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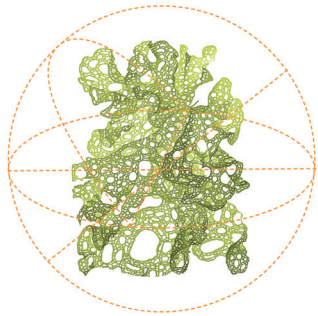
CHAPTER FOUR

REGENERATIVE THINKING

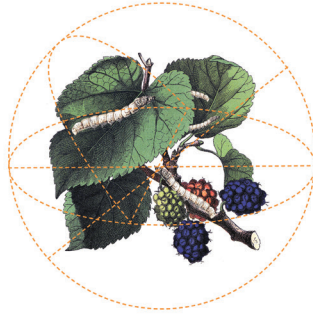


SELF-REPLENISHING REGENERATIVE APPROACH

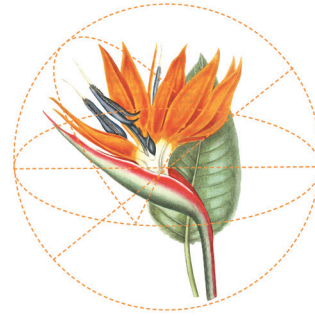
AN ARCHITECTURAL INTENTION TOWARDS
A CONDITION WHICH SUSTAINS HEALING
OF CONTAMINATED ENVIRONMENT



MICRO-ORGANISMS



INSECTS



PLANTS

REGENERATIVE ARCHITECTURE FOCUSES ON THE NATURAL WORLD AS THE BUILDING BLOCKS AND GENERATOR OF THE ARCHITECTURE. THE THEORY OF REGENERATIVE DESIGN IS BASED ON THE BELIEF THAT EVERYTHING CONSTRUCTED/BUILT HAS POTENTIAL TO BE INTEGRATED INTO AN EXISTING NATURAL NETWORK. THE NATURAL WORLD IS CONSIDERED A SHARE HOLDER AND COPARTNER TO THE BUILT ENVIRONMENT.



4.1

REGNERATIVE THINKING

The potential of the site is currently overlooked and the town planners developing the emerging node at the R24 and R57 intersection run the risk of disregarding the site's natural wetland filtration role in the greater Vaal River system. The greatest potential for the water treatment facility lies in the site's existing hydrology, natural diversity, existing infrastructure and land form. The project intends to protect the existing wetland as well as the established natural diversity by strengthening and activating the environmental potential of the neglected parcel of land. The urban-rural nature of the site has the potential for the client to engage with the community of Bophelong by integrating a community development interface for job creation and stewardship which will nurture a sense of well-being for the people.

4.2

A SELF-REPLENSHING SYSTEM

Architecture as a disconnected object requires a constant input of resources and energy which disadvantages the environment. Sustainable approaches use technology to reduce these inputs, yet the architecture remains separate from nature. In nature everything self-replenishes itself, naturally recycled and regenerated - there is no waste created or non-renewable resources that are used. The potential of regenerative approach is realized when the production output from the collaborative system is greater than the resources introduced into the system. Regenerative thinking brings an understanding that it is possible for architecture to co-exist with nature, together producing more than what is consumed, thus leaving the environment in a healthier state. (Littman, 2009:20)

4.3

NATURE VS MAN

“Humans need to understand how to tap into the environment without destroying the diversity or existing natural mechanisms. When ecosystems suffer so does the everyday quality of life of the people in that environment” (Quodlibet, 2005:online)

Recently an understanding of this relationship between man and nature and the effect we have on the environment has stirred up a movement in the built environment, which has led to the development of sustainability assessment tools. Sustainable development is defined as development which has minimum adverse impact on the built and natural environment according to the rating received. (Littman, 2009:1) Although the ethos of the standards aspire to effectively address sustainability, the current standards and accepted norms are generally very low, resulting instances where the exercise results in superfluous tick lists. The awareness and strong movement towards biodegradable, renewable, sustainable and carbon-neutral solutions are admirable, yet with the movement it is also important to develop an understanding of the object in its ecosystem and the natural systems which can be enhanced or tapped into. (John, et al, 2004:319)

A paradigm shift is occurring from sustainability to a position of natural resilience. This movement of resilient thinking has recently brought about an ethos and understanding that the built environment is a vital part of the natural world and natural systems. Through this perspective of living systems working with, and integrated into the built environment it is possible to have an urban system that is not only sustainable, but rather capable of renewal and regeneration. This gives it the resilience and ability to adapt to urban pressures and disturbances to avoid environmental collapse. (Peres, 2015:40)

The focus of this intervention is to understand the production routes/ infrastructure that will support an ecosystemic approach to challenge conventional methods of heavy metal removal from contaminated water. The intervention’s alternative infrastructure focuses on creating a treatment system using self-replenishing mechanisms/elements which fulfill the same role as conventional treatment processes. Decontamination processes are costly and time consuming, yet natural systems are inexpensive and readily available. The proposed alternative infrastructure for water treatment explores biological remediation methods for each process involved with heavy metal removal.

4.4

SYSTEM METHODOLOGY

A system is an interconnected set of elements organized in a coherent way to achieve a purpose. A system must consist of elements, interconnections and a function. The systems behaviour is determined by its purpose. (Meadows, 2009:28)

The system is be divided into the following categories:

1. The Purpose/function
2. The Interconnection
3. The elements

THE FUNCTION OF THE SYSTEM

Why is the system needed? In this intervention the water entering the river network is contaminated with heavy metals. The function of the system determines which elements are required to remove the heavy metals. If the function had to change then so would the elements. The function of the system involves the restoration of water, including removal of heavy metals in industrial effluent, treatment of grey water and removal of pollutants in storm water.

THE INTERCONNECTION

The interconnection is the relationship which holds the elements together. In the proposed system the contaminated water flowing through the system connects all the elements.

THE ELEMENTS

The elements are the visible, tangible parts, most likely seen by the observer. The system would not function properly if all the elements weren't present.

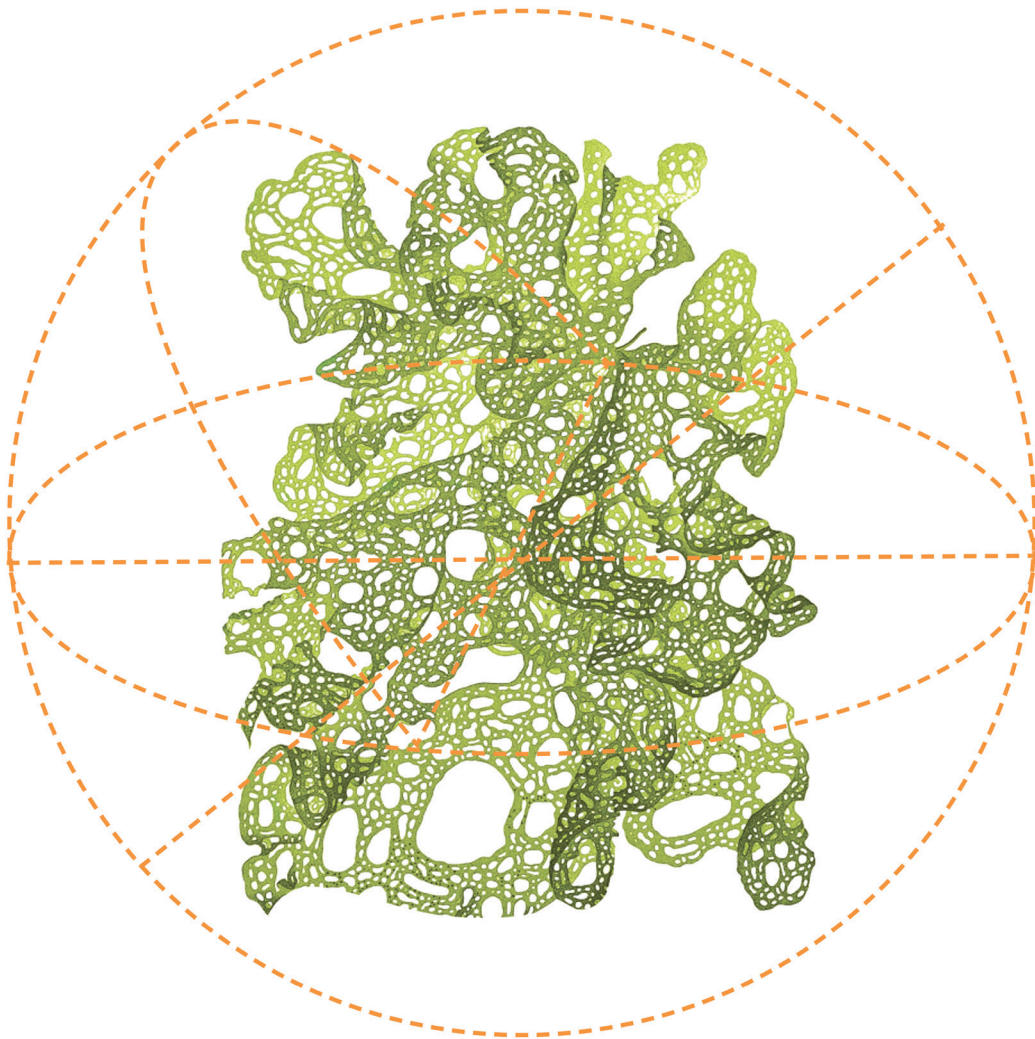
In this intervention the elements of the system are:

1. Algae which removes the heavy metals
2. Biodegradable silk biofilms on which the algae grows
3. Constructed wetland for the treatment of the building's grey water and removal of pollutants in effluent and storm water
4. Anaerobic digester for solid waste and saturated biofilms



INDIGENOUS ALGAE

MINING ALGAL - MICROBIAL
ULOTHRIX SP.



Algae biofilms are created through a process of free-floating organism that attach themselves to a fabric medium to create a slime layer. Once the biofilm has been saturated, it is removed and placed into a shredder which feeds into an anaerobic digester. A revolving algae silk biofilm challenges the conventional idea of large scale wastewater facilities that require a large area of land for cultivation of the organisms for the treatment of water.

Figure 4.1: Algae used for the removal of heavy metals from contaminated water. (ResearchGate,2016)

4.4.1

ELEMENT_ ALGAE

Biotechnology is the use of living organisms to perform specific industrial or manufacturing processes, specifically in this instance, to improve the water in the environment.

Micro-organisms have evolved to respond to heavy metal environmental stress with proven capability to take up heavy metals and transport them across the cell's membrane through reduction reactions. These processes are irreversible and ensure less risk of metal releasing back into the environment. (Malik, 2004)

The algal strain: *Ulothrix* sp. an indigenous mining algal-microbial has been tested to remove the heavy metals including copper, lead and chromium (Orandi, 2012). These are the same metals identified at sample point V7. (Groenewald, 2000:124) Growing metal resistant algal-microbial such as *Ulothrix* sp. poses a cost effective method for metal remediation due to the proven effectiveness of removing heavy metals and the cells ability to self-replenish. (Malik, 2004)

A revolving algae silk biofilm challenges the conventional idea of large-scale wastewater facilities that require a large area of land for cultivation of the organisms for the treatment of water. This alternative method has a smaller footprint due to the rotating belt that is submerged in the trough of contaminated water. (Bergstedt, 2013).

Algae biofilms are created through a process of free-floating organism that attach themselves to a fabric medium to create a slime layer. Once the biofilm has been saturated, it is removed and placed into a shredder which feeds into an anaerobic digester.

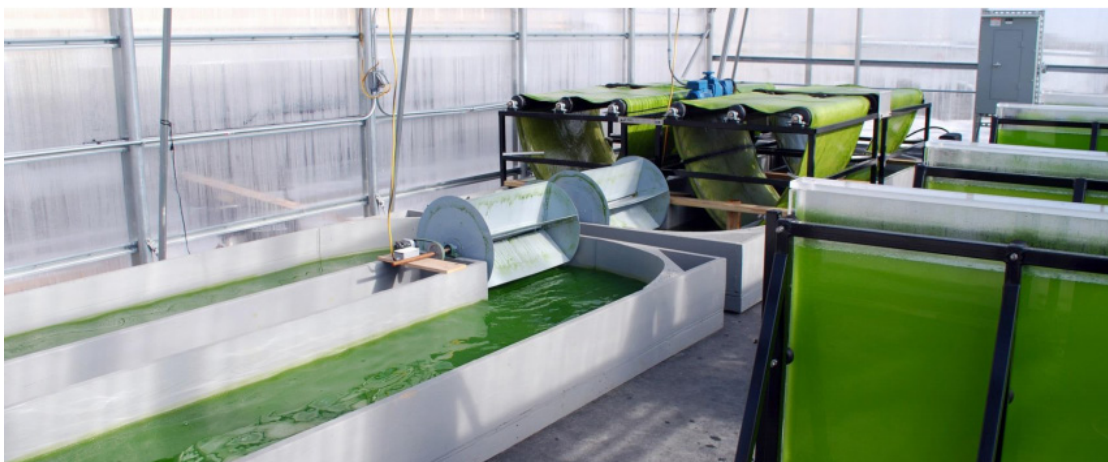
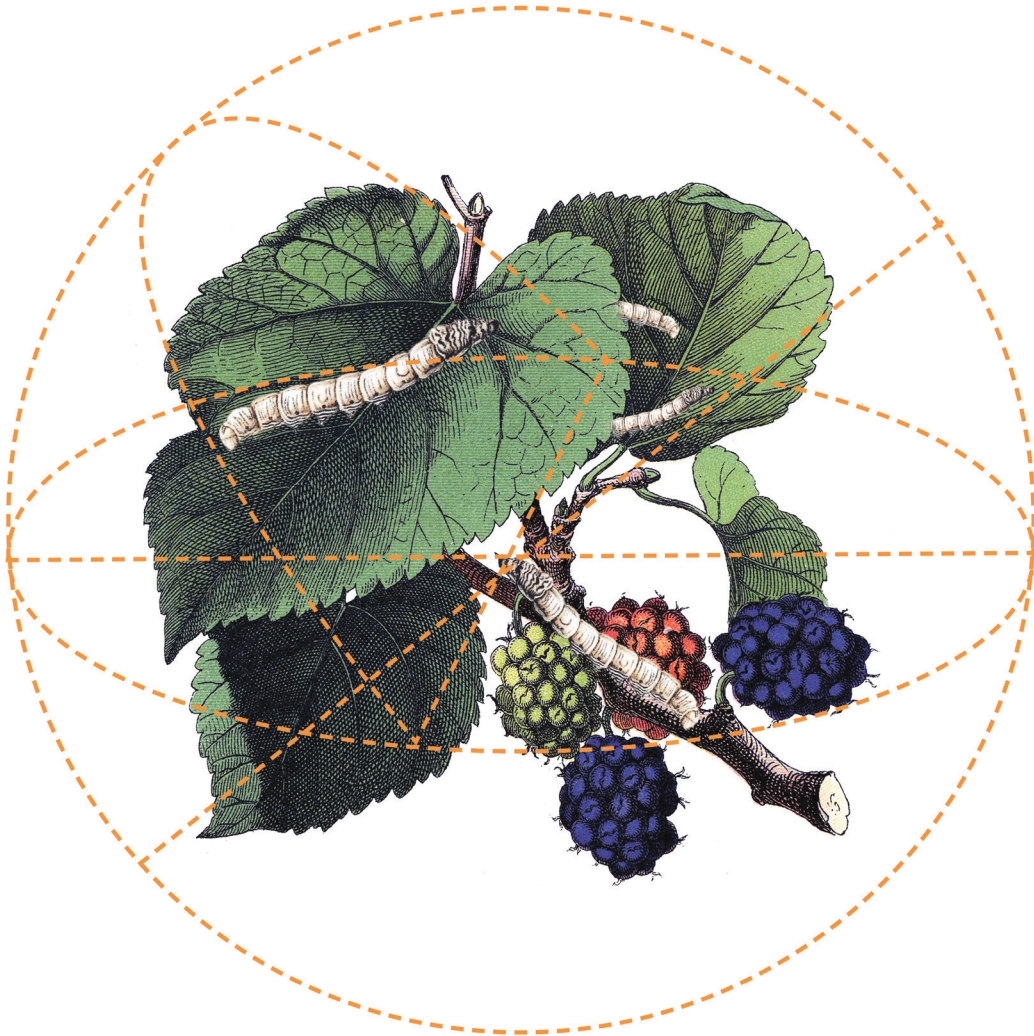


Figure 4.2: Revolving algal biofilm (ChEnected, 2016)



SILK BIOFILM MEDIUM

THE REARING OF SILKWORMS FOR
THE PRODUCTION OF SILK



Natural silk fibers which are made of pure protein are known for their lightness, strength and durability. The good tensile properties of silk make it particularly suitable for the fabric medium on which the algae grows to create the biofilm.

4.4.2

ELEMENT_ BIOFILM

New sustainable production methods for the components needed for water treatment facilities have been developed. One of these methods includes the use of silk as the foundation for biofilm. The good tensile properties of silk make it particularly suitable for the fabric medium on which the algae grows to create the biofilm. Silk's natural properties enhance industrial ecology, produce less environmental stress and allow for ease in the process, as it can be shredded into the bio digester along with the algae - both being biodegradable.

The common silkworm *Bombyx Mori's* silk membranes have remarkable performance which is on par with synthetic technologies. Natural silk fibers which are made of pure protein are known for their lightness, strength and durability.

The production of the silk biofilms forms part of the community development interface of the water treatment facility. The rearing of silkworms and fabrication of the biofilm forms a critical part of the community development interface with the intention to create job opportunities for the women of the township of Bophelong.

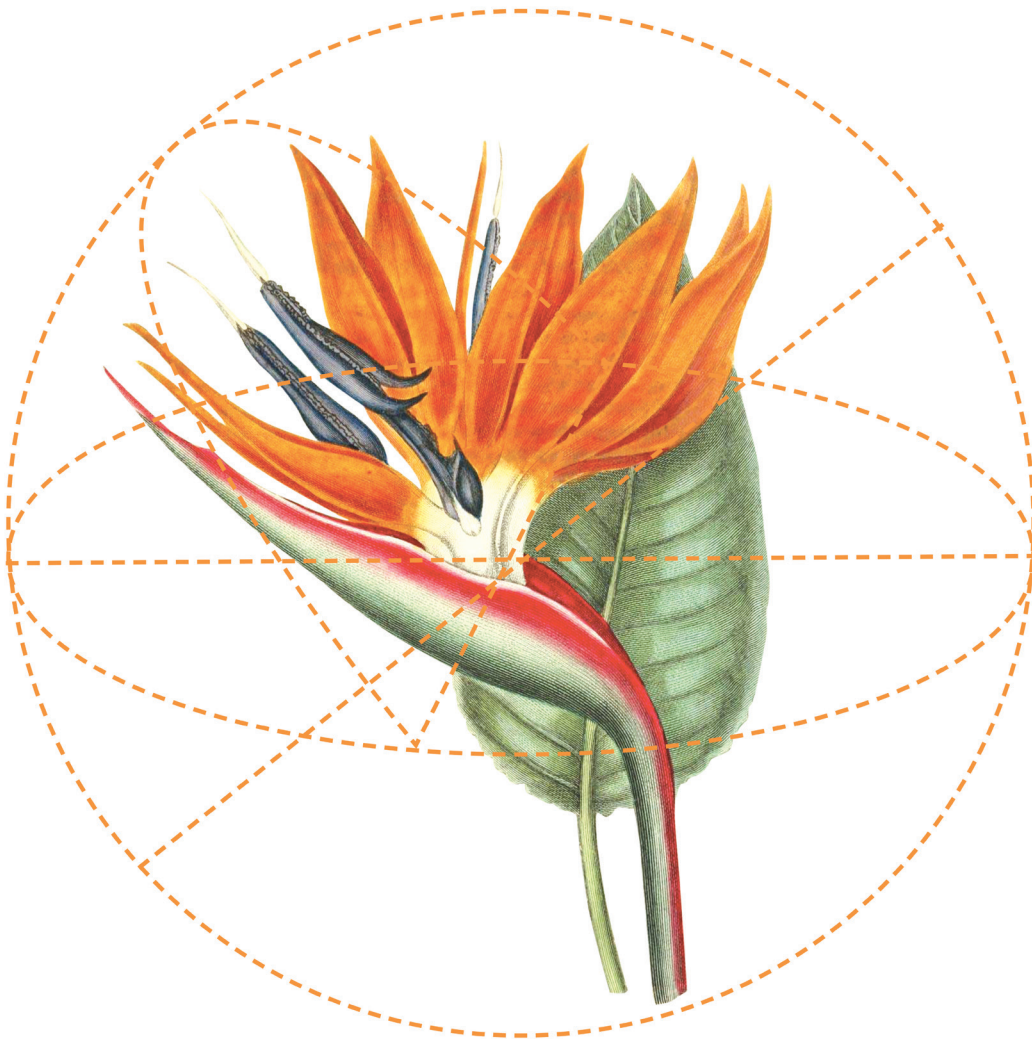


Figure 4.3: Replenishable Biofilm Fabrication. (Women in Sericulture, 2016)



PHYTOREMEDIATION

HYPER - ACCUMULATING PLANTS
FOR THE REMOVAL OF
HEAVY METALS



Micro-organisms have evolved to respond to heavy metal environmental stress with proven capability to take up heavy metals and transport them across the cell's membrane through reduction reactions. These processes are irreversible and ensure less risk of metal releasing back into the environment. The algal strain: *Ulothrix* sp. an indigenous mining algal-microbial has been tested to remove the heavy metals including copper, lead and chromium.

Figure 4.4: Phytoremediation water treatment infrastructure. (Saier, 2010)

4.4.3

ELEMENT_ PLANTS

Phytoremediation is a process which uses plants to remove contaminants from the soil, sludge, sediment, ground water, surface water as well as waste water. The process utilises the plant's biological processes and physical characteristics of the plant. Plants use a variety of mechanisms to cope with heavy metals. There are two types of heavy metal accumulation by plants in constructed wetlands: phytoextraction and rhizofiltration.

Phytoextraction involves hyper-accumulating plants which take up the metals and concentrate them into the roots and stem (biomass) of the plant so they can be harvested and disposed. This is achieved by safely incinerating the biomass.

Rhizofiltration is the process by which plants absorb, precipitate and concentrate heavy metals in their roots. This can be achieved by filtering water through a mass of roots. The pollutants remain absorbed in or to the root system of the plants. The main advantage of phytoremediation is that it is a cost effective and efficient method once established.

Phytoremediation has however proved to be a challenge to implement previously as the effectivity is directly proportional to the time the plants are allowed to grow, requiring commitment to a long-term remediation process. A further challenge is that the method requires that the contaminated wetland plants are harvested and disposed of.

In this intervention phytoremediation will be used as the secondary treatment mechanism as part of the long term vision for the water treatment facility. The following plant species will be planted and left to establish an alternative long term solution to address the heavy metals found in the V17 water samples.

Chromium (Cr)

Azolla (duck weed), Bacopa Monnieri (water hyssop), Vallisneria americana (tape grass), Eichhornia Crassipes (water hyacinth), Hydrilla (water weed), Pistia (water lettuce), Salvinia Molesta (kariba weed), Spirodela polyrhiza (giant duckweed)

Copper (Cu)

Aeolanthus Biformifolius, Azolla filiculoides (Water fern), Bacopa Monnieri (water hyssop), Vallisneria americana (tape grass), Eichhornia Crassipes (water hyacinth), Lemna minor (common duckweed), Pistia (water lettuce)

Lead (Pb)

Azolla Filiculoides (water fern), Bacopa Monnieri (water hyssop), Vallisneria americana (tape grass), Eichhornia Crassipes (water hyacinth), Hydrilla (water weed), Lemna minor (common duckweed), Salvinia Molesta (kariba weed), Spirodela polyrhiza (giant duckweed), strelitzia reginae (bird of paradise)

4.4.4

ANAEROBIC DIGESTER

Anaerobic digestion is used as a waste management method for the disposal of the algae biofilms which contain heavy metals. Anaerobic digestion is a process by which micro-organisms breakdown biodegradable material in the absence of oxygen. The process produces biogas, a renewable source of energy, which can be used directly or converted to electricity by using a gas motor and generator conversion method. (Engineering News, 2016: online)