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Artificial urban wetlands

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Definition: An artificial or constructed urban wetland is a new or restored marsh area within a city designed to manage anthropogenic discharge such as wastewater, stormwater runoff, or sewage treatment, and to assist in land reclamation after ecological disturbances associated with mining and urban development. They may also provide habitats for native and migratory wildlife.

Synonyms: constructed urban wetlands; treatment urban wetlands; engineered urban wetlands; restored urban wetlands

Introduction

With climate change bringing about less predictable weather events, altering the patterns of rainfall, and generating more extreme events, renewed attention has been given to how nature-based solutions can be re-absorbed into urban design and planning. One of these responses has been attempts to recreate wetlands through artificial constructions in cities, recognising their potential natural role in water and land management, biodiversity, hydrology, and human health, and reversing in part the loss of natural wetlands that has accompanied urbanisation. Despite planning initiatives to reduce urban sprawl and promote more compact cities, the rapid expansion of the world's urban population has put pressure on natural landscapes at an unprecedented rate and wetland loss has continued to point where it is claimed between one third and one half of all wetlands have been lost over the last past two centuries (Davidson, 2014; Hu et al, 2017).

Non-traditional water management approaches such as SuDS (Sustainable Drainage Systems) have helped in meeting the challenges of climate change and urban growth, but there is recognition for a fundamental change in how in future urban water and flood risk are managed. The adoption of constructed or artificial urban wetlands as part of blue-green infrastructure centred on living with and making space for water are increasingly adopted internationally (O'Donnell et al, 2017).

Contributing to water management and habitat development

Whilst constructed wetlands are acknowledged to have three main applications - waste water management, flood control, and habitat creation – most scientific research has focused on water management viewing them as engineering systems understood and created through complex processes involving physical, chemical and biological mechanisms.

Since the early pioneering work in the 1960s and 1970s, ecological engineering technology involved in the construction of artificial wetlands has evolved quickly and now mean a diverse set of wastewater can potentially be treated – from municipal wastewater from housing, through industrial waste to agricultural wastewater as well as storm-water and other run-off (Masi et al, 2018). The core principles remain the same, with the nature of construction for wastewater treatment commonly tanks or waterproofed pods so that treatment systems are self-contained and isolated from the surrounding area. Water flow can be surface or subsurface and depending on site conditions can be naturally flowing or pumped. This focus on artificial wetlands as purification systems, seeking to replicate the various naturally occurring processes under controlled conditions, has dominated the ways in which artificial wetland development has progressed. Scholz (2015) provides an excellent account of the development of scientific knowledge in the use of wetlands to reduce pollution.

In seeking to make gains in water quality through improvement and efficiency of treatment performance attention has been given to the development of appropriate plants, substrates and operational parameters. Although debates over the role of plants in water treatment continues (Saggai et al, 2017; Shelef et al, 2013), the selection of macrophytes and plants usually reflects the characteristics of natural treatment systems of wetlands so that hydrophilic and aquatic species are used having the advantage of absorbing pollutants and then utilising these in their growth. Substrate conditions – essential to the hydraulic connectivity (flow of water through) the wetland and to the growth of plants and microbial community structure – has also been subjected to scrutiny, with the differing benefits and properties of rock types and the use of by-products of other activity (eg rubble) selected to form the substrates being shown to influence the efficiency of artificial wetlands. However, as one of the few parameters that can be controlled in individual wetland sites, much research has focussed on how to influence the hydrology of selected sites. While ideally, a natural flow of water through the site makes it easier to manage and be sustainable, this is seldom achievable as more urban based sites are selected for the construction of artificial wetlands. Emphasis has thus been placed on artificial water flow management, with Gorgoglione and Torretta (2018) providing a useful overview.

Evaluation of artificial wetlands suggest that as water treatment they are less efficient than traditional water treatment plants. As Ingrao et al (2020) note, their pollutant removal efficiency may be less consistent, as it may vary seasonally in response to changing environmental conditions, including rainfall and drought require larger spaces. They also required larger spaces making them only economical where land is available and affordable. Offsetting this, constructed wetlands offer environmental quality preservation, landscape conservation, and economic convenience has assisted to make them a solution in water management and treatment. There also remains a knowledge gap around effective sustainability and long-term management of sites, with most known about its construction and formation.

Rationales for the creation of artificial urban wetlands have thus turned to other contributions they can make to the increasing emphasis in public and urban policy on urban sustainability objectives. City authorities are shifting away from sustainable urban drainage and sewer networks as static means of capturing and diverting water to reduce run-off to more dynamic management practices to add value through use of captured water to enhance sustainability. As such, artificial wetlands are being repositioned as an opportunity to couple such storm-water functions of flow control, infiltration, detention, and/or retention within landscape-scale ecosystem conservation and/or restoration (Ahn & Schmidt, 2019).

Artificial wetlands are increasingly too being viewed as offering opportune sites for the creation of new ecological habitats or for the restoration of a degraded ecosystem, by attracting wildlife species, especially birds, and establishing a green area. As such wetlands contribute valuable landscape components in urban green corridors, whilst also generating connections between nature and local urban communities. Although some research has mentioned that these systems can also be public recreation and education sites, these are generally viewed as ancillary benefits (Knight et al, 2001). A similar secondary benefit is their value as sources of biomass material helping to offset energy needs or as sources of food and fibre (see Avellan and Gremillion, 2019). Whilst this reflects a focus on how constructed urban wetlands may be able to contribute to the urban circular economy, the small scale of operations raise doubts about their efficiency and reliability to be economic.

<u>Positioning in urban sustainability debate</u>

As the Convention for Biological Diversity noted in 2015, wetlands are significant contributors to meeting many of the United Nations' Sustainable Development Goals (SDGs). Although, in their natural state, wetlands sequester some of the largest stores of carbon on the planet with the bulk of sequestered carbon being in the soils rather than in the plant communities, when disturbed or warmed, the reverse action takes place and they release the three major heat-trapping greenhouse gases (GHGs), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Understandably therefore one of the major priorities for limiting future temperature increase is protecting all types of wetland ecosystems from direct human disturbance (Moomaw et al, 2018).

It is less clear however what contribution artificial urban wetlands can make. Positively, in enhancing the return to economic use of polluted and contaminated land, constructed wetlands are viewed as an efficient and relatively low cost approach. And in enhancing the provision of accessible drinkable water, life-cycle analysis of the environmental impacts of artificial wetlands over traditional wastewater treatment plants indicate their lower GHG emissions and where specific forms of free water surface artificial wetlands are used, significantly lower levels of CO_2 and CH_4 are emitted (Mander et al, 2014).

Less certain at present is how artificial wetlands can contribute to carbon sequestration as part of urban and regional responses to climate change. Calculating net sequestration on existing evidence is problematic, although studies do suggest that depending on plant settings and operational conditions, there are positive gains in capturing carbon (de Klein and van der Werf, 2014). Nevertheless, such contributions are small. Moomaw et al (2018) offer one estimation of the impact of wetlands on CO_2 suggesting that the area of new wetlands needed to remove one percent of the current annual increase in atmospheric CO_2 is about 2,000,000 km^2; an increase of about 17% of the current wetland coverage of the globe. Despite the fragility of the evidence, these studies do underline the overall assessment of scientific knowledge that (i) priority has to be on the retention of *existing* wetlands as their contribution is much more significant and much more difficult to replace and (ii) that *new or restored* wetlands have to be of significant scale globally to make a marked impact on climate change. Current understanding of the occurrence and variability of carbon storage between wetland types and across regions does represent a major impediment to the ability of nations to include wetlands in greenhouse gas inventories and carbon offset initiatives (Carnell et al, 2018).

In short, the evidence suggests that the **direct** effect of urban wetland development in carbon reduction and thus climate change is limited. It might be that the **indirect** effects are equal or more significant. The Taskforce on Scaling Voluntary Carbon Markets (2020) suggests that these range from increased biodiversity, job creation, and support for local communities, as well as health benefits from avoided pollution. There is the potential that as such projects if located in less developed or socio-economically poorer areas will result in carbon credits generating flows of private capital into these communities, areas and nations.

Expanding future use, extending benefits

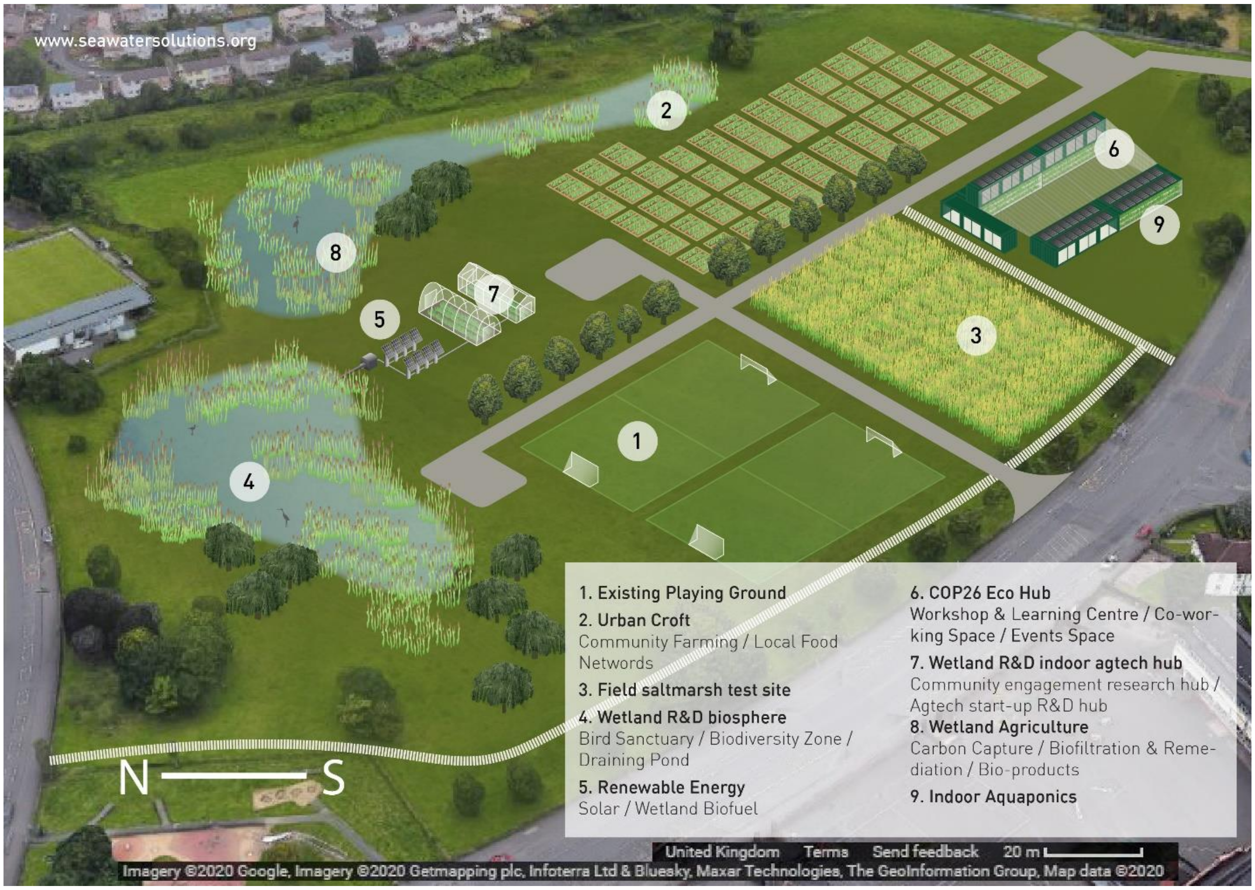
Widespread adoption of artificial urban wetlands and indeed Blue-Green Infrastructure (BGI) has been hampered not only by uncertainties regarding the performance and maintenance of the infrastructure itself as noted above, but also a lack of confidence that decision makers and communities will accept, support, and take ownership of such infrastructure (Thorne et al, 2020). Whilst there is considerable research being undertaken to provide the scientific evidence and knowledge to generate insights required to help allay such concerns about functionality, less easily resolved are socio-political uncertainties relating for example to citizen attitudes and political decision making. Little research has focussed on how to best design wetlands as part of urban infrastructure (Ahn and Schmidlt, 2019) and there is an absence of guidance on how to integrate successfully community stakeholders into restoration planning.

Natural resource professionals are increasingly faced with the challenges of cultivating community-based support for wetland ecosystem restoration and this is most acute in the setting of urban projects. Here, often the natural dimensions of wetlands have disappeared and communities thus struggle to envisage the character and nature of the artificial or restored wetland, and its position within their communities.

Based on their study in Newcastle upon Tyne, UK, O'Donnell et al (2017) advocate that in order to overcome barriers that have constrained blue-green infrastructure projects and the adoption of constructed urban wetland initiatives, there is merit in looking beyond the flood protection and water management benefits derived from them. Whilst these may remain the central rationale for investment in wetland and BGI construction, respondents in their research suggest that promoting the areas as multifunctional space and identifying the multiple benefits of any scheme can be vital to get local support. This means connecting with a wider set of stakeholders, including urban communities and those involved in other areas of local governance and municipal service provision.

Imagining such schemes is likely to be vital for the future expansion of constructed urban wetlands. One recent example is that being proposed in Glasgow ahead of the COP26 summit in 2021 as a pilot project (Figure 1). Led by a small commercial enterprise company specialising in wetland use, Seawater Solutions, the project envisages how wetland technologies to manage water and flooding, aquaponics and food production can build local supply chains, and enhanced social assets to help in place-making can reconfigure underutilised urban spaces.

Figure 1: Integrating urban wetland technologies into communities



Such approaches require changing how wetland developments are planned and delivered, seeking greater collaborative working and co-funding from organisations and departments with a range of different remits and objective whilst also extending the value of artificial urban wetlands within the local community. Through active community engagement, there is enhanced potential for behavioural and cultural change to embrace artificial wetlands compared with solely relying on public observation that has to date formed the traditional approach to their development in cities and communities (O'Donnell et al, 2017).

Additional synergies between green technology and urban quality of life can also arise. In areas where wetlands provide important water resources and are a key part of water management approaches, studies in China, USA and Australia have suggested that both the distance to the nearest wetland and the number of wetlands within close proximity significantly influence house sales price, along with a number of other property-specific and neighbourhood attributes (Boyer and Polasky, 2004; Du and Huang, 2018; Tapsuwan et al, 2009). There is greater recognition of the role wetlands play in improving the quality of human surroundings and providing cultural ecosystem services as aesthetically pleasing places for recreation, education and spiritual development. Potential benefits include improved physical and psychological health, increased community connection and sense of place, and those derived from community involvement in urban conservation (Carter, 2015).

Summary and conclusion

As a potentially significant contribution to creating more sustainable cities globally, the creation of artificial urban wetlands has been gaining renewed attention. Whilst there is a strong and expanding corpus of scientific knowledge into how artificial wetlands can assist in water management, help rehabilitate contaminated and polluted land, and to a lesser extent assist restore the ecological balance of local areas, encouraging expansion of such wetlands has often proved controversial. With more attention being given as to how wetland technologies can be integrated environmentally, economically and socially into urban society, there are exciting new opportunities to see artificial wetlands contribution urban sustainability. Developing local food production, enhancing local social capital and strengthening community involvement with wetlands points offers different and important ways in which urban wetlands will assisting globally in shaping urban futures.

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