INTERNATIONAL JOURNAL OF ADVANCED INNOVATIVE TECHNOLOGY IN ENGINEERING

Published by Global Advanced Research Publication House Journal

Home page: www.ijaite.co.in

Design and Implementation of Water Extraction

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Article History

Received on: 25 April 2022

Revised on: 15 May 2022

Accepted on: 31 May 2022

Keywords:
Atmospheric Water Generator, Water Extraction, Relative Humidity, Atmospheric Air

e-ISSN: 2455-6491

Production and hosted by
www.garph.org

ABSTRACT

This paper provides a method for extracting water from atmospheric air. According to a UN report, the global demand for freshwater will exceed supply by 40% in 2030.Due to a number of factors like climate change, rapid growth in population and massive urbanization. Water extraction system from air uses a method in which we condense the water present in atmospheric air by bringing it below its dew point. There are other methods by which we can extract water from the air like the use of Peltier effect, wet desiccation. Here uses vapor compression refrigeration cycle with the help of compressor. This system is most effective in areas where relative humidity is high and in coastal areas.

1. INTRODUCTION

The single most serious challenge that India has now is a lack of drinkable water. Wastewater and agriculture waste damage the majority of water resources. Diarrhoea affects about 150 million people each year, with over 0.8 million people dying as a result of it. Fluoride poisoning affects 68 million individuals in over 250 areas. Arsenic poisoning affects around 20 million individuals worldwide. This situation offered the original research questions for the group, prompting us to concentrate open collecting water from humidity. Our group produced a research question to accurately represent the facts of atmospheric water creation after focused on this issue. Because atmospheric water producers are currently available as items on the marketplace, its concept must stand out in those way, either via originality or improved usefulness, in enough to support the investment of time and money under this work. Moreover, the production of atmospheric water is a power operation. Traditional systems are unable to provide considerable volumes of water at a reasonable cost. In view of above factors, the following objective has been developed: to design and develop a system for extracting pure drinkable water from atmosphere, with a focusing on enhancing the power need with the final objective of operating the devices with sustainable power.

A. Development Norms

Transparency: Such effort is made to create the procedure more comprehensible, consistent, and dependable. Additional architectural adjustments, fresh concepts, and improvements may all be conveniently adopted, and study can keep improving the item for general use.

Integrity: Authenticity entails considering the balance of shape and structure, completion, and the development of human principles and interactions, as well as being appealing and practical to be using. The development of this System in such a way that it achieves and shows architectural consistency is in line with other team developed of accountability and openness. The aim is to obtain every one of these standards in order to provide a superior product that respects the interests of the others.

Trust: The major challenge is to create individuals feel at ease with our AWG so that they can utilise it to its greatest capacity and profit. The goal is to create a quality goods that is trustworthy.

B. Water Extraction Methods

In environmental disciplines, meteorological, hydrological, and climatic research, liquid water is a fundamental element of the environment. Water vapour affects fuel balance of the Greenhouse effect, which generates and sustains climatic movements. The environment receives power from sunlight solar irradiation, non - radiative recombination transportation from the Earth 's core, and thermal assimilation [10]. 2 km of surrounding atmosphere contain 11,000–32,000 m3 of clean water for most places of the earth.

The trademarked removal of freshwater from atmosphere process is typically extracted of air humidity into a stream of water and was developed for huge water production, up to 1100 m3 each day. The EWA process harnesses air moisture in a comparable manner as distillation, that relies on an infinite supply of sea water. EWA technologies could be a feasible option for water system in areas in which neither seawater nor infrastructures are provided. EWA method removes humidity levels in 3 parts: moisture soaking on a hard adsorbent, liquid vaporisation at mild temperature (65–85°C), and condensing with a thermal pump-connected passively condensation. EWA technique could be a viable choice for water supply in dry regions [11].

The one leading source of disease in the globe – is a shortage of adequate safe drinkable freshwater. Approximately two in of each five persons on the earth today without dependable availability to clean water, per the April 2008 edition of Vogue Magazine, Environmental Issues version. Given rising water contamination and climate change, traditional supplies of distilled water are rapidly disappearing and becoming progressively insufficient to address the demands of the world's large community. Freshwater produced from conventional resources including such canals, ponds, and the earth must also be carried over great areas to being consumed because to its fundamentally static characteristics. These raises expenses and necessitates massive volumes of resources.

There seems to be a pressing need to find a new resource of drinkable water which is both widely accessible and capable of meeting the world's massive water demands. Developing a reliable, long-term clean water alternative will preserve lots of people while also improving people well of living. In crisis control and for defense applications in distant places, a system that really can deal with severe circumstances such as a lack of tap water, no consistent electricity provider, and high temperatures and moisture variations would be advantageous.

Over the last few years, environmental water producers have been meeting the demand for drinkable water; nevertheless, the current technology has restricted usefulness. In harsh environmental circumstances, such as low percent moisture and high heat, current technologies are not really a viable solution. The development's goal is to build and construct a next generation capable of producing 11-21 litres of water per day in a variety of climates and delivering water in situations under 32% humidity levels. The system must create fantastic water while also being power effective, with an energy-saving replacement energy resource incorporated. It is also necessary for the item to be movable.

Contribution of this paper is

- This research demonstrates a new, easy, and novel approach for collecting water from the air. The novel water collecting model works by utilising a Thermoelectric Cooler 15A Peltier Module to produce condensation.

- To design the simple and cost-effective prototype model for extracting water from air.
- Analyze percentage of extracted water from air.

2. Related Work

The literature review of this paper comprises from the journal on the internet, paper proceedings and research, books and lectures. The literature review is done to investigate cases of the projects that may arise to overcome it. The literature review gives a great knowledge on the fundamentals of the project.

Mishra, V. et. al. [1] offered a summary of different methods for extracting water from ambient air. To begin, sun supported absorbing or adsorbed techniques in that organic adsorbent substances are employed to collect or adsorption humidity at nighttime were demonstrated. Renewable heat is used to replenish the humidity, which is subsequently kept in liquid state following flowing through with a condensation tube. Piezo module is employed in another approach to harvest ambient water using the idea of thermoelectric refrigeration. As environmental air passes through to the wet side of module, it is chilled to the dew point, and water vapours start to condensed at that air temp.

Srinidhi N. A et. al. [2] built a kit for collecting environmental water; facilitated the design and knowledge of cooling condensing techniques, as well as learning valuable design and prototype skills. Throughout the year-long concept design, each person in the team seemed to have the chance to lead a section of the implementation. Necessary services for handling huge tasks and fulfilling key milestones have been developed. Everything of this was done as part of a technological effort that necessitated cooperation with one another and was based on architectural standards. These items will be beneficial to individuals of the group as they progress.

Hamed et. al. [3] outlined the basics of water extraction from atmosphere technologies and methods. There is also an overview of the analytic and empirical investigations that look into effectiveness. There are also some novel models that considerably extend the photovoltaic dehumidifier approach for absorbing and rejuvenation. The amount of investigation being done in this field is also still expanding in order to resolve the critical issues that prevent these technologies from competing with the other methods such as hydrodistillation.

Jianan Yao et. al. [4] developed a novel, easy, and unique technique of collecting moisture from the atmosphere, depending on a water extraction technique that uses the earth as a cold source. The different type of soil cold air hydraulic loading mechanism is built using an inventive technology that consume less energy by using a fixed temperature soil as the cooling mechanism. The computed using the following utterance of compressor liquid and news source air temp is achieved by trying to compare the centre composite layout test with the test conducted and analysing the compressor water and news source temp under various wind flow rate and high moisture, and the ideal shipping wind velocity variety below certain temperature range is acquired as per to the statistical prototype.

Peeters et. al. [5] Collecting water vapour from the atmosphere could be a remedy to regional water shortages, but it requires a lot of energy. Once tried to compare to saltwater desalination and the utilise of clean water supply and sewage water source materials, energy usage forecasts for water-from-air factors associated adsorption mechanism, thermally wettability swapping polymeric materials, cooling procedures, and membrane processes of dissolved dissolved salts expose that all these techniques really aren't productive. It represents a realistic choice when there are no local drinking resources of water and lengthy transportation is not even an alternative for macroeconomic considerations. Directly energy from the sun innovation for freshwater from atmosphere generation, for example, is an appealing way to untangle the public water confluence. Climate change is expected to hasten the use of water-from-the-air technologies in local water delivery systems. Environment, relative humidity, and temperature profiles all influence the best water-from-air technique. The best geographical area for every innovation is indicated on a globe map.

Mrs. N. Deepa, Gokulprasad et. al. [6] intrinsic energy requirements of water vapour capturing processes in different atmospheric conditions are quantified as the specific water yield (L kW^{-1} h^{-1}). Distinction is made between passive systems that use natural phenomena like solar energy directly, and active systems with human transformation of the energy vector. The generation of thermoelectric energy involves water use and may even lead to overall water consumption instead of production. Technologies involving air cooling to provoke condensation of the water vapour reach specific water yields of 1–4 L kW^{-1} h^{-1} but their application is strongly dependent on atmospheric conditions. A specific water yield of 0.1–1 L kW^{-1} h^{-1} is commonly achieved for an ad/absorption–desorption cycle with a desiccant material. Depending on climate conditions, either passive systems with desiccants or active cooling of condensation surfaces is energy wise the optimum choice. The intrinsic energy requirements of atmospheric water harvesting are more than hundred times larger than seawater desalination. Fundamentally new concepts are needed to make atmospheric water an affordable fresh water source.

Mr. Ajinkya Wankhade et. al. [7] present work is focused towards the design and development of refrigeration system for producing water from air for 6 minutes cycle on the working principle of adsorption system by using Activated carbon and ammonia selected as working pair. Amount of water collected from the system depends upon the atmospheric conditions (like DBT, DPT, and RH) and the amount of air blown on the evaporator. The location selected for installing our project is Pune, Maharashtra. The principal feature of the water obtained by use of this method is the absence of harmful microorganisms and bacteria in it. At the same time, the water obtained from this process has certain trace elements which are necessary. This method used for extracting water from air are much effective than other methods as they do not use ground water, but atmospheric air.

Nedariya, H. S. et. al. [8] presented techniques for remote villages in order to produce clean drinking water. In which a six feet depth pith as made and have one condensation chamber (Water Storage Tank) in it. A 4.5 W fan is used to suck the air from the atmosphere. This fan is operated by 12 V solar plates. In this, we can extract about 250 ml water. If we provide more depth and higher capacity fan than we can extract more amount of water.

Wang, Y. et. al. [9] present study covers all of the research based on water extraction from atmospheric air, including theoretical and practical (different experimental methods) research. A comparison between different results is made. The calculated efficiency of the systems used to extract water from atmospheric air by simulating the governing equations is discussed. The effects of different limitations, which affect and enhance the collectors' efficiency, are studied. This research article will be very useful to society and will support further research on the extraction of water in arid zones.

Benjamin Franklin et al (1758) [1] conducted an experiment to explore the principle of evaporation as a means to rapidly cool an object. They concluded that evaporation of highly volatile liquids such as alcohol and ether could be used to drive down the temperature of an object past the freezing point of water.

Michael Faraday (1820) [2] discovered that compressing and liquefying ammonia could chill air when the liquefied ammonia was allowed to evaporate.

Dr. John Gorrie (1840) [3] presented the concept of chilling towns to protect citizens from "the dangers of extreme heat." Chilling, thought, is the essential to preventing infections like fever and ensuring that victims were pleasant. It investigated with artificially refrigeration and created a system that generates ice to use a horse-powered compressors, freshwater, wind-driven sail, or water vapour.

Willis Carrier (1902) [4] suggested and modeled air conditioner systems to increase production process management. The device was capable of controlling both temperature and moisture. Rather than passing air via heated coils to warm surfaces with vapor, passed it via cool coil to chill the air, lowering the moisture in the environment.

Thomas Midgley et al., (1930) [5] refrigerants were developed, and they were the world's largest earliest non-flammable refrigeration and air conditioning fluid, greatly increasing security of air conditioning units. Nevertheless, the compounds were associated with the equipment to ozone layer depletion and was taken out through countries around the world following the Montreal Protocol in the 2000s. Hydrofluorocarbons (HFC) have grown in importance since they do not deplete the ozone layer.

H. Polnder et al (2007) [6] 14 MW generation for a straightforward wind generation was researched, and the generator techniques for control scheme and dynamic stalling control were examined. Investigators created a 14 MW perpetual straightforward generation and discovered that enabling active rate stall management requires a significant rise in generating cost of the unit.

Frainhofer-Gesellschaft (2009) [7] technique is based on various concept of hygroscopic brine-a saline solution that absorbs humidity across a tower-shaped structure, absorbing moisture from the atmosphere. It is then vacuum-sucked into a container some few metres above the surface. Sunlight warms the saltwater, and then dissolved either by freshwater it has collected. The melting temperature of the water is less than would be at standard air pressure due to the atmosphere.

Ahmed M. Hamed et al (2011) [8] The use of solar energy to heat a sandy bed saturated with calcium chloride for water recovery from atmospheric air was examined. They also looked at the influence of several factors on production, such as architectural qualities and weather circumstances. Participants indicated that a solar-powered dehumidification scheme with a fine sand ground can effectively recover moisture from the atmosphere, with an estimate of 2.0 litre of clean water retrieved per sq. metre, whenever the remedy accumulation at balance with daytime circumstances is around 30%, and the weather of procedure of such a framework defines the able to operate accumulation of the remedy, so it is suggested to use remedy with greater quantities.

Caylee Johansson et al (2011) [9] wanted to offer a concept for a viable home turbine to gather energy and reapply it to a residence or an electric automobile. They chose to suggest a tiny wind generator because it would be inexpensive to buy and construct, would require little care, and would not be unsightly in the backyard. Researchers came to the conclusion that the Beltz Limit should be considered in to concern, which indicates that "the basic rules of preservation of matter and energy enable no and over 59.3 percent of kinetic energy of wind to be caught for a theoretical perfect wind-extraction system.

Marc Parent (2012) introduced the concept of obtaining water from air moisture and experimentally validated the prototypes in a desert in Abu-Dhabi, where the mechanism, which is similar to a wind generator, gathered roughly 1500 litres of water daily. it shows the concept utilizing simple technical phrases such as condensing, that is the transformation of every gas stuff to a water condition. It is a normal occurrence that occurs frequently in the air, resulting in the freezing of increasing water vapour and the formation of clouds. Dew forms when the temperature falls underneath the dew point at a constant air pressure because the air is rich in water molecules [10].

3. Material And Methods

This section is described briefly about the methodology used in experiment, analysis and design of extraction of water in atmospheric air.

Figure.1: Flow of Methodology

A. Components Used

TEC1-12715: The TEC1-12715 40x40mm Thermoelectric Cooler 15A Peltier Module is the simple application of Peltier Thermoelectric Effect. The module features 127 semiconductor couples in the area of 40mmx40mm.

Figure 2: TEC1-12715 Peltier Module

Thermoelectric coolers, sometimes referred to as TEC or Peltier Modules, generate a temperature difference on both sides. One side becomes hot, while the other becomes chilly. As a result, based about which sides to utilise, it may be used to both heat or chill objects. It can also create energy by taking advantages of a thermal difference.

As soon as the temperature is removed from the hot end, this Peltier functions perfectly. When you turn on the devices, the hot side heats up immediately and the cold side cools down rapidly. The Peltier will rapidly achieve stagnation and accomplish nothing because the heat from the hot end is not removed (using a heat sink or even other device). To remove temperature from the warm end, it proposes utilising an old computer CPU cooling or the other iron blocks. It was capable of making the chilly side so unpleasant with a pc power source and Processor cooling that couldn't touch it. The thermoelectric cooling (TEC) modules is an electrical device made of semiconductors that acts as a tiny heating system. Temperature will be transported from one end of the modules to another by connecting a Dc voltage source to a TEC. It produces both a chilly and a hot end. Computer CPUs, CCDs, portable refrigeration, medical devices, and other commercial applications use them extensively.

Thermoelectric Cooling Kit: Semiconductor cooler are a type of solid refrigeration that combines semiconductors and electronics manufacturing technology. The Thermoelectric Peltier is a temperature control and chilling unit kit is however one instance.

Figure 3: Thermoelectric Cooling Kit

The TEC1-12706 Thermoelectric Cooler 6A Peltier Module is used in the DIY semiconductor chilling system. The package includes two heat drains, one for the warmer side and the other for the cold end. The larger the temperature drain, the more temperature is removed.

This package contains a blower that serves as a condenser. This connects to the larger heat absorber. In between two temperature drains is the TEC1-12706 thermoelectric Peltier unit. The temperatures will be reduced by the unit.

Heat Exhaust Fan: Super High Speed Blower DC Cooling Fan AVC 12v 4.5a / 12 volts 4.5 amps 80mm x 80mm x 38mm Box Fan High RPM High Airflow Exhaust Fan Industrial Grade Heavy Duty TUV CE RU Certified High Quality.

Figure 4: Heat Exhaust Fan

Brand: AVC Ratings: 12v dc 4.5aTermination: 4 wires PWM No. Of Blades: 5Type: Ball Bearing Blower Fan Cooling Fan Super High Speed High Airflow Dimension: 80mm x 80mm x 38mmCertification: TUV CE RU Certified High-Quality Grade: Heavy Duty Industrial Grade.

SMPS: 12 Volt 30 Amp 360 Watt DC SMPS Switching Mode Power Supply for CCTV & LED Strip with Metal Case / Aluminum Base with Metal Case & Cooling Fan AC DC

Figure 5: SMPS

Package Includes

1 x Cooling Fan
1 x Fan Gauze
1 x Guide cold plate
1 x Radiator
1 x Thermal insulation gasket
1 x Pack of Screws

B. Methodology

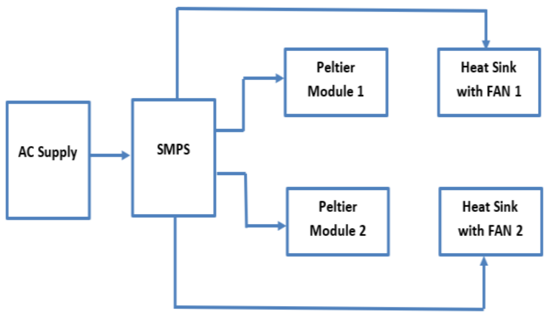

Figure 6: Block Diagram of Proposed System

This research uses a cooling and heating technology to harvest moisture from the ambient air. The cooling method utilizes a compressor to raise the refrigerant's pressure and temperature, and the heated refrigerant travels through a condenser unit to lower its temp. The refrigerant is then transported through the pane, changing state and cooling to an absolute zero temperature.

This low temperature coolant is fed into the evaporator section, which helps to cool the environment, and the refrigerant then flows into the compressors, continuing the process.

We're going to build up a fan arrangement to provide a continual flow of air to the evaporator coil. By lowering the temperature underneath the dew point, liquid contained in the air as moisture is removed. Water condenses from of the atmosphere and is collected. The compressors is equipped with a temperature sensing microcontroller that continuously checks the system temperature and turns off the blower whenever the temperature hits its melting point. This keeps ice from forming in the coiled.

Refrigeration cycle: The procedure of transporting temperature from a lower concentration to a higher temperature is known as cooling. The refrigerant's main aim is to extract temperature from a decreased medium.

Dew Point: At this temperature, air compresses and water drops develop.

3. Amount of water in 1m3 of atmosphere (in L) for various moisture and temp situations

The proportion of relative pressure of the water (Pw) to saturated pressures is known as relative humidity (RH)

$$RH = (Pw/P) \times 100$$

The relative pressures of water (Pw) can be calculated using the equation for saturation pressure (Ps) and relative humidity (RH).

$$Pw = (H/100) \times P$$

C. CAD Model

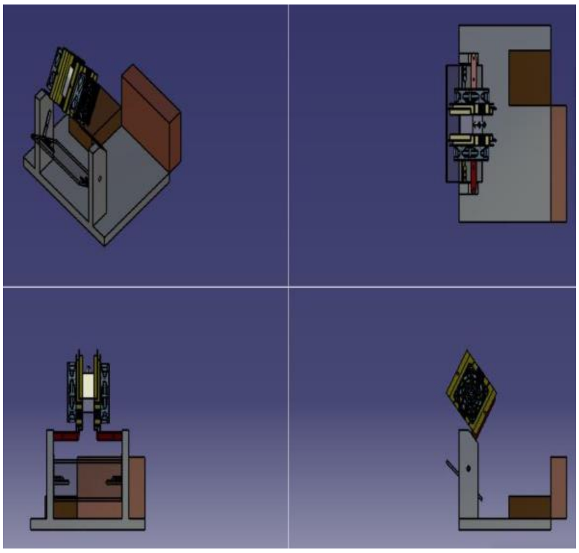

Figure 7 (a): CAD Model of Proposed System

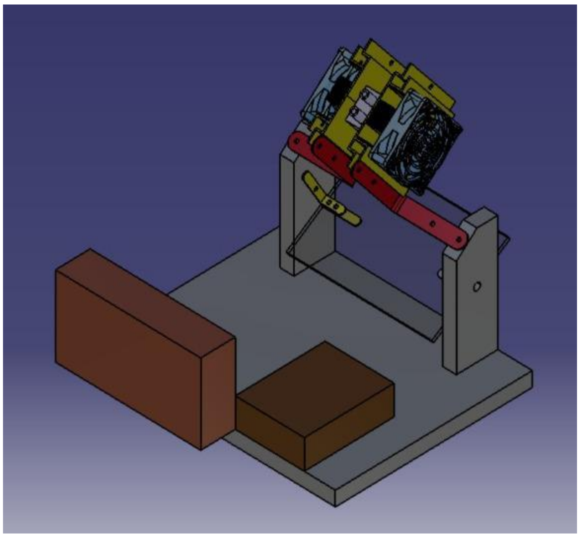

Figure 7: CAD Model of Proposed System

D. Experimental Setup

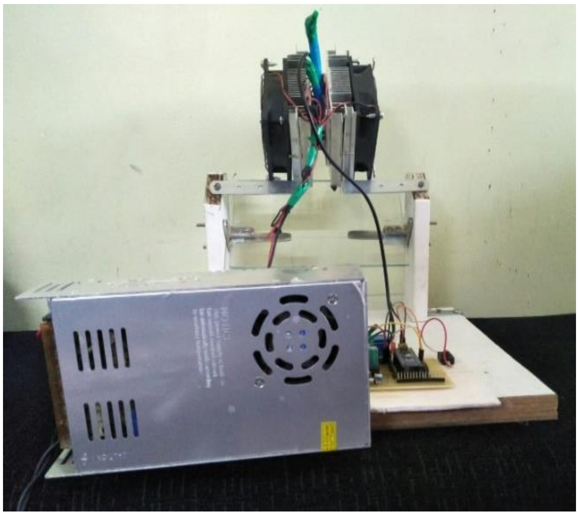

Figure 8: Experimental Setup

Figure 9: Experimental Setup

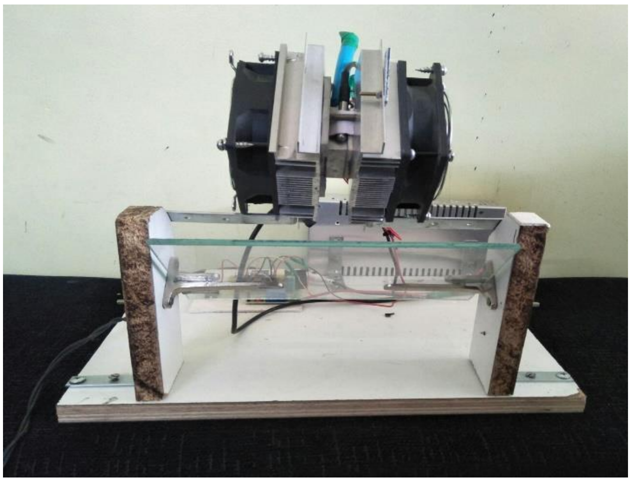

Figure 10: Experimental Setup

4. RESULT ANALYSIS

The prototype is put to the test in a variety of environments, each with a distinct temperature and relative humidity. The prototype has been examined in an outdoor environment since air flow and environmental humidity conditions are higher in an outdoor space than in a sealed room.

Table 1: Experimental Result are carried out in Nagpur on 18:05:2022, with Relative Humidity is 53%

Operational Time	Water Extracted in ml
07:00 AM – 09:00 AM	160
09:00 AM – 12:00 AM	210
12:00AM-02:00PM	220
TOTAL TIME: 7 HOURS	Water = 590 ml

Calculation

Total time of operation= 420 min

Total water Extracted = 590 ml

Water extracted per minute =590/360=1.40 ml/min

After conducting the experiment in Nagpur city having average relative humidity 53%, we got 1.63 ml of water per minute.

Amount of water generated per day of operation=1.63*53*24 = 1786 ml.

Amount of water generated per year of operation=2.073*360 litres = 746.40 litres per year.

5. Application

- Water absorption from the atmosphere could be utilized to reduce humidity levels by acting as a humidifier.
- We can make water even in remote locations when subsurface levels are low.
- It can be utilized in emergency situations as well as by the army.
- Can be used in places when water is accessible, such as highway rest stops.
- In various locations, conditions, and acute demands, the AWG has specialized functions and applications. Because of its mobility and endurance, it might be regarded a logistical advantage. It is a reasonable investment due to its dependability, as it only requires two factors to generate water supply: air and power.
- The AWG is a must-have in the restaurant or foyer of restaurants, bars, and resorts that require large quantities of fresh ice cubes. If mineral water tanks are substituted with AWG, corporate organizations can eliminate the use of plastics.
- In natural disasters and epidemics, the presence of AWGs can save lives and improve sanitary circumstances. Water supply is a high concern for emergency management organizations to preserve excellent health; the mobility and dependability of AWGs in creating drinkable water will show to be a crucial technical solution in preserving health and lives.

6. Advantages

1. It is extremely portable, cost-effective, and simple to operate.

2. There is no necessity to invest in costly pipeline infrastructures.

3. Rapid and adaptable installation

4. There is no need for a traditional water source.

5. To manufacture fresh, clean water, all you have to do is connect it into an electric outlet.

6. It's practical, reliable, and secure.

7. Provides you with complete management regarding the water usage.

Conclusion

Despite the availability of enough water supplies, its unequal distribution causes a shortfall and the need for transportable clean water. Water stressed regions are home to even greater than 3 billion humans. According to a review of studies, one of most popular approach for effectively removing moisture from ambient air is aerosol, in which freshwater is created for nothing as a consequence. The dehumidification strategy, on the other hand, is the perfect way to obtain water inactively (or use a renewable resource) so it can be used anyplace, apart from the dew gathering techniques, that can just be utilised in places with rising amounts of humidity, including such coastline and alpine terrain, but unlike Earth-water gathering methodologies, that could indeed just be utilised in accessible, fine sand locations like desert areas.
Humans can harvest additional water from the environment by implementing this principle to a highly moist area. The layout makes it easier to gather water. The device's architecture is just so easy that it may be taken everywhere. Adventurers, climbers, fishers, and others will benefit greatly from the outfit. A motor cycle combination or a hold sustainable power resource, such as photovoltaic or winds, can likewise be used to power an environmental freshwater production. A water removal device could be used to quickly provide drinking water. The capacity of an extract system to link to a nearby Wi-Fi or Wireless device, as well as its capability to be an Internet of Things (IoT) device, will enable the person to interact with it naturally. In the near future, water collection mechanisms should be improved. As an outcome of all of the previous scientific investigation and the appealing prospects that they have presented, water removal is able to expand the limits of current technology and will significantly help to minimise water problems.

Conflict Of Interest

The authors declare that they have no conflict of interest.

Funding Support

The author declare that they have no funding support for this study.

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