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# APPLICATION OF SUSTAINABLE GREEN NANOMATERIAL FOR DESERT CULTIVATION

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**Abstract**

Green chemistry is a major approach to protect and improve the environment for the purpose of achieving sustainable development, and its most important principles in pollution prevention are summarized through the use of renewable raw materials such as biomass in order to achieve recovery, recycling and organic biodegradation. The greener technique was to create a natural cover to cultivate sandy lands by preparing its four layers derived from the available biomass, this technique meets with the criteria of sustainable environmental and economic development.

The first layer composed of palm tree leaves, which was formed in the form of a woven fabric to support the layers of the green cover and assist in the fixation process of the green cover on the sand surface. The second layer consisted of sawdust, which supports the woven fabric of palm tree leaves (the first layer) and conserves the moisture content and water droplets that leak out from the upper two layers which were the hydrogel and the nutrients. The third layer was the nutrients layer, which was made up of the remains of the potatoes after the greener extraction method of the hydrogel and a grounded mixture of both date seeds and egg shells to provide suitable nutrients that support plant's growth. The last layer formed from the hydrogel as a coating thin film on plant fibers (jute or palm tree tissue) for the purpose of water absorption falling on it. This film of hydrogel protects the plant seeds (barley) against the drought and atmospheric effects, assist the plants to immerse their roots inside the plant fibers layer and support the roots extension to the nutrient layer down to bottom. There is a great benefit from such a green method due to its high efficiency for the direct reclamation of sandy land. Also, this method can provide us with sustainable green concepts through the adoption of biomass to develop the methods of reclamation of sandy lands, treatment of desertification, preservation of the environment and sustainable development to overcome scarcity of water and decreasing food and energy locally and globally.

***Keywords*:** Biomass, Hydro Gel, Desert treatment, Sustainable greener cultivation technology

## Introduction

The modern green technologies are considered one of the best ways to protect and improve the environment for the purpose of achieving sustainable development, and this concept has attracted the attention of researchers in recent years to adopting its principles with regard to indicators of environmental efficiency by showing the real benefit in the stages of planning, design, application and sustainability in various vital areas of the human being. Anastas and Warner, 1998; Mike, 2002). These technologies included the possibility of using biomass and its organic nanoparticles to solve contemporary environmental issues through the sustainable green technology in the treatment process steps on its final impact on humans and the environment (de Bont, 1993; Keith *et al*., 2012). Natural organic products resulting from biomass and manufactured smart polymers that respond to environmental influences can be designed to respond with a variety of variables such as temperature, pH, antibacterial, and these polymers have their unique applications as conveying systems for food or medicines through their susceptibility. High absorption of water by physical or ionic bonding and formation of the hydrogen atom with water molecules. (Baohua and Jinlian, 2005)

The environmentally sensitive hydro gel (H-gel) and its distinct role as natural food or drug transporting systems possess unique properties, one of which is that it is an open thermodynamic system. For example, when conditions such as temperature, humidity, and pH in the external environment change slightly, the volume of the hydrogel will it swells or shrinks dramatically.

From spectra of the electron microscope SEM of starch-derived aqueous gel (photo 1), it was found that it clearly possesses the porosity characteristic and is an indication of its wide susceptibility to water absorption, as the maximum absorption of water reached (95 g/g weight) in its aqueous solutions. (Soleimani and Sadeghi, 2012).

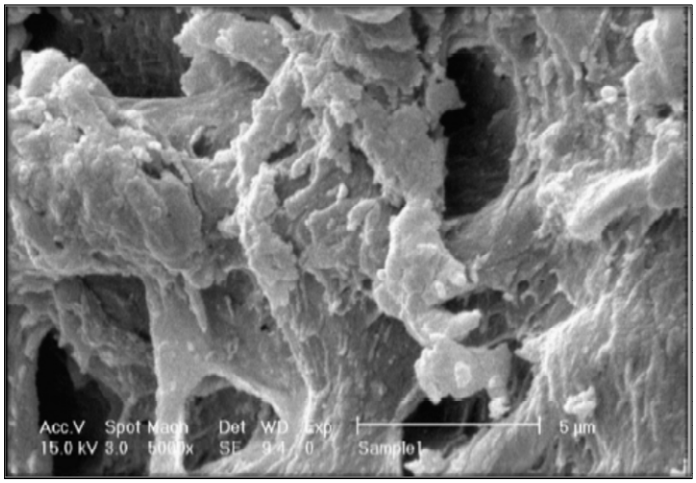


**Photo 1 :** Porous surface of starch-based hydro-gel polymer (Soleimani and Sadeghi, 2012)

The unique physical and chemical characteristics of the natural organic compounds extracted from the plant, as in the H-gel of starch and its ability to absorb high water, these compounds and their characteristics have brought the interest of researchers in the applications of green sustainable development and nanotechnology in the industrial field in a broad way and put it strongly in the literature newly

published scientific and applied areas. (Al-Khalaf and Hussein, 2018)

In recent years, Japanese technologies (Mebiol Corporation), (Makiko and Yuichi, 2002; Yuichi *et al*., 2004; Yoshioka *et al*. 2016; Yuichi Mori, 2011; Yoshioka *et al*., 2015) and an Indian company (Chemtex Corporation) (Chemtex Speciality Limited, 2011) have emerged, and these technologies have dealt with specific aspects of land problems used to grow plants in different conditions using nanotechnology and the hydrographic membranes industry of chemicals, as those membranes possess high capacity to store large quantities of water and nutrients to support plant growth and efficiency of cultivation.

The Japanese company (Mebiol) has created a thin film called hydrogel, the hydrogel film is used to grow specific crops, such as leafy vegetables and practically anywhere without depending on the presence of the soil, as the film prevents harmful germs from entering.

One of the advantages of the technology is that it reduces the consumption of water and fertilizers, and it is easy to verify the roots of plants due to their attachment to the surface of the hydrogel membrane, it is the nanopores that block bacteria and viruses, which greatly reduces the use of pesticides, water and fertilizers, as shown in Figure (1).

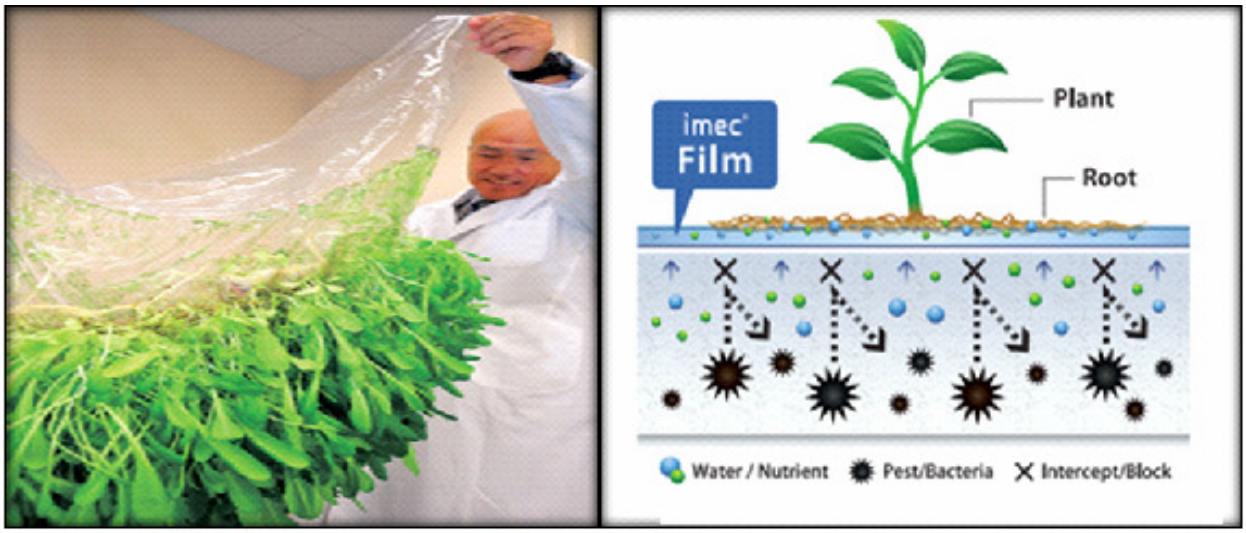


**Fig. 1 :** A schematic illustration of Japanese technology

One of the disadvantages of Japanese technology of hydrogel membrane as an alternative to soil in plant cultivation is that it needs a high cost because of its need for more than six stages of installation in greenhouses, in addition to the pre-configuration of the land of the agricultural field through the installation of film layers, as in figure (2). This technology is currently used in the deserts of the United Arab Emirates and in areas exposed to pollution risks in China.

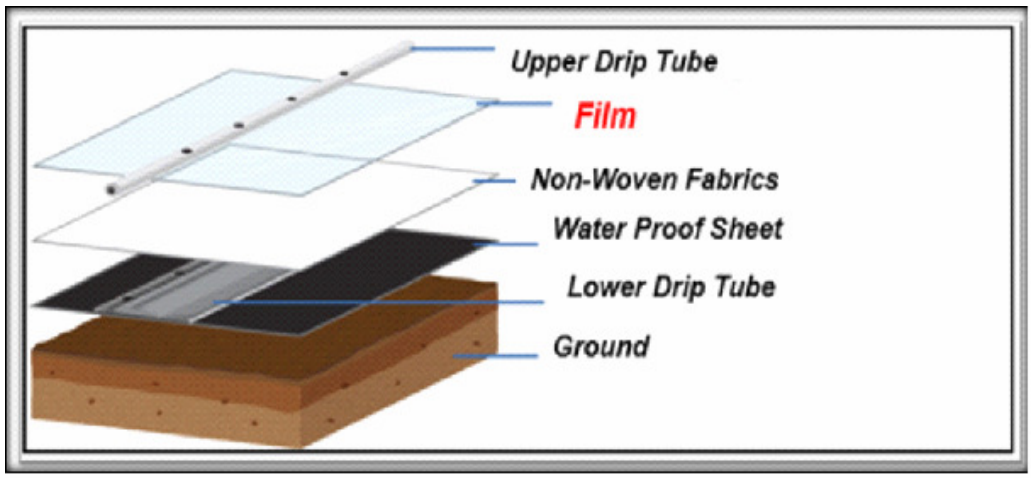


**Fig. 2 :** Layers of hydrogel membrane in Japanese technology

In 2016, the Indian company (Chemtex) that relied on the preparation of a polymer (potassium polyacrylate) hydrogel with a high absorption and water storage capacity (90% w/w) for agricultural purposes under the brand name (Alsta Hydrogel), (Chemtex Speciality Limited, 2011) which helps countries with a dry climate and dependent on watering for rain water to use this technology, which enables the soil to retain water and nutrients for a longer period of time and not evaporate and thus reduces the number of irrigation times. Where the potassium hydrogel powder mixes with the soil around the roots of the seedlings of plants by a rate ranging between (1-2 kg/$m^3$) per cubic meter of soil and the mixing is under a soil layer with a thickness of (5 cm) to avoid the decomposition of the potassium hydrogel polymer by radiation the sun, as in photo (2).

**Photo 2 :** Illustrates the Indian technique by mixing hydrogel with soil around plant roots

One of the major disadvantages of this technology is the high cost of treatment methods and thus the inability of poor countries to apply it (Makiko and Yuichi, 2002).

Moreover, this technology did not take into account contemporary environmental issues such as desertification and global warming in a comprehensive way, both methods (Japanese and Indian) were not taken into consideration treatment the surface of the soil, whether it is sandy, in addition to that, the methods of treatment above are not sustainable green to preserve the natural resources, as well as the chemical pollution resulting from them, whether in complex recycling operations or soil pollution at use granules of chemically synthesized polymer.

In 2014, a research study (Isabel *et al.*, 2014; Rojas *et al.*, 2006; James *et al.*, 2000) showed disadvantages of the effect of using chemical polymers (poly acryl, polyvinyl alcohols) that act as a water-absorbing hydrogel and their auxiliary role in farming operations and reducing planting watering. The study indicated that the acidic function (increasing the alkalinity of the soil) and electrical conductivity will change to depths greater than 30 cm below the surface of the soil, after the decomposition process of these polymers and thus the pollution of groundwater after fertilizer leaks to it and the loss of basic soil properties in the long term. The study also recommended the necessity of continuing scientific research between producing industrial companies and researchers to find solutions and alternatives to current technologies, to address problems such as water scarcity, diminishing soil properties, and providing nutrients and fertilizers with high efficiency in sustainable green ways.

In this paper, an Iraqi sustainable green technique will be presented as an alternative to Japanese and Indian techniques according to an assessment of the advantage and disadvantages and on any idea adopted, which materials were used, what were the costs and what are their resulting waste after use it.

## Materials and Methods

**Typical green procedure for preparing H-gel:**

A known weight of potato tubers available in the local market (100 g) was taken after cleaning it well with water and then squeezing mechanically and filtered the juice to extract the gel from the potatoes without using the heating and boiling solvent process (instead of the traditional extraction with a Soxhlet extractor apparatus) to avoid the negative impact on the chemical composition of the extracted gel and consequently the possibility of losing protons that possess the ability to adsorb and physical and chemical bonding (formation of hydrogen bonds) and its physical and chemical applied effects, especially with regard to the loss protons carried on hydroxyl group or for oxidation and reduction on the hydroxyl and converts them into carbonyl or carboxyl groups and thus a change in color. Then the resulted filtrate from the mechanical process of the potato is heated to 35 °C with constant stirring for 20 minutes, then the filtrate cools down at room temperature to obtain a H-gel, as the remaining impurities of the potato are excluded for use in other areas as food for animals or in the nutrient layer within the layers of green cover technique, where the percentage of juice (<70% w/w).

The main reason behind the use of the (natural) mechanical method without using traditional method of extraction, to maintain the chemical structure of the extract juice, especially ensuring that the proton $H^+$ (positive hydrogen ion) is not affected by the action of heat and solvent factors, which possesses very different physical properties applied to that of the positive ion.

For example, this effect leads to the formation of the unstable chemical formula (Enol form), which often turns into alcohol, aldehyde, or ketone that results from the phenomenon of proton transfer (Tautomerism) between the oxygen and carbon atoms in the hydroxyl group and the double bonds in organic compounds (esters, ketone, and aldehyde).

**Materials**

According to the sustainable green method in manufacturing and producing the green cover and its layers derived from the natural biomass available in the local market, no chemical was used in its manufacture.

**Typical method for preparing green mat layers:** (Al-Khalaf *et al*., 2019)

The green mat consisted of four layers derived from the natural biomass, as follows:

**First layer**: The first layer consisted of palm tree fronds (texture) to support the top layers of the cover and help install the mat on the surface of the sand.

**The second layer**: As for the second layer, it consisted of sawdust supporting the palm frond layer and preserving the moisture content and the water droplets that are applied to it from the two layers of water gel and nutrients.

**The third layer**: The third layer was the nutrient layer consisting of the residue of potato after extracting process with the groats of both the residues of dates and eggshells, for the purpose of providing a nutritional environment suitable for plant growth.

**Fourth layer**: As for the fourth layer, it consisted of a thin layer of aqueous gel on vegetable fiber, the purpose of which is to absorb the water falling on it in a way of watering by sprinkling and protecting the seeds of the planted (barley) planted on it from drought.

**Cultivation process**

The barley plant has been practically cultivated on top of the sand layer taken directly from the desertification site in the north of Babylon governorate towards the Nile town, as described in detail at the Iraqi patent 2019, (Al-Khalaf *et al*., 2019) so that the cultivation was carried out according to practical models prepared for this purpose and its specifications, dimensions, and clarifying the practical results through which the plant was cultivated and for several times and matching the results obtained in the success of culture and the production of the vegetable total for barley plant for the purpose of treating desertification using the green mat.

## Results and Discussion

The scientific literature published in the last ten years has clearly demonstrated that hydrogel or aqueous gel has a high ability to absorb water in large quantities compared to its limited quantity and with limits (95 g/g) in its aqueous solutions and keep it under conditions of temperature changes and pH.

Which of these scientific facts had a clear effect on the basis of the emergence of Japanese technologies (Mebiol Corporation; 2011) and Indian (Chemtex Corporation; 2016) that were used in agricultural applications globally as one of the solutions available to the problem of water scarcity and the quality of agricultural soil.

In 2019, according to one aspect of this Iraqi technique that gives an easy way to produce and install uncomplicated and inexpensive sustainable green natural to green mat its layers are derived from naturally available biomass. The layers of this green organic cap are formed from plant residues which are coated with a thin layer of aqueous gel naturally manufactured.

Therefore, by taking advantage of the arrangement of its layers one above the other according to their complementary functional role to each other so that they are used to cover non-arable soils as in desert soils or sand dunes (desertification phenomenon) or arid that are difficult to cultivate and as a result, the green mat layers are combined and coherent as one layer across The supply of plant roots that extend through the layers of green mat and sand to form soil suitable for cultivation of plants and agricultural crops. Watering by spraying water process at calculated rates daily and without using pesticides and chemical fertilizers. The main purpose is to provide comprehensive natural solutions to solve food and energy problems, livestock development, protect and improve the environment, and treat desertification and global warming.

On the other hand, this invented technique provides the optimum sustainable method for exploiting natural plant wastes, whether for palm tree fronds (first layer support) or sawdust or natural cellulose fixing for plants (second supportive layer) or in plant nutrients or potato residues after being squeezed naturally with what it contained from the dates residues and egg shells (third layer) or in the hydrogel layer coated on the vegetable fiber (fourth layer) to absorb water and keep the surface of the cover moist, as in figure (3):

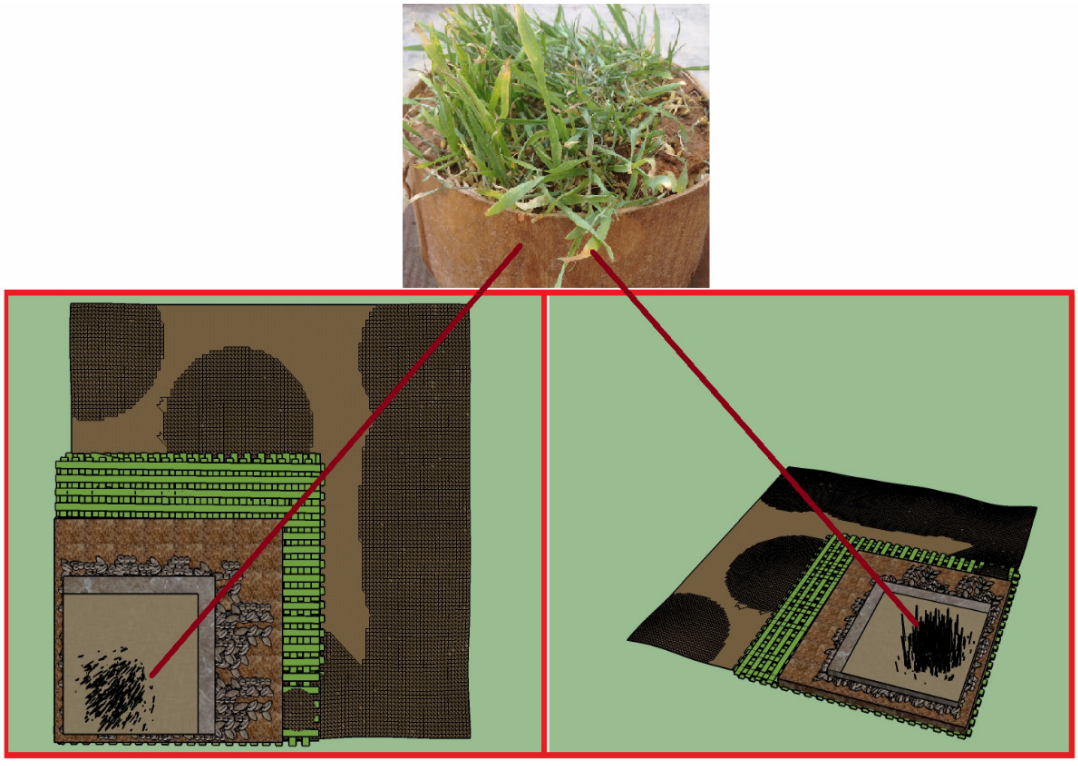

**Fig. 3 :** Illustration design of green mat layers over sand and simulated with barley plant culture model

This green cover technology, with its natural composition of biomass components and natural organic materials available, has important applications in several areas, the most important of which is desert reclamation and the treatment of desertification through stabilization and cultivation of sand dunes.

The technology also aims to apply the philosophy and method of using sustainable green techniques when

conducting planting (barley) plants over the green cover of sand dunes.

It also included the use of a coating of aqueous gel as a natural extract of potatoes (starch) in addition to the other layers of the green cover in plant cultivation and preservation of other environmental effects such as lack of water, high temperatures, droughts, the spread of desertification, and a decrease in food and energy.

An assumption from a practical point of view and economic feasibility, when applied on the ground and for an estimated area per acre by knowing the area of the practical model (500 $cm^2$) and the amount of potatoes used for it is estimated at (100 g) and the amount of water used per day (100 ml/liter), the actual need for potatoes per acre is equal to (50 kg) and the amount of water required for watering by spraying Equal (50 liters).

## Conclusion

The Iraqi technique is a way to reclaim desert lands and it is inexpensive and highly selective in planting the plants over sand, and therefore this study can provide us with new concepts and foundations for developing agricultural production methods in a clean, sustainable, green and highly efficient manner.

### Conflict of interest

State that the author has no conflict of interest.

### Acknowledgment

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