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ENHANCEMENT OF GREEN BUILDINGS USAGE FOR REDUCTION OF ENVIRONMENTAL IMPACTS

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الملخص

تتجمع فوائد المبانى الخضراء فى ثلاثة مجموعات: بيئية, و اقتصادية, و اجتماعية. من ناحية وجهة النظر البيئية, تستطيع المبانى الخضراء أن تقدم عدة حلول لتصميم و بناء مبانى صحية فعالة ذات تأثير ايجابى على البيئة.

المبانى الخضراء تقلل من الاثار الضارة للمبانى على البيئة و صحة الانسان بواسطة تخفيض كمية استهلاك المبانى للموارد الطبيعية, و تخفيض كمية الملوثات و تدهور البيئة, و تخفيض المخلفات, و تحسين كفاءة استخدام الطاقة و المياه و أى موارد أخرى. بالاضافة الى ذلك فان المبانى الخضراء توفر بعض الوسائل الفعالة لتحقيق العديد من الأهداف العالمية مثل مكافحة التغير المناخى, و ايجاد مجتمعات مستدامة, و المستهمة فى تنمية الاقتصاد. و احد أهم عناصر المبانى الخضراء هى الواجهات الخضراء.

و وفقا لهذا فان البحث فى البداية يتناول التعريف بمفهوم العمارة الخضراء و ما هى الصفات التى تتسم بها المبانى الخضراء, و ما هى المبادئ التى تقوم عليها المبانى الخضراء, ثم يقوم البحث بعرض الفوائد البيئية للمبانى الخضراء, بالاضافة الى الأهداف العالمية التى تسعى الى تحقيقها المبانى الخضراء مثل كفاءة استخدام الطاقة, و المحافظة على المياه, و جودة الهواء الداخلى, و تقليل المخلفات, و مكافحة التغير المناخى, والمحافظة على الموارد الطبيعية. و حيث ان من اهم عناصر المبانى الخضراء هى الواجهات الخضراء فقد تطرق البحث الى تعريف الواجهات الخضراء, و فوائد الواجهات الخضراء, بالاضافة الى تأيرها الحرارى فى تخفيض الحرارة, و فى عمل الظلال و العزل الحرارى, و التبريد, و اخيرا يتناول البحث أنظمة الواجهات الخضراء, و طرق استخدام وسائل الرى المختلفة فى رى نباتات الواجهات الخضراء مثل نظام الرى بالتنقيط, ونظام الرى الألى, و الرى من خلال شبكة أنابيب.

ABSTRACT

The benefits of green buildings can be grouped within three categories: environmental, economic and social. Form the environmental point of view, green building can offer many solutions to design and construct efficient, healthy buildings that benefit the environment.

Green buildings reduce the harmful impacts of buildings on the environment and human health by reducing the amount of buildings consumption of natural resources, reducing the amount of pollution and degradation of environment, reducing waste, and improving the efficiently of using energy, water and any other resources. Moreover, they provide some of the most effective means to achieve a range of global goals, such as fighting climate change, creating sustainable communities, and driving economic growth. One of the most important items of green buildings is the green facade.

Accordingly, the research started by identifying the concept of green Architecture and its characteristics, and the principles that stands for them. Then the research demonstrated the Environmental Benefits of Green Buildings and the Global Goals of Green Buildings such as Energy Efficiency, Water Conservation, Indoor Air Quality, Waste Reduction, Fight Climate Changes, Material Efficiency and Conserve and restore natural resources. And as the green façade is one of the most important items of green buildings, the research showed the identification of green facades and their benefits, as well as the thermal impacts of Green facades such as temperature reduction, shading and insulation and Evaporative cooling. Finally the research showed green facades systems and their irrigation systems such as gravity fed drip irrigation Systems, automated irrigation systems and watering through a pipe network.

KEYWORDS: Green buildings, Eco cities, Urban design, Environmental impacts, Green façade.

1. INTRODUCTION

It is estimated that by 2056, global population will be increased by over 50% [20], and urbanization is growing very fast, accordingly the building industry is rapidly growing in energy use, resulting into many series environmental problems [13].

These problems include air pollution, heat island, negative health effects, water and noise pollution, increase of waste disposal [13], exhaustion of energy resources, carbon dioxide emissions, global warming, and climate changes [20].

Presentation of green buildings is a useful stage towards environmental protection, providing better environment and restricting negative effects. Moreover, green buildings save energy consumption by providing cooling effect, reduce heat island effect and provide better environmental conditions. They may be defined as a tool of increasing efficiency of buildings resources as energy, water and materials while reducing building impacts on human health and the environment [13].

2. METHODOLOGY

2-1 Green Architecture

Green architecture is an approach to buildings that minimizes harmful effects on human health and the environment. It can be a guard to air, water, and earth by choosing environment -friendly building materials and construction solutions [11]**.**

Green architecture defines an understanding of environment-friendly architecture, and it may have characteristics such as [11]:

- Ventilation systems designed for efficient heating and cooling.
- Energy-efficient lighting and appliances.
- Water-saving plumbing fixtures.
- Landscapes planned to maximize passive solar energy.
- Minimal harm to the natural habitat.
- Use renewable power sources such as solar power or wind power.
- Use Non-synthetic, non-toxic materials.
- Use of recycled materials.

Green buildings are the practice of making structures and using processes that are friendly to the environment and resource-efficient throughout a building's life-cycle from stage of design, construction, operation, maintenance, renovation and deconstruction [2].

Green buildings are buildings that reduce or eliminate negative impacts, can provide positive impacts on our climate and natural environment, save natural resources and improve quality of life [5].

Green buildings bring a set of techniques, materials and technologies contribute to enhance its environmental performance when they are integrated in a construction project [19].

Green buildings are eco-construction optimize energy efficiency, limit water consumption, and make maximum use of recyclable and non-toxic materials. They generate little waste during the construction process and occupation [19].

2-2 Green Buildings Technology

The concept of Green Building Technology is referred to as Sustainable building technology, which means that the building is designed in such a way that it consumes

less energy, has great design flexibility, a low maintenance cost, and improved air quality [4].
According to data, building and construction activities worldwide consume three billion tons of raw materials every year. By using green building technology, this number can be minimized without compromising the durability and strength of the structures [4].

3. DISCUSSION

3-3 Environmental Benefits of Green Buildings

Green buildings aim is to reduce the environmental impact of buildings, considering the statistics of future sustainability that reducing buildings consuming of natural resources and the amount of pollution is a must [9].
Green buildings reduce the harmful impacts of buildings on human health and the natural environment by [9]:

- Efficiency using energy, water, and other resources.
- Protecting occupant health and improving employee productivity.
- Reducing waste, pollution and environmental degradation.

Moreover, Green buildings can reduce or eliminate negative impacts on the natural environment, and provide positive impact on the environment at the building or city scales by [6] :

- Using less water and energy or natural resources.
- Generating their energy.
- Using renewable resources such as using sunlight through passive solar, active solar and photovoltaic techniques.
- Using plants and trees through green roofs, rain gardens.

3-4 Global Goals of Green Buildings

Green buildings provide some of the most effective means to achieve a range of global goals, such as [7]:

- Energy Efficiency.
- Water Conservation.
- Indoor Air Quality.
- Waste Reduction.
- Fight Climate Changes.
- Material Efficiency.
- Conserve and restore natural resources.

3-4-1 Energy Efficiency

Green buildings economize an average 30% of energy consumption over conventional buildings, and it was found that residential and commercial buildings consume much more energy than industrial and transportation, reaching between 20% and 40% in developed countries, therefore energy saving systems in green buildings depend on the efficient use of three main items; lighting, heating and cooling systems [17].
Green buildings must be fitted with solutions that offer electrical energy, contribute in supplying energy [19], and include means to reduce energy consumption such as [8],[9]:

- Installing solar panels to use energy from the sun.
- Designing windows in a way that allows as much natural light as possible to reduce the use of artificial light.

- Increase the efficiency of the building envelope, by using insulation in walls, ceilings, and floors.
- Use shades, and trees to shade windows and roofs during the summer while maximizing solar gain in the winter.
- Using solar water heating to reduce energy loads.
- Bringing more sunlight inside the building to decrease the amount of energy used to illuminate, heat and cool spaces.

For energy saving efficiency there are some considerations to be taken such as Buildings shape and orientation have a significant impact on building energy consumption. Reasonable building layout reduces the energy consumption during construction use; and the power consumption of the heating and air conditioning system.

- Insulation of buildings external walls reduces the energy consumption during use and improves the thermal performance. The external wall insulation is used in the cold winter to avoid the loss of indoor temperature, and is used in the hot summer to avoid solar radiation to raise the indoor temperature.
- The Green buildings reduce the energy consumption of HVAC system, and the HVAC system energy efficiency can reach up to 30%, as the HVAC system consume more than 50% of the total energy consumption in the general buildings.
- Daylight lighting reduces the demand for power light sources and reduces energy consumption and environmental pollution, as building lighting consumption in commercial buildings consume more than 30% of the total power consumption.
- Building sun shading during summer is an economical and effective way to reduce energy consumption and achieve the purpose of building energy efficiency.

Green buildings can save energy of 50% or more in 2050, and help in limiting global temperature to raise to 2°C.at a building level, as Green buildings in South Africa save energy consumption between 30 - 40% every year, and in India they save energy consumption about of 40 - 50% compared to conventional buildings, also they achieved the LEED certification in the US and other countries to consume 25 % less energy than non-green buildings [6].

3-4-2 Water Conservation

The United Nations World Water Development Report indicates that water for all uses is becoming scarce and is leading to a water crisis. Growth in water use has caused a significant reduction of water tables as water used in buildings is one of the higher consumers of national water consumption [20].

Green buildings reduce water consumption; therefore they must be designed to use water efficiently by managing waste water, irrigation water and rain water [19].

The protection and conservation of water throughout the life of a building can be accomplished by [9]:

- Using duel plumbing system that recycles water in toilet flushing.
- Using non-sewage, rainwater and grey water for subsurface irrigation to minimize waste of water.
- Using thermostatic mixer shower taps and low-flow shower heads saves water that is lost during adjusting a shower temperature as shown in figure [1].

- Utilizing water conserving fixtures such as ultra-low flush toilets, and aerator tap fittings to reduce the amount of waste-water as shown in figure [2].

Figure (1): Low-flow shower heads Thermostatic mixer

Figure (2**):** Ultra Low Flush Toilet Aerator taps

Green buildings in Australia have produced 51% less potable water, and in India has saved water for about of 20 - 30% compared to conventional buildings, and in South Africa potable water was saved between 20 - 30% every year, and they achieved the LEED certification in the US and other countries to consume 11 % less water than non-green buildings [6].

3-4-3 Indoor Air Quality

Poor indoor air quality has a serious impact on health and productivity [9]. According to the World Health Organization, lung and respiratory diseases caused by poor indoor air quality are three of the top five leading causes of death [14] as Indoor air pollutant levels are about two to five times higher than those of outdoor air [15]. Indoor air quality depends on well-designed ventilation and moisture control, which affects energy efficiency [3].

The pollutants which are found in indoor air can be as follows [16]:

- Volatile organic compounds (VOC), which are emitted from building materials, and cleaning materials.
- Microbial volatile organic compounds, such as mold and mildew.
- Semi volatile organic compounds, which come from fire retardants and pesticides.
- Inorganic gases, carbon monoxide, and nitrogen dioxide.
- Particulate particles from burning fuels in cars and from burning combustion products.

Good indoor air quality aims to reduce air pollutants to protect the health of the building's occupants, to reduce stress and to improve the quality of life [8].

Indoor Air Quality is important in material selection for construction by using materials with few or no toxic elements, moisture resistance, and have minimum emission of Volatile Organic Compounds [13] .

Green buildings improve indoor air quality by reducing the use of materials that may emit elements that are dangerous to the health by choosing friendly environmentally construction materials and finish products with zero or low emissions [9].
A study stated that green buildings reduced SBS, influenza and allergies symptoms by 20% to 50%, 9% to 20% and 8% to 25% respectively. This due to the fact that green buildings provide better environment that reduces stress and results in longer life [17].

3-4-4 Waste Reduction

The construction industry is one of the major waste generators, which causes several environmental, social and economic problems. Waste takes the form of unwanted materials generated from construction and demolition processes. Reduction of waste in the construction buildings can save considerable amounts of non-renewable resources [20].
The most effective factor of reducing the environmental impact of construction waste is by reducing or preventing waste generation as much as possible. This will provide economic benefits and reduce the quantity of waste and green house gas emissions [20].
Green buildings help to reduce the quantity of waste. They aim to reduce waste by using the minimum amount of materials, recycled materials, reuse materials, and durable materials with longer life [20], and utilizing energy efficient designs and appliances[12].
Also the extension of the useful lifetime of a structure enables waste reduction [19].

3-4-5 Materials Efficiency

Green and high quality building materials are used to minimize indoor air quality impacts, to avoid toxics, and to reduce waste.
Material selection is very important for the construction of a sustainable building, so an environmental assessment of the building materials has to be done as follows [4]:

- Gathering technical information about the materials.
- Evaluation to calculate the cost, and to check for durability.
- Using the evaluation to compare between materials, and then selecting the better material.

Friendly environmentally materials and renewable sources are used with materials from recycled and reuse of waste for construction. Alternative materials can be used based on resource efficiency, efficient use of energy, water conservation and economic cost [13].
Green buildings use recycled material, local resources and durable and long life materials.

3-4-6 Fight Climate Changes

Buildings are responsible for over 30% of global green house gas emissions, and therefore they are a major contributor to the climate changes [14]. Global warming could have major consequences if sufficient steps are not taken to limit greenhouse gases to be able to eliminate approximately 30% the world's emissions of greenhouse gases in the construction sector by 2030 [19].
A large portion of fossil fuel consumption, which cause nearly 70% of the global carbon emissions, is caused by heating buildings[12]. Green can buildings play a significant role in reversing the implications of climate change. They can reduce green house gas emissions, so the global carbon emissions could be reduced by 15-20% every year.[12].
Also they can save emissions about 84 gigatonnes of CO2 by 2050, by using energy efficiency and the use of renewable energy [6].
When green buildings use green energy, like geothermal, solar or wind technologies, there will be no carbon dioxide emissions[10].

Green buildings in Australia have produced 62% fewer greenhouse gas emissions than average Australian buildings, and in South Africa have been shown to save on average carbon emissions every year [6].

3-4-7 Conserve and Restore Natural Resources

Natural resources are running out and their extraction has environmental harmful effects such as: Soil erosion, destruction of natural habitats, and disappearance of fish stocks. The exploitation of these resources generates pollution which represents an increasingly dangerous threat to the quality of water, soil and air. Current production, construction and consumption, along with global climate change are factors that show that the stock of natural resources will not remain sufficient to satisfy the needs of a world population that is growing widely [19].

Buildings, development and transportation infrastructure have significant environmental impacts on natural resources by replacing natural surfaces with harmful materials, creating runoff that washes pollutants into surface water. Urban runoff constitutes a major threat to water resources, as it has been identified as the fourth leading source of impairment in rivers, third in lakes, and second on estuaries [19].

Restore natural resources is the management of the human use of natural resources to provide the maximum benefit to current generations while maintaining capacity to meet the needs of future generations [20].

There are two types of natural resources [19] :

- Natural biological resources are the drinking water, cultivated soils, the air, the forests that provide oxygen for the atmosphere, along with all plant and animal species.
- Natural energy resources are used to produce energy. They include the air, the sun, water, geothermal sources, plants and fossil fuels.

The conservation of natural resources is the main objective of Green buildings.

3-5 Green facades

One of the most important items of green buildings is the green facade.

3-5-1 Green facade definition

A green facade is created by growing climbing plants up and across buildings facade, either from plants grown in garden beds at its base or by container planting installed at different levels across the building [21].

It can be also defined as a type of vertical garden installed on a building wall. Facades generally consist of a support structure with plants holding to it and grow upwards. The plants are often grown without soil, or they can be grown in soil at the base of the building [25].

3-5-2 Green facade benefits

Green facades are installed on the building wall to provide an attractive look to the building, create a cooler microclimate immediately adjacent to the building through shading the building facade, provide cooling from evaporation of plant foliage, capture of air particulate particles and volatile gaseous pollutants [21].

Green facades can contribute in improving the environment by adding green areas by covering vertical green areas to buildings walls and could be increased by raising the buildings height as shown in figure (3) [23].

Figure (3): green facades add vertical green areas

Moreover, green façade prevent pollution by reducing dust in the air, as by increasing the green façade height, the pollution percentage becomes lower in the road surrounded by these green facades, as shown in figure (4). And when the ratio between the green façade height and the road width equals 1, the pollution reduction percentage becomes 30%, and if the ratio between the green façade height and the road width equals 2, the pollution reduction percentage becomes 45% [23].

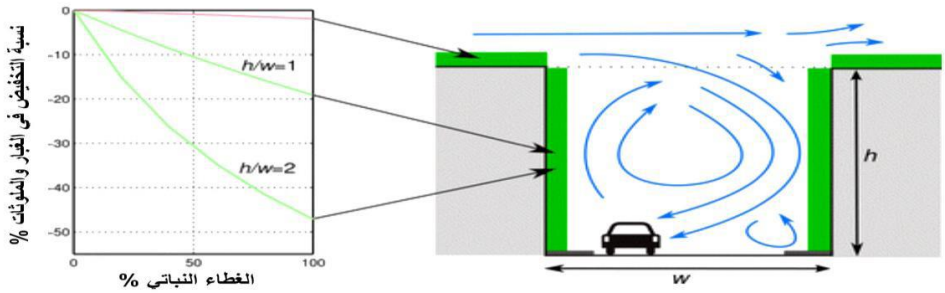

Figure (4): green façade effect reducing air pollution

Also green facades play a significant role in improving the outer environment by [23]:

- Adding a beautiful view to the building gives positive effect.
- Dispersion of sun ray that falls on the façade results in reducing thermal temperature coming from the façade to the surrounding environment.
- Reducing carbon dioxide levels and increasing oxygen in the atmosphere.

Also green facades play a significant role in improving the inner environment by [23]:

- Shading the building façade to reduce wall thermal temperature that results in reducing thermal temperature inside the building.
- Dispersion and absorption acoustic waves coming from outside the building to reduce noise levels inside the building.
- Purification air from dust and dirt to cool and clean air before entering the building.

3-5-3- Thermal impacts of Green facades

One of the significant effects of Green facades is it can reduce temperatures and can reduce the effect urban heat island and provide thermal comfort**.**

a- Temperature Reduction

Green facade can reduce up to 8.4 °C in the humid climates. Plants can reduce the temperature of a building by shading walls from the sun, so the daily temperature is reduced by about 50% [24]. Also by evapotranspiration (*the process by which water is transferred from the from the soil and other surfaces to the atmosphere by evaporation,*

and by transpiration from plants), a large amount of solar radiation can be converted into latent heat so the temperature does not rise up. Green façades which are fully covered with plants covers between 40% - 80% of the received radiation, depending on the amount and type of plants. Surface temperatures of vertical facades covered with plants are cooler than light-colored bricks and black surfaces as shown in figure (5) [22].

Figure (5): building façade covered by plants

Moreover Green facades have the ability to reduce wind speed falling to the facades of the building, and modifying the climate of the adjacent gap to the facade of the building. The transfer of heat energy through a concrete wall is significantly lowered if building façade is covered by plants [22].
In Japan, experiments show that vines can reduce the temperature of a veranda with south-western exposure, and In Africa, a temperature reduction of 2.6 °C was observed behind vegetated panels of vines [17].

b- Shading and insulation

Green facades provide shade and aesthetic use. They offer shadow effects similar to other artificial systems with a plus evaporative cooling and beauty**.** The use of plants in green facades prevents the solar radiation of entering the building. The amount of this effect depends mostly on the density of the plants.
A small part of solar radiation is used for photosynthesis of the plants, and the rest is used in the evaporation of water. This makes the plants block the solar radiation without increasing its temperature. The transmittance a leaf is 0.2 and the absorbance of 0.5 [24].
Bioshader experiment was done at the University of Brighton, showed that when a window is covered with plants, the internal temperature reduced between 3.5 °C - 5.6 °C, and the solar transmittance of the plants ranged from 0.43, with a single layer leaves, up to 0.14 with five layers of leaves, also the reduction in radiation solar ranges from 37% for a sigle layer, up to 86%, with five layers of leaves as shown in figure (6) [24].

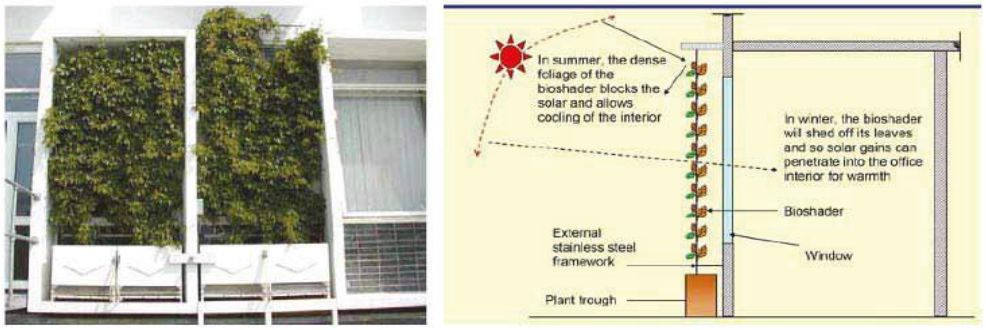

Figure (6): The Bioshader experiment

The natural shade of the plants contributes in saving the facades vegetated energy in buildings. The magnitude of this effect depends on the density of the plants. The ivy is the species that provides the maximum cooling effect, comparable to the effect of shade trees [18].
In an experiment to show the effect of shading buildings walls with plants, it is found that more thermal energy flows into the non-shaded walls because of the direct exposure to the sun and resulted in higher surface wall temperature. The energy absorbed will transmit into the inner wall surfaces, resulting in rising of the interior temperature. Accordingly, when an air conditioning system is used to cool the room, more energy will be consumed [22].
A project of the Institute of Physics of the Humboldt University of Berlin, showed that the shadow created by plants reduced the energy consumption of the building, as shown in figure (7)[24].

Figure (7): Institute of Physics, University of Humboldt

c- Evaporative Cooling

The evaporation of water is an effective way to cool a building. The evapotranspiration is an important environmental benefit of green facades in buildings. Green facades provide with evapotranspiration, a high potential for reducing temperatures of the surfaces of buildings and improving the environment inside and around the buildings**.** Cooling effect of plants makes difference in temperature as much as 4.2 ° C. The evaporative cooling depends on plant type and exposure [24].

3-5-4-Green Facades Systems

Green facades are divided into two main types [23]:

- Green walls, in which the roots of the plants reach the soil around the building, and usually the plants climb on columns and boundary walls as shown in figure (8-a).
- Living walls, in which the roots and the plants are fixed on the building wall and have its own irrigation system. They could be fixed inside or outside the building s shown in figure (8-b).

Figure (8-a): green walls

figure (8-b): living wall

The three types of vegetation used in green facades are shown in figure (9)

- Self-climbing plants.
- Climbing plants that need a construction placed in front of the wall along which they can grow and climb.
- Hanging plants which grow from pots on the roof or balcony.[22]:

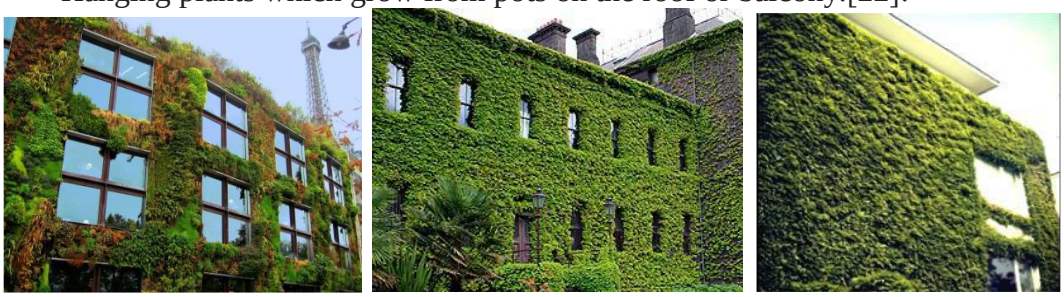

Figure (9): samples of covering the facades with plant

Green facades have four main systems which can fits better with the surrounding environment. These systems are as shown in figure (10):

- The plants are fixed directly to the wall
- The plants are fixed on a net and the roots reach the ground.
- The plants are fixed on a net and the roots do not reach the ground.
- The plants and their roots fixed to the wall.

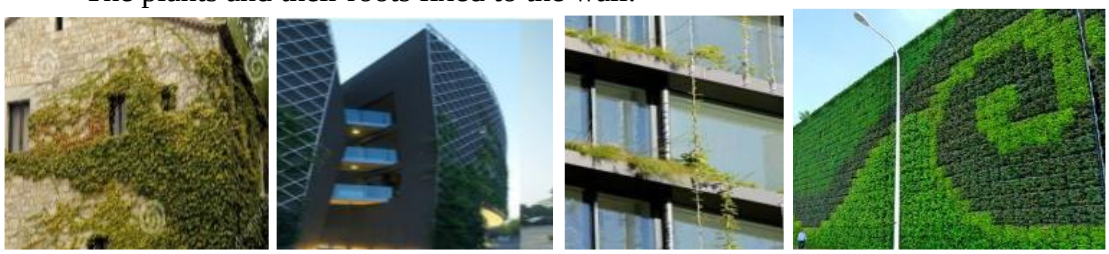

Figure (10): the four systems of green façade

Designers can use more than one system to get better results according to the buildings conditions, figure (11) shows that the third and the fourth systems are used in one building. The fourth system is used on the solid walls, and the third system is used under the windows [23].

Figure (11): using different systems for one building

3-5-5-Irrigation Systems for Green Facades

Green facades cannot be sustained without irrigation; therefore irrigation systems for green facades must be installed as soon as the plants are located in the green facades [27].

There are many ways for irrigation of green facades such as:

1- Gravity Fed Drip Irrigation Systems

One of the most common ways to irrigate green facades is by using a gravity fed drip irrigation system. A conventional drip irrigation system is installed at the top of the green façade, and then the water is released and dripped onto the top row of plants, when the plants are sufficiently irrigated, the water runs down by gravity, until the whole facade is watered. A drip irrigation lines are installed on ever y row of the green facade, if the plants require a lot of water regularly, ensuring that each and every plant gets plenty of water. The water can be recycled by using a pump or can be collected at the bottom of the façade using a tray that drains it away [26].

When using a recycling system, an irrigation tank is used to be the source of the water. The tank is either remote-controlled or directly located underneath the green facade. The irrigation tank is filled manually to provide sufficient supply of irrigation water by using a pump to lift the water from the tank to the green facade. Water is distributed to the plants and then the exceeded water is pulled downward by gravity. The exceeded drainage water is collected at the bottom of the facade and is returned to the tank. The water is then used over and over [28]. Also irrigation run-off is captured in a tank located at the bottom of the facade and is recycled back through the green facade [27].

When the water is drained away, this will be a direct irrigation system and does not have a water tank or pump. The irrigation water comes directly from an external water source as the city water. This water is provided with fertilizer. The water runs through channels to the green facade and is distributed to the plants. As water is pulled downward by gravity, the exceeded irrigation water is collected in a tray and sent to a sewer drain [28].

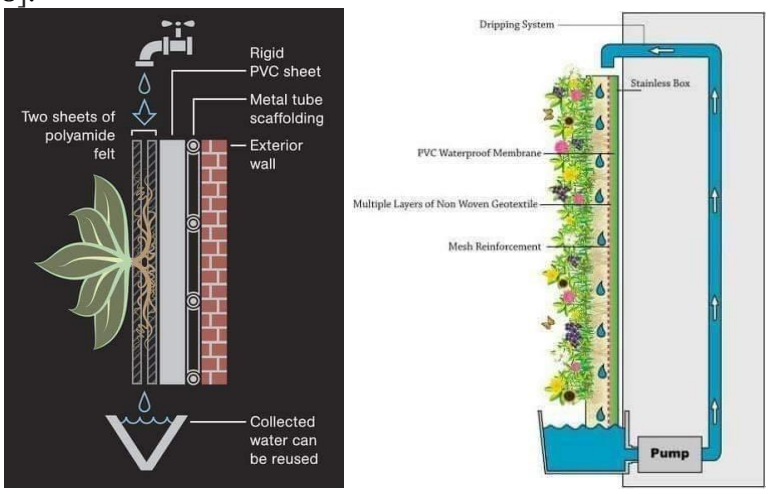

Figure (12): using Drip Irrigation system

There are many advantages of the drip irrigation system such as[29]:

1- Reduced water use:

Drip irrigation brings the water to the plant roots, so it requires half to a quarter of the volume of water required comparing with overhead irrigation systems.

2- Joint irrigation and fertilization:

Drip irrigation can improve the efficiency of both water and fertilizer. Small amount of plant feeding is possible by using drip irrigation. This will improve nutrient applications to meet plant needs.

3- Reduced pest problems:

Disease problems are reduced because drip irrigation does not wet the row middles or the foliage of the crops as does overhead irrigation.

4- Simplicity:
Using Polyvinyl chloride (pvc) and polyethylene parts in several diameters are easy to assemble. Cutting and gluing is easy which allow easy maintenance.
5- Low pumping needs:
Drip systems require low operating pressure comparing with overhead systems. Small pumps are used to irrigate small areas using drip systems.
6- Automation:
Drip-irrigation application may be simply managed and programmed with an AC- or battery-powered controller, thereby reducing labor cost.

2- Automated irrigation systems
Automated irrigation systems with remote control are used for facades in high locations, or where the access is difficult. The settings of the system can be changed; as, on hot days, the frequency or duration of irrigation cycles may be increased [27].
In the automated irrigation system, a secondary network of drip lines is connected to another primary one with a fertilizer station which automatically provides water and injects the nutrients. The network is spaced every 80 cm approximately and due to the capillary action and gravity, the water is spread into all plants [30].
In this system water consumption is low, with average between 5 - 15 l/week/sq. depending on the seasons, this means around 200 to 500 l/year/sq. the period of watering is short but frequent, and average between 2 to 5 minutes and 1 to 5 times a day, depending on weather.
This allows the water to be spread to all plants more slowly and to be absorbed by all plants, and avoids wastage [30].

3-Watering Through a Pipe Network
Another way of watering the green facades is by using a pipe network which it is a network of perforated plastic pipes runs throughout the entire of the green facade. Then the water with fertilizer is released through the perforations in these pipes to the plants. The release of the water is controlled by an electronic timer. A little soil is used in this method so it is considered a hydroponics system of irrigating the plants [26].
In hydroponics systems, a fertilizer injection system is used for plant feeding that allows controlled doses of fertilizer into the irrigation system. The hydroponics green facade systems need 0.5-20 liters of irrigation water per square meter per day. The internal green facades need 0.5 liter, and the external green facades need 20 liter. Irrigation cycles will be required several times a day [27].

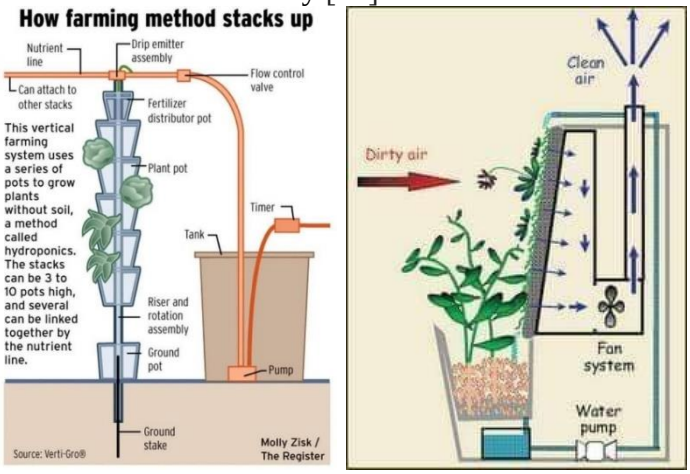

Figure (13): using hydroponics system of irrigating

4. CONCLUSION

Green building respect the environment and make efficient use of resources. They are clean, sustainable buildings, designed with natural materials; use little energy and renewable energies.

Green buildings are designed to reduce the overall impact of the built-up environment on human health and the natural environment, through:

- The efficient use of energy, water and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and harm to the environment.

Green buildings can incorporate sustainable materials (reused, recycled, recyclable, or from renewable resources) in the construction, create a healthy interior environment with a minimum of pollutants and functional landscape planning that requires less water.

Moreover, green façade play an important role in improving the inner and outer environment by many ways:

- Reduce thermal temperature inside the building by insulate and shade the outer walls of the building.
- Improve natural ventilation and Purify air inside the building.
- Increase acoustic insulation from outside to reduce noise levels inside the building.
- Give better look to the building.
- Reduce air pollution from carbon dioxide.
- Dispersion of sun ray.

5. RECOMMENDATIONS

Accordingly, in order to succeed in applying green façade, many points have to be taken in consideration such as:

- Preparing good studies before starting construction green facades.
- Choose the right system which matches with surroundings.
- Put into consideration the environmental aspects in applying the green facade systems.

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