# Phytoremediation as Green Infrastructure and a Landscape of Experiences

# PART V: Phytoremediation

## Chapter 12

## PHYTOREMEDIATION AS GREEN INFRASTRUCTURE AND A LANDSCAPE OF EXPERIENCES

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### ABSTRACT

The idea of reconciling landscapes through remediation is not new to the discipline of landscape architecture. However the potential of using transformative remediation to build urban form as a large-scale landscape network and that makes the process of remediation part of an urban landscape experience is still underdeveloped in theory and practice. This paper examines how a remediation process could be exhibited and become a staged design element, and how landscapes of cleaning can become part of the urban infrastructure to create new neighborhoods for research, education, working, and living. The example of two adjacent sites on the contaminated Elbe – Island in Hamburg, Wilhelmsburg Germany demonstrates how the purification process of water and soils can be showcased and experienced by the public and how the landscape framework becomes part of the urban infrastructure. The paper proposes a structural landscape framework for how remediation could become an artistic, aesthetically pleasing intervention with environmental value.

Keywords: connectivity, experience, green infrastructure, green urbanism, landscape architecture, landscape urbanism, phytoremediation

### 1. INTRODUCTION

Urban brownfields are a challenging and a common landscape especially in industrial and post-industrial cities. They inhibit economical growth and use of urban land. Their industrial heritage often isolates them from the urban fabric and

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creates physical barriers. However the sensual, aesthetic quality that goes along with derelict land has been discovered by implemented designs in landscape architecture (Kirkwood, 2001, Latz, 2001, Latz and Partner, 2008, Weilacher, 2008). Prominent examples for remediated new parks on former urban brownfields include: Landscape Park Duisburg-Nord (Latz, 2001 Latz and Partner, 2008, Weilacher, 2008), and the Gas Works Park in Seattle (Johnson, 1991) and the Westergasfabriek Park in Amsterdam (Spens 2007). While they are successful examples of urban park developments that are remediated landscapes they are still not well integrated into their larger urban context. A systematic and strategic approach to remediation landscapes that are connected from the regional to the local scale and that tie into the urban fabric as a continuous network and as a part of a green infrastructure framework is still underdeveloped.

Another objective of this research is the exploration to reveal phytoremediation as an aesthetic experience. Can plants be used as a visible design medium determining each stage of the cleaning process as a sensual experience and create a unique and meaningful landscape? The proposal is made to understand phytoremediation as a process-oriented tool for an evolving green infrastructure network that defines new landscapes. This paper begins with a description of phytoremediation and explains the key elements of green infrastructure. A recent case application conducted by Richard Weller (Weller, 2008) illustrates how green infrastructure can shape urban form. Finally two visionary design proposals by the UMASS Urban Design Laboratory 2007 and 2008 for contaminated sites on industrial brownfields on the Elbe – islands in Hamburg, Wilhelmsburg demonstrate how a landscape of remediation shapes the framework for new urban infrastructure, connects to the existing urban fabric, and becomes a rich aesthetic experience.

## 2. PRINCIPLES OF PHYTOREMEDIATION [1]

Phytoremediation has the capacity to assist in the remediation of polycyclic aromatic hydrocarbons, oils, greases, and heavy metals – which are among the common toxics found in urban brownfields. The simultaneous treatment of these multiple contaminants makes phytoremediation a cost effective and attractive option for urban brownfield areas (Raskin and Ensley, 2000) [2]. Plants typically used in phytoremediation include hybrid poplars, willows (Populus ssp., Salix ssp.), grasses, reeds, and cattails (Festuca ssp., Lolium ssp., Phragmites spp., Typha spp.), penny-cress and mustard (Brassica ssp., Thlaspi ssp.) (Marmiroli and McCutcheon, 2003). These plants' root systems help to rebuild soil structure in the rhizosphere, and through the deposition of organic material from leaves, branches and root cells. Another advantage is that remediation can take place

without minimal disturbance of the site and can be tailored as site-specific solutions. As a process-oriented tool phytoremediation takes a long time, often years or decades. The time dimension can be turned into an advantage if each stage of the cleaning process has a distinct character and sense of place while performing remediation and simultaneously creating green infrastructure.

## 3. GREEN INFRASTRUCTURE

Green infrastructure is an emerging planning and design concept that provides a framework for conservation and development. It acknowledges the need for providing places for people to live, work, shop, and enjoy nature. Green infrastructure helps communities to plan development in ways that optimize the use of land to meet the needs of people and nature. Green infrastructure can shape urban form, is principally structured by a hybrid hydrological drainage network, complementing and linking relict green areas with built infrastructure that provides ecological functions (Benedict and McMahon, 2006). It applies key principles of landscape ecology to urban environments as a multi-scale and multi-layered approach. The green infrastructure pattern derives from ecological and social process relationships with an emphasis on connectivity (Ahern, 2006). Following the principles of green infrastructure as a planning and design concept, phytoremediation can become one significant and complimentary element that creates the framework for future development.

## 4. CASE APPLICATION FOR GREEN INFRASTRUCTURE - PERTH, WESTERN AUSTRALIA

Weller (Weller, 2008) superimposed current landscape urbanism ideas (Waldheim, 2006) onto quotidian suburban master planning. In the Wungong Urban Water Landscape Structure Plan he joins planning and design, focuses on landscape as an infrastructural system and aims for structural influence. Existing vegetation and the Wungong River System are part of the landscape structure that ensures the protection and creation of landscape systems – habitat, drainage and open space. Park avenues become a system of linear elements for stormwater treatment and recreational corridors. They create the framework that organizes roads, schools, and developable land. Weller's approach is applied and reflected in the design proposals of the UMASS Urban Design Laboratory. The phytoremediation network is the basis for green infrastructure. It establishes the framework to (re-) connect a derelict site to an adjacent neighborhood.

## 5. REMEDIATED LANDSCAPES "RHIZOTOPIA" AND "VERINGKANAL WATER CYCLES" - [4]

Two recent studies by the UMass Urban Design Laboratory engage phytoremediation, green infrastructure and urban experience. Both study areas are located in the western territory of the International Building Exhibition Hamburg 2013 on the Elbe islands in Hamburg, Wilhelmsburg and are dominated by industrial brownfields close to residential areas. A former oil refinery is the core area of "Rhizotopia". Soils and ground water are contaminated with toxic organic materials and heavy metals. The second study area, the Veringkanal, is a once important industrial canal of the Elbe islands. The high contamination with heavy metals in the sediments prevents adaptive reuses of the canal.

### 5.1 Rhizotopia

The proposal for a "Remediation infrastructure as a green infrastructure framework" transforms the contaminated waste landscape into a healthy urban landscape that is well integrated with the city. The reed and grass planted remediation ditches and multi-lane alleys of fast-growing, deep rooting hybrid poplars and willows become part of the street and pedestrian circulation network that structures the urban form for the future and connects to the existing neighborhood (Figure 1). After the area is cleaned up, the water remediation network can be transformed into a surface stormwater treatment system and the multi-lane alleys can become street boulevards.

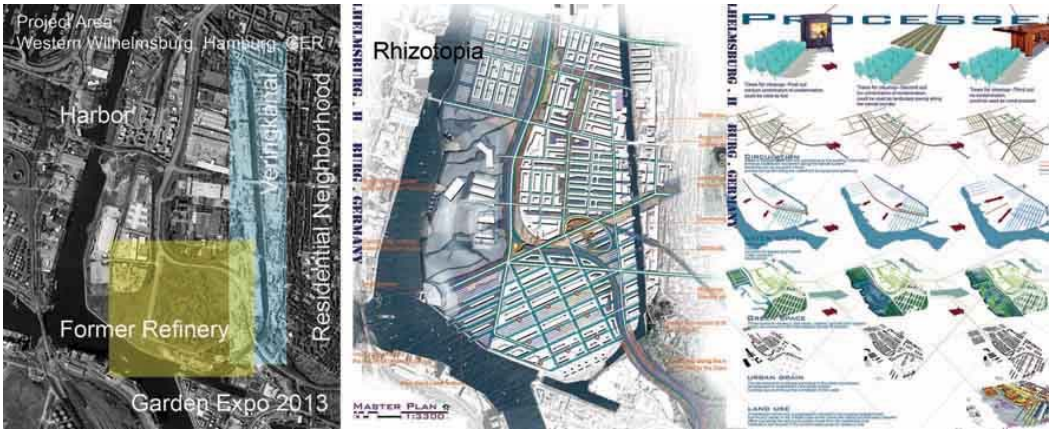


*Figure 1.* Project Areas - The remediation network provides the framework for a multi layered green infrastructure as design system. (Samimi, Wang, 2007)

The ditches are also a physical reference to the historical water layer infrastructure of the Elbe-islands with a hierarchy of inter-connected ditches and

swales that create a unique land-water topology. In addition, the remediation infrastructure is a habitat for wildlife, and the poplars and willows can be harvested and used as fuel or building material. Monitoring infrastructure complements the remediation grid system: An underground interpretive laboratory, the "Rhizotron", is designed for examining plant root growth. As public stations they contain enclosed columns of soil with transparent windows that permit viewing, measuring, and photographing the slow process of phytoremediation (Figure 2).

In conclusion, pedestrian movement within the remediation framework becomes an aesthetic experience that changes over time through the successional and adaptive media of plants and the water ditches as organizing elements for remediation and surface stormwater treatment in a later phase. This multi-layered green infrastructure is complemented by educational elements.

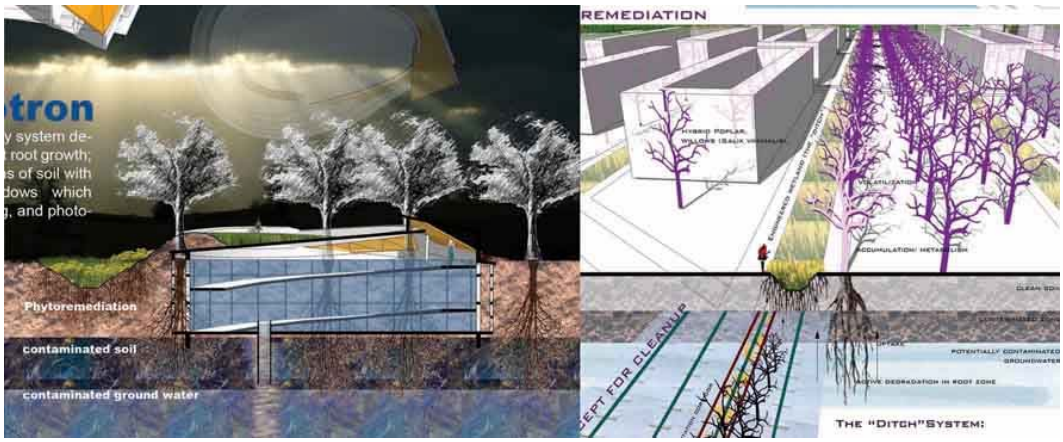


*Figure 2:* Rhizotron: An underground laboratory designed for examining and experiencing plant root growth complements the green infrastructure of ditches and tree boulevards. (Samimi and Wang, 2007)

## 5.2 Veringkanal Water Cycles

For the area around the Veringkanal the remediation strategy incorporates decentralized storm and waste water treatment proposals that are interlinked through the processes of water cycling. Indigenous wetland vegetation like Phragmities and Iris are planted in the drained canal. Periodic flooding establishes a dynamic water table that supports the development of a biologically-active wetland zone. Seasonal harvesting of biomass ensures that metals in the plant material are removed from the nutrient cycle, and safely incinerated as fuel for heating buildings. New development will follow strategies of decentralized storm

and waste water treatment that reduces burdens on existing urban infrastructure. Remediation and self-sustaining systems introduce new landscapes of sensual experiences. The Veringkanal becomes the central spine for arterial lateral branches. Stormwater is collected from the adjacent neighborhood and flows into the canal. These branches simultaneously create a new trail system for pedestrians and cyclists and make the Veringkanal an urban greenway (Figure 3).

*Figure 3:* Plants for remediation and waste treatment are green infrastructure as a changing landscape for sensual experience . (Lynch et al, 2008)

## 6. CONCLUSION

Principles from the emergent theories of Green Infrastructure can be understood and applied in a new way to form unique landscapes of remediation. Transformative remediation as a systematic design tool provides conceptual bridges between aesthetics and ecological design. F. L. Olmsted designed urban landscapes as experiences as well as environments. ”Antiquated conceptions of landscape beauty … persist and must be reconsidered through the lens of new paradigms of ecology” (Meyer, 2008). Stokman (2008) proposes urban constructed wetlands as part of the people’s experience of ecological processes in the landscape. Designing performance - oriented phytoremediation landscapes is a process of manipulating time because of their dynamic quality.

Thus phytoremediation as an experience and framework calls for:

1. Re-creation of systematic connectivity - from isolation to network in a flexible framework that structures a multi – layered urban infrastructure.

2. Visible transformation of toxics and contaminants as a sensual experience through the dynamic media of the landscape. Staging of phytoremediation as landscape typologies.
3. Landscapes to support environmental education and interpretation.
4. Remediation as a tool to build new districts and neighborhoods on former brownfields and a source for economic growth and revitalization.
5. Integration of micro scale with urban and regional scale as a multi-scale approach.
6. Decentralized, local, on-site strategies.
7. Interdisciplinary collaboration between scientists, designers, and planners.

The long-term time requirement for phytoremediation can also provide an opportunity: Changing and growing plant communities can be staged, each step of the cleaning process can transform into specific landscape typologies that build up the framework for urban form and green urban infrastructure and that is simultaneously a landscape of experiences. The design proposals of the Urban Design Laboratory explored the potential to make remediation landscapes useful and beautiful.

## 7. ACKNOWLEDGEMENTS

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## 8. ENDNOTES

[1] Phytoremediation and Bioremediation designate different concepts and potential applications. Because this paper does not focus on the scientific use of remediation methodologies the term "phytoremediation" is used throughout. Phytoremediation is a plant-based approach and bioremediation is a microbial approach. Bioremediation uses micro-based technology for the degradation of organic compounds. Phytoremediation uses green or vascular plants to remove organic contaminants or heavy metals from the environment. Phytoextraction is the use of metal-accumulating plants that can transport and concentrate metals from the soil to the roots and aboveground shoots. Rhizofiltration is the use of plant roots to absorb, concentrate, and precipitate heavy metals from water (Ensley, B. 2000, pp. 4-5). In: Phytoremediation of Toxic Metals (Raskin, I. and Ensley, B. Eds.). New York, John Wiley and Sons.

[2] Ensley compares the economical benefit of phytoremediation to conventional remediation methods:: "The relatively low potential cost of phytoremediation allows the treatment of many sites that cannot be addressed with currently....available methods… The economic and

environmental advantages provide an excellent reason for the use of this approach in the treatment of contaminated sites. Plants can be grown and harvested economically; leaving only residual levels of pollutants (Ensley, B. 2000. Rationale for Use of Phytoremediation. pp. 3-11). Conventional cost double and more (Glass, D.J. 2000. Economic Potential of Phytoremediation. pp. 15-31. In: Phytoremediation of Toxic Metals (Raskin, I. and Ensley, B. Eds.). New York, John Wiley and Sons.

[3] Benedict and Mc Mahon describe principles of Green Infrastructure. Most relevant are: 1. Connectivity is key. 2. Context matters. 3. Green infrastructure should be grounded in sound science and land-use planning theory and practice. 4. Green infrastructure can and should function as the framework for conservation and development. 5. Green infrastructure should be planned and protected before development. …7. Green infrastructure affords benefits to nature and people. 9. Green infrastructure requires making connections to activities within and beyond the community. 10. Green infrastructure requires long-term commitment. (Benedict, M.A. and McMahon, E.T. 2006. 37)

[4] Strategies and visions were developed under my direction in the UMASS Urban Design Laboratory 2007and 2008. The scientific framework was established in collaboration with Prof. PHD Guy Lanza, Department of Environmental Sciences, UMASS. Rhizotopia design team: Jinglan Wang, Duanchai Samimi (2007)
Veringkanal design team: Todd Lynch, David Maynes, Chris Metz, Duanchai Samimi (2008)

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