing of wetlands as a nutrient sink is an important step to counter the major problem of nutrient pollution in European aquatic ecosystems, and would improve compliance with the European Water Framework Directive (2000/60/EC) and the Marine Strategy Framework Directive (2008/56/EC). To establish a market for PES in wetlands, it requires a product, a market, a buyer, a standard and methodologies to reliably estimate the retention/reduction of nutrients (JOOSTEN, oral 2018). For carbon, for example, such a network already exists in form of the MoorFutures certificates. However, structures for trading with nitrogen are not available until now. Nevertheless, there are some theories, examples and pilot-projects about financing the ability of wetlands to hold back nutrients.

After an introduction into the processes of nutrient retention and affecting factors, we show different international examples of approaches and pilot projects. Finally, we discuss limitations for wetland restoration - key tool for common implementation of WBZ concept.

Nutrient removal processes in wetlands

Nutrient trading, which falls under water pollution, is more complicated than other trading systems due to the complex nature of nutrient sources, transformations, and transport in waterways (KOSTEL et al., 2014).

Nitrogen in wetlands is removed through two biologically mediated pathways as well as sedimentation and soil adsorption (SONG et al., 2012). Primary production by macrophytes and benthic microalgae temporarily immobilizes N, whereas permanent N removal occurs through a series of biochemical processes as mineralization of organic nitrogen and nitrification of NH_4^+-N, followed by denitrification (REDDY et al., 1989). Denitrification is the reduction of inorganic oxides (NO_3^- and NO_2^-) to gaseous end products (N_2O and N_2), carried out by facultative anaerobic heterotrophic bacteria, by using the inorganic oxides as an electron acceptor for anaerobic respiration to generate energy (POE et al., 2003; LU et al., 2009). Nitrate immobilised by plants or microbes can be rereleased to soil following death and decomposition of these organisms, its removal from the system only occurs if the vegetation is harvested as part of the management of the system (HANSON et al., 1994; VERHOEVER et al., 2006).

This variety of physicochemical and biological processes can be influenced through numerous environmental factors (LEE et al., 2009, SONG et al., 2012). Those include water temperature and pH, hydraulic residence time (HRT), oxygen availability, nitrogen concentration, organic carbon supply, type and density of vegetation, water levels, the characteristics of microbial communities, climate, the distribution of wastewater and influent characteristics, wetland bathymetry, sediment, soil type and texture and the topography of the valley (HANSON et al., 1994; CLEMENT et al., 2002; POE et al., 2003; LEE et al., 2009; LU et al., 2009; SONG et al., 2012; DZAKPASU et al., 2012). These parameters are often related to denitrification rates and vary spatially and temporally depending on changes in and interaction of these environmental conditions (CLEMENT et al., 2002; LEE et al., 2009; SONG et al., 2012).

Seasonal changes influence the denitrification, because the temperature influences the growth of plants, microbial activity and oxygen diffusing rates in wetlands. Biological nitrogen removal is most efficient at 20-25°C (LEE et al., 2009). Denitrification slow down below 15°C and above 30°C and almost ceases below 5°C. Therefore, the overall nitrate removal rate is significantly higher in summer than in winter (POE et al., 2003; LU et al., 2009; SONG et al., 2012; DZAKPASU et al., 2012). Nitrogen removal efficiency varies greatly with flow conditions and residence time. An 8-day HRT with a pH between 6.5 and 8.5 leads to optimal denitrification (LEE et al., 2009). Biofilm improve the denitrification rates because periphytic algae provide a desirable carbon source for denitrifiers. Under nutrient-rich conditions, well-developed periphytic biofilm show an increase of denitrification from 20% to more than 50% in summer and from 10% to 30% in winter (LEE et al., 2009; LU et al., 2009). Common macrophytes in wetlands are reed (*Phragmites australis*), cattail (*Typha* spec.) and bulrush (*Scirpus* spec.). The rhizosphere of these macrophytes provides surface areas for the most energetic reaction zone. It facilitates various physical and biochemical processes caused by the relationship of plants, microbial communities, soil and contaminants (LEE et al., 2009).Wetland systems with vegetation typically remove greater amounts of total nitrogen than non-vegetated systems (LU et al., 2009).

To achieve quantitative predictions of the nitrogen retention ability of riparian peatlands despite these adverse circumstances, WETTRANS, a matrix model connecting flow paths and nitrogen transformation was developed with a quasi-stationary mass balance approach (TREPEL & KLUGE, 2004).

To quantify N and P losses from diffuse sources such as field runoffs the EUROHARP Toolbox combines nine contemporary quantification tools (QTs). It provides end-users with guidance for choosing the appropriate quantification tools that will satisfy existing European requirements on harmonisation and transparency for quantifying diffuse nutrient loss (BORGVANG et al., 2003; KRONVANG et al., 2009).

Methods

Water pollution credit trading theory

Pollution credit trading is a market-based regulatory compliance alternative to traditional command-and-control (CAC) regulations. The market-based approach can achieve the same aggregate level of pollution control as a CAC program, but permits dischargers to share the pollution control burden more efficiently. For water quality, pollution credit trading, allocates reductions in pollutant loadings across point and nonpoint sources in a watershed using a least-cost criterion. Allowing point sources with high abatement costs to trade pollution credits with nonpoint sources that have lower costs may reduce that total abatement costs of water quality improvement. Point-nonpoint-source trading gives publicly owned treatment works and industrial point sources an option of bringing agricultural and urban nonpoint sources under control instead of requiring more controls at point sources (HOAG & HUGHES-POPP, 1997).

Six guidance factors that influence the success of a marketable permit-trading program for water quality (HOAG & HUGHES-POPP, 1997):

1. Transaction costs - Low transaction costs increase the trade potential. Transaction costs can be reduces by specialization and agreements between polluters and the government.
2. Number and relative discharge of participants – Allowing point-point- and point-nonpoint-source trading increases the potential trade benefits. However, too many or too few participants can make trading difficult and costly.
3. Abatement costs – Participants gain when marginal abatement costs differ between traders. Trading costs are minimized when marginal control costs equalize across all dischargers.
4. Enforcement costs- When neither maximum emissions nor cost parameters are identical across firms, enforcement costs may be higher for a trading program compared with a CAC program.
5. Trading ratio – Uncertainty about pollution abatement, particularly for nonpoint polluters, leads to safety factors for trading, which increases the marginal costs of trades and decreases trading potential.
6. Loading limits – Loading levels must exceed regulation limits to stimulate trading.

In essence, a regulator sets a ceiling on the amount of pollution allowed for a whole group of polluters within a "bubble" and issues permits to individual polluters within that bubble for their share of the total amount. Polluters can then buy or sell pollution discharge allocations so that those who can clean up cheaply can do so and then make money by selling spare pollution credits to those for whom cleaning up would be more expensive (JACOBSEN et al., 1994).

Numerous types of markets exist for ecosystem services and no one type of market is best in all situations. WOODWARD and KAISER (2002) identify four types of markets for water quality trading: exchanges, bilateral negotiations, clearinghouses, and sole-source offset.

Exchanges

Exchanges are the most traditional and easily recognized markets for trading goods or services. Exchanges provide a meeting place for buyers and sellers to exchange a well-defined commodity at a price determined by supply and demand. Exchanges provide clear prices and thus clear incentives to participants and involve the lowest transaction costs of any market structure (WOODWARD and KAISER 2002). However, a key requirement for exchanges is that the commodity being exchanged be uniform and well defined; this is a serious drawback for water quality trading (KOSTEL et al., 2014).

Bilateral negotiations

Bilateral negotiations arise when a commodity to be traded has little uniformity. Buyers and sellers must clearly communicate the nature of the commodity and its price, as in a conventional market for used cars, which has greater uncertainty about the commodity than the new car market. Unfortunately, these negotiations generate high transaction costs. Because of the lack of uniformity in nutrient credits, WOODWARD and KAISER (2002) expect bilateral negotiations to be common in nutrient credit trading, despite their high transaction costs.

The Nutrient Farming project in the USA tries to establish a bilateral negotiated market (HEY, 2008; KOSTEL et al., 2014) see below.

Clearinghouses

A Clearinghouse is a market structure in which an intermediary breaks the link between the generator of abatement credits and the user of those credits. The state or some other entity pays for pollution reductions and then sells credits at a fixed price to polluters needing to exceed their allowable loads. A clearinghouse differs from a broker in a bilateral market in that clearinghouses eliminate all contractual or regulatory links between sellers and buyers so that parties interact only with the intermediary.

The PS/NPS trading program in the Tar-Pamlico Basin is a good example of a Water Quality (WQ) clearinghouse (WOODWARD and KAISER (2002) see below.

Sole-Source Offsets

Sole-source offsets are simply an action by a polluter to offset emissions by providing or purchasing an offset taking place elsewhere, in the absence of a defined water quality market. Sole-source offsets may have high transaction costs (as the buyer must effectively create their own trade); however, if the project is a true “win-win” situation, transaction costs may be low relative to the gains from trade. Oversight costs to government regulators are likely to be lower than in more formal markets due to the limited number of “trades” taking place (WOODWARD and KAISER (2002).

An example of Sole-Source Offsets are the German compensation agencies, which offer compensation measures with the help of Ökokonten (eco-accounts). Well-established method of compensation is the carbon trading with MoorFutures (www.ausgleichsagentur.de) see below.

Results

Nutrient Farming (USA)

The Wetlands Initiative’s (TWIs) alternative trading strategy of nutrient farming will use wetlands to remove nutrients. Rather than growing corn and soybeans, a nutrient farmer will “grow” wetlands. The “harvest” is the excess nitrogen and phosphorus removed from the incoming surface water and carbon dioxide, which is removed from the atmosphere. The farmer can manage the land to optimize the natural wetland processes that sequester or remove phosphorus, nitrogen and carbon. Unlike BMP strategies, nutrient reduction credits can be verified because nitrogen and phosphorus concentrations can be measured at the intake and outfall of the nutrient farm. Landowners then sell nutrient reduction credits, either through an open market or long-term contracts, to other crop or livestock farmers, municipalities or industries that release excess nutrients to surface waters and cannot cost effectively remove these nutrients themselves (HEY, 2008; KOSTEL et al., 2014).

Over 2009–2012, TWI and several partners conducted a research study to assess whether such a market would be environmentally and economically feasible in the Big Bureau Creek Watershed, a sub-watershed of the Lower Illinois-Lake Senachwine watershed. This work was supported by an U.S. Environmental Protection Agency Targeted Watershed Grant (www.wetlands-initiative.org/nutrient-credit-trading/). Based on a cost comparison analysis performed between conventional biological nutrient removal at wastewater treatment facilities and treatment wetlands, nutrient farms can cost effectively remove nitrogen to proposed nutrient criteria. For example, the annual cost for a sanitary district located in the upper Illinois River watershed to construct and implement biological nutrient removal control to meet nutrient criteria of 2.18 mg/l TN and 0.5 mg/l TP would be US$ 211 million. The annual cost of restoring and operating 130,000ha of nutrient farm wetland, which is the area required to remove the sanitary district´s monthly demand, is US$ 103 million or 51% less than advanced wastewater treatment costs (HEY et al., 2005b).

Since the performance of treatment wetlands is seasonally dependent, the nutrient farms have to be designed to meet the monthly demand of industrial and/or municipal discharges. Therefore, during certain times of the year, such as the summer and fall, there is an excess capacity to remove nutrients in the wetlands and the nutrient farms could generate surplus credits. Thus, the 130,000 ha of treatment wetlands would remove a surplus of 26,100 Mt of nitrogen and 2000 Mt phosphorus with a total value of approximately US$ 56.3 million. If secondary markets for these excess nutrient credits could be developed, then the savings could reach as high as 60-70% of the cost of conventional biological nutrient removal (HEY et al., 2005a; HEY et al., 2005b).

The nitrogen market would need to be locally based. Dischargers of nitrogen would likely have to buy credits from sellers downstream of their discharge point. In this way, elevated concentrations of nitrogen in the river system would be minimized. In cases where the nutrient farm is located at a distance from the point of nutrient discharge, regulatory agencies will need to identify stream reaches where nutrient transport will be allowed as a designation use (HEY et al., 2005b).

Such a market system, adapted for local conditions, could drive nutrient runoff reduction in similar agricultural watersheds throughout the Midwest (www.wetlands-initiative.org/nutrient-credit-trading/).

However, until large-scale nutrient farms are in existence and operating experience is gained, there will be reluctance to use this technology. Pilot projects, in various ecoregions, are necessary to establish optimal design and operating procedures and to demonstrate the economic efficiency of treatment wetlands (HEY et al., 2005a). Statewide numeric nutrient standards limiting nitrogen and phosphorus from point sources like municipal facilities are required to create the demand necessary to drive nutrient credit trading markets in Illinois. These standards are still some years off (www.wetlands-initiative.org/nutrient-credit-trading/).

Tar-Pamlico (USA)

The North Carolina Division of Environmental Management (DEM), North Carolina Environmental Defence Fund (EDF), Pamlico-Tar River Foundation, and Tar-Pamlico Basin Association (a coalition of dischargers) adopted a two-phase plan to achieve nationally determined nutrient reduction goals (WOODWARD & KAISER, 2002). The parties agreed to finance development of an estuarine computer model for the basin, evaluate wastewater treatment plant engineering, and implement a nutrient reduction trading program during phase 1 (1990 to 1994). The model assesses the relative importance of nutrients from point and nonpoint sources and tracks and targets Best Management Practices (BMPs) for reducing agricultural nonpoint-source discharges (HOAG & HUGHES-POPP, 1997). Results of the model will be used to develop refined nutrient reductions for Phase II of the strategy (JACOBSEN et al., 1994).

Association members are jointly responsible for achieving the total annual nutrient loading allowance, but members may allocate individual discharge levels among themselves. If the association could not meet the nutrient loading allowance, it could buy nutrient credits by contributing funds to the North Carolina Agricultural Cost Share Program (ACSP). ACSP is a voluntary program that provides technical assistance and pays farmers 75% of the average cost to implement agricultural BMPs. Association funds would supplement state cost-share money allocated to the Tar-Pamlico Basin and finance additional personnel for BMP review and identification (JACOBSEN et al., 1994; HOAG & HUGHES-POPP, 1997; WOODWARD & KAISER, 2002).

On this way, a municipal wastewater treatment plant could help fund grassed waterways on croplands instead of installing expensive, high-tech controls at the plant (JACOBSEN et al., 1994).

In order to establish a point/nonpoint trading system, an appropriate trading ratio must be determined. The trading ratio is the amount of nonpoint source control that a point source discharger must undertake to create a credit for a given unit of point source discharge. Under the Tar-Pamlico strategy, an Association member pays $56 per kg of excess nutrient discharges to the nonpoint source control fund administered by the ACSP. This figure is based on the average nonpoint source control costs in a neighbouring watershed, which had sufficient cost and nutrient reduction data and includes a safety factor of 3:1 for cropland BMPs and 2:1 for confined animal operations (JACOBSEN et al., 1994; HOAG & HUGHES-POPP, 1997).

The safety factors are included to account for the fact that nonpoint source loadings are less predictable over time and space because they are more random than point source loadings and are less reliably controlled than point source controls. All BMP credits have a useful life of ten years unless cost share program contracts with the nonpoint sources provide for a longer period (JACOBSEN et al., 1994; HOAG & HUGHES-POPP, 1997).

By allowing polluters to buy or sell pollution allocations among themselves, the program lets market forces produce a cost-effective outcome. The most cost-effective methods of control, whether point or nonpoint, will be used to reduce pollution, resulting in a lower total cost for pollution control. Trading programs take advantage of the differences in pollution control costs between various polluters and provide incentives for some polluters to "over control" their discharges or emissions through the ability to sell their extra pollution allocation (JACOBSEN et al., 1994).

Northern Everglades Payment for Environmental Services (NE-PES) Program (USA)

The Northern Everglades Payment for Environmental Services Program (NE-PES), which started in January 2011, was based on the ecological success of the pilot program Florida Ranchlands Environmental Services Project (FRESP) (MATZDORF et al., 2014).

Since 2005, a coalition of non-governmental environmental organizations, state and federal agencies, ranches, and researchers has been developing a Pay-for-Environmental Services (PES) program that would compensate cattle ranches in Florida´s northern Everglades region for providing water storage and nutrient retention on private lands (BOHLEN et al., 2009).

Its aim was to: field test credible, yet cost-effective, methods for producing and documenting the environmental services of water storage and nutrient (phosphorus (P) or nitrogen (N)) load reduction, designing a comprehensive program, including the contracting processes, and facilitating negotiation between buyers and sellers to determine a price for services. In the pilot phase, participating ranchers are being paid for the total costs of installing and operating different Water Management Alternatives (WMAs) on their land. They are given a fixed annual “participation payment” for 3 years, with an option to renew (BOHLEN et al., 2009; LYNCH & SHABMAN, 2011).

The WMAs include rewetting previously drained wetlands, managing, pasture drainage to increase water retention, pumping water from regional canals into a natural or grazed treatment wetland for nutrient removal, building impoundments to store more water on the ranch, and constructing simple gravity water control structures to return the water with reduced nutrients to the regional system (BOHLEN et al., 2009; LYNCH & SHABMAN, 2011; MATZDORF et al., 2014).

For nutrient removal WMAs, it is expected that a reduction in nutrient loads could be determined using measures of flow and concentration of nutrients in the diverted water and flow measures and nutrient concentration in the return discharge (LYNCH & SHABMAN, 2011).

The nutrient removal services would be affected by the weather as pumps could only be operated when water level in canals reached a certain elevation discharge (LYNCH & SHABMAN, 2011).

The paying authorities were not able to create a financial plan to take account of such fluctuations. In addition, ranchers, as sellers, preferred a fixed annual income source. To address the concerns, a model was designed to calculate annual water- and nutrient-retention based on average rainfall over ten years. A fixed annual payment was to be based on this forecast. The aim was to develop a precise but at the same time easy-to-use model which took account of specific local conditions, such as existing and planned land use, size, soils, vegetation, topography, and existing and proposed water management infrastructure (LYNCH & SHABMAN, 2011; MATZDORF et al., 2014).

Ranchers must document the measures implemented and the ecosystem services provided in order to receive their annual payment. For nutrient removal WMAs, the pump records will show whether the pumps were running as required when the canal reached stages that in the contract were supposed to trigger pump operations (LYNCH & SHABMAN, 2011; MATZDORF et al., 2014).

Upstream Thinking (UK)

South West Water (SWW) provides drinking water and wastewater services throughout Cornwall and Devon along with small areas of Dorset and Somerset in southern UK – an operating area of more than 11,000 km^2 with 1.6 million residents. Around 90 % of the drinking water comes from reservoirs and rivers. Since 1989, SWW has made substantial investments in environmental improvements to bring the region's drinking water, sewerage systems and bathing waters into line with UK and European Union standards (MATZDORF et al., 2014).

Upstream Thinking is part of SWW´s long-term business plan to reduce its environmental footprint and manage the impact of diffuse pollution on costumers´ bills. The National Farmers Union, the Environment Agency, Natural England and the Farming and Wildlife Advisory Group support it. The programme has two main elements: advice and grants for farmers to use Best Management Practices (BMPs) and the restoration of peatland in partnership with landowners. Grants are targeted at farms with land connected to rivers above water abstraction points. The aim is to reduce the amount of unwanted substances in river water, which in turn helps to control the cost of chemicals and energy needed to turn raw water into high quality tap water. Farm advisers visit farms and carry out an assessment resulting in a whole-farm plan. This includes a water management plan and future capital investment proposals targeted at water quality improvements. Upstream Thinking funds up to 50% of the investments and enabling farmers to access funding from other sources (www.upstreamthinking.org, www.southwestwater.co.uk).

Delivered by the Exmoor Mires Partnership, the second part of the Upstream Thinking programme successfully investigated and restored over 2,000 hectares of land on Exmoor in 2010-15. Work to block drainage ditches on Exmoor also continues, with a target of restoring a further 500 hectares of peatland (www.exmoormires.org.uk, www.upstreamthinking.org).

Integrated constructed wetlands (Ireland)

In rural areas of Ireland wastewater from domestic treatment typically decentralised, i.e., wastewater is treated on side. The most common method of on-side wastewater treatment is private septic tanks and associated percolation areas. Overall, there are 400,000 septic tanks in use around the country (McAULIFFE, 2011).

Often septic tanks are leaking or incorrectly constructed. Percolation areas are frequently clogged and do not treat the wastewater adequately. Typical treatment efficiencies of this system are of the order of 40% removal of organic matter, and 15% removal of nitrogen and phosphorus. The EU views faulty septic tanks and percolation areas as a major environmental concern. In October 2009, Ireland was taken to the European Court of Justice by the European Commission for failure to put in place adequate legislation to cover septic tanks and percolation areas (McAULIFFE, 2011).

Clearly, the government will be forced to take act to address this issue. A likely solution is the upgrading of existing septic tanks and percolation areas. This cost is likely to be borne by the homeowner. With this in mind, it is obvious that an effective and affordable domestic wastewater treatment method is required in Ireland (McAULIFFE, 2011).

Integrated Constructed Wetlands (ICW) are engineered systems designed to replicate the wastewater treating ability of natural wetlands (GORMLEY, 2010). There are a number of advantages to using constructed wetlands. Treatment efficiencies are typically very high. Removal rates of up to 95% of organic matter, nitrogen and phosphorus have been reported. Running costs are quite low as the plants and soil microorganisms treating the wastewater do not need any fuel/electrical supply. The construction costs are also favourable compared to the other methods, as the landowner only have to bear between 20% and 1/3 of the costs. The rest is payed by the EU and Irish funds (HARRINGTON, 2017). Furthermore, the biomass can be harvested and changed into wood-chip pellets. The system can be regarded as sustainable and wetlands can be built to fit the landscape (McAULIFFE, 2011).

As described by SCHOLZ et al. (2007), the concept of Integrated Constructed Wetlands (ICW) employs the free water surface flow (FSW) constructed wetlands (CWs) model and incorporates the concept of restoration ecology, specifically mimicking the structure and processes of natural wetlands. They are characterized by a multi-celled configuration with sequential through-flow and are based on the holistic and interdisciplinary use of land to control water quality. Typically, ICW systems have shallow water depths (10 – 30 cm) and contain many plant species, which facilitates microbial and animal diversity (NYGAARD & EJRNÆS, 2009; JURADO et al., 2010; DZAKPASU et al., 2012; HARRINGTON, 2017).

ICWs can deal with domestic wastewater (primary, secondary or tertiary) and farmyard soiled water and have the potential, subject to further research and development, to address wastewater from food processing, water-vectored animal waste, organic and animal sludge's, landfill leachate, road/urban runoff and intercepted diffuse water-vectored pollution (GORMLEY, 2010, HARRINGTON, 2017).

Discussion

As shown in the example of Nutrient Farming and Upstream Thinking, nitrogen retention with help of restored wetlands is more cost-effective than sewage treatment plants. Example calculations from Germany gives similar results. For this purpose, SCHRAUTZER (unpublished) determined the cost-effectiveness of nitrogen retention in wetlands at the Ritzerau project farm in Northern Germany by including the factors size of the used area, the purchase price, the share of planning, the share of construction work and the nitrogen retention rate in kg N. Results of the calculation was a price of € 28 / kg N. The efficiency of sewage treatment plants is clearly lower with a price of € 50-100 / kg (LLUR).

Despite the high demand for nitrogen retention and the computational proof that wetlands represent a low-cost alternative, there are no examples of a functioning nitrogen market. At least by taking into account the prerequisites for a market model of JOOSTEN (oral, 2018), that requires a product, a market, a buyer, a standard and methodologies to reliably estimate the retention/reduction of nutrients (JOOSTEN, oral 2018). In Germany it is currently being examined to what extent nitrogen trading can be linked to carbon certificates of the MoorFutures project.

MoorFutures is an instrument of the voluntary carbon market developed by the University of Greifswald and Agricultural and Environment Ministry of Mecklenburg-Western Pomerania (Germany). Businesses or private individuals may offset their carbon emissions by purchasing certificates. The certificates are generated by rewetting peatlands in the participating federal states to reduce carbon loss. A MoorFutures emission certificate equates to a saving of one tonne of carbon dioxide, which is achieved over a period of 30 or 50 years. The price of a certificate currently lies between 30€ and just under 70€, depending on the project area and term. Registered serial numbers and entries in a project registry identify the certificates and clearly assign them to specific projects. The amount of carbon emissions saved compared to conditions before the rewetting is calculated using the Greenhouse Gas Emission Site Types (GEST) approach (MATZDORF et al., 2014; JOOSTEN et al., 2015; www.moorfutures.de). At the moment MoorFutures 2.0 are under development. MoorFutures version 2.0 is an extension of the existing MoorFutures standard for carbon credits. In the new version, further ecosystem services are incorporated and provided in tandem with emission reductions. The five additional methodologies will include improved water quality, flood mitigation, groundwater enrichment, evaporative cooling and increased mire typical biodiversity. Thus, MoorFutures v. 2.0 is a carbon+ standard: Additional effects are not prescribed but are targeted and, so far as possible, quantified (JOOSTEN et al., 2015).

The approach of the Nutrient Farming goes into a similar direction as the Moor Futures, except that just like in the NE-PES project elicit factual inflow and outflow is measured. This is associated with a high technical complexity and enormous installation costs. Such an effort only makes sense if a farmer owns large, contiguous lands in river valleys or peatland areas. This is hard to find in Europe due to the fragmentation of the landscape. Cooperative agreements between all farmers of a river section would be conceivable, so that a cohesive floodplain area can be rewetted. Thus, the nitrogen value could be measured at the inlet and outlet of the rewetted area. Farmers would then be paid according to the size of their land share.

Also, the Tar Pamlico project is not easily transferable to Europe. In addition to the problems that occur in the United States, there is the additional turmoil in Europe that flowing waters often flow through several EU countries. In order to operate efficient water protection, a European solution is indispensable. However, for smaller rivers, which only flow through one country or even only through one federal state, this approach is more conceivable.

In addition to the problem of how a market can be integrated, the problem is that if farmers in Europe comply with the existing Fertilizer Ordinance and reduce their livestock down to maximal two units per ha, there is no reason for them to buy certificates in many areas. Therefore, each farmer should be given an emission value adjusted to his farm, which is limited to e.g. 80% of the actual output corresponds. In order to meet legal requirements, they would need to reduce their nitrogen output or mandate someone to withhold nitrogen for them to compensate. This is how a market could arise. Furthermore, farmers can be held accountable at the regional level through the 'polluter pays' principle. Either farmers give land for the creation of wetlands, or they pay for the creation of wetland. Beside, buyers and sellers will not participate in a trading program if the program has no tradable commodity. Pollution caps must be set below key ecological thresholds to achieve environmental goals, and market caps must be set at a point that will drive demand for credits to achieve active market trading.

Politically steering development in the direction of nature conservation over the change in the subsidy policy makes sense. The Common Agricultural Policy (CAP) is a policy area of the European Union. Today it is based on two pillars. The first pillar involves direct payments to farmers. These payments have been decoupled from production since 2006 and are only dependent on the agricultural area. The second pillar of the CAP covers a variety of possible rural development measures, including environmental and climate change. The funding guidelines of the CAP are usually adopted every seven years and are based on the multiannual budgets of the EU. Between 2014 and 2020, EUR 312.7 billion (29%) was planned for market-related expenditure and direct aids (pillar 1) and EUR 95.6 billion (9%) for rural development (pillar 2) (www.bauernverband.de**). A shift of funds from the first to the second pillar would lead to provision of public and common good as high water quality and high biodiversity. In addition, the promotion of economic approaches such as paludiculture leads to the reduction of nutrients.** Paludiculture is the cultivation of biomass on wet and rewetted peatlands. Ideally, the peatlands should be so wet that steady (long-term) peat accumulation is maintained or re-installed. The basic principle of paludiculture is to use only that part of net primary production (NPP) that is not necessary for peat formation (WICHMANN & JOOSTEN, 2007). This topic is part of the subproject of the working group of WICHMANN within the CLEARANCE project and therefore will not be further explored here.

In other countries some large corporations are investing in environmental projects to create an ecological image. A well-known example is The Toyota Motor Corporation. They follow the slogan: “1 vehicle, 1 tree” (NAYAZRI, 2018). The first forest planted by Toyota became open to the public in 1997 in Japan (SHIBUSAWA, 2011). Since then, the company has funded numerous afforestation actions worldwide.

In addition, by 2050, Toyota aims to reduce the negative environmental impact of automobiles as closely as possible to zero and contribute to the creation of a sustainable society. This is to be achieved by researching more environmentally friendly vehicles and by further commitment to environmental protection. Since 2000, Toyota have provided assistance to organizations researching, developing technologies and training people to improve the environment (www.toyota-global.com/sustainability/environment).

Maybe other companies will follow their lead and invest in nature conservation, with a little political pressure.

In summary, there are some good ideas and approaches around the world to naturally control the nutrient pollution of water bodies. In financing the projects or in marketing the nutrient retention, it is important to be aware of the difficulties by quantification of retention rates and the fact that many different interest groups are involved. In order to minimize the problem of measurability and the many interest groups, it is recommended to start pilot projects for sub-basins. In this context, potentials for nutrient retention including success control and monetary effort should be tested and analysed.

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