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Implementation of Controlled Hydroponics in Urban Infrastructure

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Abstract: *Hydroponics in Greek language means "Agriculture without soil" which means in hydroponics just water is essential to sustain the growth of plants and provide them a strong medium for nutrient transportation. It is well known that as the urbanization of the world taking place, the total net sowing area of agriculture decreasing rapidly due to illegal encroachment of builders and industrialists which poses a question mark on food security as well as environment balance and pollution. The more urbanization takes place the more incidents of encroachment of agricultural fields are happening rapidly which is unchecked till now because of the rising rate of population growth in case of the world in general and India in particular. It's time to think innovative as well as constructive in the direction of creating space for agriculture in manmade concrete jungles such as high rising buildings, mammoth size bungalows, congested societies, unhygienic and irregularly populated colonies and such spaces like this in urban areas, metro cities as well as small towns so that the high ending goals of food security as well as environment protection can be achieved together. Hydroponics could solve this problem and can help to achieve these two ambitious goals in single go. As hydroponics is a technique which doesn't require actual natural soil or humus to sustain the plant growth, rather it requires electronically controlled environment along with water solution of exact nutrient composition for exact type of crop and this plant can be installed anywhere. Now in this research, the implementation of controlled hydroponics is described over the roof of high rising buildings as these spaces are not used for any of commercial activity and easy to sustain the growth of hydroponics plant.*

(**Keywords:** *Greek, Agriculture, Hydroponics, Controlled, Encroachment, Urban, Ambitious, Technique, Congested, Environment, Nutrient, Food security, etc.)*

I. Introduction:

Hydroponics in general can be described as agriculture using water and in technical language; it is a method of growing plants using mineral nutrient solutions, in water, without soil. Generally over the earth surface plants may be grown with their roots in the mineral nutrient solution only or in an inert medium, such as perlite, gravel, mineral wool, expanded clay pebbles or coconut husk, but scientists discovered in the 18th century that plants absorb essential mineral nutrients as inorganic ions which are in the dissolved form in water. In natural conditions, soil acts as a mineral nutrient reservoir but the soil itself is not essential to plant growth. When the mineral nutrients in the soil dissolve in water, plant roots are able to absorb them. When the required mineral nutrients are introduced into a plant's water supply artificially, soil is no longer required for the plant to thrive. Almost any terrestrial plant will grow with hydroponics. Hydroponics is also a standard technique in biology research and teaching.

Controlled Hydroponics is a technology for growing plants in nutrient solutions which are water containing fertilizers with or without the use of an artificial medium such as sand, gravel, vermiculite, rockwool, perlite, peatmoss. coir, or sawdust to provide mechanical support in a technically controlled environment. Under this systems there is no other supporting medium for the plant roots: aggregate systems have a solid medium of support. Hydroponic systems are of two types which are- **open** type, in which once the nutrient solution is delivered to the plant roots, it is not reused to sustain the grwth of another crop and another variant is **closed type,** in which surplus solution is recovered, replenished, and recycled).

In controlled conditions like greenhouses, it is high technology and capital-intensive and can be act as a highly productive, conservative of water and land, and protective of the environment so that the system can generate employment, carbon credit as well can act as an urban agricultural field to enable agriculture even over the top of a building and inside any constructed infrastructure without changing or minimum changing of its original design and another best reason for the popularity of hydroponics is that it requires only basic agriculture skills. Under the controlled agriculture, basically regulating parameters like the aerial and root environment is a major concern in such agricultural systems, production takes place inside enclosures designed to control air and root temperatures, light, water, plant nutrition, and adverse climate.

In the present scenario there are plethora of controlled environment/hydroponic systems are available with each promising component of controlled-environment agriculture is of equal importance, whether it be the structural design, the environmental control, or the growing system. But cost affectivity is the major concern that is why in this research a low cost controlled environment based analogous hydroponics system is presented in which parameters like Temperature, Air pressure and flow, nutrient water level and flow, light intensity, humidity level and external seasonal changes has been controlled using microcontroller based technique.

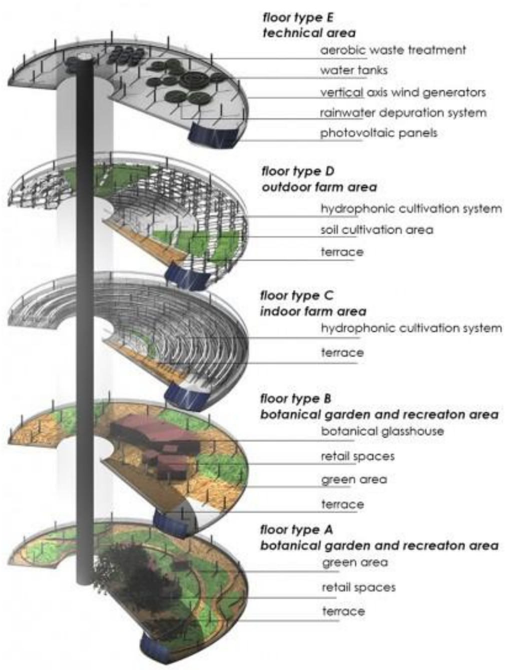

Fig: hydroponics based six story agricultural farm (curtsey- Capellini Architects)

Using the same controlled hydroponics a design of vertical farm is being developed by an Italian architect and The firm was selected as one of the 30 finalists among hundreds of contestants for the 2013 Vertical Farm & Botanical Garden SkyScraper (Seoul) Competition organized by SuperSkyScrapers. For its competition entry, Capellini Architects created a 250-meter tall skyscraper built to cultivate fresh, high quality agricultural products in the heart of the city. The project, 5 Terre Style Vertical Farm, is eco-friendly and zero-carbon productive; designed with an eye on pollution reduction and environmental and economical sustainability.

II. Literature Review:

First initial published work on growing terrestrial plants without soil was the 1627 book *Sylva Sylvarum* by Francis Bacon, printed a year after his death and after that Water culture became a popular research technique. In 1699, John Woodward published his water culture experiments with spearmint and found that plants in less-pure water sources grew better than plants in distilled water because of the availability of nutrient content on them. And a leapfrog achievement was observed in 1842, when a list of nine elements believed to be essential to plant growth had been compiled, and the discoveries of the German botanists Julius von Sachs and Wilhelm Knop, in the years 1859-65, resulted in a development of the technique of soilless cultivation. In 1929, **William Frederick Gericke** of the University of California at Berkeley began publicly promoting that solution culture be used for agricultural crop production. Gericke refused to reveal his secrets claiming he had done the work at home on his own time. This refusal eventually resulted in his leaving the University of California. In 1940, he wrote the book, *Complete Guide to Soilless Gardening.*

A history is created in the1960s when Allen Cooper of England developed the Nutrient film technique. The Land Pavilion at Walt Disney World's EPCOT Center opened in 1982 and prominently features a variety of hydroponic techniques. In recent decades, NASA has done extensive hydroponic research for their Controlled Ecological Life Support System or CELSS. Hydroponics intended to take place on Mars are using LED lighting to grow in different color spectrum with much less heat.

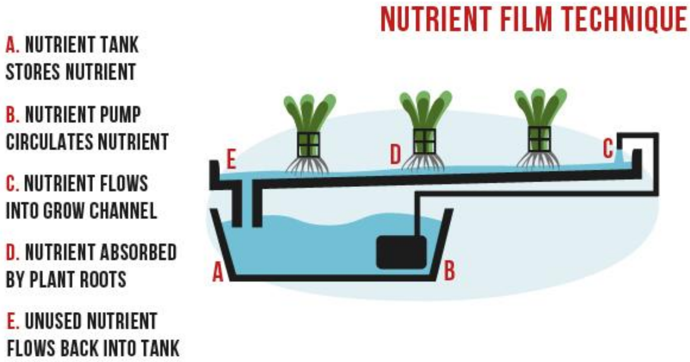

Fig: nutrient film technique.

III. Principle:

The system described here is based upon the electronic sensor controlled artificial environment development in which humidity control, water level control, water floe regulation, temperature regulation and light intensity regulation has been done so that hydroponics can be implemented in minimum cost with greater efficiency.

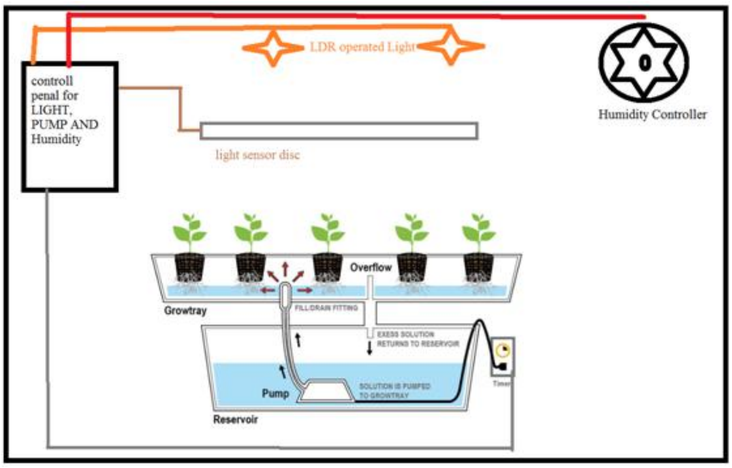

Fig: flow diagram of controlled hydroponics.

In the system the temperature is controlled using analogous circuitry so as the light intensity and humidity but as far as the flow of nutrient and its level is concerned, AT89S52 microcontroller has been used to regulate the process with greater efficiency. But in overall system development it is maintained that less component and programming is being used so that the overall design remain less expensive as well as user friendly.

IV. Methodology:

a) Temperature And Humidity Controlling:

For this application diode sensor is used which is generally a silicon diode and act as a temperature measurement transducer and silicon Temperature Sensor is a diode specifically designed and optimized for this function and widely used for temperature sensing applications in automotive, consumer and industrial products where low cost and high accuracy are important Packaged in a TO-92 package it features precise temperature accuracy of ±2°C from –40°C to +150°C.

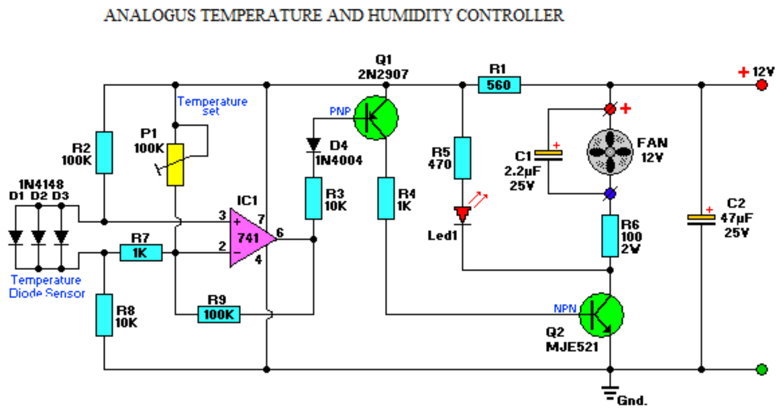

Fig: schematic of temperature and humidity controller.

On the signalling line of temperature sensor a humidity controller is implied which operates as humidity level in the premises remain higher than the prescribed limit.

b) Nutrient level and nutrient flow controller:

For this reason microcontroller AT89S52 is used and a program using C language is developed precisely for this purpose. The nutrient flow meter senses the level of nutrient in the plant vessel in comparison with reservoir and activates the pump if level degrades.

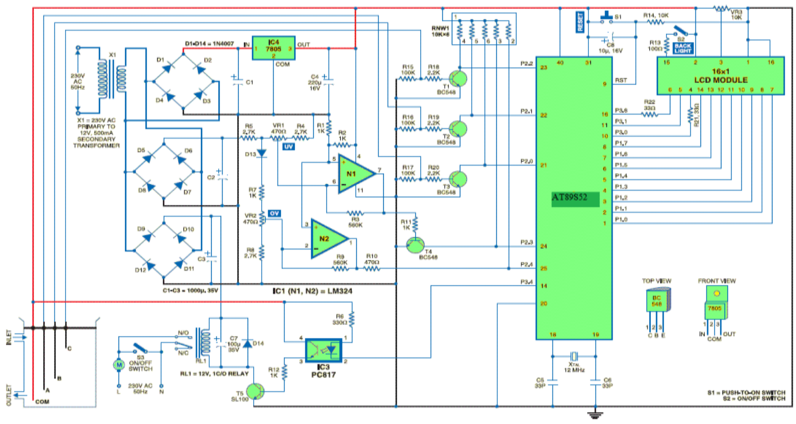

Fig: nutrient level and nutrient flow regulating circuit.

The nutrient flow is checked by tracing the current voltage consumption in comparison with the total pumping capacity of centrifugal pump.

c) Ldr Based Light Intensity Automation:

As light is act as an inducer of photosynthesis in plants and without this plants cannot make their food than it is essential to maintain proper light intensity required for the growth of plants in controlled hydroponics and for this Light Dependent Resistance sensor is used to detect real time level of illumination and if required than regulate the light illumination through turning on and off the LED bulbs.

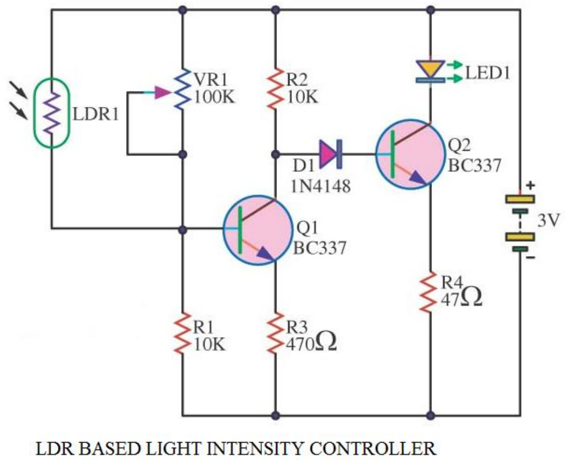

Fig: LDR based light automation.

V. Observation And Results:

The controlled hydroponics is implemented over the roof top of a scaled model of a building is implemented. The optimum conditions have been maintained for the plants to grow and constant observation has been done.

The outcomes are as follows:

Days	**Number of plants per tray**	**Temperature Max/ min.**	**Humidity Max/min.**	**Nutrient flow**	**Observed growth/day**
01	4	23/18	65%/40%	4 ltr/minute	Optimum as in nature
02	4	27/18	65%/40%	4 ltr/minute	Optimum as in nature
03	4	26/17	62%/42%	4 ltr/minute	Optimum as in nature
04	4	28/16	67%/45%	4 ltr/minute	Optimum as in nature

Table: Optimum growth observation chart.

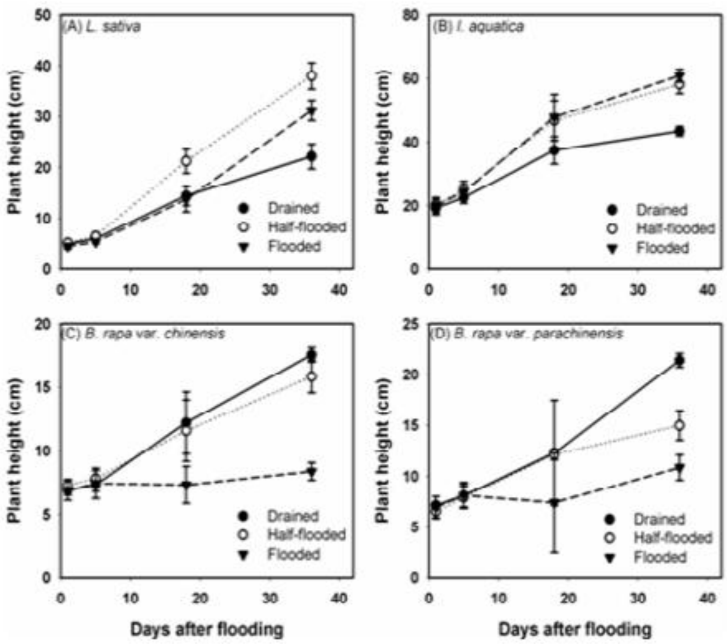

Fig: graphical representation of growth of Wheat, Barley, Tomato and Rice plants.

The installed controlled hydroponics is shows optimum efficiency in the installation site as it adopted the venue. The controlled environment generated by electronic circuitry sustain the growth of various test sample plants and maximum growth has been observed.

The controlled system developed with the help of sensor based automation and programming shows greater efficiency. The system is effective if installed indoor as well as outdoor conditions.

VI. Conclusion:

Implementation of controlled hydroponics in urban infrastructure is very effective and a unique way to succeed the both of the basic goals of attaining food security and environmental protection as the system enables agriculture even in those areas where there is no soil available such as deserts, polar regions, waste lands and constructed areas such as house, apartments etc. Recently NASA implemented Controlled Hydroponics in Mars and Moon. It all shows that the controlled hydroponics system serves as the futuristic smart cultivation technique and save the future of mankind.

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