THE LIVING HOUSE PROJECT

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ABSTRACT

For the ISTIAS IP 2014 we decided to rebuild and rethink the cities using biomimicry, we were inspired by the millenary cycle of water in the mountains. The project is a high complexity manmade independent ecosystem able to filter and reuse most of its waste using natural filtration systems.
Nowadays cities are artificial and they are not at all adapted to the surrounding environment. This has a big impact on nature and, therefore on the planet's future. Seeing that human population keeps growing and the need for food and water is increasing, it is obvious that we need to find solutions to these problems in a way that can be an advantage in a long term. Applying the concept of biomimicry into building design, must result in a solution that can prove almost as efficient as a natural ecosystem. Our Project is perfect for the cities but it can be adapted for the countryside as well, in order to save precious space needed for food production for the ever-growing population of earth.

INTRODUCTION

Biomimicry and biomimetic are different terms for the imitation of nature. The words come from two expressions: bios (meaning life) and mimesis (meaning to imitate) .The way to apply this concept into the world pretends to emulate the nature with sustainable solutions.
The main idea is that the nature has already solved many of the problems related with different aspects like energy, food production, climate control, non-toxic chemistry, transportation, packaging…

In biomimicry nature is a model, a mentor and a measure.
Model: Biomimicry is a new kind of science that studies nature's models and then emulates these forms, processes, systems, and strategies in order to solve human problems in a sustainable way.
Mentor: Biomimicry is a new way of viewing and valuing nature. It introduces an era, based not on what we can extract from the natural world, but what we can learn from it.

Measure: Biomimicry uses an ecological standard to judge sustainability of innovations. After 3.8 billion years of evolution, nature has learned what works and what lasts.

Biomimicry, as a new science based in some principles named **"The Design of Life"** they can be summarized into six sentences:

- Principle 1: Surviving is the result of evolution
- Principle 2: Be efficient
- Principle 3: Adapt when preconditions change
- Principle 4: Development goes along with growth
- Principle 5: One is an integrating part of its environment
- Principle 6: Use "life-loving" chemistry

In order to use these principles there are two ways to work with nature; a problem-based approach or a solution-based approach.

Problem-based approach: According to this method the first step for the designers is to search the world for solutions and identify problems. Then, biologists need to apply nature's mechanisms in order to solve similar issues.

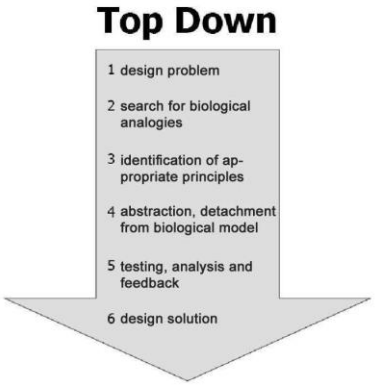

Figure 1 Top Dow

One developed example is the design of the Mercedes-Benz Bionic, a car inspirited by the boxfish and the tree growth patterns.

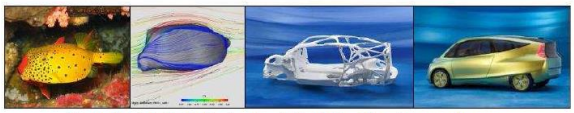

Figure 2 Mercedes-Benz Bionic

Solution-based approach: this system is based on a biological or ecological research. This studies can be applied as different models in order to solve determined human design problems.

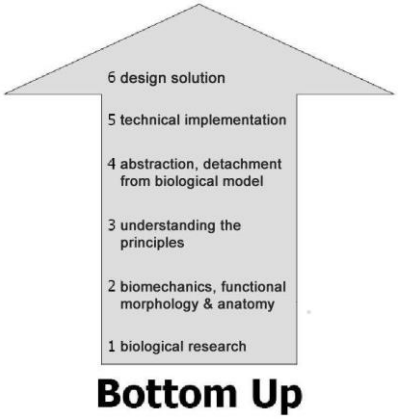

Figure 3 Bottom Up

As an example, we can find in the lotus plant waterproof characteristics, which can be used to develop new materials.

Figure 4 Lotus plant

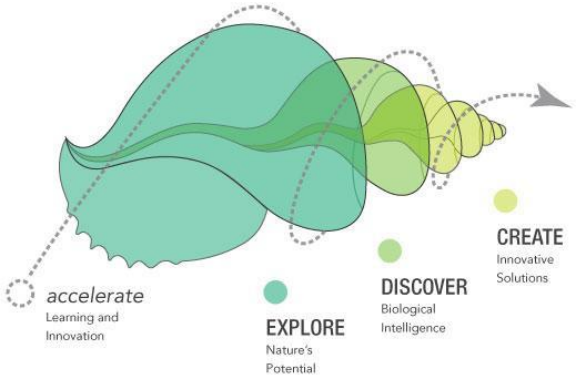

Figure 5 Biomimicry cycle

In addition to biomimicry principles there are also some different levels according with the application of the concept. Therefore based in some studies about biomimetic technologies, it is apparent that there are three levels of mimicry: the organism, behaviour and ecosystem.

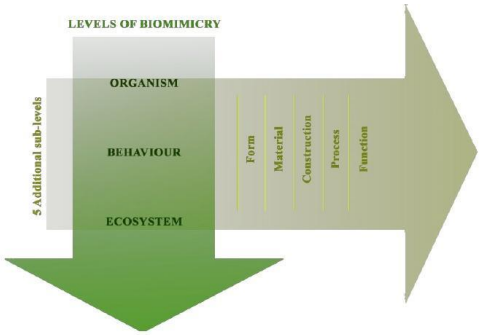

Figure 6 Levels of biomimicry

The organism level refers to a specific organism like a plant or an animal and may involve mimicking part of or the whole organism. The second level refers to mimicking behavior, and may include translating an aspect of how an organism behaves, or relates to a larger context. The third level is the mimicking of whole ecosystems and the common principles that allow them to successfully function.

Biomimicry, where flora, fauna or entire ecosystems are emulated, as a basis for design, is a growing area of research in the fields of architecture and engineering. That is one of the main idea in which we are based on in order to develop our project about the integration ecosystem in a building.
There are characteristics of designed objects such as buildings, and characteristics of the way designs are produced, which lend themselves well to description and communication via biological metaphor. The ideas of wholeness, coherence, connection and integration, used to express the organized relationship between the parts of the biological organism, can be applied to describe similar qualities in the well-designed artefact. The adaptation of the organism to its environment, its fitness, can be compared to the harmonious relation of a building to its surroundings, and, more abstractly, to the appropriateness of any designed object for the various purposes for which it is intended.

Biomimicry attempts not only to imitate nature's solutions but also to distil from nature the qualities and characteristics of natural form and systems that may be applicable to our interpretation of architecture

The principle of Biomimetic strives to learn how nature has learned and to not necessarily imitate but distil from nature the qualities and characteristics of natural form and systems that may be applicable to our interpretation of architecture.

Nowadays, planet Earth is getting warmer and more polluted as the years pass. It's possible to explain this behavior through the fact that the ozone layer is getting destroyed by CFCs. Also the entire ecosystem is changing every day and there are several species that are extinguished and others close to the same fate.
All this events are probably happening because of one species, Homo sapiens. Since mankind appeared in planet Earth, it has been using and abusing its resources, without giving anything back. It can be compared to a cancer that is destroying the organism (planet), so if human beings continued living like this, the organism will die .
Humans now are trying to correct the mistakes and save their home, due to the fact that there's no other planet to live on yet.
Because of this, mankind needs to adapt to nature without destroying it, and one of the most obvious ways is to adapt natures mechanisms to its lifestyle and needs.
By creating a filtration systems inspired in nature's own ecosystems we can improve our contribution to the world. Wastewater becomes freshwater and garbage becomes food and thus life emerges again.

Our project's idea was based on an entire ecosystem. Also we have mixed some other nature ideas like the termite mounds, some algae, plankton, shrimp and fish filters or mountains way of filtering (sand, gravel, etc).The idea is to try to mimic an ecosystem as a whole not just parts of it and try to include the house in the natural cycle of life and death, so when the house's life cycle is ending it can return to nature and provide nutrients for the next cycle that starts. The water cycle is mimicking the mountain water cycle where the water forms small springs that were previously filtered by the sand and the gravel and water the vegetation along their way to the valley and the plain.

Ecosystem:
This concept can be defined as a community of organisms together with their physical environment, viewed as a system of interacted and interdependent relationships and including such processes as flow of energy through trophic levels and cycling of chemical elements and compounds through living and nonliving components of the system.
According to the separations in different levels of biomimicry we decided to use the ecosystem level.
An advantage of designing at the ecosystem level of biomimicry is that it can be used in conjunction with other levels of biomimicry (organism and behaviour). It is also possible to incorporate existing established sustainable building methods that are not specifically biomimetic such as interfaced or bio-assisted systems, where human and nonhuman systems are merged to the mutual benefit of both.

A further advantage of an ecosystem based biomimetic design approach is that it is applicable to a range of temporal and spatial scales and can serve as an initial benchmark or goal for what constitutes truly sustainable or even regenerative design for a specific place.

Ecosystem based biomimicry can operate at both a metaphoric level and at a practical functional level. At a metaphoric level, general ecosystem principles (based on how most ecosystems work) are able to be applied by designers with little specific ecological knowledge.

On a functional level, ecosystem mimicry could mean that an in-depth understanding of ecology drives the design of a built environment that is able to participate in the major biogeochemical material cycles of the planet (hydrological, carbon, nitrogen, etc) in a reinforcing rather than damaging way. Also required would be increased collaboration between disciplines that rarely work together such as architecture, biology and ecology.
Ecosystem scientist principles can be applied to the design process by transforming them into a set of design principles:

- Ecosystems are dependent on contemporary sunlight.
- Ecosystems optimize the system rather than its components.
- Ecosystems are attuned to and dependent on local conditions.
- Ecosystems are diverse in components, relationships and information.
- Ecosystems create conditions favorable to sustained life.
- Ecosystems adapt and evolve at different levels and at different rates.

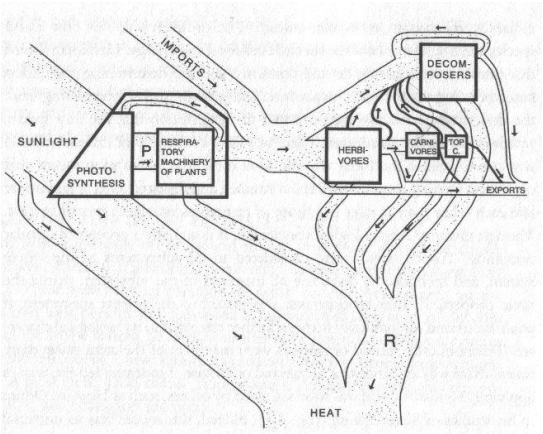

Figure 7 Ecosystem model

Termite mounds:

In a behaviour level, biomimicry is not an organism by itself. It may be possible to mimic the relationships between organisms or species in a similar way. An architectural example of process and function biomimicry at a behaviour level is demonstrated by Mick Pearce's East-gate Building in Harare, Zimbabwe and the CH2 Building in Melbourne, Australia Both buildings are based in part, on techniques of passive ventilation and temperature regulation observed in termite mounds, in order to create a thermally stable interior environment. Water which is pumped (and cleaned) from the sewers beneath the CH2 Building.

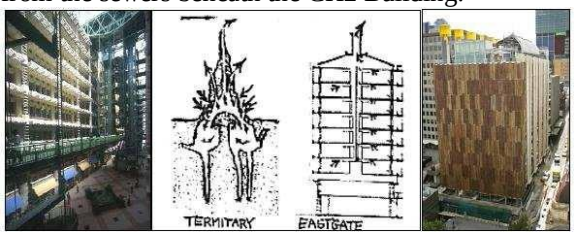

Figure 8 East-gate Building in Harare, Zimbabwe and CH2 Building in Melbourne, Australia.

SCINTIFIC STUDY

Biomimetic construction concept

To achieve the best integration in the ecosystem and to be part of the cycle of life, we need to use local resources for the construction of the project. Using biodegradable materials as wood, rocks and earth we assure a natural end of life. This means that even if this house is abandoned or ruined it will not affect the environment, in the contrary it will be beneficial for the ground, providing nutrients and retaining water for the regeneration of the local ecosystem.

To make this idea more clear we can think about the rainforest trees, they maintain the ground wet during the dry season using their capacity of absorption and keeping shadow in the ground thanks to the canopy. The canopy refers to the dense ceiling of leaves and tree branches formed by closely spaced forest trees.

Our project works in the same idea, we make shadow in the floor protecting and nourishing the ground and there is an entire ecosystem in the upper stories and this in the future will reintegrate the ground and provide nutrients to it.

Figure 9 The forest flora

The problem that we face nowadays is that we are transforming our lands in dessert, deforesting the rainforests, building and leaving the underfloor totally covered without any source of nutrients and losing them with time.

Figure 10 Deforesting in Brazil

With our project we will give a second life to the houses, and even we can go further and put this idea in the cities in the desert like Phoenix, Las Vegas or Dubai, cities who are expanding the most at the moment but in a short time they will be abandoned because they live based in fossil fuels economy. We can use this economic power and expansion of this cities to create forests in the desert. One successful example is the reforestation of the desert of Egypt with residual waters.

Design

The building is constituted by 8 apartments, each one of them is designed to have the capacity to inhabit a family of four people.

Inside the apartment the materials used for the floor will be mostly wood for rooms and the ceiling will be made out of wood, as for the kitchen and the bathrooms the materials will be made of ceramics.

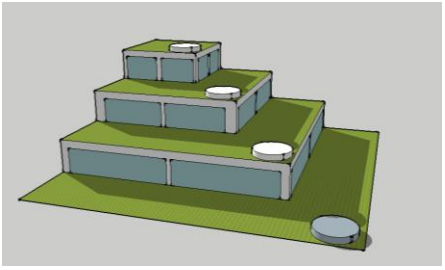

Figure 11 Building

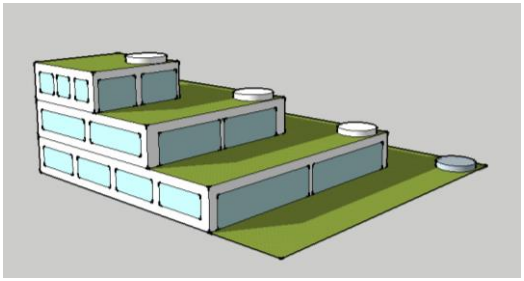

Figure 12 Building

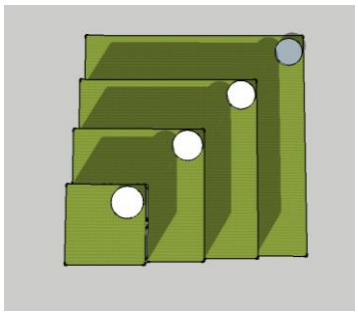

Figure 13 Building

Water treatment

Grey-water treatment

Grey-water is wash water. That is, grey-water all wastewater excepting toilet wastes and food wastes derived from garbage grinders. There are significant distinctions between grey-water and toilet wastewater (called "black-water"). These distinctions tell us how these wastewaters should be treated /managed and why, in the interests of public health and environmental protection, they should not be mixed together.

Grey-water contains far less nitrogen than black-water

Nine-tenths of the nitrogen contained in combined wastewater derivate from toilet wastes (i.e., from the black-water). Nitrogen is one of the most serious and difficult-to-remove pollutants affecting our potential drinking water supply.

Grey-water contains far fewer pathogens than black-water

Medical and public health professionals view feces as the most significant source of human pathogens. Keeping toilet wastes out of the wastewater stream dramatically reduces the danger of spreading such organisms via water.

Grey-water decomposes much faster than black-water

The implication of the more rapid decomposition of grey-water pollutants is the quicker stabilization and therefore enhanced prevention of water pollution.

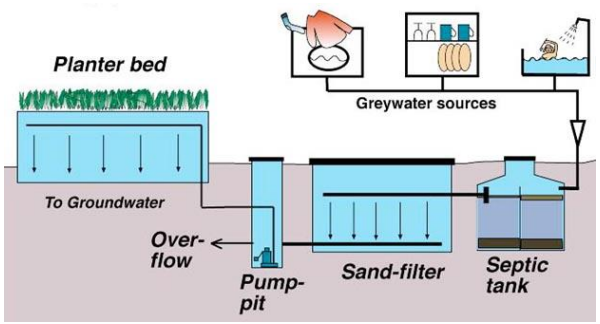

Figure 14 Advanced grey-water treatment

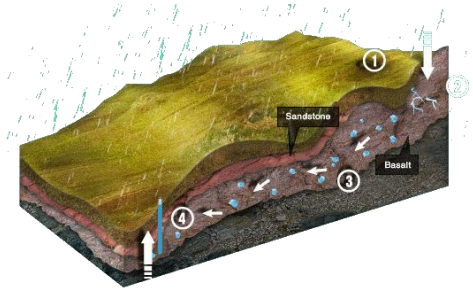

Figure 15 Filtration

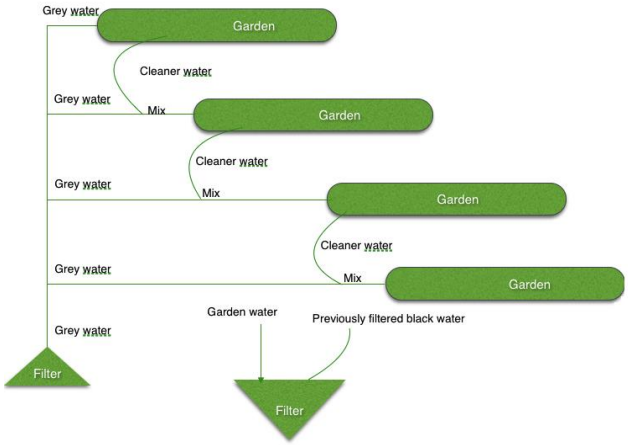

Figure 16 Water cycle

Basically we will use the grey-water to water the plants in the garden and use the garden as a next filtration system for obtaining fresh water. The garden filtration system is made up of tiles that are replaceable after they are not usable anymore. The tiles are made of different layers of sand and gravel covered by a layer of earth. The irrigation system will be made up of pipes that go underneath the soil and water the plants at the root level. Underneath all the layers there will be a recipient for collecting the extra water that will be further used in other filters to get fresh water, thus completing the cycle.

Black water treatment

Black water treatment methods make use of physical, biological, and chemical methods to treat the solid and liquid organic and inorganic waste.

The goals are to remove solids, break down organic compounds, eliminate microorganisms that cause disease, remove harmful chemical substances and prevent or eliminate offensive and harmful odors and soil discoloration, in order to be able to reuse the water.

Focusing mostly on the alternatives that strive to mimic nature´s way of treating black water, we can include bio-digesters, man-made wetlands, which are too big to use in a small project, and reed beds, composting toilets and black water recycling systems.

Bio-digesters typically seek to make more efficient, effective use of anaerobic and aerobic digestion to treat black water. Plants that absorb nitrogen, phosphorous and even metals might be planted in a man-made wetland or reed bed.

This technology is based upon the cleansing power of three main elements: soil dwelling microbes, the physical and chemical properties of the soil, sand or gravel, and finally the plants themselves.

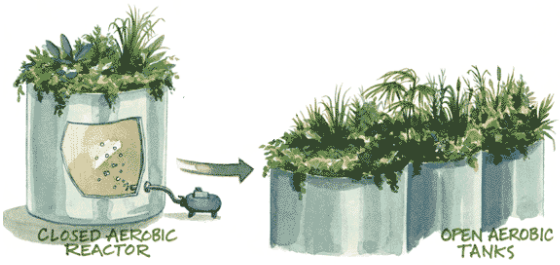

Figure 17 Eco-machine

Stage One - Sediment Digesters: micro-biologically colonized gravel filters sit beneath a blanket of sediment and draw contaminated water up into the greenhouse. In these filters the oil is heavily concentrated and its biological brake-down begins.

Stage Two - Mycro-Reactors: Sediment digested water is trickled through a wood chip media housing mycelium, the web-like tissue of mushroom forming fungi. The mycro-reactors contain fungal species known to secrete enzymes capable of breaking down petroleum hydrocarbons and effective at removing other contaminants as well. Enzymes collect in the water passing through the system and are then pumped into the next stage of treatment.

Stage three - Aquatic Cells: A series of six vertical tanks housing a diversity of algae, bacteria, protozoa, zoo plankton, snails, and fish. Shrubs and emergent plants frown from racks floating within these tanks. Water passing through this system comes into prolonged contact with these living communities and is purified, aerated, and seeded with living organisms before it is discharged to the final stage.

Benefits

- Tertiary treatment for new applications with tight discharge consents
- Satisfies new building regulations
- Very low maintenance
- Aesthetically pleasing and environmentally friendly
- Easy to install
- Takes advantage of the heightened 'environmental awareness'

DISCUSSION

Advantages and disadvantages

The living house project is a great idea with the help of which one can minimize the land usage while still feeding the masses. All this will happen in a structured and controlled environment.

Upsides:.

- No weather issues. No crop failures due to droughts, pests, etc.
- Organic by default. No herbicides, pesticides, or fertilizers needed.
- Water-cycle neutral. No agricultural runoff. Black and grey water are recycled.
- Smaller footprint. Less land is used.
- Potential electrical generation. Methane from composting non-edible waste can be converted into electricity.
- New sustainable environments. A house in the urban center can be self-reliant instead of captive to massive traditional farming infrastructure.

Downsides:

- Expensive. The technology to do this is expensive and may not scale properly. Urban properties are expensive.
- No proof of concept .There is not any actual profitable proof-of-concept yet, to prove that this project works.

- Some technology is not ready. Lighting, recycling, and power generation are not prime-time ready yet. Especially LEDs.
- Garden height limit. It is not allowed to grow plants with large extended roots and / or tall heights.

CONCLUSION

During this work, biomimicry concept was explained and analyzed. This concept tries to solve a problem in this world through nature's inspiration, trying to imitate its mechanisms and its "super powers".
It will require large funds to develop the building and the systems that we proposed. The inhabitants mentality is as important factor as the technology, because they need to be implicated for a better performance.
This building would be more suitable in a hot and dry environment, where it is difficult to have a green place near the residences.
The living house project is still only a concept which is not proven yet, but it has the potential to become real.
Humans are always imitating nature to solve problems, create new tools in order to have more comfort and quality of life, but always forgetting that we are a part of nature. This is probably the biggest problem we are facing, and our project reintegrates in this cycle again.

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Figure 18 The logo of the IP2014