Applications about the use of MOFs in agricultural activities

Mahmoud El sayed Abdull Aziz
Zagazig University ,Al-Sharkiya, Egypt

Mahmoudelsaied82@gmail.com

Abstract– ***Actually the water shortage problem is one of the biggest challenges which Egypt faces and we should create a solution to solve it, so how to reduce the consumption and get water from alternative sources, we chose the atmospheric water as a source for our target to supply enough amounts of water. search about prior attempts and knew it's strengths and weaknesses points. our solution is to make a device based on a porous metal-organic framework {MOF-801,} that captures water from the atmosphere at ambient conditions by using low-grade heat from natural sunlight This device is capable of harvesting 2.8 liters of water per kilogram of MOF daily at relative humidity levels as low as 20% and exploit this amount of water to irrigate some crops that doesn't consume much water and can be planted on the roofs of homes like peppermint by using an irrigation system to reduce the wasted water dependent on the conditions of weather (temperature and humidity) . To test the efficiency of our prototype, we chose design requirements which are Safety, efficiency, environmental and economic impact, low weight, and testability [1]. Our test results were satisfying, as our project is promising. After all the calculations and measurements, we found that our prototype meets all design requirements and able to get and save water, and that is the main aim for us.***

I. INTRODUCTION

Nowadays, Egypt is facing many grand challenges, as we know. One of them is water conservation; it is one of the most serious challenges. In addition, as it affects the other Egypt's Grand Challenges like industrial base, energy, population growth, etc. …The portion of Egypt from water is decreasing every year. Thus, the danger increases. So, if we do not solve the problem, we will suffer from water lack in the future. Concerning prior solution, there were some solutions like putting biosensor on the taps to make it open it there is a hand under it and close if there is no. Also, some countries follow smart garden system that consumes about 50% from usual rate. Moreover, there is another that pays for those who use washing machine (5A highest efficiency), like Australia. Although, these solutions are working well, they are not efficient enough as it may cost highly. So, after a long research, we intended to use a porous chemical substance, called MOFs, metal-organic frameworks {MOF-801, [Zr6O4 (OH)4(fumarate)6]} . The crystallization of this substance shows reservoirs that can be used to store water from the air. Then we used this produced water in a domestic irrigation system for some simple nutritious like mint, radish, or coriander. Water output of this system depends on the results of two sensors. One for weather temperature and the other for soil humidity. We tested it to make sure that our prototype meets all design requirements we chose (Water conservation, Economic impact and increasing food supply, saving money). After testing it, we found the results as the following, about water conservation; our prototype uses water from the device of MOFs instead of using water from usual sources. Not just this, also, our prototype consumed1.4 L / day instead of 17 L / day to irrigate 40cm × 20cm growing media. For economic impact and increasing food supply, our prototype may be used to irrigate several nutritious crops that do not consume much water for domestic needs. Moreover, concerning saving money, we use MOFs technique instead of using the desalinating process that is high in cost. In addition, you do not have to buy these crops as these are planted in your house. so our prototype meets all design requirements and it is suitable for designing [2][3]. We depend on chemistry do determine the quantity of produced water from MOFs, specifically, this law is:

$$(m_w)_{mof} = Q_{thermal} - Q_{loss}/(h_{ad})$$

Equation 1

Where m_w is the amount of harvested water, $Qthermal$ is thermal energy input, $Qloss$ is heat loss from the MOF layer to the environment and h_{ad} is the enthalpy of adsorption.

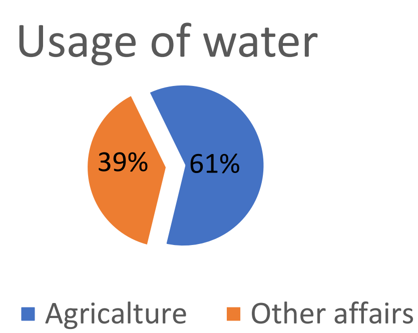
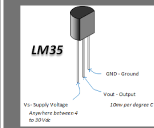


Fig. 1 Usage of water in daily life

II. MATERIALS & METHODS

Table 1 The top table shows all the components of the agricultural system in addition to the chemicals

Glass 	Water pump 	Buttons 	RF transmitter 
Connectors 	Regulator 	Battery 9v 	Resistors 
LM35 sensor 	Adaptor 	Hose 	Palter 
Soil moisture sensor 	Arduino 	Led 	Chemicals for "MOF801" 

We bought two sensors (temperature sensor and soil humidity sensor) and we connect them to the Arduino to get their readings and compare them if the humidity of the soil is larger than 700 and the temperature is smaller than 40 then the system will work and the led will be on. If the humidity is smaller than 600 and the temperature is greater than 40 °, the system will stop and the led will be off. There is a remote to turn of the system if it is raining. The pump will pump water hose that will irrigate the soil in a very conservative way through dripping. We use 9V battery to operate the two sensors and an adaptor to the pump. This system gets its water from MOF (metallic organic framework) as the metals crystals will adsorb water that is found in the air and collecting them together to get water drops that will be put in a water tank and we made an apparatus for the MOF and connect it to a water tank that our irrigation system will take water from.

Water conservation: We saved large amount of water by using new source of water and we control the amount of produced water so, there won't be wasted water [4].

Economic impact and Increasing food supply: as the water we produce is used in irrigation in agriculture to grow crops and produce food.

Saving money: As by using MOF is much cheaper than distillation.

Saving energy: as we use only 9V battery to operate the sensors and 12V battery to the pump.

III. Analysis

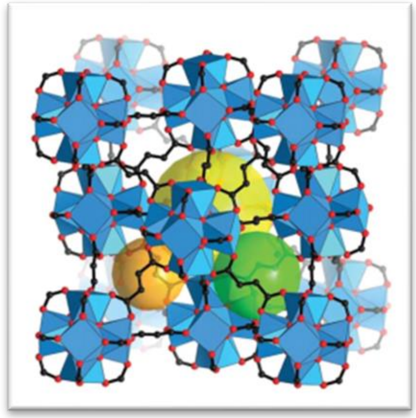


Fig. 2 Synthesis of the molecule in compounds of MOFs

Because we're working on water conservation, our prototype can be a suitable solution for this problem. The solution will be using MOFs that produce fresh water from the humidity for use instead of using water from usual resources. As its crystalline shape shows as a reservoir that can be used to store water from the air as shown in Fig. (2). In addition, this water will be used in a domestic controlled irrigation system. This system controls the output of the produced water to the plant by two sensors, for temperature and humidity as shown in Fig. (3) and its simulation is shown in Fig. (4). By the way, we will grow some nutrients plants they do not consumed much water like radish, mint, and rocket. Since the prototype is suitable for designing, we should illustrate more information about the components of it.

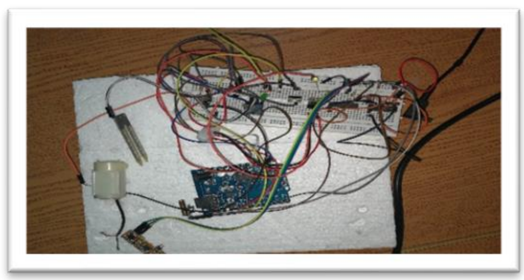


Fig. 3 control circuit

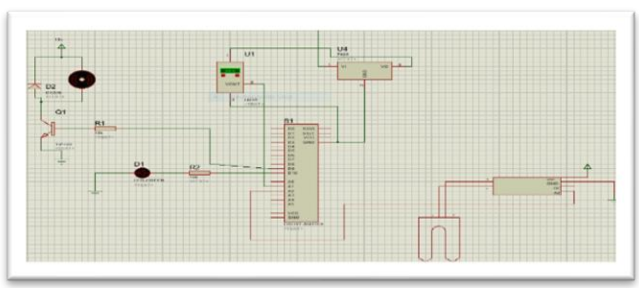


Fig. 4 Control circuit executive diagram

The components:

1)Arduino:

For getting values and gives instructions for executing according to these values.

2) Connectors:

To connect the components of the circuit together.

3) Lm35 sensor:

For calculating the value of surrounding temperature.

4) Soil moisture sensor:

For calculating the value of humidity of the soil.

5) Water pump:

To pump the water from the container into growth media.

6) Regulator:

To reduce the volt from 9V to 5V.

7) Adaptor:

To reduce the volt from 220V to 12V for the pump.

8) TIP:

For switching on and off the pump.

9) Buttons:

to control options of on and off of the circuit in the remote.

10) Battery 9V:

For giving power to the to pump to run

11) Hose:

For transferring water from the container to the growth media.

12) Led:

Is indicator to show if the pump is running or not.

13) Rf transmitter:

To send the sign in surrounding media

14) Resistor:

To reduce the current intensity.

15) Palter:

For cooling produced water.

16) Fumaric Acid & Formic Acid & Zirconium oxychloride & DMF & Methanol:

For preparing MOFs 801 .

Fig. 5 Components of a mini farming system

Laws and theories:

1- We used the law of calculating value of temperature according to reading of Lm35 sensor, it is as the following:

(temp= “value of Lm35” *500.0/1023.0)

2- We used this law to determine the quantity of produced water from MOFs, specifically, this law is:

$$(m_w)_{mof}= Q_{thermal} – Q_{loss}/(h_{ad})$$

Where, mw is the amount of harvested water,
$Qthermal$ is thermal energy input,
$Qloss$ is heat loss from the MOF layer to the environment and
had is the enthalpy of adsorption.

3- We used pressure for pump: P = F / A

Where, P is the pressure in pascal
F is applied force in newton
A is area m2

4- We used a law that calculate speed of water flow:

$$V= \sqrt{\frac{2g}{h}}$$

Where, V is the speed of water flow
g is acceleration due to gravity, = 9.8 m/s2
h is the height of the container.

IV. Results

After construction the tests that applied to the prototype indicated in :-

❖ Test of the irrigation system efficiency:-

1/The pressure are directly proportional to increase in the area of irrigation and pledge access all of the water that plants need to them.

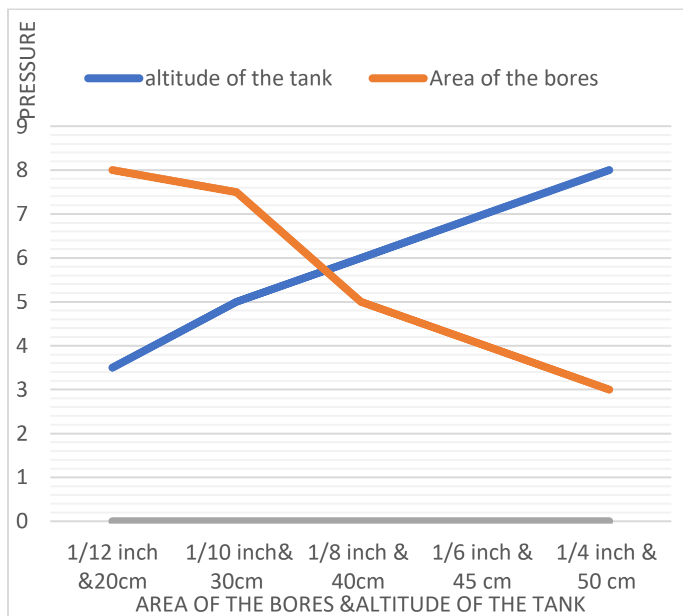


Fig. 6 Relationship of pressure to irrigation area

2/the amount of water that plants obtain is very important to keep growth process safe thus we make a relationship between humidity in soil & temperature(C) and the amount of water(ml) which will be added to the growth media to calculate the true amount that should be added.

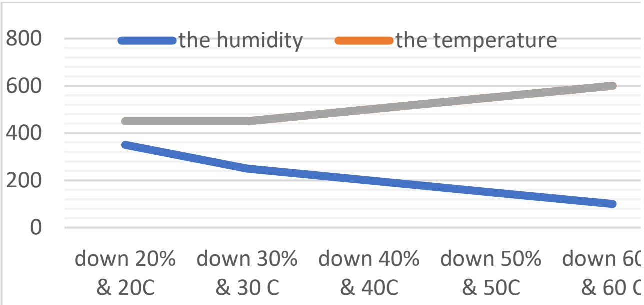


Fig. 7 Relationship of humidity to different temperatures

- <u>The machine that harvest the water from the air efficiency:-</u>

1/There is a strong relation between the amount of humidity and determine the materials or chemicals that we will use in building the machine thus we compared between this material in the following graph.

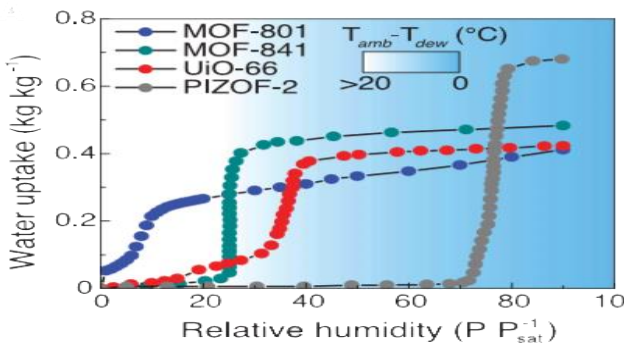


Fig. 8 Relationship of moisture to the type of organic chemicals used

2/the efficiency of working our chemical at different pressure.

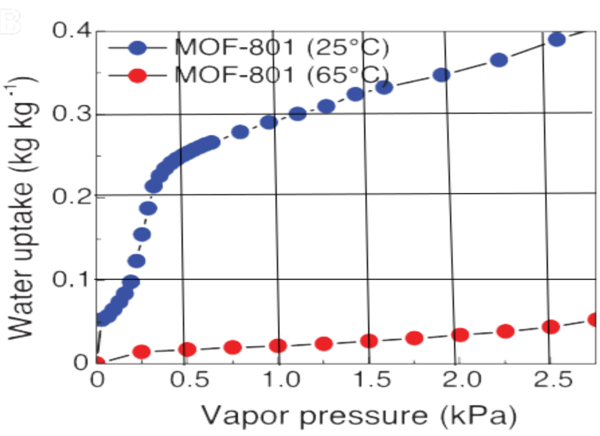


Fig. 9 The effect of different pressures on the materials used

V. CONCLUSIONS

We can conclude our work on this project in little words, our project is testable, efficient and meets all design requirements which we put for it. We made our prototype to produce 1.4 liters and that what happened, we expected in the beginning of the semester that the prototype will cost more than the budget but it is only 560 L.E, and our prototype avoids all challenges we stuck water out of the air and store it we used a material called metal organic framework or MOFs and these are constructed from metal ions that are in minerals and organic units and they mixed together and stir to make MOFs if we zoom to the material we will find that the structure (illustrated in fig5) metal ions and organic are linked together it encompasses space. The liquid will bind to the framework to the interior of the pores. one-third of the world population live in arid regions where water is scarce but the air of those regions contains about 30%humidity our device can take up the water from that atmosphere concentrate it and deliver liquid water using nothing but the sunlight and MOFs, by using a longer organic unit we can change the pore size by choosing a different metal we can change the metal composition so we can do a different kind of reaction absorbing different kind of gases. we exploit the produced amount of water to irrigate some crops like peppermint and used an irrigation system that use sensors of the temperature and humidity of the soil to reduce the wasted water and give water to the plant when needed with enough So, and due to all these points of strength and from the tests results, we guarantee that our project is able to solve water problem personally [5].

VI. RECOMMENDATION

After carrying out the project, there are some recommendations to improve the project in the future and help other people working on the same project in the future:

- The inherent structural and compositional diversity of metal−organic frameworks makes them attractive for applications in heterogeneous technologies.so you can use it in many fields.

-Developing more advanced cheap sensors for the irrigation system to increase its accuracy

-Using GMO’s to increase production or add traits like disease resistance, drought resistance, herbicide resistance

-Using better material pipes to increase the quality and the efficiency of the water transportation

-Work on using economical and cheap materials that lead to the same efficiency to save money and decrease the cost of the project

-Improve the efficiency of the lateral irrigation systems to cover wide areas with reducing wastewater.

VII. ACKNOWLEDGMENT

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VIII. References

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