The Recycling Greenhouse Concept: Turning Waste into Resources

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Abstract—*The water related challenges across the world are growing strongly by economic growth and climate change. There is a great need for innovative solutions in this regard. "The recycling greenhouse concept" deals with the present problem by utilizing the harvested rainwater and community waste water. This could be a "stepping-stone" for the way to encourage innovative and cost effective water solutions from the traditional solutions of water saving. The initiative has already been taken by the Indian department of Science and Technology, GOI in the collaboration with the Dutch Ministry of Economic Affairs as a project on joint water technology entitled as "Dutch Indian Water Alliance for leadership Initiative".*

1. "INTRODUCTION"

Directly or indirectly, water affects all facets of life. Without it, there would be no vegetation on land, no oxygen for animals to breathe and the planet would look entirely different than it does today. Water is necessary to keep people's bodies and the environment healthy and should be valued and protected as the precious resource it is. Seventy per cent of the earth surface is covered with water, which amounts to 1400 million cubic kilometres (m km^3). However, 97.5 per cent of this water being sea water, it is salty. Fresh water availability is only 35 m km^3 and only 40 per cent of this can be used by human beings. Out of the total fresh water, 68.7 per cent is frozen in ice caps, 30 per cent is stored underground and only 0.3 per cent water is available on the surface of the earth. Out of the surface water, 87 per cent is stored in lakes, 11 per cent in swamp and 2 per cent in rivers.[1]

Unfortunately, due to continued misuse of our water resources and climate change, many regions of the world are already water stressed. In fact, 2.5 billion people (36 per cent of the world population) live in these regions and more than 20 per cent of the global GDP is already produced in risk as water-scarce areas affecting total agricultural and other production. This is especially troubling when considering analysis by the International Food Policy Research Institute (IFPRI), which found that 4.8 billion people – more than half the world's population – and approximately half of global grain production will be at risk due to water stress by 2050 if status quo, business-as-usual behavior is followed. The IFPRI study also found that 45 per cent of total GDP ($63 trillion) will be at risk due to water stress by 2050. That's 1.5 times the size of today's entire global economy![2]

India too, comes under particularly acute water crisis condition though India's climate is not particularly dry, nor is it lacking in rivers and groundwater. Hence, India's water crisis is predominantly a manmade problem and day-by-day the water related challenges in India are growing strongly by economic growth and climate change. A rapidly growing economy and a large agricultural sector stretch India's supply of water even thinner. Water is critical for future growth (see Table 1) and there is a great need for innovative solutions. India is already facing a water crisis and it is only going to get worst as wastage of water causes serious mismanagement in proper utilization of water specially in agriculture and greenhouse cultivation. Water used in a greenhouse is frequently not diverted to collection facilities or recycled. "The recycling greenhouse concept" deals with the present problem by utilizing the harvested rainwater and community waste water. A much better approach, and often a more economically beneficial approach, is to collect and recycle the water that is not used by the plant. Water and fertilizer solutions that miss the plant containers or eventually drain from the container fall to the floor of the greenhouse to be absorbed into the subsoil and may get waste by leaching process. The recycling greenhouse is ideally located nearby communities and food processing industries, who are relying on local crop production.

Table 1. Per capita water availability in India

Year	Population (Million)	Per capita water availability (m^3/year)
1951	361	5177
1955	395	4732
1991	846	2209
2001	1027	1820
2025	1394	1341
2050	1640	1140

Source: Government of India, 2009. [3]

The initiative in this regard has already been taken by the Indian department of Science and Technology, GOI in the collaboration with the Dutch Ministry of Economic Affairs as a project on joint water technology entitled as "Dutch Indian Water Alliance for leadership Initiative (DIWALI)". A cooperation with The Netherlands on addressing water challenges is of great strategic and economic importance. This offers opportunities for technological cooperation between Dutch and Indian private and public parties. Under this project, different methods are conceptualized for the conservation and proper utilization of water, which are listed as follows:

1. New urban sanitation
2. The recycling greenhouse concept
3. Low cost desalinization
4. Water farming
5. Mineral mining from polluted groundwater

The first two concepts i.e. "New urban sanitation" and "The recycling greenhouse concept" are the priority areas under DIWALI agreement and in this paper, we are focusing in the "The recycling greenhouse concept". [4]

2. "CONCEPT POTENTIAL"

In areas where freshwater is scarce, recycling of wastewater seems to be a common sense. The greenhouse waste water reuse for irrigation potentially reduces overall freshwater consumption, which is threatened by dwindling supply and a growing population. The key drivers of "The recycling greenhouse concept" are conserving rainwater, utilizing the waste water from plant containers and condensation and re-utilization from the evaporated water from greenhouse. From the studies, it is revealed that collecting the water after the condensation process from the greenhouse is much purified and human can use it in drinking purpose. Hence, closing the loops of minerals, energy and water "The recycling greenhouse concept" can become the key processes for a sustainable "zero waste" society.

2.1 Set-up:

A greenhouse is very efficient for cultivating crops under controlled conditions. Plants evaporate about 75 per cent of their water consumption for cooling purposes (the photosynthesis process). This water evaporates and increases the humidity of the air when cultivation is in a greenhouse. A big part of this humid air condensates at the glass or plastic ceiling of the greenhouse and can be collected in the roof area with a rain gutter system. The evaporation is driven by the photosynthesis process of the plant at day light. The condensation is accelerated when the ceiling is cooled by re-circulating cool water through the ceiling. This cooling water can be by harvested at night and collected in a water storage system. In the Recycling Greenhouse idea (see Fig. 1) the irrigation water for greenhouse cultivation is produced from wastewater treatment with electro-flocculation, separation and digestion of the collected waste water and efficient harvesting of rain water. The irrigation water contains the minerals from the wastewater and is fed into the greenhouse crops. The crops evaporate and the condensate water is collected and stabilized by polishing marble filters.

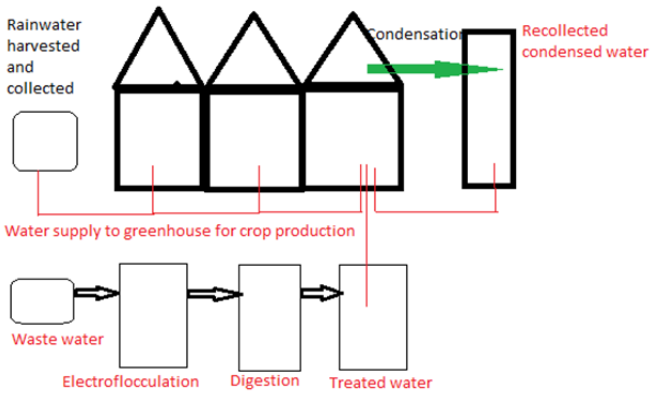

Fig. 1: Set-up for greenhouse recycling.

2.2 Recycling Methods:

1. Collecting drainage water from a soilless substrate, and using it to irrigate an adjacent crop grown in soil (open system).
2. Recycling drainage water in a closed system; with or without disinfecting the drainage water.
3. Recycling drainage water diluted with rain water or with desalinated water.

2/3: 1/3 method: the drainage water discharged from 2/3 of the greenhouse can be used to irrigate the remaining third (a common method in roses).[5]

2.3. Benefits:

- Reducing water waste or preventing off-site pollution.
- Recycled water is the one of the economical way to ensure an adequate water supply for all growing seasons, thus increasing overall yield.[1]

- Upon recycled, nutrients and other water additives are recycled, so reduced amounts of application of fertilizers and other chemicals (50-70 per cent) which reduces ground water contamination and ecological damage in agronomic regions are the other advantages of recycle systems.[5]
- Drinking water recovery.

2.4. Drawback:

The cost of storage and additional pumping depending on the site. These costs may make some kinds of recycling systems too expensive. However, in many cases, these additional costs may be recovered through water and chemical savings over time. [5]

2.5. Key Challenges:

1. Chemical Aspects: The water source contains chloride and other elements, very little of which is absorbed by the plant. Thus in a closed system, chloride will accumulate over a period of time. When it exceeds a certain concentration, depending on the sensitivity of the crop, it can adversely affect the crop. Different plant types react differently: tomatoes are considered to be relatively resistant, while roses are considered sensitive.

2. Phyto-Pathological Aspects: Localized infection from fungi, bacteria, nematodes, and viruses can spread in the system and potentially cause swift contamination of the plant population.[6]

3. "CONCLUSION"

India is not a water deficit country, but due to severe neglect and lack of judicious use of water, several regions of the country experiences water stress from time to time. Further neglect in this sector will lead to water scarcity during the next 1-2 decades. It is therefore necessary to prevent this crisis by making best use of the available resources and bringing out the ideas and technologies which will result in the most efficient utilization of every drop of water and thus helpful to conserve water.

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