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Received on: 15/07/2017
Accepted on: 05/02/2018
Published online: 07/10/2018

Design a Gray Water Treatment System for a Virtual Building Working by Solar Energy

Abstract- This work has showed that gray water can be used in irrigation with great success. It includes the explanation of how water recycling will save water for irrigation and agriculture use, reduce the costs of constructing purification plants, and add natural filters to the environment. It also aspires to invite companies to reduce the proportion of phosphate and other harmful substances in the composition of soap. In addition, it is possible to reduce the amount of suspended solids in a gray water by installing filters on the washing machines themselves, so that the volume of problems in the plankton is reduced at the refineries. It was found that the decrease in the consumption and rationalization of electric energy was observed for other purposes using the solar cell system, which is considered as a source of power supply system.

Keywords- Gray water, solar energy, BOD5, COD, TOC, Oils and fats.

How to cite this article: Kh.M. Essa, H.A. Mahdi and M.H. Mohammed, "Design a Gray Water Treatment System for a Virtual Building Working by Solar Energy," *Engineering and Technology Journal*, Vol. 36, Part C, No. 1, pp. 79-85, 2018.

1. Introduction

Reducing water consumption and protecting water quality are the main objectives of Green building [1,2,3,4] and from critical case is to increase the water consumption and water shortage expecting in our country in future. Therefore, institutions must increase their depending on water that is collected, using them and purified, and reuse to the maximum possibility frontier. It can protect and conserve water throughout the life of a building by designing a dual plumbing system that recycles water in the toilet [5,6,7]. However, the advantage of using recycled water (treatment) is to improve water quality and energy efficiency. Therefore, the use of treated wastewater for irrigation and other uses reduce demand for potable water. Gray water is medium water between pure clean water (white water) and wastewater (black water), examples for grey water, laundry water, shower and plunge water, and water from laundry in washing machines [8, 9]. It is semi-pure water, because it is clean water mixed by washing with some oils, soap and simple pollution only, some evaluation statistics the percentage of gray water out of the total water used in homes is about 55% [10]. As well as it contains low pollution ratio of organic matter, nitrogen, microbes and bacteria. Therefore, it is easy to deal with during the stages of purification and lower costs of treatment compared to sewage

water, in addition recycling and reuse is harmless to the environment and health. It is possible to install purifier's devices and recycling at home for this purpose, opposite black water requiring large and complex processing plants. There are many new technologies and innovations registered in the world that enable gray water purification and reduce in many fields, perhaps the most important is the use of irrigation gardens and plantations, and return them for use in boxes for packing (Siphon water). In reality, there are new technologies that enable gray water to be restored, as it once was, pure and potable. For connection between the gray water treatment system and PV solar powered pumping equipment to be energetically and economically efficient, Efficient use must be made of the water resource, i.e, only the amount of water needed for the irrigation should be raise [11].

2. Description of the Design System

The system is designed to treatment gray water that resulted from washing process in a government building, then using this treatment water to irrigate a virtual building, it working by solar energy generated from solar panels, which leads to reduce the dependence on traditional energy in generating electricity, as well as reduce the environmental pollution resulting by throwaway of gray water to river and reduce water consumption. When dependent the value of

different concentrations of BOD₅, COD, TOC and TSS before and after tests for any persona Daily in America that show in Table 1[1], notes a decrease significant of concentration BOD₅, COD, TOC and TSS After treatment.

A typical scheme of gray water system comprises gray water collection tank, pumps, filters and water treatment tank (Figure 1).

Table 1: Characteristics of Gray water before & after treatment from concentration by Mg/l for any persona in the day [14]

Grey water (mg/l)	Properties	
	Before	After
BOD ₅	20-34	10
COD	48	25
TSS	18	10
Tot.N	0.9-1.6	Nil
Tot.P	2.5-3.1	Nil
PH	9.5	6-8.4
Oils & Fats	30	Nil

The bacterial properties of water after treatment should be 2.2mg/liter of coli bacteria.

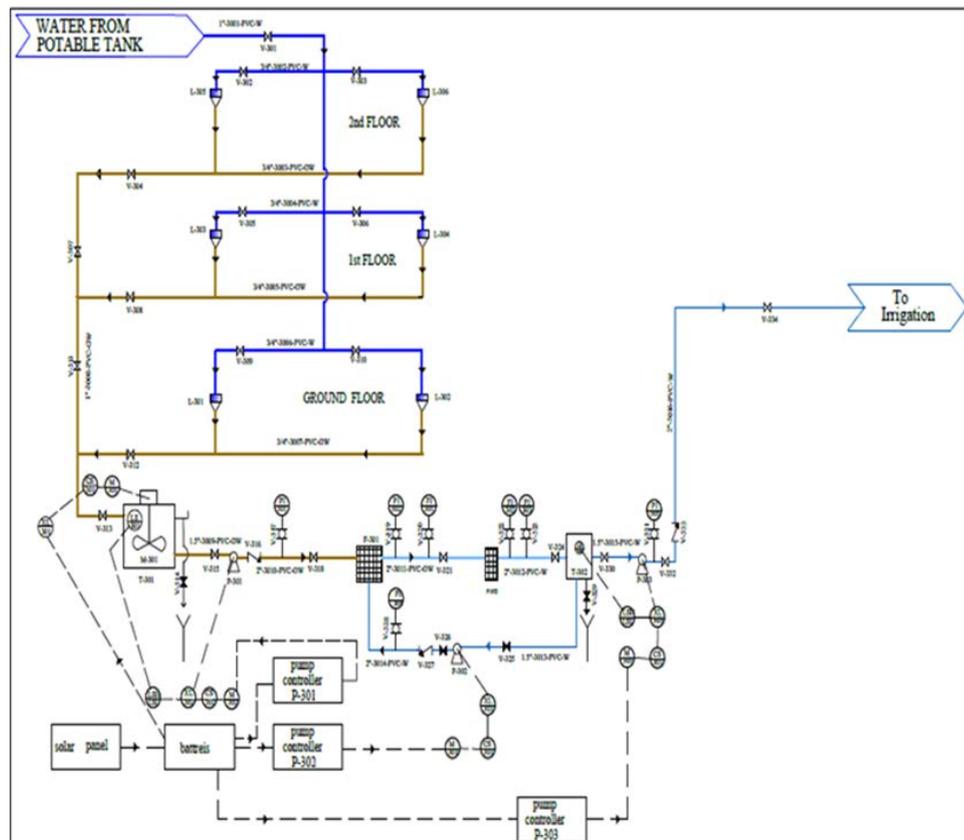


Figure 1: Schematic of Gray water Treatment System (piping and instrumentation)

The gray water is assembling in the tank contains a mixer for homogeneity the gray water collected which leads to sedimentation solid suspension (hair and fiber) at the bottom of the tank and floating dissolved materials such as fats and soap on the surface of the water, and then water is pumped to sand size filter to remove any other suspended solids, then pumped to carbon filter for remove contaminants, impurities, taste and odor from water, then the water treatment collection in the tank Treated water can be used directly for irrigation. The sand filter is washed by treated water with a process called Back Washing Process. Gray water is collected from bathroom for the three floors to the gray water tank by a network of PVC pipes, valves and fittings, pressure indicator; flow meter .The size of pipe required depends on the flow rate of water in the system. First surface pump of DC type 12-24 v, working by solar panel with 150W, model PS150BOOST240 delivery volume of 870l/h, delivery head 30 m and the second surface pump of DC type 12-24 v working by solar panel with 65 W , model PS150BOOST240 delivery volume of 900 l/h, delivery head 5 m, third pump of surface pump of DC type 12-24 v working by solar panel with 150 W, model PS150BOOST240 delivery volume of 870 l/h ,delivery head 30 m. gray water tank made of PVC with volume of 10 m³ consist of mixer type 621, made of S. St with capacity 0.07 m³ , flow rate 70 m³/hr and motor 1000 rpm, working by solar pane 300 w, treated water tank made of PVC with volume of 10 m³ .There are different types of filters ,Sand filter with Filtration rate, volume 2 m³ and length 1.5m , carbon filter with Filtration rate, volume 0.2m³ and length 0.5 m [12]. This design was adopted government building consists of three floors, on each floor there are two bathrooms; one of them is for men and the other for women. The building is used by 200 people, system works for 5 hours a day and 5 days per week and 15 liters grey water per day for person , 3000 liters per day for 200 people. There are two stages in this work:

1- Determination of the gray water treatment requirements.

2- Determination of the peak photovoltaic power required to system.

The pipes system is designed to be separated from the main pipe line of the building, the bathrooms of each floor were connected in parallel to each other by pipes diameter 0.75 inch and connected the bathrooms of each floor respectively with a main pipeline diameter 1 inch. A pipes network was used to transport the gray water to the gray water tank. These pipes connect

the bathroom for each floor. These pipes are connected to each other with gate valves.

In the first surface pumps a gray water passing through by sand and carbon filters from grey water tank with volume (10 m³) to Water treated tank with volume (10 m³) at 3.5 hours and operating 5 days in week. If the pressure drop between inlet and outlet filters it higher ,this mean the filters are dirty, and its need cleans by using circulation washing pump .The third surface pump pumps water from Water treated tank to irrigation. Grey water tank, pumps, filters, water treated tank and irrigation system are connected by plastic pipes with diameter 2 inch, On the pipelines used different valves (Gate, Ball and Check) with pressure and flow indicators.

I. Design of mix agitator

The calculation of agitator depended in turbulent state, Rt 104, and Newtonian liquid, the power consumed by an agitation mobile in the absence of whirlpool formation can be written [13].

$$P = N_e \times (N / 60)^3 \times d^23 \times \rho \times 103 \quad (1)$$

The flow rate of an agitation impellor, which governs the number cycle, fluid speeds within the agitated liquids and, in general, the agitation intensity is given by:

$$Q = N_{qp} \times d^23 \times n \times 60 \quad (2)$$

II. Design of solar power system

In order to sizing the solar system , we need to note the power rating of each appliance that will be drawing power from the system .Table (2) represented the stand alone electric load, the total power usage daily equal to 1288W.H then the power value determine the size and number of panels.

Table 2: Stand-alone electric load

Load	Qty	Wattage	Use Hrs/day	Use Days / week	÷	Watt.hrs
Surface pump	1	65	1	1	51	13
Surface pump	2	150	4	5	5	1200
Mixer	1	300	0.25	5	5	75
DC Average daily load						1288

The average daily load value will be increase by the batteries is not 100% efficient and other losses occur in a system. five number of PV panels are used in the system, and the power output of each panel 80 w, five rechargeable battery having of 65 A.H are used in the system,

The required capacity of the batteries is determined on the basis of the daily power consumption and the minimum number of days for which the system can still be in effective operation under overcast weather. The result shown in wiring diagram for PV powered gray water treatment system shown in Figure 2.

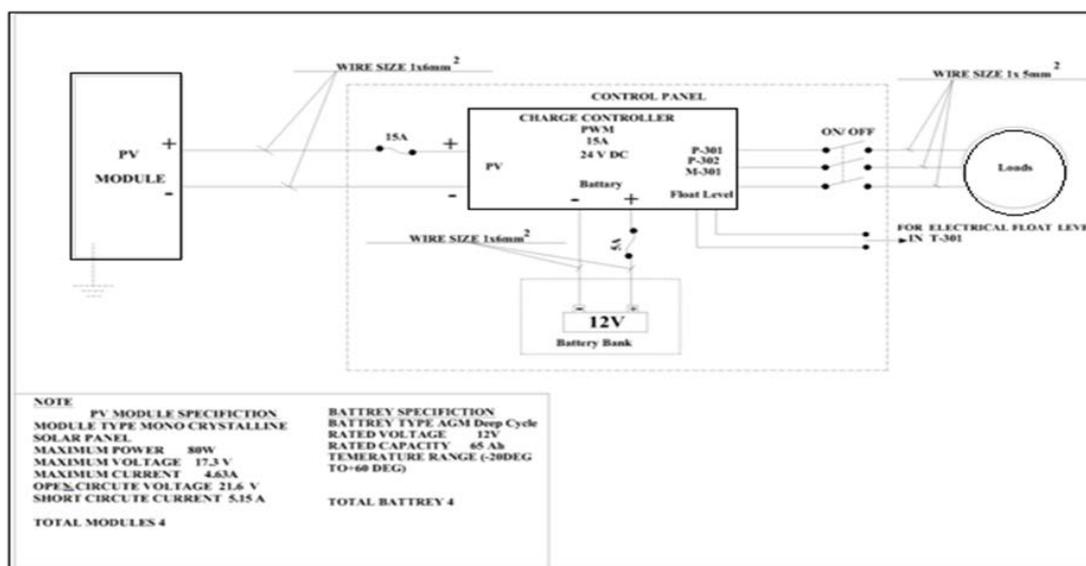


Figure 2: Schematic electric wiring diagram

3. Devices Used

The devices that used to measuring the properties of gray water (BOD5, TOC, TP and TN) after treatment:

- 1- Digester: The samples put in the digester to measurement total P, Nin period times.
- 2- Photo Flex: Using for measurement the principles of TP and TN for the gray water in period times after digesters it.
- 3- BOD measurement: Using for determination of BOD5 for the gray water in since period time.
- 4- TOC analyzers: Using for measurement total organic carbon (TOC) for samples.

4. Results and Discussion

Laboratory experiments were carried out on different concentrations of BOD5, COD,

TOC and TSS within the field of gray water concentration, as shown in the block diagram below, Initially the process is sedimentation of suspended materials and fats from the water, Secondary process of filtration by using two types of filters, sand filter and carbon filter to remove of suspended solid residues and odors respectively. The change in ratio of suspended solid, organic carbon, chemical dissolved materials and biochemical demand (TSS, TOC, COD and BOD5) of gray water when compared it before and after treatment from the result is shown in Table3.

Table 3: Characteristics of Grey Water before & after treatment from the result of Experimental process

Test Date	In				Out			
	TSS Mg/l	TOC Mg/l	COD Mg/l	BOD5 Mg/l	TSS Mg/l	TOC Mg/l	COD Mg/l	BOD5 Mg/l
2/7	25	40	74	37	10	2	25	10
16/7	28	43	76	32	11.2	2.1	24.7	10.3
28/7	32	48	82	42	12.8	2.4	26.2	11.7
2/8	23	36	72.5	36	9.2	1.8	25.3	12.6
16/8	32.3	48.6	84.3	45	12.9	2.4	29.5	10.3
28/8	27.4	43.7	81.7	38	10.9	2.1	28.5	10.6
2\9	23.8	38	72.6	40.6	9.5	1.9	25.4	11.3
16\9	23.2	34.7	68.7	32.6	9.2	1.7	24	9.1
28\9	24.7	38.6	73.8	35.7	9.8	1.93	25.8	9.9
1\10	28	43	80.2	42.8	11.2	2.15	28	11.9
15\10	26.4	40.5	79.4	39.2	10.5	2	27.7	10.9
28\10	23	38	72	36	9.2	1.9	25.2	10

In addition, especially increased in the concentration of BOD5, COD, TOC and TSS after treatment, which means the possibility of treatment of gray water with this method and the use of water after treatment for irrigation and others. We note from the charts Figures 4,5 and 6 that obtained it from the result, the change in the values of chemical and physiological properties of the gray water before and after treatment, where we note the decrease in the values of BOD5 for readings for every 15 days and for a period of 4 months by 32% and COD removal rate of 53% and also note the values of TSS by removing 48%

This indicates the effectiveness of the sand filter to remove solid organic compounds and plankton and reduce all organic compounds. This reduces the contaminants in the gray water before treatment. As for the BOD5, removal after the carbon filter it was observed 73% and the COD removal rate was 66 % and percentages TSS removal was 60%. We conclude that through the carbon filter, dissolved and insoluble organic pollutants were removed and reduced contaminants in the resulting water. Good quality water was obtained which could be used in agriculture and water with an acceptable odor to supply the fountain.

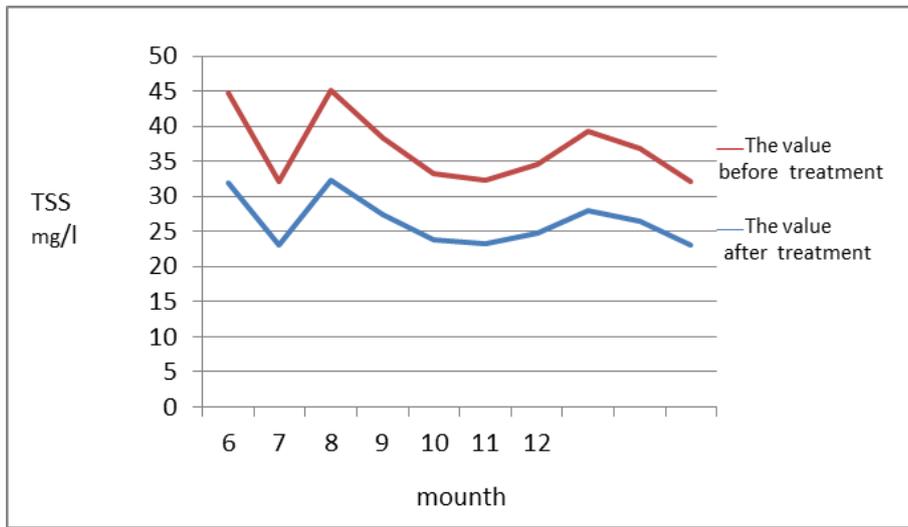


Figure 3: The relationship between TSS and months of work

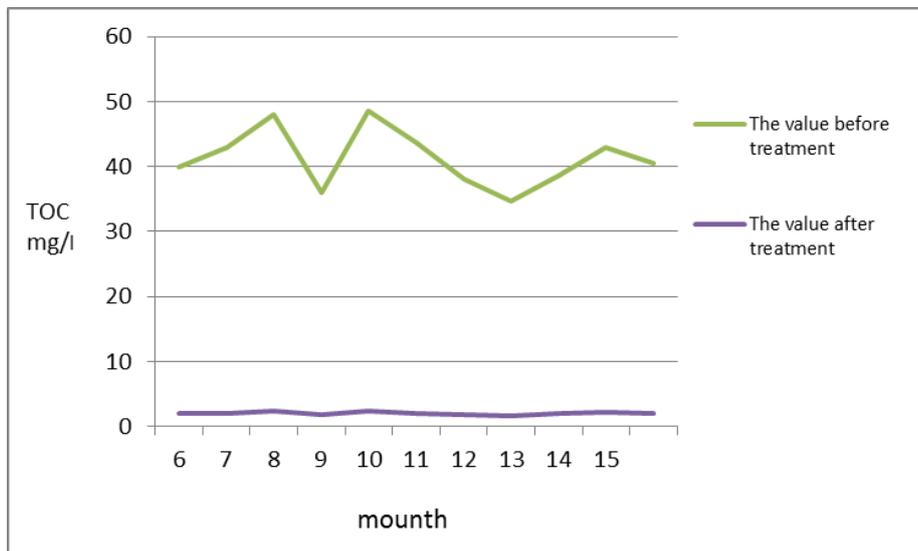


Figure 4: The relationship between TOC and months of work

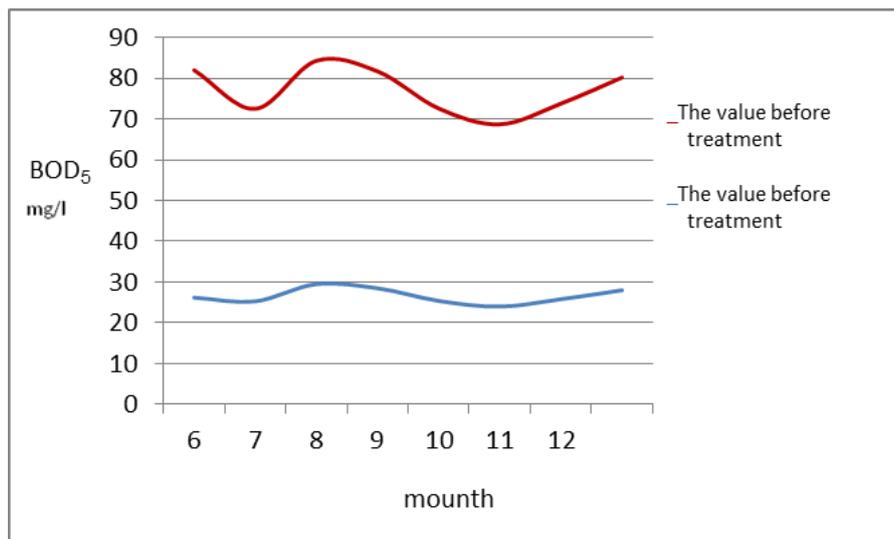


Figure 5: The relationship between BOD₅ and months of work

5. Conclusion

- 1- Choose another period time and show the effect this time with removal ratio of BOD₅, COD, TOC and TSS.
- 2- Design a larger processing system by providing the largest number of solar cells.
- 3- Possibility to design black water treatment system by using the same principle.

6. Nomenclature

C Friction coefficient (130 for PVC pipes)
 d Inside diameter of the pipe (m)
 n Number of emitters
 q Emitter discharge (liter / sec)
 Pd Head losses in meter of water per meter of pipe
 Q Flow rate in pipe (m³/ sec)
 HL Pressure head (m)
 Ne Power number
 N Speed in rpm (min.-1)
 d₂ Diameter of the agitation head (m)
 ρ Density (Kg/m³)
 N_{qp} Flow factor (depended on the type of agitation impeller)
 BOD₅ Biochemical oxygen demand
 COD Chemical oxygen demand
 TOC Total organic carbon
 TSS Total solid suspended
 Tot.N Total nitrogen

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