

Achieving Sustainable Development by Applying Biomimicry in Fashion Design

Hoda Mohamed Samy Ghazy

Assistant Prof. - Clothing & Textile Department – Faculty of Home Economics -
Menoufia University

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ABSTRACT

Humanity is facing nowadays two main problems; the first is the depletion of resources in the near future and the second is the increasing pollution the thing that raised the issue of the environment's protection and sustainability in all fields generally and in fashion design and textile especially. This demands that the designer should turn to nature to simulate the characteristics of other living organisms like animals, insects or plants and apply them in the form of technology or different applications that help enhance man's daily life which is the science of biomimicry. This clarifies the research's problem in the following questions:

Is the designer affected by the environment? Can nature offer suitable solutions to attain sustainable development? How can we achieve sustainability in the field of fashion design and textile? How can the designer make designs that can protect the environment and achieve sustainability?

The research goals are: Benefitting from biomimicry to:-

attain sustainable development in fashion design and textile - solve problems facing manufacture of clothes and textile -find different design solutions - shape the designer's line of thought which is concerned with the product's design, its life cycle and the technique used in its manufacture.

To achieve sustainable development using a descriptive experimental approach and making a practical application of biomimicry by using the reagents guide in dyeing cotton fiber with natural dyes and the change in its color according to the degree of acidity or alkalinity of the water (pH number). In addition to the best results from using biomimicry to solve the problems facing man in his life generally and its application in the field of design and manufacture of clothes and textile which leads to achieving sustainable development.

The research recommends: Benefitting from nature's strategies and systems in designing and manufacturing products that achieve sustainable development in fashion design and textile.

KEY WORDS: Ecology - Sustainable Development- Ecodesign - Biomimicry – fashion design – nature dye.

INTRODUCTION

Humanity is facing nowadays two main problems, the first is the depletion of resources in the near future and the second is the increasing pollution resulting from the huge amount of harmful waste that we produce. That is why there is an increasing awareness of the coming scarcity and the aggravating problem of toxicity which raised the issue of the environment's protection and its sustainability as a very important matter. This demands that man should deal with the environment with leniency and kindness and try to invest it without ruining or destroying it. For since the beginning of creation man's main concern was trying to cope with the environment that is suitable for his living trying to benefit from its advantages and avoid its disadvantages. The idea of any design comes from a certain human need in a certain living environment. The designer can't achieve compatibility and harmony between the designed products and the requirements of a clean environment without sufficient knowledge of the different environmental sciences especial the unprecedented, one of which is the science of biomimicry that simulates the characteristics of other living organisms like animals, insects or plants and apply it in the form of different technology and applications that would enhance man's daily life.

Sustainable development represents a challenge for designers, manufacturers and consumers at the same time, in all fields generally and in fashion design and textile especially, in order to consider the environmental values, operation methods and used materials in the manufactured products. This clarifies the research's problem in the following questions:

- Is the designer affected by the environment?
- Can nature offer suitable solutions to attain sustainable development?

- How can we achieve sustainability in field of fashion design and textile?
- How can the designer make designs that can protect the environment and achieve sustainability?

The research goals:

- Benefitting from biomimicry to attain sustainable development in fashion design and textile.
- Benefitting from nature to solve problems facing manufacture of clothes and textile.
- Benefitting from biomimicry to find different design solutions.
- Benefitting from biomimicry to shape the designers line of thought which is concerned with the product's design, its life cycle and the technique used in its manufacture.

REVIEW OF LITERATURE

Ecology:

It is the study of the interaction between living organisms and their environment. It is concerned with living organisms, their nutrition and their ways of living in different societies, communities or nations. It also includes the study of non-living factors as the climate and its characteristics of the earth, water and air (el-saidy – 2006).

Environment can be divided into three classifications which are:

-Natural environment

It includes water, air, soil, minerals, and resources of energy in addition to plants and animals which represent the different resources given by God to man in order to fulfill his different needs such as food, clothing, medicine and shelter.

-Biological Environment

It includes the individual, his family and society in addition to the living organisms in the biosphere. The biological environment is considered as a part of the natural environment.

-Social Environment

It is the different relationships among people in the society that mark man's relationship with others in his society.

It is the frame of bonds marking man's relationship with others in his society that is necessary for organizing the relationships among individuals in any environment. The elements of the cultural environment for man unite in two main aspects which are:

First: the physical aspect, it includes anything made by man such as housing, clothing, and means of transport, instruments and appliances used in his daily life. Second: non-physical side, it includes man's beliefs, habits, traditions, thoughts and culture (kasem-2002)

Sustainable Development

Although sustainable development as a concept was known long ago yet the term itself originated recently as it was first used in Rome club 1986 where it was suggested to make what was known as the eco-development which is the interaction between economy and ecology in the countries of both the north and the south. In 1987 it was given a definition by the International Committee for development and environment. This definition is the one generally used and it is also known as a future for all or our common future and it goes: It is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

In 1992 this concept was more established in the Earth Summit in Brazil and was approved by all the participation countries, the thing that generated what is known as the 21st century's agenda. The main feature for this program is its concern with continued development, and then it developed to include maintaining natural resources and biological diversity in the 2002 summit in Johannesburg which was attended by more than 100 presidents and representatives different governments, associations and institutions (Bosselmann- 2008).

Webster's dictionary defined it as the kind of development that uses the natural resources but doesn't allow its drain or destruction either partially or totally. Myrdel defined it by progressive movements for the entire system as a whole. William Rolkins House, the US Environmental protection Director defined it as: it is that act that acknowledges the necessity of accomplishing economic growth that suits the abilities of the environment springing from the fact that economical development and environmental preservation represent an integrated process and not a decreasing one. Hence sustainable development aims at enhancing man's life but not at the expense of the environment. Thereby sustainable development at its essence means thinking about the future and the coming generations. (<http://www.maaber.org>)

The integration between economic considerations and environmental considerations while making different decisions is the perfect way for accomplishing sustainable development from the previous definitions of the sustainable development we can conclude its dimension as follows:

Dimensions of sustainable development

Sustainable development deals with four main dimensions that interfere and integrates each other.

1. Economic development and trying to achieve justice in the distribution of fortunes.
2. Social development and achieving equality, cohesion and social mobility.
3. Preserving the environment and the natural resources.
4. Technological transformation: it is the quick transformation of the industrial societies into a new clean technology that is more efficient and more able to reduce the environmental pollution.

The global community has to give full respect for this cultural and social diversity and enable everyone in the socially to decide his own future. Hence the United Nations report has stressed the strong relation between economic and social development and preserving the environment and it referred to the fact that it is impossible to apply any strategy related to sustainable development without considering the developmental demands for the three aspects “economic, social and environmental”. (The report of the International Committee for Development and Environment 1987) (Bosselmann-2008)

Characteristics of sustainable development

Sustainable development has many characteristics that can be summed up as follows:

- Long term as time is its main dimension in addition to the quantitative and qualitative dimensions.
- Takes into account the right of future generations in the natural resources.
- Takes into account preserving the biosphere in the natural environment.
- Human development is considered one of its main aims with special concern for the poor.
- Preserves the diversity of societies and its religious and cultural privacy.
- It is based on coordination and international integration in the use of resources and if regulates the relationship between rich and poor countries.
- The foundations of sustainable development and its components. (Wikipedia – sustainable development) (Abugouda -2011).

Ecodesign

Sustainable development represents a challenge for designers, manufacturers and consumers at the same time to consider the environmental values, operating methods and the materials used in producing the different products. Environmental thinking brings out new challengers but at the same time it brings out completely new opportunities. (Sayed - 2014.) Ecodesign is defined as any form of design that limits any environmentally destructive effects by integrating it in life activities (Cowans -1996).

Ecodesign is considered as one of the integrated design fields that preserves the environmental industry with its different many specialties. The environmental industry meant the presence of a conceptual tool that simulates the models derived from the natural ecosystem and a frame work to develop a concept for the environmental and technical issues. This means that the profession of design is no longer related to what the new products will do but with reinventing a design culture that can be attained (<http://Wikipedia.org/wiki/>).

Biomimicry

The word is derived from Bio which means life and mimesis which means imitation or simulation and it is a branch of science that tries to find solutions for technological and technical problems by studying nature and biology and imitating its technology and way of work.

It is an innovation approach that aims at finding sustainable solutions for the challenges facing man by simulating patterns and strategies that were time tested by nature. Its goal is to create new products, operations and policies for a better adaptation on earth on the long run and enable people to find solutions derived from nature for a healthy planet. Asking for nature’s advice is an ordinary act in daily inventions. (<http://biomimicry.net.>)

It is also known as man’s simulation or imitation of the characteristics of other living organisms such as animals, insects or plants and applying them in the form of technologies or different applications that help in raising the efficiency of the daily life of human beings. This science can be applied when engineers and biologists work together to understand the mechanism of the living world then trying to apply that on humans in order to attain the highest environment and economic efficiency (Benyus 2002).

Biomimetics is not a new idea. Since time immemorial, simple people and scientists have been watching and studied nature’s best ideas and then imitates these designs and processes to find answers and solve many situations in the human history. The word *biomimicry* appeared in 1982 and

was generalized in 1997 by scientist and writer Janine Benyus with her book *Biomimicry: Innovation Inspired by Nature*. In this publication, Biomimicry is defined as a “new science that studies nature’s models and then imitates or takes inspiration from these designs and processes to solve human problems”. Benyus suggests looking to Nature as a “Model, Measure, and Mentor”

Nature as a model: The science of simulating life observes the operations, systems and strategies of nature in order to imitate them to reach sustainable solutions for human technical problems.

Nature as a tutor: simulating life offers us a new way of observing nature and evaluating it which leads us to an era where we no longer depend on what we can get from nature but on what we can learn from it.

Nature as a standard: The science of simulating life uses the environmental criterion as a standard to judge the sustainability of inventions. For after 3.8 billion years nature has been able to know what may last and continue. When we observe what nature is the only real model that has worked for long periods of time (Benyus 2002).

Approach to biomimetic investigation:

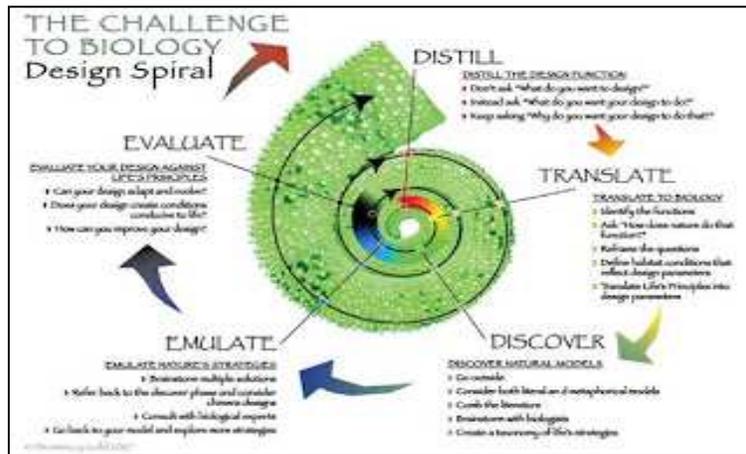
Approaches to biomimicry as a design process typically fall into two categories: defining a human need or design problem and looking to the ways other organisms, termed here design looking to biology, or identifying a particular characteristic, behavior or function in an organism and translating that into human designs, referred to as biology influencing design (figure 1).

a- Define the problem and its context

b- Find organisms with a similar problem, see what they do, find many divergent organisms to see which has the best / most relevant strategy.

c- Translates the best strategy to a buildable thing, if necessary, find an expert to help.

The approach where designers look to the living world for solutions requires designers to identify problems and biologists to then match these to organisms that have solved similar issues. This approach is effectively led by designers identifying initial goals for design (<http://biomimicryarch.blogspot.com>).



Fig(1) Design spiral " design to biology approach

Applications of biomimicry in fashion design and textile in order to achieve sustainable development:

Sustainable development depends on achieving two main things which are: the right to development?

1. Man is primarily responsible and is a trust holder.
2. Nature with its different resources that God has given to man to serve him in his life and man’s continued use to them.
3. Technology with what it means from using knowledge in investing the natural resources, solving nature’s problems and facing the dangers threatening it. (<http://socialscience2009.wikispaces.com>).

There are lots of designs that were made by biomimicry to achieve sustainable development:

- Some clothing companies used different environmental design styles in order to change the future of the spinning and weaving industry to be more environmentally friendly by recycling of used clothes to decrease the use of resources. They used textile materials that are

biodegradable in order to decrease its negative effects on the environment. They also used plant dyes instead of toxic chemical materials to improve the appearance of the fabric (Taieb – 2010)

- The first shirt designed for man that decomposes into compost. Tregima is a manufacturer of sports shirts and tennis clothes in Germany that is highly active in the field of environment and society. Both Tregima and EPEA have cooperated to develop the first shirt in the world that decomposes into a bio-fertilizer in a safe way.
- EPEA chose the threads, the dyes and the suitable materials to produce the shirt that can decompose into a bio fertilizer according to the “Cradle to Cradle” design standards. They cooperated together to develop very special kind of threads, then the materials are chemically tested to suit both man and the environment. This was possible because Tregima let EPEA examine and track all the production stages and inspect the final product. All this resulted in producing the first shirt in the world that takes into consideration the consumers’ safety and health. The shirt will decompose to provide food for the environment (<http://www.trigema.de/cms/Cradle-to-Cradle>).
- **CRADLE-TO-CRADLE CLOTHING**
Zoe Alexander Fisher designed a hand-felted wool coat during her sophomore year at Sarah Lawrence College. Worn in winter, the garment can be disposed of by planting it in the spring. The wool acts as a fertilizer for the embedded seeds, which grow into food-producing plants throughout the summer in time for a fall harvest. Zoe Alexander Fisher’s seed-embedded coat is worn in winter, planted in spring, grown in summer, and harvested in winter (figure 2).



Fig (2) wool coat which Manufactured by cradle to cradle way

- Chris Ebger a British scientist managed to invent smart clothing threads that change their color according to any rise in the body temperature. He said that this kind of clothes will be suitable for children as it would make any rise in body temperature same thing that can be seen after it was only felt as the threads will change their color. He said that the clothes will be in three colors pink, blue and light green. If the child’s temperature exceeds 37 c the clothes will change their color into white. The idea was derived from the chameleon that changes its color to match the color of its surroundings (figure 3 and 4)



Fig (3) clothes change their



Fig (4) the chameleon

Color according to rise in the body temperature

- A group of footwear manufacturers devoted themselves to develop a very special kind of footwear that was manufactured by using highly advanced techniques. It changes its color according to how the woman would like to wear it. The foot wear that carries the name volvorii is supplied with a flexible built in electronic ink screen away from the shoe insole. It is also supplied with a low energy Bluetooth receiver that enables the woman to choose the color and shape that she wants for the shoe through a special application on her smart phone. The new footwear has a very elegant design, high heels and is made of high quality materials. Extremely and it is brought up now to receive the funding necessary for its production presenting in the market.



Fig (5) footwear changes its color according to how the woman would like to wear it

- **“SHEDDABLE” GARMENTS THAT REDUCE LAUNDERING**

Katie Ledger wants you to make like a serpent and molt—the layers of your clothes, that is. Inspired by the way a snake sheds its skin, the London College of Art student envisions garments with layers that slough off without the need for laundering. “Shed Me” garments slough off their layers like a snake, reducing the need for frequent laundering.

In addition to slashing the heavy energy burden that washing and drying entail—an average laundry cycle uses up to 40 gallons of water and 5,500 watts of electricity, according to the U.S. Department of Energy—Ledger’s “Shed Me” project imagines clothes that change color and even style with the removal of each successive layer.



Fig (6) garments slough off their layers

- One day in 1948, the Swiss engineer George de Mestral was cleaning his dog of burrs picked up on a walk when he realized how the hooks of the burrs clung to the fur. His realization led to the invention of Velcro and a multimillion – dollar industry.



Fig (7) the idea of Velcro

- **Learning from Lotus Plants How to Clean without Cleaners**

Ask any school child or adult how leaves keep water from sticking to them, and they'll almost certainly say, "Because they are so smooth." Yet one of the most water repellent leaves in the world, that of the Lotus (*Nelumbo nucifera*), isn't smooth at all. The myriad crevices of its microscopically rough leaf surface trap a maze of air upon which water droplets float, so that the slightest breeze or tilt in the leaf causes balls of water to roll cleanly off, taking attached dirt particles with them.

Now, microscopically rough surface additives have been introduced into a new generation of paint, glass, and fabric finishes, greatly reducing the need for chemical or laborious cleaning. For example, GreenShield, a fabric finish made by G3i based on the "lotus effect," achieves the same water and stain repellency as conventional fabric finishes while using 8 times less harmful fluorinated chemicals.

(<http://biomimicry.net>)



Fig (8) microscopically rough leaf surface of Lotus Plants

- Shark skin is very rough in fact so rough that dried shark skin can be used as sanding paper. The skin covered by little V- shaped bumps, made from the same material as sharks teeth. The rough surface has been shown to reduce friction when the shark glides through water which is why sharks are surprisingly quick and efficient swimmers.

The u shape on a shark's skin generate tiny vortexes, bringing the water closer to the body and reducing drag. At the Sydney Olympics, all gold – medal – winning swimmers wore swimsuits with the same properties as sharkskin. This important development led to a new sphere of business activity. (<http://www.slideshare.net>)

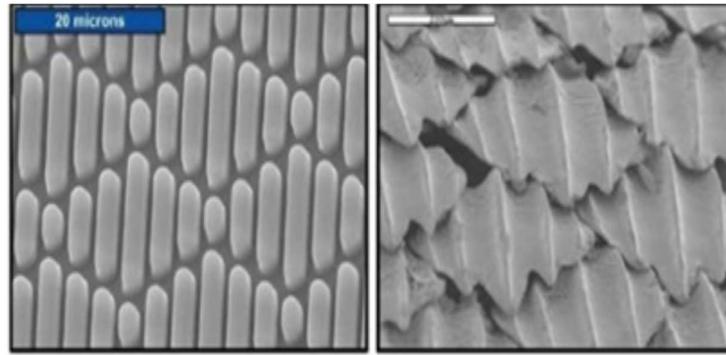


Fig (9) *Sharklet™ Surface Technology* *Galapagos Shark Skin*

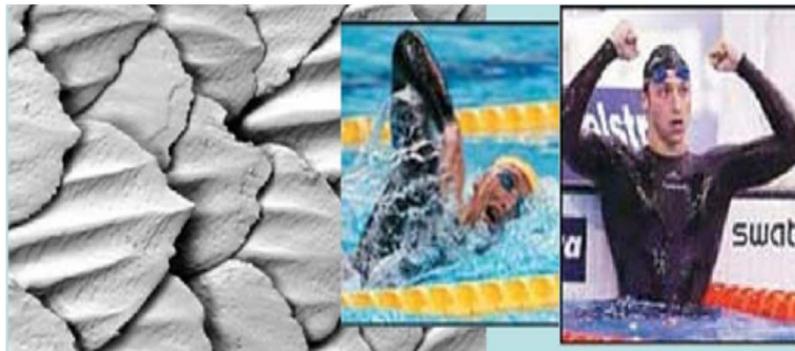


Fig (10) the shape of shark skin and the swimsuits with the same properties as sharkskin

Experimental work:

Some plants contain a natural pH indicator that changes colors according to the acidity of the solution. They contain a pigment molecule called flavin (an anthocyanin). This water-soluble pigment is found in Red cabbage apple skin, plums, poppies, cornflowers, and grapes.

This feature can be employed in fashion design by dyeing clothes at home in an easy, fast and safe way. We can obtain different colors later by changing the acidity of the washing water. In this research we will use the red cabbage as an example for natural PH indicator. This method has been used before to obtain PH paper strips using red cabbage indicator.

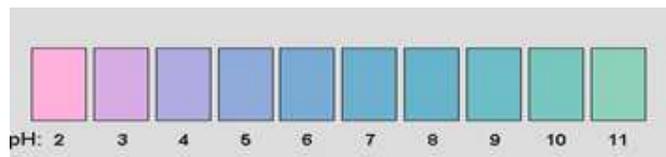


Fig (11) color scale of the red cabbage papers

Red cabbage juice indicator is easy to make, exhibits a wide range of colors, Very acidic solutions will turn anthocyanin a red color. Neutral solutions result in a purplish color. Basic solutions appear in greenish-yellow.

The color of the juice changes in response to changes in its hydrogen ion concentration. pH is the $-\log[H^+]$. Acids will donate hydrogen ions in an aqueous solution and have a low pH (pH 7).

Procedure:

- 1- To obtain the Red cabbage juice indicator cut it in little slices (figure 13). Put them in a pot and pour enough water to cover them (figure 7). Boil for half an hour, then turn off the heat and let the temperature come down. Pour the blue-violet liquid you have obtained into a large, low container (figure 14). The boiled cabbage slices are edible and you can use them in a recipe (figure 15)



(www.funsci.com)

2. To obtain the dying bath:

- Prepare one liter of red cabbage juice then add Alum mordant (KAL (SO4)2-12H2O) with a percentage of 20 grams per liter and table salt Na Cl for a homogeneous distribution of color with a percentage of 10 grams per liter.
- Immerse the sample 20 cm X 20 cm (100% cotton with a weaving combination single jersey). Dying should last 30 minutes with temperature of 100 c with continuous stirring for a homogeneous color.
- Hang the piece of cloth to dry then cut it into small rectangles.
- Prepare different acidic solutions (use home vinegar i.e. acetic acid) with different concentrations.
- Also different alkaline solutions with different concentrations of baking soda.
- Cut the dyed sample into small rectangles in these solutions and note the change in color.
- Dying accomplished manually at home.

RESULTS

- Sample dyed in purple as shown in the figure (16).



Fig (16) the color of sample after dying

- The sample's color changes to crimson drifting to red by subjecting the sample to diluted vinegar i.e. subjecting it to acid as shown in the figure (17)



Fig (17) the color of sample after acid

- The sample's color changes to blue by subjecting it to a baking soda solution i.e. subjecting it to alkaline as shown in the figure (18)



Fig (18) the color of sample after alkaline

- The sample whose color changes to red when subjected to acids, changes to blue when subjected to alkaline with a degree of blueness that differs according to the concentration of the solution, as shown in the figure (19)



Fig (19) the color of sample turns from red to blue

- The sample whose color changes to blue when subjected to alkaline, change to red when subjected to acids, as shown in the figure(20)

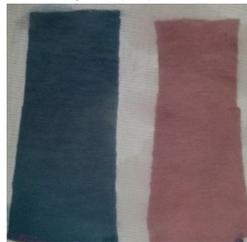


Fig (20) the color of sample turns from blue to red

- We can conclude from all the previous that we can obtain a range of blue and red colors for the fabrics dyed with red cabbage or any other plants containing flavin dye (an anthocyanin).
- Thus any woman can dye any piece of cloth with red cabbage or any other plant containing reagents guide in an easy, environmentally safe way then change the color of the product later according to the acidity of the washing or rinsing water.
- Thereby we can apply the concept of biomimicry by simulating the chameleon that changes its color according to its surroundings. Also by using plant dyes that are environmentally safe and that can be used in manufacture.

Recommendations:

- Benefitting from nature's strategies and systems in designing and manufacturing products that achieve sustainable development in different life fields.
- The designer's approach to the life cycle of the product should change from the concept of (from cradle to grave) to the concept of (from cradle to cradle).
- Using biomimicry as a main method to solve the problems facing us in different fields.
- Designers should grasp the different environmental concepts that should be an essential part of their designing approaches.
- Using the different environmental sciences in design and production.

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