EXTRATION OF WATER FROM ATMOSPHERE

'Onkar Sawant[1], Hrushikesh Patil[2], Chetan Mane[3], Samshad Anasari[4]

Vitthal Chormale[5]

[1]Student, Saraswati College of Engineering, India, onkar.j.sawant@gmail.com
[2]Student, Saraswati College of Engineering, India, 7hrushi@gmail.com
[3]Student, Saraswati College of Engineering, India, manechetan95@gmail.com
[4]Student, Saraswati College of Engineering, India, shamshadansari30@gmail.com
[5] Professor, Saraswati College of Engineering, India, vitthal.a.c@gmail.com

Abstract: Non-conventional water resources have emerged as means to meet or supplement irrigation demand for reforestation and agriculture in water scarce regions. Dew water is among those resources that have received little attention. In this paper, designing an interesting new prototype of technology capable to collect potable water from the air by condensation, It is designed to harvest potable water from the atmosphere providing sustainable and affordable water sources to remote communities in the rural that are facing water poverty issues. It is realized with biodegradable materials and conceived to integrate visually and aesthetically into the traditional villages. Although it is still in an exploratory phase, the aim is to collect an potable water a day. It is designed to be easily built and maintained by local villagers without electrical tools. Air always contains a certain amount of water, which means water can be taken directly and locally from the environment. This Project aims to empower water-poor communities with the ability to produce clean water from the atmosphere using a passive system (no energy consumption) and natural phenomena (gravity and condensation). The tower is designed for multiple harvesting methods – rain, fog and dew – and is estimated to collect, potable water a day.

KEYWORDS: Atmospheric water condensation, Air to water technology, Fog collection.

Introduction:

By 2050, the global population is expected to rise to nine billion and there have been significant calls for a change in the way the world is dealing with growing water shortages. The approaching water crisis will threaten half of humanity by 2030. Our ever-increasing population is stretching our ability to provide clean water for our needs, from agriculture and manufacturing to the most basic one of all: drinking water. In the desert, where water is scarce and few living things are to be found, some species possess the most amazing designs to survive. In some parts of deserts, finding water is a long journey. However, even when water is found it doesn't mean it is safe, as it can be contaminated. Many solutions are emerging; yet, they have to be simple, no costly and easy to maintain and to be applied. New technologies and biomimicry are constant solutions to make water collection and purification easy, dependable and affordable. Biomimicry is an approach to innovation that seeks sustainable solutions to human challenges by imitating nature's patterns and strategies. The goal is to work in inventing products that are well-adapted based on nature long experience. In fact, nature has already solved many of the problems we are facing. In the following paragraphs we discuss some of the emerging innovations in water technology that may have some answers to our water related problems.

Fog harvesting: Even in areas without considerable rainfall, at certain times of the day the air contains enough moisture to be captured and stored. Fog collection refers to the collection of water from fog using large pieces of vertical canvas to make the fog condense into droplets of water and flow down towards a trough below the canvas. It has the advantage of being passive, requiring no external energy source to perform its collection.

Dew harvesting (or dew collection) is simply taking advantage of water vapor in the atmosphere to harvest clean and potable water through condensation, a passive process that allows water particles to return to the earth in a pure form. Dew harvesting has been practiced by humanity as far back as ancient times, in areas where rainfall and groundwater resources are scarce. When there is any humidity at all in the air and there is a surface that is cool enough to provoke condensation, dew will condense on that surface until the humidity is gone. Vegetation in desert regions have developed modifications that allow them to collect their own humidity from the air, for example, and through efforts of reforestation in desert regions this technology has advanced abundantly around the world.

Rain water harvesting (RWH) is a technique of collection and storage of rainwater into natural reservoirs or tanks, or the infiltration of surface water into subsurface aquifers (before it is lost as surface runoff). One method of rainwater harvesting is rooftop harvesting. With rooftop harvesting, most any surface — tiles, metal sheets, plastics, but not grass or palm leaf — can be used to intercept the flow of rainwater and provide a household with high-quality drinking water and year-round storage. Other uses include water for gardens, livestock, and irrigation, etc.

With advancement in this field , it has become necessary to combine all the three methods into one system so as to improve the output .

Hence now we present a project by designing an interesting new prototype of technology capable to collect potable water from the air by condensation, It is designed to harvest potable water from the atmosphere providing sustainable and affordable water sources to remote communities in the rural that are facing water poverty issues. It is realized with biodegradable materials and conceived to integrate visually and aesthetically into the traditional villages. Although it is still in an exploratory phase, the aim is to collect an potable water a day. It is designed to be easily built and maintained by local villagers without electrical tools. Air always contains a certain amount of water, which means water can be taken directly and locally from the environment. This Project aims to empower water-poor communities with the ability to produce clean water from the atmosphere using a passive system (no energy consumption) and natural phenomena (gravity and condensation). The tower is designed for multiple harvesting methods – rain, fog and dew – and is estimated to collect, potable water a day.

Literature Survey:

M. Tomaszkiewicz el.al [1] Compared reforestation and agriculture water demands to mea-sured dew volumes to assess the feasibility of irrigation from dew harvesting. We estimate water demands of selected crops and trees seedlings using evapotranspiration (ET)-based modelling, while correspond-ing dew volumes were experimentally measured during the dry season.The result stated that dew harvesting can bean effective method to mitigate seedling mortality because sys-tems are stand-alone, inexpensive, and simple to build. Moreover, systems can be relocated once reforestation plots have been estab-lished and have no adverse impact to natural landscapes.

J.F. Maestre-Valero el.al [2] This paper analyses the dew collection performance of two polyethylene (PE) foils in a semi-arid region (Southern Spain). The dew collecting devices consisted of two commercial passive radiative dew condensers (RDCs) of 1 m2 tilted to 30_. They were fitted with two different high-emissivity PE foils: a white hydrophilic foil (WSF) recommended as standard for dew recovery comparisons by the International Organization for Dew Utilization (OPUR), and a low-cost black PE foil (BF) widely used for mulching in horticulture. These results suggested that increasing the surface emissivity over the whole IR spectrum could be more effective for improving RDC yield performances than increasing the surface hydrophilic properties. On a practical point of view, BF could be considered as a suitable material for large scale RDCs, as in our study it presented several advantages over the reference material, such as higher dew collection performance, longer lifespan and much lower cost.

Ben Gido el.al [3] Proposed an index for assessing the feasibility and energy requirements of atmospheric moisture harvesting by a direct cooling process. A climate-based analysis of different locations reveals the global potential of this process. We demonstrate that the Moisture Harvesting Index (MHI) can be used for assessing the energy requirements of atmospheric moisture harvesting. Result stated that AMH to be a viable resource of freshwater a different moisture harvesting process, other than direct cooling of the moist air, should be sought. Since AMH by direct cooling wastes a large portion of the energy on cooling the air, future vapor separation methods may provide a technological alternative to reduce the AMH operational costs.

M.A. Muñoz-García et.al. [4] Present a system that generates electricity with a solar photovoltaic module, stores it in a battery, and finally, uses the electricity at the moment in which air humidity and temperature are optimal to maximize water condensation while minimizing energy consumption. Also, a method to reduce the evaporation of the condensed water is proposed. The objective of the system is to sustain young plants in drier periods, rather than exclusively irrigating young plants to boost their growth. Result state that if the system is to be used in dry climates, a conductor with a better external thermal isolation in addition to a heat sink with lower thermal resistance should be implemented.

M.H. Mohamed el.el. [5]This system depends on extraction of water vapor from atmospheric air by using des-iccant material. The desiccant material (calcium chloride solution) absorbs water from humid air during night time then, it evaporates the absorbed water during the day time by solar energy. The evaporated water condensates on the solar collector sides and the condensed water droplets are collected. The new model presents15% improvement in theoretical results compared with other published models. This work aims to eval-uate the effect of different operation conditions (initial desiccant concentration, initial mass of solution and host materials) on the system performance characteristics (system efficiencies, evaporation rate and water productivity).

Tingzhen Ming el.al. [6]In this article, we proposed a SCPP with collector being replaced by black tubes around the chimney to warm water and air. The overall per-formance of SCPP was analyzed by using a one dimensional compressible fluid transfer model to calcu-late the system characteristic parameters, such as chimney inlet air velocity, the condensation level, amount of condensed water, output power, and efficiency. It was found that increasing the chimney inlet air temperature is an efficient way to increase chimney inlet air velocity and wind turbine output power.

Manoj Kumar el.al. [7] Investigated exper-imentally new composite material for storage and production of water from atmospheric air . Experiments have been performed in the Indian climatic condition at NIT Kurukshetra, India [29° 58′ (latitude) North and 76° 53′ (longitude) East] in the month of October. Three numbers of newly designed solar glass desiccant box type system (SGDBS) having a capture area 0.36 m2 each, have been used. The result found that water production rate depends upon the concentration of $CaCl_2$ in the saw wood. Maximum quantity of water production by the composite material having 60% concentration is 180 ml/kg/day.

Magrini A el.al. [8] An interesting solution may be an equipment for water extraction that contemporarily uses the cooled air for refrigeration, which consists in a combined HVAC system for the dual purpose of water production and air-conditioning. A case study represented by this kind of HVAC system, for a hotel in a sub-tropical arid climate, is proposed in this paper, to demonstrate the advantages of this solution. To this aim, the comparison is made between a typical HVAC system and an integrated air conditioning system, optimized for water production from air, in order to highlight advantages and capabilities of the second one. The result stated that the integrated system produces water and guarantees air conditioning with a global cost reduction for the HVAC system energy and the water supply of 7-19%, referring to the local rates.

Beatrice White el.al [9] Work examines the fog-harvesting ability of patterned and non-patterned samples in spray chamber experiments. The samples were prepared from different materials and the patterns under investigation were channels, hydrophobic patches and hydrophilic patches of contrasting wettability to mimic and optimize the alleged natural fog-harvesting ability of the Stenocara beetle. Fog-harvesting results based on the amount of collected water showed no significant differences among all samples, as the influence of “wind” was found to be the more dominant factor compared to the samples’ wetting characteristics. Video analysis of the experiments, however, revealed differences in the water collection and water removal mechanisms and were concluded to be more helpful than water collection results in the assessment of the various competing mechanisms in fog-harvesting experiments.

Dia Milani el.al. [10] Paper examines an alternative solution for emergency situations where freshwater and utilities are often interrupted. Generating freshwater from the atmosphere using a small-scale air-cooled desiccant wheel dehumidifier was experimented. Condensed water was collected and systematically recorded against local meteorological data. A synthetic model simulating the actual lay-out of the experiment was built in TRNSYS. The model validated the experimental results and generated approximately 52 litres in9 days.

Dhruvin L.el.al. [11] This paper provides an extensive literature review on development of liquid desiccant regeneration using solar energy. The paper also includes the recent findings of hybrid solar system in which either two sources of heat is used for regeneration of liquid desiccant or solar energy is used for regeneration of liquid desiccant along with other application. The result stated that the concept of hybrid solar system, the many problems like building cooling, potable water etc. can be overcome at much more lower cost than the conventional system for cooling and potable water.

Magrini A el.al. [12] The water vapor condensation in the HVAC system chillers can be employed to increase the sustainable use of resources by using the condensed water for domestic consumption. Preliminary investigation on a design of an integrated HVAC system for the air conditioning of a hotel combined with water production is presented. The preliminary calculation shows that the produced water could be efficiently used for various destinations and, in some cases, its treatment could be finalized to produce drinking water.

M.M. Morad el.al. [13] Developed a solar-powered desalination system using condenser integrated with flat-plate solar collector and vacuum pump for producing fresh water and compared its performance with the ordinary solar desalination system without vacuum pump under different operational conditions. The experimental results reveal that the developed system increases water productivity for all water salinities compared with the ordinary system due to the presence of vacuum pump. The same results also reveal that water productivity increased and cost decreased by increasing water flow rate using the developed system while the vice versa was noticed using the ordinary system.

J.F. Maestre-Valero el.al. [14] Studied, five passive radiative surfaces were analyzed for dew formation in south-eastern Spain; a dew condenser (RDC), a modified Class-A pan evaporimeter, the water stored in an open pond, the water stored in a covered pond, and the suspended shade cloth cover which covered the pond. The RDC was more productive than the pan as the latter cooled less overnight and also underwent interspersed processes of evaporation and condensation. The researched shows in the case of the RDC, both modeling approaches gave satisfactorily estimates whilst they were less accurate for the pan. On the water bodies, the water thermal inertia usually maintained the night water surface temperature above the dew point and strongly limited the dew formation. On the contrary, dew has been proven to exist on the cover, although the low amounts of dew deposited hinder its drainage to the water.

Vipul Sharma el.al. [15] Study report the fog collection mechanism in Bermuda grass, Cynodon dactylon, which is commonly found in several regions of the world. The fog collection ability of this grass can be attributed to two characteristic structural traits: well-arranged conical spines with sharp edges, wherein the deposition of fog droplets occurs, and hierarchically organized seedheads having flattened surfaces with gradient grooves that transport the coalesced water drop in a directional manner. The researched shows the characteristic structural features of this and other similar plants will lead us to the fabrication of bioinspired materials and devices to harvest fog in an efficient manner.

Girja Sharan el.al. [16] Paper described the construction and functioning of a water production plant in northwest India (Kothara). Rain and dew are collected; for dew special attention has to be taken. In particular, special condenser architecture (ridges) is designed using Computational Fluid Dynamics simulation and improved condensing surfaces are operated. The result shows that water passively harvested from atmospheric moisture may be cheaper than that from reverse osmosis and does not pollute the environment, supporting the importance of dew and rain resources to provide supplementary supply of potable water in arid and semi-arid environment.

O.M. Harb el.al. [17] Conducted two field expirnment at Marsa Matrouh Agricultural Research Farm during summer seasons of 2013 and 2014 using drip irrigation system, to evaluate the effect of some fog water harvesting models (f.w.h.m) of model-1, model-2, model-3 and model-4 under some farmyard manure (FYM) rates (20, 30, 40 m3)/fad on groundnut productivity. Results cleared that model-1 exposed its superiority on the total water amount harvested during the two seasons that led to give significant greatest values of, pods, seeds yield/plant or /faddan, biological yield/fad., shelling %, seed and harvest index, seed protein and oil percentage and water use efficiency, and also that model confirmed its superiority and led to give the lowest percentage of number of seeds/pod, number of pods and seed/100 (g).

Nasiru I. Ibrahim el.al. [18] Study aims to investigate water extraction process from a solar cooling system using a vapor absorption chiller under variable fresh air ratios. Their system consists of an evacuated tube solar collector, lithium bromide absorption chiller and a fan coil unit (FCU). A parametric study was carried out to investigate the effects of flow rate of the fluid in the collector, solar insolation, fresh air volume ratio, temperature and humidity on the system performance and rate of water production. The results showed maximum collector efficiency of 0.66 at an optimum flow rate of the collector fluid of 0.3 kg/s at Ac = 28m2, Tf = 45 _C, I = 800 W/m2 and R = 50%. For the same conditions, useful energy to the generator was found to be 14.8 kW and water production rate was 8 L/h.

Katherine M. Kinder et.al. [19] Study implemented a novel experimental method utilizing an environmental test chamber to evaluate how air quality and temperature affects CWFA untreated product water quality in order to collect data that will inform the type of water treatment required to protect human health. The result found that temperature and benzene air concentration affected the untreated product water from a CWFA system. Benzene vapor concentrations representing a polluted outdoor environment resulted in benzene product water concentrations between 15% and 23% of the USEPA drinking water limit of 5 μg/l.

In contrast, product water benzene concentrations representing an indoor industrial environment were between 1.4 and 2.4 times higher than the drinking water limit.

M. Ebner et.al. [20] Studied to determine to what extent S. sabulicola relies on water supply by fog harvesting. The following parameters were monitored: 1) climate, 2) stem runoff, 3) leaf water potential (LWP) and 4) soil water content (SWC). The result indicated that fog harvest of S. sabulicola occurs mainly via stem flow with subsequent absorption by the root system and that fog catchment therefore represents a substantial water source for this species.

D. Bergmair et.al. [21] The use of water vapor selective membranes can reduce the energy requirement for extracting water out of humid air by more than 50%. They performed a system analysis of a proposed unit, that uses membranes to separate water vapor from other atmospheric gases. This concentrated vapor can then be condensed specifically, rather than cooling the whole body of air. They showed that by introducing a low-pressure, recirculated, sweep stream, the total permeate side pressure can be increased without impairing the water vapor permeation. This measure allows energy efficiency even in the presence of leakages, as it significantly lowers the power requirements of the vacuum pump. The result showed that such a constructed atmospheric water generator with a power of 62 kW could produce 9.19 m3/day of water (583 MJ/m3) as compared to 4.45 m3/day (1202 MJ/m3) that can be condensed without membranes. Due to the physical barrier the membrane imposes, fresh water generated in this manner is also cleaner and of higher quality than water condensed directly out of the air.

Talaat A.Salem et.al. [22] This research investigates the suitability of harvesting fog and rain water for irrigation using a pilot fog collector for water quantity, water quality, and economic aspects. A pilot fog collector was installed at one location at Delta Barrage, Egypt. Freeze liquid nitrogen was fixed at the back of the fiberglass sheet to increase the condensation rate. The experiment was conducted during the period from November 2015 to February 2016. In general, all physicochemical variables are observed with higher values in the majority of fog than rain water. Regarding the water quantity, a significant increase in the harvested fog quantity was observed after cooling the collector surface with freeze liquid nitrogen. The current fog collector produced the lowest water quantity among different fog collectors worldwide. However, these comparative results confirmed that quantity is different from one location to another worldwide even in the same country. The cost of the unit water volume of harvested water by the current pilot collector is relatively low among different collectors worldwide.

J.Y.Wang et.al. [23] This high efficient semi-open system of fresh water production is established with novel consolidated composite sorbent. This device collects 14.7 kg of water with packing 40.8 kg of consolidating sorbents in 0.4 × 0.4 × 0.6 m size of sorbent bed. the consolidated active carbon felt combined with LiCl sorbent and its corrugated filling mode are invented, which has large cycle sorption quantity, excellent heat transfer performance, and enough mass transfer channels. This appliance ensures the large adsorbing capacity at 23oC and 90% RH, and achieves a large amount of desorption (0.65g/g) between 70-80oC with 8.8 Pa flow resistance. The pressure drop and velocity distribution of the actual operation in the unit structure of sorbent bed are simulated, and the water mass is calculated to analyze the sorption and desorption performances of the device.

Ritwick Ghosh et.al. [24] In this pilot study, they have explored the possibilities of fog capture from CT (cooling tower) plume in a thermal power plant; CT plume accounts for one of the major sources of industrial water losses. Their study shows that a recovery of about 40 percent water from the drift loss e amounting to a saving of nearly 10.5 m3 of water per hour from a 500 MW unit e could be achieved using the proposed fog harvesting strategy. Unlike the natural fog harvesting schemes where the fog laden flow is predominantly horizontal, fog flow stream in a cooling tower rises against the gravity. Three parameters are found to influence the collection efficiency predominantly: the shade coefficient of the mesh, effective dripping length of water droplets along the fog net, and angle of inclination of the mesh with respect to the vertically rising fog stream. The observed collection efficiency is more than twice as compared to those of other globally operational fog collectors. Results offer the design bases for full-scale fog harvesting systems that can be deployed in power plant cooling towers and a wide range of other artificial fog generators.

Future Scope:

- Agriculture : Water produced by the tower can be used for irrigation and farming.
- Environment: the water management training program can introduce the principles of permaculture.
- Technology: Future developments include a shared internet connection point for rural villages, which can connect the isolated

communities and bring valuable realtime information (e.g., weather forecast, market prices of crops)

- Defense sector.

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