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An efficient method for water treatment of artificial ponds in Jordan Valley based on photovoltaic pumping system

Graduation Project 2

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May 5th,2019

Abstract

An as fact, 2% of the Palestinian population in the West Bank live in Jordan Valley. This valley has high agricultural value since it produces 50% of the total agricultural production In Palestine. However, this area suffers from a lack of water because of the current political situation. Therefore, the water distribution is being done on a periodic basis and farmers need to store water on site so as to be able to irrigate their field during the anonymous days. This nature of the water pumping process and the limited amounts of available water for irrigation pushed farmers toward constructing artificial ponds in their farms so as to be used at the time where there is no water available from the main source. However, artificial ponds may affect the environment negatively due to the creatures which live in it such as Algae that attracts mosquitos and causes bad smell. Thus, in this paper, a simple and low-cost photovoltaic based pumping system is proposed to inject chemical material in the water of these artificial ponds to get rid of algae. The proposed system is mainly consisted of a pump that is powered by a photovoltaic array and pumps the proposed chemical material which is potash alum in the artificial pond using a rotary nozzle that is fixed on a pipe around the ponds. The system is affordable and reduces the production of the unwanted creatures. As a result, the system reduces chemical Oxygen demand (COD) value from 7200 mg/L to around 95 mg/L, which is considered the main cause of algae blooming. The product is powered by 50W foldable solar panel and it costs about 213 USD.

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1. Introduction

1.1 Overview

Palestine, in general, suffers from limited water sources. This problem localizes in the Jordan valley that stretches from the Dead Sea in the south to Bissan in the north, and from Jordan River in the east slopes to mountains in the west. The total area of the Valley is approximately 720 thousand acres, divided into three areas that are attached to three governorates, Tubas (North Valley), Nablus (Middle Valley) and Jericho (South Valley). Due to the political situation there is a control of water amount that is pumped for Palestinian regions. Thus, this area suffers from lack of water, whether for drinking, agriculture and other human uses. This area has a high agricultural value; therefore, it needs a huge amount of irrigation water as compared to other regions.

In Palestinian side of Jordan Valley, there is a parodic pumping policy applied there. The water is pumped in specific days and specific times in insufficient quantities for crops irrigation [1]. This situation is due to the political situation in this region. Anyway, to solve this problem, farmers try to store water in large tanks mounted on specific structure. However, this is against the law considering Oslo Accords where any construction activity needs permit from the Israeli side. [1][2]. Farmers, therefore, use another solution for collecting and reserving water, whereas they dig to make artificial ponds so as to collect water from rainfall, nearby artesian wells and any excess water. Artificial ponds are real good collecting technique, as it is an integrated way to collect and store runoff surface water from rainfall that runs on roofs of greenhouses. Agricultural plastic greenhouses are one of the facilities that can be used to collect rainwater. Each agricultural greenhouse with an area of 1 acre can collect about 300 cubic meters annually of fresh rainwater that suits for planting all kinds of crops, and they rely on artesian wells around them. However, they were prevented too by Israeli authorities for environmental reasons, since these ponds create many environmental problems. Such artificial ponds cause bad view, bad stinky smell and collecting many types of insects, flies, frogs, cockroaches, worms and the most dangerous are the insects and microorganisms that are attracted by the algae that is formed on the surface. These insects and microorganisms may carry viral and bacterial diseases that destroy the crops and affect their quality [3][4].

Here also farmers try to solve the growing algae problem by adding many types of fish like Tilapia, Lionhead, and Koi that feed on algae and some insects that the pond attracts. However, this solution is not suitable because it affects fish badly and killed it due oxygen depletion and polluted water. The excessive algae and phytoplankton growth due to the high levels of phosphorus and nitrogen, during the nighttime hours cause very fast death for these fishes. Additionally, as algae and phytoplankton die, the process of decomposition also requires significant amounts of dissolved oxygen [5]. If these blooms are dense or die, the impact to fish can be more severe and cause fish-kills. Moreover, shading that is caused by dense blooms limits photosynthesis and dissolved oxygen levels too at the pond bottom, resulting in a buildup of potentially toxic compounds, even in aerated ponds. This situation can lead to fish kills as well[6].Based on that, there is a direct need to treat the water in these ponds so as to address the current political, environmental and economic situation in Jordan Valley.

1.2 Literature Review

In general, algae pollution has become a global issue recently. The solution is to treat and control the growth of algae by such methods including biological, physical and chemical controls; each of which has its own benefits and disadvantages. While some methods are environmentally unfriendly and other methods are expensive. Zhang et al [7] studied the ultrasonic removal of Microcystis aeruginosa. It was chosen for study because it is a major bloom-forming and poisonous algae species and is widely found in natural waters. Similarly, Heng et al [8] reported the effectiveness of ultrasonic irradiation on algae removal by coagulation. . In addition to that, Wang et al [9] studied the removing of algae from lake water and its attendant water quality changes using ultrasound under different conditions. Moreover, Zhang et al [10] Introduced a new technology for effective removal of algae cells from the source water in water treatment works by Sonication-Coagulation. On the other hand, Ghernaout et al [11] studied algae and cyanotoxins removal by coagulation-flocculation. Due to that algae can cause significant disturbances including taste and odor, production of disinfection by-product, obstruction to coagulation, clogging of filter, and assimilable organic carbon for growth of biofilm in drinking water supply. Hu et al [12] studied the feasibility of using coagulation for treating slightly polluted algae-containing raw water of the Pearl River combining ozone pre-oxidation with poly aluminum chloride (PAC). It was concluded that O_3 pre-oxidation and PAC-enhanced coagulation have greatly increased the removal of algae, turbidity, and natural organic material compared with PAC coagulation only.

Hoko and Makado [13] presented sampling and analysis of parameters according to APHA standards. Jar tests simulated coagulation, flocculation and sedimentation to determine the optimum coagulant and algaecide dose, and contact time for removal of algae. They have shown that algal removal increased with increasing contact times increasing algaecide dosage and increasing settling. In the meanwhile, Shen et al [14] studied algae removal by drinking water treatment of chlorination coupled with coagulation. It was showed that the higher the algae density, the more the algae removed. They investigated that during algae outbreak period, 96% or more algae can be removed using the coagulant and chlorine of dosages of approximately 20 mg/L and 4.0 mg/L, respectively.

Phoochinda and Whit [15] investigated algae removal using froth flotation. It was reported that decreasing the pH values of the algal suspension, may increase the algal removal efficiency up to 80%. In another work, Kwon et al [16] studied removing of algae and turbidity by floating-media and sand filtration.. The filtration system removed more total phosphorous (TP), total nitrogen (TN), turbidity, chlorophyll-a (Chl-a) and COD_{cr} than dissolved organic carbon (DOC) and UV_{254}.

Finally, Shehata et al [17] claimed that algal removal rate increased when using oxidants combined with alum-potassium permanganate; this was the most effective treatment combination for algal removal.

Based on the reviewed research, there are several possible approaches to control algae. Management practices for nuisance algae are divided into two major categories: nutrient manipulation and direct control techniques. Nutrient manipulation, particularly reduction of nutrient inputs, should be viewed as the best approach for long-term control of algal problem. There are situations for which significant nutrient reduction is impractical or ineffective; under these conditions, direct control of the algal biomass may be the only alternative available. Direct control methods should only be viewed as temporary solutions and should be coupled with long term strategies for reducing nutrient input.[18]

Nutrient manipulation can be done for example by mechanical mixing (water circulation), using surface-mounted pumps. This mixing of the water column disrupts the behavior of cyanobacteria to migrate vertically in addition to limiting the accessibility of nutrients [19], the higher flow velocity through the impeller is more likely to damage algae. A safety net must be provided to ensure that any person accidentally falling into the water near the pump will not be drawn into the impeller. The disadvantage of the mixing or circulation of water is often the high maintenance required to the systems and the efficiency of the system reduced depending on the water quality [20]. However, if the circulation system is run an average of 12 h per day during the growing season, the total energy required is 1.89 $MJ/m^2.yr$ [21]. So all of these require high levels of water pumping, pond mixing, or aeration. Each technique has been demonstrated to reduce production of algae by decreasing the ammonia concentration in the pond, the reduced production associated with such techniques is usually insufficient to offset the increased energy costs and capital costs associated with the increased water pumping and aeration[22]. In the meanwhile, removing algae from lake water using ultrasound under different conditions could efficiently remove the algae. However, under 20 kHz with 30 W ultrasonic power and 360 s ultrasonic irradiation, the algae removal efficiency reached up to 96% when a low-concentration algae solution was considered[9]. In other studies, it shows that ultrasound was an effective method to remove algae from water with 80 W for power and 1320 kHz for frequency. Higher ultrasound power and higher frequency accelerated algae removal. Algae in the exponential growth stage were more sensitive to ultrasonic irradiation than those in the stable stage. High power and long irradiation caused microcystins release and increased the extracellular microcystins concentration, therefore, ultrasonic power below 48 W was recommended for use. [7]. The major disadvantages of UV disinfection are UV intensity decreases sharply with its passage in water and its decrease is even more significant with high water turbidity and thick plants algae structures can prevent ultrasound vibration to reach other parts of the water to be treated; microorganisms attached (hidden) to the suspended particles may escape UV irradiation and few algae types will not be affected by ultrasound because some colonial types are resistant to it, reducing the UV treatment efficiency; and microbial DNA, once damaged by UV, can be repaired via enzyme repair systems resulting in survival of the microorganisms.[23]

Direct control methods can be done using chemicals by coagulation method. It was approved that this method requires lower operating costs and little maintenance in terms of the biological operation[24]. The coagulant is rapidly and thoroughly dispersed on dosing by adding it at a point of high turbulence. The advantages of coagulation are that it reduces the time required to settle out suspended solids and is very effective in removing fine particles that are otherwise very difficult to remove[25]. The removal ratio of algae considers in many researches to be low, by potassium ferrate (K_2FeO_4) for example it was 92.5% with contact time set to 1 min, potassium permanganate ($KMnO_4$) also had a removal ratio of only 74.6% after 10 min of contact [26]. Removing algae with chemicals is considered also within nutrients manipulation treatment, which removes inorganic nitrogen and phosphate from aquaculture. This would prevent algae blooming since there is no phosphate or ammonia to feed on, which makes conditions not suitable for algae blooming any more.

Solar water pumping is based on photovoltaic (PV) technology that converts solar energy into electrical energy to run a DC or AC motor based pump. The use of solar photovoltaic energy in pumping is considered to be a primary resource for the countries located in tropical regions, where direct solar radiation may reach up to 1000 W/m^2. [27] The advantages of PV powered pumps are low maintenance, no pollution, easy installation, reliability, the possibility of unattended operation, and capability to be matched with solar radiation since, in most cases, water demand increases during summer when solar radiation is maximum. The disadvantages are the high initial cost and variable water production.[28]

Many authors have concluded the superpriority of PV based pumping system as compared to other choices such as diesel generator in remote areas [19-22, 25] Moreover, PV based pumping systems performance for agriculture application was also proven by other researchers such as [23-26]. Finally, the feasibility of PV pumping system was investigated and reported positively [27-28]

Based on that, in this study an efficient method for irrigation water treatment based on photovoltaic pumping system for artificial ponds in Jordan Valley is introduced. The method presented by a small PV-pump driven system that pumps chemical material into the water of the artificial ponds. The chemical material is pumped with high pressure to rotary nozzles that are fixed on the pipe which installed inside the pond with a specific depth so as to ensure distribution of the material to all corners of the pond.

2. Proposed chemical material for water treatment

In this research Tammun which is a village that is located in Tubas governorate is adapted as a case study. There are more than 300 – 400 artificial ponds in Tammun village valley with different sizes whereas they are in the range of (10-15) m length, (4-8) m width and (1.5-2) depth m.

In general, the farmers in this village create collecting-ponds to address the problem of water shortages. During summer, water in these artificial ponds is collected from five artesian wells around the village. In winter, water comes from excess water pumping from municipality and rainfall. It is worth mentioning that the rainfall in Palestine usually starts in the middle of October and continues up to the end of April. The amount of rainfall in the Jordan Valley and Dead Sea area has an average of 100 mm as a minimum value [29].

2.1 Sample collection and analysis

A specific site has been selected in this village and samples were collected from the site as shown in Figure (1) below, with storing temperature of (2 – 8) ^{o}C.

Figure 1: Capture of the site.

After that test analysis has been done in Analysis and Calibration unit at An-Najah National University, as shown in Table (1) below. According the test, the percentage of pH, SO4, PO_4, Cl, NO_3, Ca, Na, $CaCO_3$, K, TDS and Mg is within the range except for chemical Oxygen demand (COD) that was 7200mg/L which is very high as the allowable value is maximum 250mg/L [27].

Table 1: Sample testing results.

Test	Units	Results	Limits	Ref
pH	**--**	**6.76**		**SMWW***
Nitrate(NO_3)	**mg/L**	**1.3**		**SMWW***
Sulfate (SO_4)	**mg/L**	**30.1**		**SMWW***
Phosphate (PO_4)	**mg/L**	**0.8**		**SMWW***
Chloride (Cl)	**mg/L**	**100.0**		**SMWW***
Total alkalinity (as $CaCO_3$)	**mg/L**	**240**		**SMWW***
Total Hardness (as $CaCO_3$)	**mg/L**	**290**		**SMWW***
Total Dissolved Solid (TDS)	**mg/L**	**454.5**		**SMWW***
Calcium (Ca)	**mg/L**	**56**		**SMWW***
Magnesium (Mg)	**mg/L**	**36.5**		**SMWW***
Sodium (Na)	**mg/L**	**36**		**SMWW***
Potassium (K)	**mg/L**	**27**		**SMWW***
Chemical Oxygen Demand (COD)	**mg/L**	**7200**		**SMWW***

*SMWW: Stander Method of Water & Wastewater

COD is the amount of oxygen that is consumed in the oxidation of organic matter. It is used to measure the total amount of organic which formed due to high concentration of Phosphorus in the pond [30], high concentrations of phosphorus may result from poor agricultural practices, runoff from urban areas and lawns, leaking septic systems or discharges from sewage treatment plants, since it is considered vital nutrient for converting sunlight into usable energy, and essential to cellular growth and reproduction causing algae blooms.[31]

2.2 Proposed treating material

In this research it is aimed to conduct a nutrient manipulation to kill algae. According to many research phosphorus is the main reason for algae growing [30]. Thus, it is aimed in this research to develop a material that dissolve phosphorus so as to get rid of algae. To do so, Potassium aluminum sulfate is utilized. Potassium aluminum sulfate is a chemical (potash alum) with a chemical formula of $KAl(SO_4)_2.12H_2O$. This substance was particularly chosen because it gets rid of phosphorus which is the main reason for algae growing. This material was obtained after several laboratory experiments including using other materials that are common to be used in purification of algae, such as lime. Many researches show that the most used chemicals for controlling phosphorus in ponds, lime, and alum[24]. For lime, it was found that it is used for treatment of raw wastewaters and could affect an 80 to 90 percent removal of phosphorus, the use of lime as a coagulant appeared to be more efficient, it was also found that different steps of treatment removed different types of algae at different rates.

For alum, it was concluded that the use of alum as a coagulant is moderately effective in algal removal [24]. It includes many components, such as potassium alum sulfate that is chosen in this paper since the aluminum sulfate is a coagulant and the potassium is a very important fertilizer for plants[32][33]. Using lime alone caused a problem in the pH value that was measured and reached 12.3, since the normal pH value for irrigation water ranges from 6.5 to 8.4 [21]. To solve this problem, potash alum was added to adjust the pH value within the required limit, but that caused a problem in the volume of the material tank that became large, using potash alum alone was the last choice which gave good results and gave accepted pH value of 7.45 within the range and solved the problem of COD, that was decreased from 7200mg/L to 95mg/L. All the experiments were under laboratory conditions, at 25°C using small scale equipment. The chemical was added and then a rapid mixing to dissolve the chemical and distribute it evenly throughout the water to binds the phosphorous with the potash alum, and turned it as sediment in the bottom of water with a settling time of 15 minute. The purified water that contains the sediment should not be used in irrigation until the water is passed through a filter.

3. Design of Photovoltaic Pumping System

Solar water pumping systems may contain DC and AC motors. DC motors are direct coupling to PV generator. There are different varieties of solar pumps available in the market. According to water pumping requirement, solar water pumps may be subdivided into three categories: submersible, surface and floating water pumps.[34]

The PV power provided must cover the power demand of the pump adequately. This is determined by the relationship between the required discharge flow, the total head and the pump efficiency. This depends on the type of pump. Positive displacement pumps are preferred for large heads, whereas centrifugal pumps are most commonly used for this. In this article, a DC surface centrifugal water pump is used.[35]

The proposed PV water pumping system is designed using following steps; the first step is to decide tank, nozzle and pipes material, second step is to calculate the flow rate and the total dynamic height, then to calculate pump power required, and finally the PV generator capacity and the control of the system.

3.1 Materials selection

Many factors and constraints need to be considered in materials selection, which are the nature chemical material that is used, easy to use and the economic aspect. The tank, pipes, Rotary Nozzle and fittings material are PVC plastic since it is available, does not react with other material like metal and steel [36] and since it is lighter, easier to shake in the tank and cheaper than metal and steel.

The required number of rotary nozzle is estimated to be three nozzles, since one of them can cover a distance of 5m with radius of 360^{o} and working pressure of 2.4 bar. It is suitable to overcome the total pressure exerted against the inlet area 0.5″ of the nozzles which is almost equal 1.8 bar.[37]

3.2 Flow rate

The flow rate was calculated using the following equation[35]

$$Q = \frac{V}{t} \tag{1}$$

Where Q is the flowrate, V is the volume of the supply tank of chemical substance and t is the time to empty the tank.
To estimate the diameter of the pipe, the velocity (v) is set to be in the recommended range for centrifugal pump suction and discharge velocities which is range between (0.6-1.2) m/s, and (2.1-7.6) m/s respectively for both suction and discharge range respectively[35].

The pipe chosen is PVC (40 schedule) and its cross sectional area calculated using the following equation[35]:

$$Q = VA \tag{2}$$

Where Q is the flowrate, v is the velocity in the pipe and A is the cross sectional area for the pipe. The results above match with centrifugal pumps rules:

$$D_{\text{suction.}} > D_{\text{Discharge}} \tag{3}$$
$$V_{\text{suction.}} < V_{\text{Discharge}} \tag{4}$$

3.3 Total Dynamic Head

Then, total dynamic head (TDH) is calculated, TDH is the total equivalent vertical distance that the pump must move the water, or the pressure the pump must overcome to move the water to a certain distance as shown in Figure 2. [38]

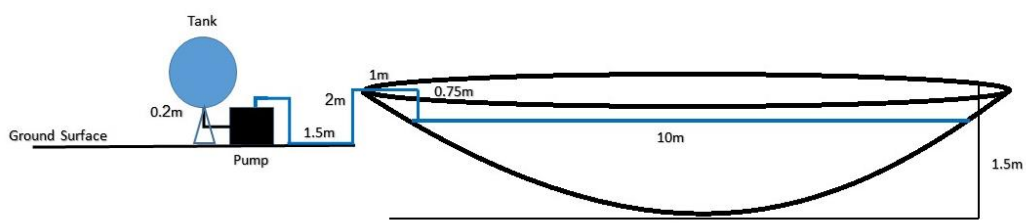


Figure 2: The typical head of the water pump.

The losses in pipes was calculated as follows:

$$R_e = \frac{vD}{\mathrm{U}} \tag{5}$$

where R_e is Reynold number, v is the velocity in the pipe, D is the diameter of the pipe and U is kinematic viscosity, which is 1.31×10^{-6} m²/s for the chemical solution.

The friction coefficient (*f*) can be found using a modified equation:

$$f = \frac{0.25}{[\log(\frac{k}{3.7D} + \frac{5.74}{Re^{0.9}})]^2} \tag{6}$$

where k is roughness coefficient for PVC pipes, which is 0.0015mm, D is pipe diameter, Re is Reynold number and L is the length of the pipes.

To calculate dynamic head losses in the pipes DH, equations (7) and (8) are used:

$$DH = \frac{K\,v^2}{2g} \tag{7}$$

Where K is the resistance coefficient, v is the velocity in the pipe and g is the acceleration due to gravity.
And to calculate K for the pipes, equation (8) is used:

$$K = \frac{fL}{D} \tag{8}$$

Where K is the resistance coefficient, *f* is the friction coefficient, L is the pipe length and D is the diameter of the pipe. K for suction and discharge is 0.405 and 67.15 respectively. For the pipe, DH is calculated for suction and discharge and it equals 7.44×10^{-3} m and 15.11m respectively.
The losses in fittings $K_{fittings}$ and DH has been calculated. Where K is the total resistance coefficient for fittings and equals 13, since it equal 1 for non-return valve (1 Item), 2 for Tee Branch flow threaded (3 Items), 1.5 for 90° Bend Threaded (7 Items), and 6 for water meter turbine wheel[39]. The total dynamic head (HD) for plastic PVC fittings is 2.92 m and 0.11 m through water meter. Using Bernoulli equation to get the value of TDH [35]

$$\frac{P1}{\gamma} + \frac{v1^2}{2g} + Z1 - hl + ha = \frac{P2}{\gamma} + \frac{v2^2}{2g} + Z2 \tag{9}$$

where P is pressure $P_{1\text{-}tank}$=13.005 Psi (89.7 kPa) and $P_{2\text{-}nozzle}$= 26.175 Psi (180.5 kPa), γ is the specific weight of the material which equals ρg where ρ is the potash alum solution density (1725 kg/m^3), ha is the head loss, v is the velocity of the fluid at the inlet/outlet, z is the elevation of the point above a reference plane that is specified and g stands for the magnitude of the acceleration due to gravity = 9.81m/s^2.

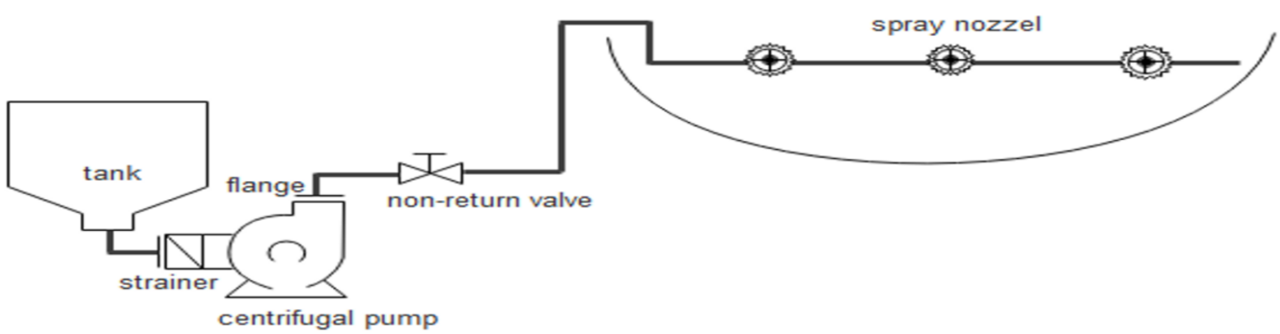


Figure 3: Mechanical diagram of the system.

3.4 Pump Selection and PV sizing

There are several types of electrical motors that can be utilized to run the pump such as ac and dc. DC motors are an attractive option because of their compatibility with the power source and because their efficiency is usually higher than that of ac motors [28], therefore DC motor was used.

The size of the water pump is calculated based on the following equation [40]

$$P = \frac{Q\, H\, g\, \rho}{(\eta)} \tag{10}$$

Where P is the pump power, Q is the flowrate, H is the total dynamic head, ρ is the potash alum solution density (1725 kg/m^3), g is acceleration gravity (9. 81m/s^2), and η is the pump efficiency.

3.5 Control System

It was considered that the system will turn on manually using a switch and turn off automatically using sensor, Relay, and Arduino. The water flow sensor consists of a plastic body called turbine wheel water meter, the flow of the rotor assembly and the Hall sensor. It will install in the pump inlet at a water tank end for detecting water flow when the water flows through the rotor assembly. The magnetic speed of rotation of the rotor and with the flow rate changes, the Hall sensor output corresponding pulse, signal feedback to the controller, which will automatically turn off the system. A sensor with an equivalent number of pulses flow through a premium output Voltage (3.5-12) V_{DC} and with current cannot exceed 10mA considered. Ends stream output 450 pulses for a liter of water, so, for this system it will equal 9000 pulses for 20 litter recommended in order to give the feedback signal.

Relay (SPDT) and Arduino (UNO) with a battery were used in the system to automatically turn off the pump after sensor feedback signal. They require a maximum voltage of 8v to operate. Choosing a panel which has a rated voltage of about 4 or 5v than the max voltage required by the system as a rule of thumb. This is because Solar panels are not very efficient and will always exhibit voltage lesser than rated and it might get worse in non-optimum conditions such as cloudy or under shade, and because the water pump holds the priority to connect alone to the solar panel since it will consume more current than any other blocks in the system, therefore 9V battery was connected to relay, water flow sensor and Arduino to ensure that they will work. Figure (4) below shows the electrical connection for the system component.

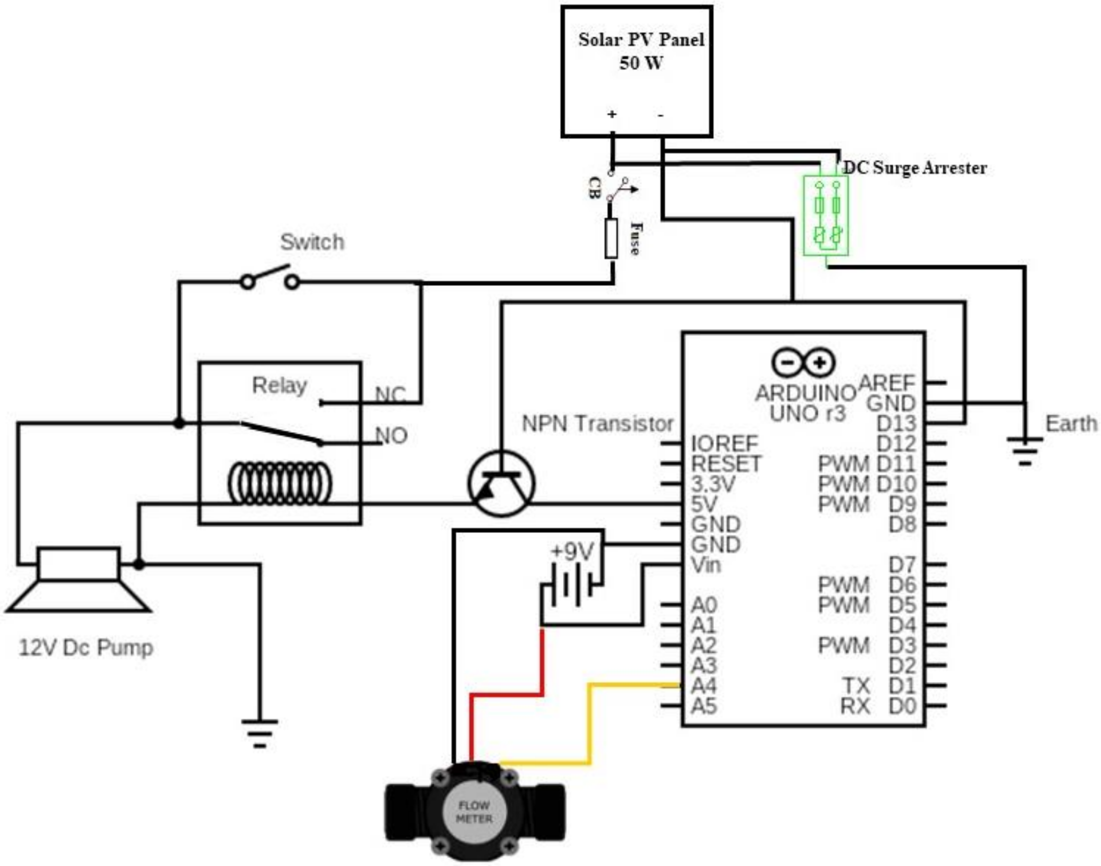


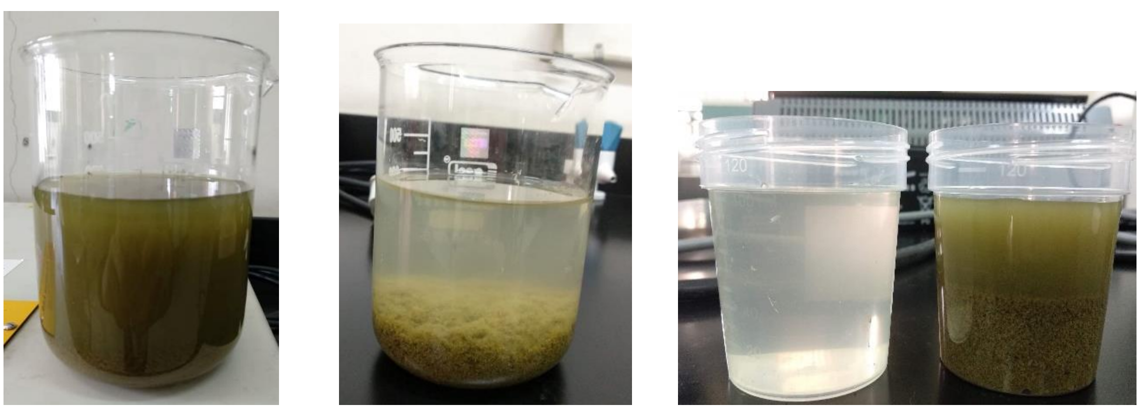
Figure 4: Electrical diagram of the system.

4. Results and discussion

Testing was done in lab temperature at 25 ^{o}C using the following tools, 200mL and 100mL Beakers containers for mixing chemical material and sample pond water, Dropper to add the chemical material to the purified water, a balance which is used to weight chemical material, and Safety goggle, gloves and lab coat.

Jar tests showed that a potash alum with water dose of 14g in 100mL of clean water and by shaking it rapidly. Then, to add 0.5mL mixture with a concentration of 0.295 mol/L in 200mL of untreated pond water and mix it to ensure the solubility of the material in it. This was sufficient to decrease COD value from 7200 mg/L to around 95 mg/L. The case study pond has a volume of 120,000 L, so the dosing volume material needed to be 300L in order to achieve the goal for both algae removing or algae prevention blooming. The tank volume of 20 L is considered since the commercial tanks are used to be that volume, and so to be easily carried by the farmer and to shake it. The pumping time will be in the sun peak hour which is 3hours, so in order to finish the 300L dose in that time the pumped time set to be 4 min, so that the flow rate estimated using equation (1) to be 0.083×10^{-3} m^3 /sec. The type of pipe chosen is PVC (40 schedules) which can handle 10 bar with nominal pipe size for suction and discharge found to be 0.75″, 0.5″ respectively according to equation (2) and the velocity for suction and discharge is set on 0.6 m/s, 2.1 m/s respectively. Reynold number (Re) for suction and discharge is 6077.86 and 11381.6 respectively using equation (5). The friction coefficient (*f*) for suction and discharge is 0.03585 and 0.03027 respectively by using equation (6). The total dynamic head (TDH) for pipes is 15.11744 m, then Head loss (ha) was calculated from equation (9) and equals almost 20 m.

All pumping is assumed to be completed using an electric centrifugal DC pump with an overall power calculated to be 36.11W according to equation (10) with efficiency of (77%)[35]. Since energy loss from Solar panel ranges is (30-35) %. A 50-watt photovoltaic foldable solar panel is chosen; it was showed that the PV size can meet the assumed pump load demand. Figure (5) (a) و (b) and (c) below shows the purified water before treatment, after treatment and the dead algae precipitated and after getting rid of all algae participated and filtering the treated water.



(a) (b) (c)

Figure 5: The purified water result a) - Before treatment. b) - After treatment and the dead algae that was precipitated. c) After getting rid of all algae participated in the bottom and the water became pure.

4.1 Economic Analysis

Table 2 shows an economic analysis and overall costs per unit of the designed system using present method.

Table 2: Economic Analysis.

Estimated Parts	Required Parts/ unit	Cost/ Parts
Centrifugal Pump	1	$50.00
Plastic tank (20L)	1	$4.96
Pex pipes (16mm, PE)	18 m	$4.96
90^{o} elbows (elbow joiner)	7	$1.65
T-elbow	3	$1.65
Non-return valve	1	$3.31
nozzles (rotor sprinkler)	3	$9.92
Chemical material ($KAl(SO_4)_2$)/Bottle	2.8 kg	$32.40
Tank stand	1	$5.56
End line	1	$0.28
Screw	4	$1.10
Arduino, Relay and switch	1	$16.53
Sensor flow meter	1	$13.77
Clipper	1	$0.28
Circuit Breaker, DC Surge Arrestor and Fuse	1	$13.77
Joints at inlet and outlet of the pump (coupling)	2	$1.10
Foldable 50Watt solar panel	1	$50.00
Total Price = $213		

5. Conclusion

In this paper, an efficient irrigation water treatment based on photovoltaic pumping system in Jordan Valley has been designed as shown in figure (6) above. A case study for a pond in Tammun village valley was selected and discussed. A well-designed PV water treatment pumping system is an attractive solution for ponds based on the results compared between the conventional pond and the proposed treatment using chemical material. As a result, the total estimated cost of the proposed system is 213$ and it is powered by a 50W foldable solar panel. Such a system is expected to serve the pond's algae blooming problem especially the ponds in Jordan Valley in Palestine. The result of this work should encourage the government for wide installation of the system to keep the environment clean and healthy.

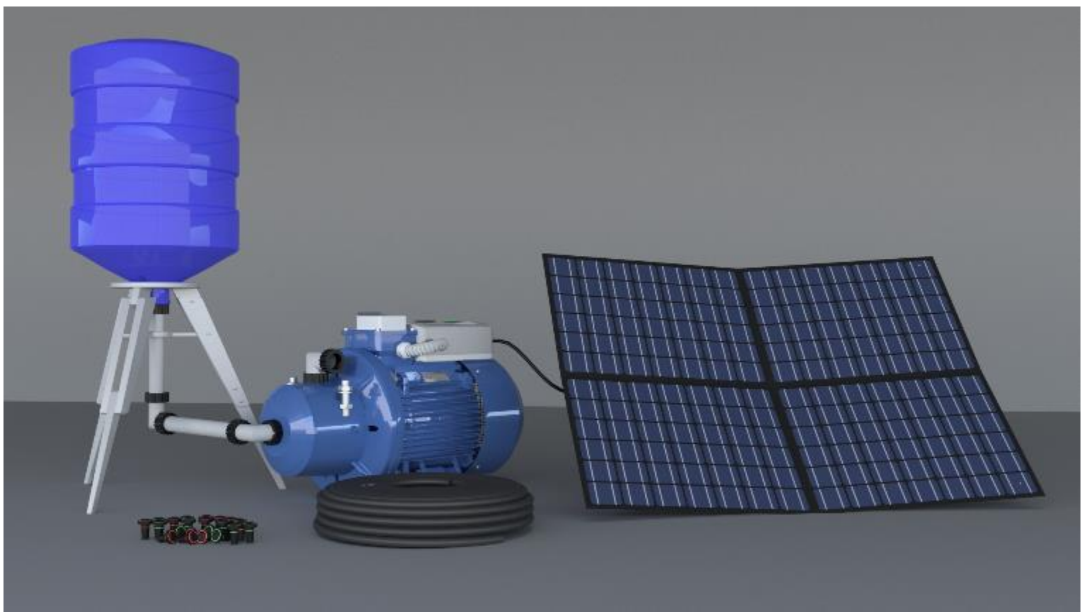


Figure 6: Proposed Design of the product.

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