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Bio-Water Management Mechanisms to Inspire New Building Solutions

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Abstract

This research paper contributes to investigating the extent to which knowledge and mechanisms of biological water management can be explored to inspire new solutions for buildings and how biologically developed methods that can be used both to provide water and obtain it from the outer casings of buildings interacting with nature can be explored, and the research methodology is first carried out by examining various examples of organisms that have highlighted and demonstrated their natural success in the good management of For the water and work of a detailed analysis of the mechanisms of these organisms in the provision and management of water, ii detailed presentation and analysis of a set of global examples simulated to the environment, which has a precedent in the application of the concept (water management through an environmentally adapted outer shell), thirdly comes the applied study by proposing checklist models with proposed relative weights based on previous studies to measure the success of analytical examples in accomplishing the task. Results: Namibia Hydrology Center ranked first with the highest percentage of use of naturally inspired water management functions, Namibia Hydrology Center ranked first with the highest percentage of use of naturally inspired water management functions, and the first (water collection) job was ranked first with the highest percentage of repetition in all study cases, while the job (water storage) was second with a percentage of 63% of repetition, and reached 100% of repetition in all study cases, while the job (water storage) was second with a percentage of 63% of repetition. The element (water collection) in the first place with the highest percentage reached 36% for the total size of all other elements of water functions, while the element (water storage) in the second place reached the highest percentage reached 23% relative to the total size of all elements of other aquatic functions, Conclusions: the strategies of balance and biological water management in organisms in nature to provide innovative solutions for the design of the exterior of the building, especially in the third world countries new to this type of building where water management strategies are transferred from nature to the architectural design of the covers of external buildings, taking into account the choice of natural strategies suitable for each environment and place, as well as the research study reached that the strategies of living organisms in water management, whether synthetic or behavioral adaptation, boils down to a set of key biological functions, namely (acquisition of water - water transfer - storage of water- storage Water - preventing water loss - water purification).

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Keywords: : Biological buildings, the importance of the water element in nature, water strategies for living organisms, the outer shells of buildings, bio-architecture.

1. INTRODUCTION

In our time, a large number of the world's population is living under a high water shortage pressure crisis and many countries face difficulties in accessing the water resources needed to meet their needs, especially when considering the right of future generations to these water resources, so current clean water resources must be protected, and since a large part of the world's water consumption occurs in urban areas, it has become an important research topic for the production of water saving strategies during the design of environments Built, because a large part of the global consumption of water resources comes from construction and housing activities, it is necessary to meet people's basic shelter needs. This increases the demand for the development of water management strategies in built environments. "Nature-inspired" methods are seen as an alternative source of solution to develop effective and sustainable strategies in architecture and are topics that are frequently included in bio research by architects in general in the direction of designing flexible and effective building structures and creating sustainable building materials and environments, and these sustainability studies focus on the development of structures and systems that are compatible with Nature, and does not harm the environment with

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the resources it uses and the waste that results from it, in the production and use of energy, and for this purpose, one of the most awaited architectural elements is the cover of the building sustainable exterior because it is the element of the building that first interacts with the external environment which is the boundary between the building and the external environments by performing many tasks such as (directing daylight, regulating heat and transporting water,..... other), it acts as a candidate between changing external environmental conditions and the internal comfort required for humans, so it is the most important element in the building, which can provide significant gains in water when designed with appropriate strategies that respond to certain climatic factors that work to perfectly manage water resources threatened by shortages.

2. RESEARCH PROBLEM

The research problem appears by answering the following question: Does the trend of bio-architecture affect the generation and production of new and innovative ideas in the field of water balance management in architecture? To what extent is this achieved successfully and flexibly? And that is in the absence of clear boundaries and a typical standard methodology about the various and multiple aspects of managing the water saving strategies adopted by the bio-architecture in sustainable environmental design and construction.

3. RESEARCH HYPOTHESIS

The research assumes that by following and adopting the trend of bio-architecture to generate and produce new and innovative ideas in the field of water balance management in architecture inspired by living organisms, this leads to the generation and creativity of new and diverse design ideas and methods in the field of strategies for providing and managing water resources.

4. RESEARCH AIMS

1. Establishing a framework based on rationalizing water consumption.
2. Working on producing strategies to save water during the design of buildings inspired by nature.
3. Presenting biologically innovative methods that can be used either to save water or to obtain water from the outer covers of buildings interacting with nature.

5. RESEARCH METHODOLOGY

The research followed the descriptive analytical approach in addition to the applied experimental approach by designing a model for a checklist with relative weights and indicative numerical values. Within the scope of this study, the focus was on water management strategies inspired by nature in order to search for answers to questions related to the characteristics and mechanisms of living organisms in nature and how It can be adapted and applied to external building envelopes. To achieve this purpose, first, learning from nature approaches were explained in the design of 'organisms' and 'architecture building envelopes', then searched for organisms that attracted attention through their water management strategies, mechanisms, and features. These objects that provide a multiple list of strategies in the field of water management, then the analytical part came by analyzing multiple examples of how water management strategies for biological phenomena are applied with relative building envelope designs in selected building design examples, and finally the applied part came in the study by suggesting A check list model with suggested relative weights based on previous studies to measure the success of the analytical examples Selected in accomplishing the task of good water management and transfer from nature and its application in the field of architectural design.

6. THE THEORETICAL BACKGROUND:

6.1. Biometics

Any science that finds its elements in different other sciences, from levels of science relationship identification to mutual influence, thus affecting the development and development of biology in other sciences. The impact of rapid development in biology has emerged in the development of new techniques, such as genetic engineering, bioengineering and other technologies, and has been demonstrated in other sciences that began in the medical field under the concept of bionic bioelectronics, and was coined in the early 1160s by J.E. Steele25 to express biology applications in electronics, a branch of engineering in which scientists and engineers try to simulate nature, so that Making use of nature and its designs in the technical fields, which has been introduced in the medical and prosthetic fields, biologist Steven Vogel defines bioelectric (1998) in his book Cats' Paws and Catapults as the most common concept in biosystem design: "The concept of bioelectric is based on living systems, and the word "systems" naturally came from the geometry of microsystems and physiological control mechanisms in humans that resemble automated control sciences and human technologies," and this concept then moves to human technologies. Various geometries within the biomimetics concept of biomimetics, Schmitt H. Otto 26, in 1161, coined this term derived from the Greek word bios (life and mimesis) simulations, to describe simulations and transfer ideas from biology to technology [1-3].

6.2. The effect of biometric pattern in architectural design

This pattern is based on the instinctive impulse of nature's love in human nature and its return to its sense of contemporary civic life. The tradition of nature is the imitation of the organism or the behavior of the organism or the entire ecosystem, in terms of its forms, materials, construction methods, processes or functions and is a source of innovation, particularly in the creation of a more sustainable structure, given the plants or animals that are highly adaptable or those that survive in harsh climates or Through climate change, it may give ideas about how buildings work or how they should work. Simulation of organisms or ecosystems involves a process of translating into solutions appropriate to the human context. This translation process often leads to designs that are not immediately similar to the organism or ecosystem that inspired it, but use the same functional concepts, and the attractiveness of natural simulations in architecture increases the link between function and shape. But the tradition of nature does not copy forms of nature; it involves ideas, solutions, or inspiration from nature in architectural challenges, so the architect needs a biological scientist to lead him to obtain biological information, because organisms solve problems with environmental challenges. Nature will lead man to expand his abilities and opportunities to solve and improve his ability to design sustainable buildings, recyclable materials and build better environments if he continues to learn from nature. Nature simulation is used as a design strategy tool in architecture in two categories, one looking for biology aimed at describing human needs and the other being the design of a biological effect that seeks nature to find a job in a living organism. Built environment designers should draw inspiration from nature not only for innovations in materials and construction methods but also in space design and building functions for sustainable future environments [4, 5].

6.3. The concept of aquaculture

Andrews, 1992, defines aquaculture as "integrated expertise derived from practical knowledge related to water resources, which is provided to learners, with the aim of acquiring positive behaviors that help them protect the aquatic environment and better rationalize and exploit water consumption." This definition focuses on the need for the pupil to pass through the direct and indirect experiences that give him the ability to deal wisely with water. Amery 1998 defines it as "an ongoing educational effort that seeks to acquire knowledge, skills and interests that contribute to solving existing water problems and reducing future water problems." Barratt, 2003, also defined aquaculture as "education that seeks to improve the relationship of community members to water resources by developing the cognitive, skills and emotional aspects of water conservation behaviors, and helping to benefit from them and develop their resources." Considering this, aquaculture can be defined as an organized educational effort that seeks researchers and students to acquire water concepts, water awareness, values and skills that regulate their behavior, and enable them to interact with the aquatic environment, thereby contributing to its protection, solving its problems, and exploiting its resources in the best possible way [6].

6.4. The concept of water management strategies in living organisms:

Water requirements and water saving strategies for living organisms vary in different climatic and environmental conditions, and through the research study it was found that organisms follow certain strategies in water management, whether synthetic or behavioral adaptation, and they boil down to a key set of functions They are (acquisition and harvesting of water- water transfer, water storage, prevention of water loss, purification of water) [7]. The function of water acquisition is achieved by absorbing water molecules such as fog or dew in the air by condensing or spreading in areas where water is limited to living organisms, while the function of water transport is achieved by gravity, poetic effect or sweating in the paper, and the function of water conservation is achieved by reducing evaporation or radiation exposure, the function of water loss is detected by erosion or evaporation [8]. All these strategies are implemented by organisms formally (synthetically) and behaviorally. In this direction, a research study on organisms that have been repeatedly proven in scientific research has been based on multiple water management strategies, and the adaptations of these organisms to provide water balance have been examined below from the research paper.

6.4.1. Examples of water management strategies in living organisms with morphological adaptations

Many living organisms in nature have developed their own methods of obtaining, using, and storing water in a sustainable manner, thanks to its morphological features that adapt to the environment in which they live, and succeeded in achieving this. The following are some of the types of these organisms:

6.4.1.1. Camel

The camel is characterized by having very complex nasal structures made of spongy bone covered with rich vascular tissue (Figure 1). Absorbing most of the moisture, it condenses into the complex nasal tissues. Thus, thanks to the structure of the nose it possesses, camels greatly prevent water loss by evaporation in the desert heat [9].

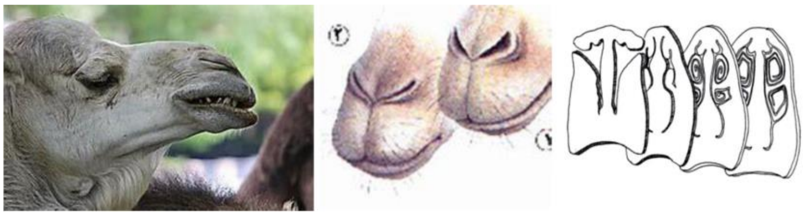


Fig. 1 Strategies for Water Management in Camel [10].

6.4.1.2. Namib Desert Insect

This beetle lives in the Namib Desert (Figure 2) of South Africa, one of the harshest environments in the world, but in turn has natural ingredients to harvest water from fog, where the insect stabilizes its body at a 45° angle, causing water molecules to collide in the fog by dorsal coincidence. Which takes a zigzag form, consisting of uneven and flat areas, to collect fresh water from desert fog and the tops of the winding surface consist of a waxy material that helps store water, while there is a dry non-greasy material in the surface to preserve water and slip from the surface of the insect with the effect of the position of the angle of the insect and its attractiveness and reach the mouth of the insect. The Namib desert beetle has inspired several research teams around the world to devise a way to harvest large amounts of fog water, more than the traditional method currently used, and the harvesting of water from fog in the traditional form depends on its interception over the mountains by dedicated networks. This method is commonly used in places such as Chile and Morocco, and can usually collect about 53 gallons of water per day, but researchers have found that new techniques inspired by the desert Namib beetle lead to the harvest of Larger amounts of water and that their simulations have increased water harvesting and the water content and frequency of fog formation may vary depending on location and season, and although rainfall may be rare in some areas, it is important to recognize that fog is a predictable and reliable water source [11].

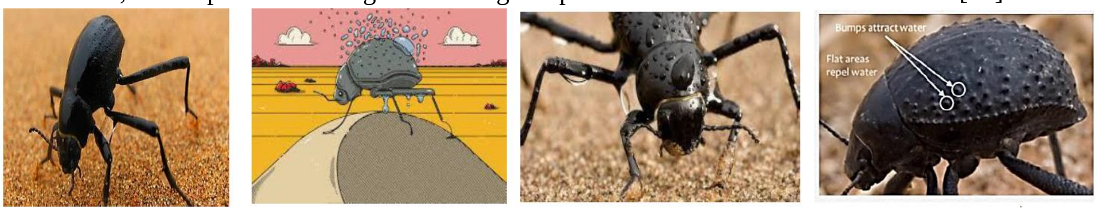


Fig. 2 Water management strategies for the Namib desert beetle [12].

6.4.1.3. Banana snail

The banana snail secretes mucus on the surface of the skin to protect its body from the rough forest floor, to prevent its body from drying out, and to enable movement and protection from predators (Fig. 3). This mucus is hygroscopic, i.e. it has a structure that can quickly attract water molecules from the surrounding environment. Apart from this, banana snails exchange negative gases from the surface of the skin instead of breathing from their lungs to reduce water loss in times of drought. The surface of the snail's skin is porous to allow gas exchange [13].

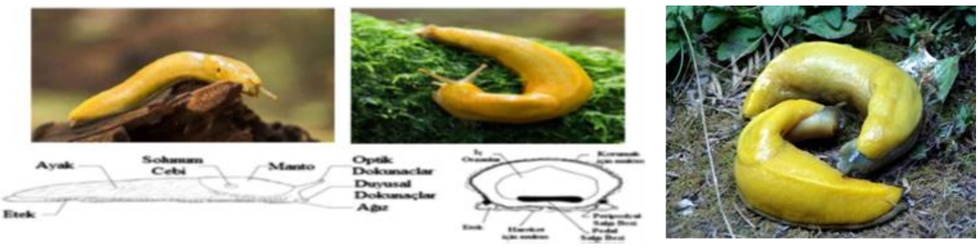


Fig.3 Water management strategies in banana snails [14].

6.4.1.4. Aloe vera plant

Many species of aloe vera live in arid environments and have a highly drought-tolerant structure. The spines of the aloe vera plant can harvest water from the atmosphere thanks to their conical structure (Fig. 4) in addition to reducing the rate of transpiration because their surface area is minimal. Airborne water droplets are first collected at the tips of the spines, and when they reach a critical size, they move towards the conical spines. Water travels to the roots and is absorbed by the plant [15].

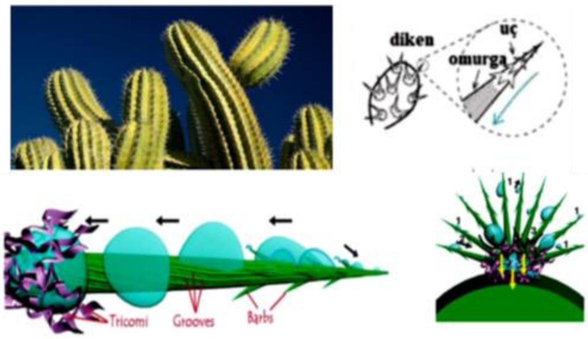


Fig. 4 Water Management Strategies for Aloe Vera [16].

6.4.1.5. Snow Flower Plant

The snowdrop plant (Fig. 5), native to southern and eastern Africa, gets its name from the small, translucent sacs that cover its leaves, making the plant appear frozen. These cysts, a different version of trichomes, are called "epidermal cyst cells." The epidermal cyst cells can collect and store water by expanding their volume thanks to their flexible structure according to the amount of water they collect. The plant uses the water it has stored in times of drought and when the salt concentration is high [17].

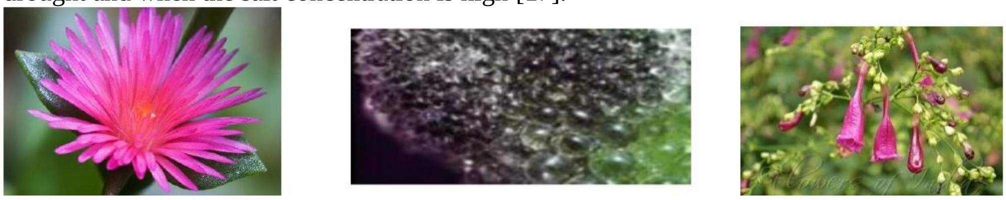


Fig. 5 Water Management Strategies for Snow Flower Plant [18].

6.4.1.6. The Spider

Some spider species, such as Uloborus Walckenaerius, Fig. (6) harvest water from the atmosphere thanks to the web structure they weave, as the nodes in these spider webs have a rough surface, while the joints have a smoother surface (Fig. 6). This difference in surface roughness causes stress. As a result, atmospheric water harvested by hydrophilic joints tends to pool between these two surfaces towards the surface of least resistance. [19].

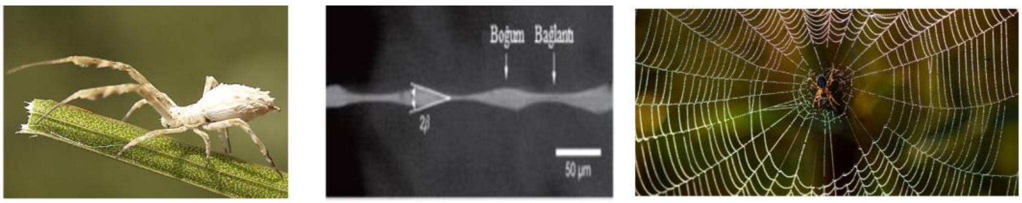


Fig. 6 Water Management Strategies for Spider Insect [20].

6.4.1.7. Hornbeam Leaf

The common English name hornbeam is derived from hardwood (which resembles a horn), Old English beam "tree" (similar to Dutch and German "Boom" and Baum), and American hornbeam and is sometimes known as blue beech, ironwood, or muscle wood. , the first from the similarity of the bark to that of the American beech, Fagus grandifolia, and the other two from the hardness of the wood and the muscular appearance of the trunk and limbs. Freshly cut hornbeam wood has a moisture content of about 60% with a maximum water absorption of 93%. The cell wall saturation limit of the hornbeam is 24%, which is highly water-conserving [21]

Fig. 7 Water Management Strategies in Hornbeam Leaf [22].

6.4.2. Examples of water management strategies in living organisms with behavioral adaptations

6.4.2.1. Stoma cells

Although the waxy layer on the surface of the plant leaves prevents water loss, it does not prevent the exit of carbon dioxide necessary for photosynthesis (Fig. 8). For this reason, plant leaves contain stomata protecting cells that control water conservation and carbon dioxide uptake by opening and closing. These cells shut off and prevent water loss in the leaves through the process of transpiration [23].

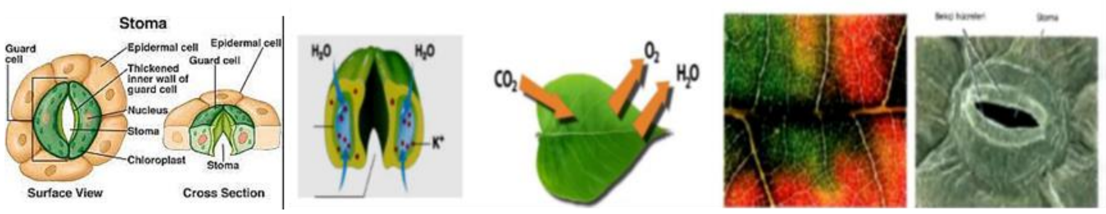


Fig. 8 Strategies for Water Management in Stoma Cells [24].

6.4.2.2. Mimosa Leaf Beam Sheet:

Mimosa Leaf It is called the sensitive plant and is considered a creeping and annual herbaceous plant. (Fig. 8) Their compound leaves fold and droop as soon as they are touched or shaken. Its original home is South America and Central America, but it can be considered at the present time as a tropical plant. This plant maintains water inside its vesicles. The mechanism of reception and radiation of the stimulus is explained by any external signals, such as touch, heat, blowing, rain, etc. The plant performs transient movements in the plant in response to an external and subtle stimulus. They are based on growth mechanisms or turgor changes of cell groups that expand their water content as the concentration of calcium and potassium ions enhances the release of water from the cells. The high ion concentration causes water to be transported into the intercellular spaces, causing the leaflets to close or contract [25].

Fig. 9 Water management strategies in Mimosa leaf [26].

TABLE 1. WATER MANAGEMENT MECHANISMS OF LIVING ORGANISMS ACCORDING TO MORPHOLOGICAL ADAPTATIONS, SOURCE (RESEARCHER):

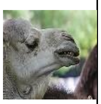
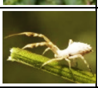
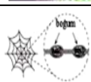
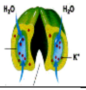
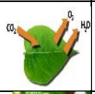
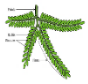
The organism	Strategy used by the organism.	The morphology used by the organism	method	water management function
1- camels 	Sponge bones covered with rich vascular tissues in camel noses absorb moisture into the air inside by intensifying them to prevent water loss at exhalation, where the camel's respiratory system is unique to the presence of a side nasal pocket that collects a significant percentage of water while breathing, and the camel's nose can close completely, preventing the trachea from drying out.	Spongy nasal bones 	Reduce evaporation rate	save water
2- Namib insect 	The insect stabilizes its body at a 45 degree angle, attracting the water-loving hills on the insect's crust water droplets from the fog carried in the air and slipping from the surface of the insect with the effect of the angle of the insect and its gravity and reach the mouth of the insect.	Water-loving hills on the insect's back 	Focusing and directing the trajectory of water droplets	transfer water - gain water
3- Banana snail 	Moisturizing skin attracts surrounding water molecules. Drawn water molecules are taken to pores.	Porous skin is hygroscopic 	mucus sorting	gain water
4- Aloe vera 	The limbs of the spine attract water droplets from the air, collecting water droplets gathered at the end of the thorns and grow.	conical spines 	gravity	save water
5- Snow flower plant 	It moves towards the base of the fork with the effect of pressure to the Lalas caused by the conical shape. Skin bags, a type of trichomes, can collect and store water in the air thanks to its flexible structure.	skin bags 	Focusing and directing the trajectory of water droplets	save water -gain water
6- Spider 	The nodes on the silk fibers absorb water from wet air.	Spider Web 	Focusing and directing the trajectory of water droplets	save water -gain water
7- Hornbeam Leaf 	Trumpet wood has a humidity of about 60% with maximum water absorption of 93% as it maintains water significantly	trumpet wood 	Focusing and directing the trajectory of water droplets	save water -gain water

TABLE 2. WATER MANAGEMENT MECHANISMS OF LIVING ORGANISMS ACCORDING TO BEHAVIORAL ADAPTATIONS, SOURCE (RESEARCHER):

The organism	Strategy used by the organism	The morphology used by the organism	method	water management function
1- Stoma cells 	The waxy layer on the surface of plant leaves prevents water loss As cells open and close to allow gas exchange in response to osmotic pressure, plants can control the opening of each stomata to reduce transpiration.	permeability 	Reduce evaporation rate	save water
2- Mimosa Leaf Beam Sheet 	Compound leaves fold and droop as soon as they are touched, shaken, or rained. Swelling changes the groups of cells that expand their water content as the concentration of calcium and potassium ions enhances the release of water from the cells. The higher ion concentration causes water to be transported into the intercellular spaces.	Compound leaves fold themselves and hang down. 	Focusing and directing the trajectory of water droplets	transfer water - gain water

It was concluded from the previous part of the research that the strategies of living organisms in water management, whether structural or behavioral adaptation, are summarized in a group of main functions (water acquisition and harvesting - water transport - water storage - water loss prevention - water purification), and these basic functions provided by Living organisms through various mechanisms with the functions that sustainable buildings must provide in terms of water use. Such a building can harvest water by itself, which is necessary for various uses; It can conserve water resources within the building, transfer existing water without energy consumption, and drain excess water. In short, buildings and living organisms perform similar functions to providing water management. In this direction, the mechanisms by which organisms in nature provide these essential functions have been investigated. The same function is provided by different mechanisms in different organisms. Each of these mechanisms offers a different solution to designs of envelopes (building enclosure), below will be presented different examples of building shells (building envelopes) designed inspired by the water management strategies of the creatures examined and thus, when the water management mechanisms of the organisms examined are considered In this section as a solution and its adaptation to building envelope designs, the characteristics of the architectural envelope will be defined.

7. ANALYTICAL STUDY

7.1. Examples of buildings inspired by nature in water management strategies, whether by structural or morphological adaptation

Water management strategies for organisms in nature can be used in architectural designs in different ways. In this framework, examples are presented, analyzed and examined in which the adaptation of water management strategies of living organisms to designs of building envelopes is similar, since the functions of the skin/shell of living organisms in nature are functionally similar to that of external buildings, an effective architectural element due to the level of Interact with the external environment, noting that some examples are at a conceptual level, while others are in the prototype development stage or have been implemented.

7.1.1. Habitat 2020 China:

The Habitat Building 2020, (Fig. 10), to be implemented in China, is a futuristic example of biomimetic engineering that combines high-tech ideas with essential cellular functions to create "living" structures that function like natural living organisms. Which is considered an urban lifestyle inspired by nature, where he sees in that city a dynamic and constantly evolving ecosystem. The building envelope is designed like a living skin, inspired by the shape and behavior of stomata in the leaves of plants such as (stoma cells), where the building skin acts as a membrane that acts as a link between the external and internal environment of the building; It regulates the conditions of heat, light, air and water and thanks to the gap-like elements on the roof of the building, rainwater is collected, filtered and used inside the building. In addition, these elements can also collect moisture in the air during times of drought as the facade acts like a membrane that acts as a link between the exterior and interior of the building, while the proposed roof instead ensures light, air and water entry into the courtyard. It automatically sets itself and responds to sunlight. Imitation leather is also designed to absorb water from the air to produce hydration [27].

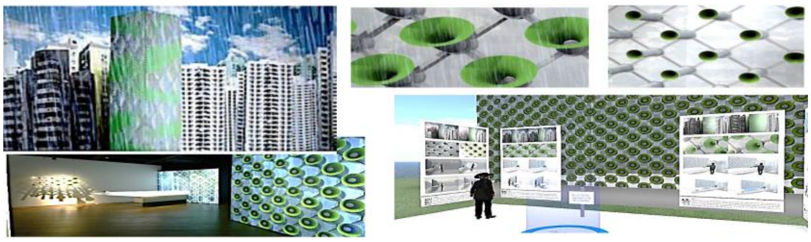


Fig. 10 Implementation of water management strategies from (stoma cells gaps) through a water harvesting device on the interface of the Habitat 2020 China project [28].

7.1.2. Forest Greenhouse Design Proposal:

Ilaria Mazzolini, an architect, biologist, and her students at the Southern California Institute of Architecture, have developed a proposal to design green greenhouses inspired by banana snails They made silicone prototypes of bladders that would encase the building, store, and release water, inspired by the secretions of slug mucus and permeable skin. It can collect and store rainwater for the Mediterranean climate region of Santa Cruz (Fig. 11). The design sought to adapt four characteristics of banana snails: their porosity and permeability, allowing their skin to breathe; The ability of the mucus that they secrete in the skin to protect against drought and predators, and their ability to adapt to changes in humidity and temperature in the environment and achieve balance and communicate with their environment through balance, in this direction, insulating bags were used as a main material for the purpose of collecting rainwater in the greenhouse cover. The steel grids connecting each of these bags form the structural system of the greenhouse. While most fenders are made of water-filled double-layer silicone, rooftop fenders consist of a single layer to catch rainwater and allow rainwater to drip directly onto the structure. During rains, the insulating units fill up, become heavy, and begin to sag and open the greenhouse casing as you pull the clamps holding them in place. Thus, rainwater is collected in bags and stored in times of drought, as well as direct irrigation of plants.

Fig. 11 Implementation of water management strategies through schematic representations of the storm water harvesting mechanism for fenders in the greenhouse envelope and three-dimensional models of green greenhouse envelopes inspired by banana snail, Mazzolini, 2013 [29].

7.1.3. Biomimetic Office Building

Michael Paulin, with a team including Julian Vincent as a biomimetic consultant, designed a biomimetic office building in Switzerland with the aim of reducing resource and energy consumption (Fig. 12) and inspired by many living organisms, with the aim of the building being light and durable in a transportation system , the skeleton of birds and squids; of ghost fish, stone plants, and snakes to regulate daylight; of termites, penguin hair and polar bear fur for environmental control; To manage the water, it was inspired by desert beetles, mimosa and hornbeam leaves, and for the acquisition and collection of water, a system similar to that of the Seawater Greenhouse project was implemented, inspired by the behavior of desert beetles to collect water from fog, knowing that the project has not yet been implemented. (30), (31)

Fig. 12 Application of water management strategies inspired by desert beetles, mimosa and hornbeam leaves in a biomimetic office building [32].

7.1.4. 7-1-4- Namibia Hydrology Center

The Water Science Center building of the University of Namibia, as shown in Figure 13, was designed in a design inspired by the water harvesting system of the Namibian beetle by British architect Matthew Parks. The building is set behind a wall with a raised, curved nylon mesh surface that faces the ocean and captures moisture in the fresh ocean air so that water can be efficiently retained. In this wall of nylon nets, Matthew Parks had discovered the Namibian beetle by talking with some indigenous people of Namibia and he was impressed by the practicality of the innovative and amazing design of the outer shell of the beetles and how they survive and survive in these harsh conditions, so Matthew tried to imitate and apply the same type of technology In the design of an external envelope for a building that converts collected water droplets into usable water, the building is a series of weapons that are placed behind a long and slightly curved nylon net used to collect water. The wall of the nylon net is directed towards the perimeter so that it can capture as much water as possible Moisture and from the fog that is located in front of the facade, and the design process for the outer shell of the building follows the same principles of the beetle in its outer shell, where the water is collected on the screen of the grid, and because of its shape and vertical orientation, the water naturally runs down the grid in a gutter system located at the bottom of the screens with the help of gravity, The water is carried through the gutters into large tanks that keep the water at an appropriate cooler. (33)

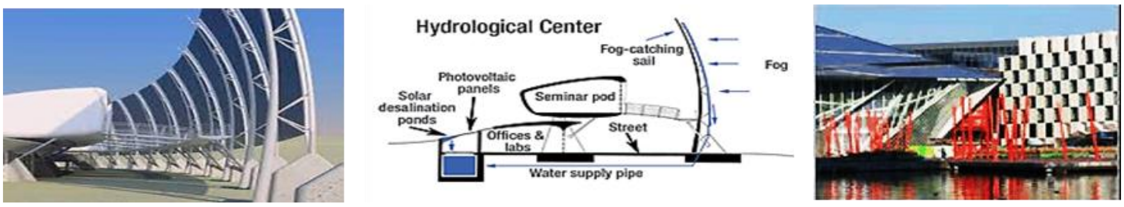


Fig. 13 The building of the Hydrological Center of the University of Namibia simulates the beetle in collecting and storing water by gutter in tanks, from biological solutions to water management strategies [34]

7.1.5. Aqua Web technology

Designed by Nexloop, Aqua Web is a new system designed by a team of NexLoop experts that will be used to obtain water in a more natural way, that is, it will be used to hold rainwater and even moisture in the environment so that we can later manage it in the processing and generation of those crops The famous metropolitan that looks very "trendy" in all the major cities of the world. It is a flexible and modular product that can take advantage of local resources and integrate into the architectural outer shells, Figure (14) It is inspired by honeycombs, each part of the building structure is hexagonal. Inside these pieces there is a web that simulates the fibers of the cobweb to harvest water from the atmosphere such as rain, fog and moisture. This mesh attracts water from the air. The drawn water is collected in flexible chambers inspired by ice flower bags. The accumulated water is transported to the necessary parts of the building through tubes that simulate the hydro-transport property of a spider web and fungi. As a result, the Aqua Web is a system that harvests, stores, and transports atmospheric water, thanks to its nature-inspired structure. Installed on a container farm for hydroponics in 2019 as part of a circular economy pilot project, the system's creators received a 2017 Ray of Hope Award thanks to the fact that it was inspired by the way nature has been able to hold fresh water, specifically in how different organisms such as bees Fungi, plants, and even spiders do this kind of work [35].

Fig.14 Implementation of water management strategies inspired by spider, rosemary and fungi using Aqua Web product in how to capture water from the atmosphere, rain and fog and use it in growing food [36].

7.1.6. Warka Tower

The Warka Water Tower was proposed by Arturo Vittore in Figure (15) in the village of Dorsey, Ethiopia, as an alternative water source and clean water system for the local population by harvesting water in the atmosphere of areas with lack of access to clean and safe water resources where this uncosted and easy-to-install tower is designed with essential elements of nature, without the need for complex engineering and structural requirements and no complex construction requirements. The Warka Tower requires any electricity or any other energy, as the prototype designed is made up entirely of natural environmentally friendly materials, as it is biodegradable and 100% recyclable, designed with a stylish, perfect frame, made of local bamboo, surrounded by a thin network of thin bioplastics, which is easy to maintain by the local population, without the need for electricity but produces only water this tower, which is 9.5 meters high, captures water droplets from the air due to high humidity in the air, and works with high efficiency allowing the tower to collect up to 100 liters of pure water per day. Yaf Spider Webs. A special polyester-knitted cover material was developed by simulating water absorption by the desert namib beetle and spider web through rough surfaces supported by bamboo frames. This special material that forms the surface of the tower attracts air water to its surface and transports it to the reservoir at the bottom of the tower and thanks to the fact that the air always contains a certain amount of water vapor, regardless of local ambient temperatures and humidity conditions, the system can collect and store 40-80 liters of water per day, even if it does not rain. As a result, the Warka Tower works normally with events such as condensation, evaporation, and gravity without the need for any energy, 3.2 copies of the project, 12 of which have been created since 2012, were built in the village of Dorsey in Ethiopia in 2015; version 4 was built in Cameroon in 2019 (37).

Fig.15 Implementation of Water Management Strategies Inspired by Spider, Cactus Thistle and Namib Beetle in Project Warka Tower [38]

7.1.7. Rain Bell technique

The rain bell technology, which was used in the facades as an element of the building envelope and was invented by Michele Richmond and Rachael Meyer, Alexandra Ramsden and Jennifer Barnes, who are the participants in the "Nature-Inspired Creation of Eleven's International Biomimicry Winners" competition (Figure 16). The project aims to develop a facade system that can store rainwater and transfer it to the building when needed, and for this purpose, The water storage feature of the Snow Flower plant has been imitated. Thanks to the epidermal sac cells in the body of the Snow Flower plant, it can store water and use the water it has stored in times of drought. This plant mechanism was extracted and transferred to the Rain Bell design, which can increase its storage capacity thanks to Its blower receives rainwater and the water accumulated here is taken by the sewage system under these facade elements, filtered and transported to the necessary places in the building [39].

Fig. 16 Implementation of water management strategies inspired by the watermelon flower using the product Rain Bell in the design of the external envelope of buildings [40].

7.1.8. Museum of Bio-Imitation

Architectural Exploration designed the Bio-Imitation Museum in Figure 17 and is inspired by the nature and cultural characteristics of the Middle East. Along the entrance, the amphitheater and the museum's restaurant are a unique oasis of the area's flora. The museum's large entrance canopy, the top cover of this oasis, was inspired by the spongy bones that maintain water balance in camel noses and the ability of cactus spines to harvest water from the air. Thanks to the biomimetic canopy that collects water in the air, the water needs of the plants in the oasis are naturally met [41].

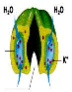
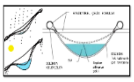
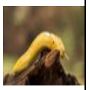
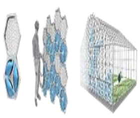
Fig. 17 Implementation of water management strategies inspired by camel noses and cactus spines in the Bio-Imitation Museum project [42].

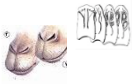
8. APPLIED STUDY

After presenting the various examples of buildings that adopt water management strategies and maintain the water balance of living organisms in the outer envelopes of these buildings, the characteristics of this biomimetic architectural envelope formed when these strategies are transferred to the design, and the function of water management in the biomimetic envelope and what this provides to the building and in In this context and in order to link them to the architecture, two checklists were created by making a table in which the above information is summarized showing the functions of gain, protection, transport, loss and purification, which are identified as the basic functions of water management, and the methods used by living organisms to provide these The tasks and percentage of frequency of the applied water management function for all examples of case-case designs are summarized in Table (3) and Table (4):

The results of the matrix measuring the extent of application and achievement of formal characteristics and digital aesthetic values in the previous study cases were formulated in Table No. (3), where the presence of the water management function in the study case was expressed with a square symbol in red, and in the absence of a water management function in the study case, it was set Square symbol in white, then calculate the percentage of the extent to which the naturally inspired water management functions are used in the project (%) in all study cases by adding the number of red squares and dividing it by the total number of water management functions, as follows:

TABLE 3: SUGGESTED CHECKLIST (1), WHICH EXPRESSES THE USE OF WATER MANAGEMENT STRATEGIES AND MAINTAINING THE WATER BALANCE OF LIVING ORGANISMS IN EXAMPLES OF DESIGNS FOR THE OUTER CASINGS OF CASE STUDY BUILDINGS, SOURCE (RESEARCHER).

Architectural example	**The Organism**	**Bio-inspired water strategies**	**Characteristics of the shape of the outer shell of a building simulating living organisms**	**The water management function applied by the simulated architectural example of living organisms**		**Percentage of use of naturally inspired water management functions in the project (%)**
Habitat 2020 	 Stoma cells	The stoma cells open and close, absorb carbon dioxide and release oxygen in response to osmotic pressure and maintain water balance in the cell, and the waxy layer on the surface of plant leaves prevents water loss.	Gaps-like elements in the building's outer shell collect and purify rainwater or moisture in the air and prevent it from losing, allowing it to be used inside the building.	collecting water Transport of water water storage Prevent water loss Water Purification	■ □ □ ■ ■	The percentage of use is about 60% of the project's naturally inspired water management functions
Forest Greenhouse Design Proposal 	Banana snail 	The hygroscopic skin attracts the surrounding water molecules to it. The drawn water molecules are taken into the pores.	Silicone fenders in the building envelope Stretches when it rains and takes the shape of a bag It collects and stores rainwater.	collecting water Transport of water water storage Prevent water loss Water Purification	■ □ ■ □ □	The percentage of use is about 40% of the project's naturally inspired water management functions
Biomimetic Office Building 	Mimosa plant  trumpet plant  Namib beetle 	Compound leaves fold and droop as soon as they are touched, shaken, or rained. Swelling changes, the groups of cells that expand their water content as the concentration of calcium and potassium ions enhances the release of water from the cells. The higher ion concentration causes water to be transported into the intercellular spaces. Trumpet wood has a humidity of about 60% with maximum water absorption of 93% as it maintains water significantly The insect stabilizes its body at a 45-degree angle, attracting the water-loving hills on the insect's crust water droplets from the fog carried in the air and slipping from the surface of the insect with the effect of the angle of the insect and its gravity and reach the mouth of the insect.	To manage the water in this building, the outer shell was designed and inspired by desert beetles, mimosa and hornbeam leaves, implementing a system similar to that found in the Seawater Greenhouse project, inspired by the behavior of desert beetles to collect and purify water from mist.	collecting water Transport of water water storage Prevent water loss Water Purification	■ □ □ □ ■	The percentage of use is about 40% of the project's naturally inspired water management functions
Namibia Hydrology Center 	Namib beetle 	The insect stabilizes its body at a 45-degree angle, attracting the water-loving hills on the insect's crust water droplets from the fog carried in the air and slipping from the surface of the insect with the effect of the angle of the insect and its gravity and reach the mouth of the insect.	The design process for the outer shell of the building follows the same principles as the beetle in its outer shell, where the water is collected on the screen of the grid and due to its shape and vertical orientation, the water naturally runs down the grid in a gutter system located at the bottom of the screens with the help of gravity, the water is transported through the gutters in tanks Great keeps water at a proper cooler and purified.	collecting water Transport of water water storage Prevent water loss Water Purification	■ ■ ■ □ ■	The percentage of use is about 80% of the project's naturally inspired water management functions
Aqua Web 	Snow Flower Plant  Spider's Web 	It moves towards the base of the fork with the effect of pressure to the Lalas caused by the conical shape. Skin bags, a type of trichomes, can collect and store water in the air thanks to its flexible structure. The nodes on the silk fibers absorb water from wet air	The outer shell of the building when using this technique is inspired by honeycombs, each part of the building structure is hexagonal. Inside these pieces there is a web that simulates the fibers of the cobweb in order to harvest water from the atmosphere such as rain, fog and moisture. This mesh attracts water from the air. The drawn water is collected in flexible chambers inspired by ice flower bags. The accumulated water is transported to the necessary parts of the building through pipes that simulate the water transport property of a spider web	collecting water Transport of water water storage Prevent water loss Water Purification	■ ■ ■ □ □	The percentage of use is about 60% of the project's naturally inspired water management functions
Warka Tower 	Namib beetle  cactus spines  spider web 	The insect stabilizes its body at a 45-degree angle, attracting the water-loving hills on the insect's crust water droplets from the fog carried in the air and slipping from the surface of the insect with the effect of the angle of the insect and its gravity and reach the mouth of the insect. The limbs of the spine attract water droplets from the air, collecting water droplets gathered at the end of the thorns and grow. The nodes on the silk fibers absorb water from wet air.	The building's exterior was designed in a way that was inspired by the shape of the shell of Namib desert beetles and the fibers of spider webs. A special knitted polyester covering material is developed by simulating water absorption by the Namib desert beetle and spider web through rough surfaces and supported by bamboo frames. This special material that forms the roof of the tower attracts atmospheric water to its roof and transfers it to the tank located at the bottom of the tower.	collecting water Transport of water water storage Prevent water loss Water Purification	■ ■ ■ □ □	The percentage of use is about 60% of the project's naturally inspired water management functions
		It moves towards the base of the fork with the	The use of this technology as an	collecting water	■	The percentage of

Rain Bell 	Snow Flower Plant 	effect of pressure to the Lalas caused by the conical shape. Skin bags, a type of trichomes, can collect and store water in the air thanks to its flexible structure.	interface element Inspired by the ice flower, which works like a blower As the amount of rain water increases, it can expand the storage volume, while in the absence of water inside, the blower can remain closed thanks to its flexibility.	Transport of water water storage Prevent water loss Water Purification	■ ■ □ □	use is about 60% of the project's naturally inspired water management functions
Bio-Tradition Museum 	Camel nose  Cactus 	Sponge bones covered with rich vascular tissues in camel noses absorb moisture into the air inside by intensifying them to prevent water loss at exhalation, where the camel's respiratory system is unique to the presence of a side nasal pocket that collects a significant percentage of water while breathing, and the camel's nose can close completely, preventing the trachea from drying out. The limbs of the spine attract water droplets from the air, collecting water droplets gathered at the end of the thorns and grow.	The outer shell of the building is thorny structures located on the upper surface of the canopy that collect water from the air, and the complex folds within the canopy increase the surface area on the roof, absorbing most of the moisture that evaporates from the inside, preventing water loss by evaporation.	collecting water Transport of water water storage Prevent water loss Water Purification	■ □ □ ■ □	The percentage of use is about 40% of the project's naturally inspired water management functions

9. RESULTS

9.1. Checklist (1) Results

Percentage of use of naturally-inspired water management functions in the project (%)

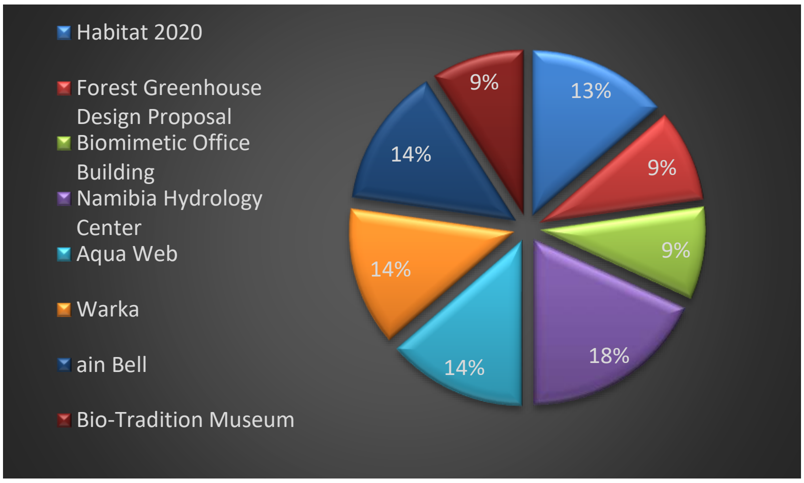


Chart (1): the percentage of the extent to which the naturally inspired water management functions are used in the study cases (%).

The percentage of repetition of the applied water management function for all examples of designs of the outer covers of the study cases was calculated by placing a red box and then dividing the number of repetitions of one function by the number of study cases, and the percentage of the size of one element of the water function relative to the rest of the elements was calculated by calculating What is its volume in relation to the volumes of the rest of the water functions.

TABLE 4: THE PROPOSED CHECKLIST (2), WHICH EXPRESSES THE PERCENTAGE OF FREQUENCY OF THE APPLIED WATER MANAGEMENT FUNCTION FOR ALL EXAMPLES OF DESIGNS OF OUTER SHELLS FOR THE STUDY CASES AND THE PERCENTAGE OF THE SIZE OF THE ELEMENT IN RELATION TO THE REST OF THE ELEMENTS.

The water management function applied by the simulated architectural example of living organisms	Bio-Tradition Museum	Rain Bell	Warka Tower	Aqua Web	Namibia Hydrology Center	Biomimetic Office Building	Forest Greenhouse Design Proposal	Habitat 2020	Percentage of frequency of applied water management function for all study cases (%)	Percentage of the volume of the water function element relative to the rest of the other water function elements (%)
collecting water	■	■	■	■	■	■	■	■	100%	36%
Transport of water		■	■	■	■				50%	18%
water storage		■	■	■	■		■	■	63%	23%
Prevent water loss	■								25%	9%
Water Purification					■	■		■	38%	14%

9.2. Checklist (2) Results

Percentage of frequency of applied water management function for all study cases (%)

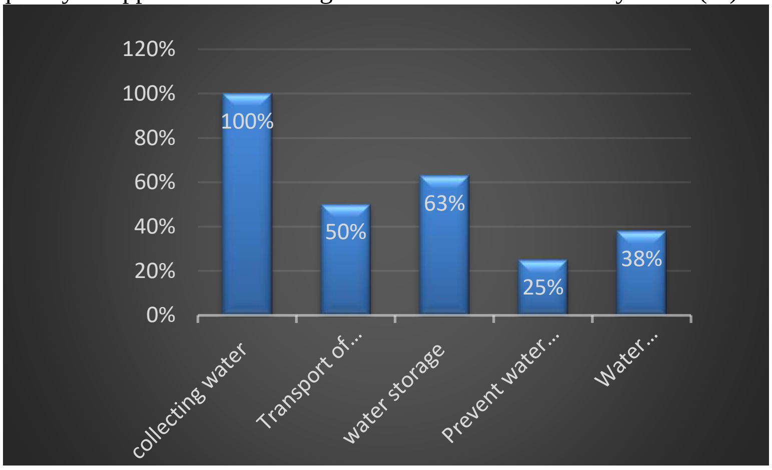


Chart (2): The frequency of the applied water management function for all study cases (%).

Percentage of the volume of the water function element relative to the rest of the other water function elements (%)

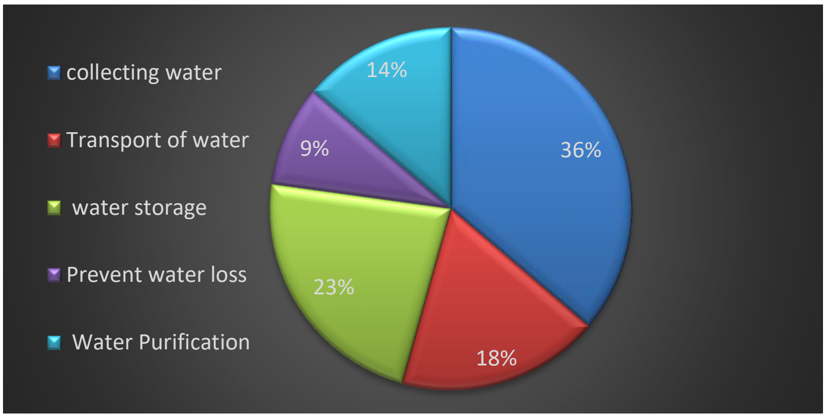


Chart (3): The percentage of the volume of the water function element in relation to the rest of the other water function elements (%).

10. DISCUSSION

From the above, a proposed model for checklist 1.2 was designed with relative weights and numerical values guided by a proposal based on previous studies in the theoretical and analytical background of the research, with the aim of measuring the success of selected analytical examples in accomplishing the task of good water management, transportation from nature and application in the field of architectural design, where the scope of this study focused on natural-inspired water management strategies in order to seek answers to questions about the characteristics and mechanisms of Organisms in nature and how they can be adapted and applied to multiple examples of outer building casings, the research discussion can be summarized at the following points:

1. The results of the extent to which naturally inspired water management functions from living organisms are used in the selected study situations have been ranked downwards from large to smaller in percentage as follows:
   Namibia Hydrology Center ranked first with the highest percentage of 18% of the use of naturally inspired water management functions, while Aqua Web, Rain Bell and Warka finished second with 14% of the use of naturally inspired water management functions, habitat 2020 was ranked third with a percentage of 13% of the use of naturally inspired water management functions, while habitat 2020 projects received a percentage of 13% of the use of naturally inspired water management functions, while projects from both Forest Greenhouse Design Proposal, Biomimetic Office Building and Bio-Tradition Museum are fourth with 9% of the use of naturally inspired water management functions.
4. The results of the percentage frequency of the water management function applied for all selected study cases were ranked downwards from large to smaller in percentage as follows:
   The job (water collection) was ranked first with the highest percentage of 100% of repetition in all study cases, while the job (water storage) was second with 63% of repetition in all study cases, while the third-place job (water transfer) received a percentage of 50% of repetition in all study cases, while the job (water purification)

was ranked fourth with a percentage of 38% of repetition in all study cases, while the job (water purification) was ranked fourth with a percentage of 38% of repetition in all study cases. All study cases, while a job (preventing water loss) was ranked fifth with a percentage of 25% of the redundancy in all selected study cases.

5. The results of the percentage of the size of the water function component for the rest of the other water functions were ranked downwards from large to smaller in the percentage as follows:
   The element (water collection) in the first place reached the highest percentage reached 36% for the total size of all other water functions elements, while the element (water storage) in the second place reached the highest percentage reached 23% for the total size of all other water functions, while the element (water transport) in the third place by a percentage reached 18% for the total size of all elements of other water functions, while the job (water purification) got the fourth place by a percentage of the fourth percentage To 14% for the total size of all other water functions, while the job (preventing water loss) ranked fifth with a percentage of 9% for the total size of all other water functions.
6. When exploring the knowledge and mechanisms of biological water management to inspire new solutions to buildings and during the examination of organisms in nature, formally and behaviorally, it has been noted that some forms and behaviors in living organisms correspond to certain ways of water balance. For example, prominent "thorns and similar shapes" can absorb from the surface, such as cactus thorns, desert namib beetle shell hills, water from the air; "shapes that increase surface area", such as the complex composition of camel nose bones that reduce evaporation; or such as preventing behaviors such as tree creases and shrinking juicer water loss by reducing radiation exposure.
7. When the designs of the biometric building cover for multiple study situations were examined, all of these methods corresponded to the five basic functions of water acquisition, conservation, transport, loss and purification. It has been noted that these functions in living organisms correspond to the water management functions available in buildings. In other words, when the mechanism of the object producing water is transferred to the design of the building's crust, the water can be collected in the building; when the property is moved, the water is transported in the building; when the conservation properties are transferred, the loss of water in the building can be prevented, and the water can be stored and filtered. While functional simulations can be created in this way between water management strategies for living organisms and construction envelopes, different design differences occur when the feature that provides these functions in living organisms is transferred to architecture. For example, the system inspired by the desert namib insect strategy was used to lower its body temperature to create condensation on the surface of the crust, in the project of the Tower of The Hips, for example, we find that it is a different architectural example that harvests water inspired by the morphological features of this insect, it turns out to explain this natural formation of the organism in different ways, in terms of materials used and design can take the basic principles of water management strategies for living organisms and transfer them to the design of the architectural crust With different materials, proportions and scales as a result, water is harvested through the architectural cover in this example.

11. CONCLUSION

From the previous research study, we conclude that the most common strategies of living organisms in managing natural water balance can be collected and summarized in the application engineering use by architects in sustainable environmental design as follows:

Compositional adaptations of organisms:

1. Camels: (water conservation strategy)
2. Cactus (water conservation strategy)
3. Namib insect (strategy of transporting, preserving, purifying, and acquiring water)
4. Banana snail (water acquisition and collection strategy)
5. Snowflower plant (water acquisition and water conservation strategy)
6. Spider (water acquisition and water conservation strategy)
7. Trumpet plant: (water acquisition and collection strategy) and (water purification strategy)

Behavioral adaptations of organisms:

1. Stoma cells: (water acquisition and collection strategy) and (water purification strategy)
2. Mimosa plant beam sheet: (water acquisition and collection strategy) and (water purification strategy)

We also conclude, based on examples of biometrical design and analysis of the inspection list tables reviewed above, we find that water management mechanisms in living organisms are closely compatible with the architectural exterior casing designs of some buildings, where they can be adapted rather than sent. In this case, the living thing has the same thing can achieve similar functions when the mechanism is adapted to different structural designs. Aesthetically different manifestations appear. In addition, building envelopes can be designed to provide the same function, even in areas with completely different climatic conditions. When water balance strategies for organisms in nature are transferred to architectural crust designs, the water management strategy available in the organism and the water management function provided by the architectural cover can be the same, in other words, the required function in architectural cover design can be achieved by examining the mechanisms of organisms that have the same function in nature. Or when the water management strategy of an organism in nature is adapted to the design of the architectural cover, the same function can be achieved in the architectural cover. In this regard, adapting living organism strategies to architectural exterior covers will provide sustainable and effective solutions.

Architectural shells (exterior covers of buildings) designed to inspire water management functions for organisms in nature reduce water consumption in buildings and contain the potential to protect existing water resources and access to the necessary water in the building, as these biogeological informed architectural shells provide sustainable solutions to the problem of depletion of the world's water resources due to construction activities.

12. RECOMMENDATIONS

1. Increase the number and quality of architectural design studies for biometrics that will be conducted in the future to provide water management in buildings so that this increase is possible with the development of methods that will encourage research and the selection of appropriate strategies from the large database of nature and facilitate the transfer of data from biology to architecture by architects with limited biological knowledge.
2. The research proposes to apply the applied research study more broadly and on a larger scale to all elements of the biological design of architecture in all areas and not only in the field of water function management, and to examine the psychological impact of that on user behaviors.
3. The need to further spread cultural and scientific awareness among designers on such new concepts in design through new computer programs specialized in the field of parametric environment.
4. The need to apply and include biological architectural design systems in the academic curriculum in specialized colleges such as engineering and applied arts so that students can keep up with the requirements of the modern market in this field.

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