Wetlands in the Management of Diffuse Agricultural Run-Off

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Abstract

Natural wetland functions modify the flows and physico-chemical composition of water, as extensive systems as well as localized pockets distributed across landscapes. Contemporary, heavily modified urban and rural landscapes generate a range of diffuse sources of pollution. Intensification of land use not only generates substantial and diverse pollutants but also displaces wetland functioning naturally mitigating at least some of the problems caused by increased run-off. Retention, restoration of construction of novel wetlands and wetland functioning in agricultural landscapes is of particular importance for the reduction of run-off from farmed land.

Keywords

Anthropocene · Pollution · Agriculture · Land use · Surface sealing · Constructed wetlands · Integrated constructed wetlands · Ecosystem services

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C. M. Finlayson et al. (eds.), *The Wetland Book*,
https://doi.org/10.1007/978-90-481-9659-3_220

Introduction

Many natural wetland functions occur in localized pockets across landscapes, modifying the flows and physico-chemical composition of water passing through them. However, in the Anthropocene, the current era in which the cumulative impacts of human activities on the ecosystems and cycles of Planet Earth are at a scale significant enough to constitute a new geological epoch (Crutzen and Stoermer 2000), we live in heavily modified landscapes.

Point sources of pollution, from factories, sewage treatment works and other discrete sources, have been subject to increasing control over the past century and more, at least across the developed world. However, diffuse inputs of both storm water and pollution from a range of sources – urban and industrial sites, infrastructure and rural land use – is of increasing prominence (Novotny 2003). Furthermore, intensification of land use displaces wetland functioning that would naturally mitigate at least some of the problems caused by increased run-off.

Retention or restoration of wetlands and wetland functioning in agricultural landscapes is of particular importance for the reduction of run-off from farmed land (Verhoeven et al. 2006).

Characterising Diffuse Agricultural Run-Off

The *Ecosystems and Human Well-being: Wetlands and Water Synthesis* of the Millennium Ecosystem Assessment (2005) outlines the extent to which agriculture has adversely affected the freshwater environment, and been the principal driver of wetland loss globally. Impacts from agricultural run-off are multiple and substantial.

The panning (surface sealing due largely to compaction especially from the footfall of livestock and use of heavy vehicles) of farmed land reduces groundwater infiltration and contributes to elevated run-off of floodwater from farmed landscapes during heavy precipitation. Concentration of flood run-off can increase its erosive power, contributing to soil erosion and consequent water contamination. Attenuating floodwater close to source is then a priority to avert these adverse consequences.

Agricultural run-off bears with it a range of pollutants. These include microbial pollutants of health concern (such as *Cryptosporidium*, faecal coliform bacteria and viruses) as well as 'sanitary determinands' (particularly organic matter with associated biochemical oxygen demand and ammonia), nutrient substances (particularly forms of phosphorus and nitrogen) and suspended solids which also carry with them a range of adsorbed and absorbed pollutants. This diversity of pollutant types can cause substantial changes in aquatic ecosystems, ranging from physical effects such as increasing turbidity and the blinding of river and lake sediments, though to eutrophication and other chemically vectored ecosystem changes as well as microbially vectored problems.

The attenuation of agricultural run-off is then a priority, although of course avoidance or minimization of the generation of run-off and its associated pollutants at source is a more strategic priority.

The Role of Wetlands in the Management of Agricultural Run-Off

Wetland systems, both natural and constructed, can play significant roles in managing run-off from agriculture (Ockenden et al. 2012). The diverse hydrological, physico-chemical and biological functions of wetlands can serve to reduce muddy flooding and other floodwater-related run-off problems, as well as capturing suspended matter, transforming organic and nutrient substances, and reducing loads of microbial contaminants.

Retention of natural wetland systems and processes, be that extensive mire, bog or other natural wetland systems or else more localized gulleys in the landscape which may provide important if often overlooked wetland functions, can radically reduce both flood peaks and pollutant loads exiting farmed land.

Constructed wetlands can also play significant roles in a range of run-off management challenges. Many constructed wetlands are designed to serve narrow purposes, such as retaining contaminated yard run-off or detaining rain-generated peak flows. However, Integrated Constructed Wetlands (ICWs, addressed in detail in another chapter in this Wetland Book) represent a philosophy of wetland design to achieve multiple, simultaneous benefits (Harrington and McInnes 2009). The range of interconnected beneficial outcomes for which ICWs may be designed includes hydrological buffering, carbon storage, nutrient retention for further productive use or else chemical transformation, breakdown of microbial and other contaminants, trapping of suspended sediment, and a range of wider ecosystem services including enhancing landscape aesthetics, providing amenity and supporting wildlife.

Other more localized and strategically placed solutions can restore important wetland functions to farmed landscapes (Heathwaite et al. 2005). Leaving unploughed contour strips (unmanaged bands of land following contour lines) in farmed landscapes, allowing natural vegetation to establish or else deliberately planting them with trees or hedgerows, can have a substantial impact on the reduction of soil loss and associated pollutants, enhancement of natural infiltration into groundwater, as well as supporting desirable wildlife including pollinators and the predators of crop pest organisms. Another particularly useful form of local intervention is the buffer zone, constituting a fringe of land adjacent to a watercourse that is fenced off, planted up or is no longer ploughed. Habitat regeneration in buffer zones can not only attenuate a substantial amount of diffuse pollution from agricultural land, but can promote the diversification of habitat in the watercourse edge with direct benefits including offsetting some of the negative impacts of run-off entering from upstream reaches that have not been protected by buffer zones. A key consideration for buffer zone design is to ensure that water-vectored pollutants can be retained within the buffer zone, and that they do not bypass the buffer zone feature via sub-surface drainage, ditch networks or poorly-sited gates funneling field run-off (Correll 2005).

Wetlands of all scales, ranging from the wetland functions of often overlooked ditches and runnels in the landscape through to extensive or strategically placed wetland systems, have multiple beneficial roles to play in agricultural landscapes, including the attenuation of run-off (Casey and Klaine 2001).

Other Solutions to the Management of Agricultural Run-Off

As noted above, a more strategic approach to avoidance of aquatic pollution is averting the generation of both run-off and associated pollutants at source. This can be achieved by a range of measures, mainly beyond this scope of this brief introductory chapter. Some simple yet effective measures include:

- separation of clean roof water from contaminated livestock yard water, reducing the volume of potential run-off. This measure also preserves the clean water for other beneficial uses, as well as reducing volumes of contaminated yard run-off that may then be more readily intercepted and treated or beneficially reused, substantially minimizing the pollutant load in run-off.
- avoidance of tillage of land and heavy grazing on steep slopes, averting erosion and protecting soil and nutrients in farming landscapes.
- contour ploughing such that furrows follow contour lines, rather than being oriented down-slope which may promote run-off and associated erosion and pollution.
- relocating gates and feeding rings from valley bottoms to the tops of hills or on drier land away from drainage lines, such that mobilized sediment and other pollutants do not flow immediately into watercourses but may instead be attenuated by natural landscape wetland functions.

These measures, to one degree or another, make use of or avoid overburdening wetland processes within farming landscapes. The net result includes better management of flood peaks and aquatic contamination and the conservation of useful resources (particularly soil and nutrients) within the farming system.

They also reflect that, viewed at a closer spatial scale, diffuse pollution may be more logically defined as comprising multiple local point sources of pollution. Wetland solutions, such as buffer zones, attenuation basins and a range of SuDS (sustainable drainage systems) and related rSuDS (rural sustainable drainage systems), may then be applied strategically to address key run-off pathways from farmed land.

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