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The Treatment of Musi River Water Sample using Slow Sand Filter and Ultraviolet Radiation (UV) with Solar Cell Power Sources

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ABSTRACT

The Musi River's water is typically used to meet everyday needs. However, because of the current high population and activities, industrial and domestic garbage are being dumped straight into the Musi River. The purpose of this research was to study the variables that affect the processing of the Musi Riiver Water Samples to get the quality standard requirements of the third-grade river water. Water is filtered using a slow sand filter with a 50–70 cm sand height fluctuation and four different UV irradiation times 15, 30, 45, and 60 minutes. The results of this investigation showed that 2% DO was obtained for the filtration of Musi River water using a slow sand filter with a height of 70 cm sand. BOD_5 and COD degradation were determined to be 82% and 93%, respectively. Meanwhile, 29/100 ml of E. Coli was discovered for the UV radiation therapy after a 60-minute irradiation period.

***Keywords**: musi river, filtration, slow sand filter, UV radiation*

ABSTRAK

Air Sungai Musi biasanya digunakan untuk memenuhi kebutuhan sehari-hari. Namun karena tingginya jumlah penduduk dan aktivitas saat ini, sampah industri dan domestik banyak dibuang langsung ke Sungai Musi. Tujuan penelitian ini adalah untuk mempelajari variabel-variabel yang mempengaruhi pengolahan Sampel Air Sungai Musi untuk mendapatkan persyaratan baku mutu air sungai kelas tiga. Air disaring menggunakan saringan pasir lambat dengan fluktuasi ketinggian pasir 50–70 cm dan empat kali penyinaran UV yang berbeda yaitu 15, 30, 45, dan 60 menit. Hasil penelitian menunjukkan DO 2% diperoleh untuk penyaringan air Sungai Musi menggunakan slow sand filter dengan ketinggian pasir 70 cm. Degradasi BOD_5 dan COD ditentukan masing-masing sebesar 82% dan 93%. Sedangkan E. Coli sebanyak 29/100 ml ditemukan setelah radiasi UV setelah masa penyinaran 60 menit.

***Kata Kunci**: sungai musi, filtrasi, saringan pasir lambat, radiasi UV*

I. Introduction

Musi River is a river that exists in the province of South Sumatera. With a length of 750 km, this river is the longest river in Sumatra Island and separated from Palembang City into two parts. Ampera bridge that became an icon of Palembang city across this river. Since the area of the Sriwijaya kingdom until now, this river is famous as the main transportation for society. This river separated the city Palembang into two parts: an area that is downstream across in the north part and across the pit in the south part. Musi River with the other rivers, make a delta close to Sungsang City. Based on the results of the exploration by (Abia et al., 2016), it was concluded that the river is largely defiled by index and pathogenic organisms and the use of undressed river water will pose a high implicit threat of infection. The threat of infection due to the use of this water for particular and ménage purposes increases in the stormy season compared to the dry season. Most importantly, conditioning that affects deposition disturbance will increase the threat of infection for river addicts.The topmost hazard associated with the ingestion of water is the microbial risk due to water impurity by human and/ or beast feces. Drinking polluted water results in thousands of deaths every day, substantially in children under five times of age in developing countries. These conditions caused by consumption of polluted water, and poor hygiene practices are the leading causes of death among children worldwide, after respiratory conditions. Therefore, lack of safe drinking water force, essential sanitation and hygienic practices are associated with high morbidity and mortality from excreta related affections. Based on Public Health Hazards Due to Unsafe Drinking Water article, Ensuring water quality and safety requires the active participation of all stakeholders in the medical community. Nevertheless, the maturity of healthcare professionals have entered limited training in the evaluation of waterborne conditions. Lack of safe water to meet diurnal requirements is a reality for numerous people around the world and has serious health consequences. The situation is getting worse due to population growth, urbanization, and increased domestic and artificial water use described by (Pal et al., 2018). Contact with drinking or unsafe water can cause problems or serious risk to human health . Hence, water quality is a critical issue to insure public health. Since water is nearly associated with diurnal mortal conditioning, delivering safe drinking water is one of the important public health precedences. Acceptable access to safe water, perfecting quality of water source, treating ménage water, and storing it safely, acceptable sanitation installations, and encouraging good hygiene practices, especially hand washing can help waterborne conditions (Bain et al., 2014). The growth of the human population has caused the increase of human needs. To fulfill the human needs which vary, societies built their houses at the river side. In certain areas in Indonesia, the scarcity of clean water still frequently appears, including in big cities and finally the society utilizes water to survive so they are using water at the riverside which is containing dirt. The Musi River is a natural resource that is becoming one of the main lines of trade and the largest supplier of water for the residents of South Sumatra. Regional Water Company (PDAM) of Tirta Musi utilizes the Musi River as a source of raw water to fulfill the water needs of the population. The total customer of PDAM Tirta Musi has as much as 198.000 connections, or equal to 95% of the needs of clean water in Palembang. The need for clean water in the city of Palembang increased to 272 m3/day during the dry season. The river conditions declining quality and the quantity can be seen from the watershed which has increased critically. Currently, At the upper part of the river Musi there is a crowded residential area in the city of Palembang with the flow of Musi River that through the settlement, where the activity of citizens in river waters is still quite high, including the activities of washing, bathing and defecating, where many peoples dispose their leftover food, garbage and dirt or feces, both human and animal waste, even the activity of boat washing. High activity in river waters can also affect the quality of the river water, even causing pollution of the river water. Surely, this condition will affect the people who live in the river, considering there are many activities of the community in the river waters (*Spatial Analysis of Water Quality in Area of the Riverbank of Musi River in Palembang City*, 2020). The Musi River water samples would be processed by using a slow sand filter and UV lamp radiation taken from the locations under the Ampera Bridge where more than 12 million people live. The river was selected for the present study because it is heavily polluted with domestic and industrial wastewater. About 300 million liters of sewage join the river every day and there is no base flow contribution even during the monsoon season (October-December). Thus, slow sand filtration has been honored as an applicable technology for drinking water treatment in rural areas and is honored as a suitable filtration technology for taking off water dropped pathogens and reducing turbidity. It's able to perfect the physical, chemical, and microbiological quality of water in a single treatment process without the addition of chemicals and can produce an effluent low in turbidity and free of bacteria, spongers and contagions (Guchi, 2015). Filter media leaching was noticed in the trials; thus, filter media and construction two-pilot scale of material selection must be carefully evaluated to eliminate risks of pollutant occurrence in drinking water (Sabogal-Paz et al., 2020). Other research obtained two SSF to have revealed the occurrence of pharmaceutically active compounds (PhACs) in surface water as well as in groundwater (D'Alessio et al., 2015). The effectiveness of the purifier to remove *E Coli* and reduced turbidity varied and was generally high at different purifier depths and flow- through classes. This can be attributed to the conformation of Schmutzdecke on the sand outside and the adsorption process. Effectiveness variation of sand purifier to remove *E. Coli* at 0.3 m, 0.6 m and 0.9 purifier depths and at 200 L/hr.m2, 300 L/hr.m2, and 400 L/hr.m2, inflow- through classes isn't significant. It signifies that a slow sand purifier is effective in removing *E. Coli* at these depths and inflow rates. Natural exertion and protistan cornucopia on the top subcaste of the Schmutzdecke along with adsorption and mechanical trapping of microorganisms could presumably be the mechanisms of *E. Co*li junking in water at different depths and flow rates. Still, the variation in effectiveness of slow sand purifiers to reduce turbidity at 0.3 m,0.6 m and 0.9 purifier depths is significant (Bagundol et al., 2013). The study was to compare BSFs operated with residence periods of one day (Young-Rojanschi & Madramootoo, 2014), two, and three days for *E. Coli* removal, dissolved oxygen (DO) profiles were carried out by (Young-Rojanschi & Madramootoo, 2015). Radiation UV is an electromagnetic radiation to the wavelength shorter for an area with a light appear, but longer from X rays that small. Generally, rays said move or movement from one place to another place with speed, that we call it propagation speed of light (c) , frequency (f), and wavelength (ʎ). The three categories of invisible high-energy UV rays are 1) UVC rays are the highest-energy UV rays and potentially could be the most harmful to your eyes and skin. Fortunately, the atmosphere's ozone layer blocks virtually all UVC rays. But this also means depletion of the ozone layer potentially could allow high-energy UVC rays to reach the earth's surface and cause serious UV-related health problems. UVC rays have wavelengths of 100-280 nanometer (nm). 2). UVB rays have slightly longer wavelengths (280-315 nm) and lower energy than UVC rays. These rays are filtered partially by the ozone layer, but some still reach the earth's surface. In low doses, UVB radiation stimulates the production of melanin (a skin pigment), causing the skin to darken, creating a suntan. But in higher doses, UVB rays cause sunburn that increases the risk of skin cancer. UVB rays also cause skin discolorations, wrinkles and other signs of premature aging of the skin. 3) UVA rays are closer to visible light rays and have lower energy than UVB and UVC rays. But UVA rays can pass through the cornea and reach the lens and retina inside the eye. Overexposure to UVA radiation has been linked to the development of certain types of cataracts, and research suggests UVA rays may play a role in development of macular degeneration. In addition, Indonesia is located in the tropics and receives daily solar radiation energy unity of large, unity of time approximately 4.8 kW/m^2 . It is smaller when compared to central Australia, Central America and some European countries (more than 6 kW/m^2) or Saudi Arabia, Egypt, and several countries in Africa (5.5 6 kW/m^2). However, Indonesia received radiation throughout the year with a longer time during the year of the sub- tropical countries. It is clear that this nation is required to improve the utilization of solar energy as a renewable energy source that is abundant and non-pollutant. The increase in the above can be done in the form of the cost of research in research institutions and universities, so can produce a solar- powered with ever-increasing efficiency. Today, the increase in the utilization of solar energy in Indonesia is already perceived for example by the movement of the use of a thousand solar modules. However, the solar modules are goods imported from developed countries that have been established to carry out research on solar cells even though they are poor solar power. As a country with abundant solar energy wealth should continue to raise awareness for the need to research solar power conversion technology, so that one day Indonesia is able to fabricate solar cells and even solar-powered devices on the other. Research on solar cells material is still widely open. It pointed to the benefits of a MBSF coupled with a solar pasteurizer in order to bring safe, low cost, clean, and energy dependable water to people in need. The results of this study are anticipated to give a frame for the unborn studies fastening on the impact of operating conditions on the real scale systems. The coupling of the MBSF with the solar pasteurizer will give a dependable source of drinkable water not only in the individual lodgment but also in the places where a large number of people live together similar as in the service and exile camps, or in the harbors during disasters (Sizirici, 2018) . Solar energy is one of alternative energy that will not finish if used continuously because it comes from nature. Utilization energy from sunlight can be divided into three principles of direct heat, in this case sunlight directly heats objects which will be heated. The hot water will be used, for example to take a bath. The water is also heated but the heat contained in water will be converted into electrical energy. So, in this research, the problem of the study is how to treat the Musi river water sample by using a slow sand filter and UV lamp using radiation from photovoltaic solar cells to kill and eliminate microorganism such as *E. Coli* with the aid of electricity in the form of PV solar cells from silicon material so that the product obtained free of bacteria and also the electricity used efficiently because it used solar power.

II. Methodolgy

The Musi River Water Samples would be processed by using a slow sand filter and UV lamp radiation taken from the locations under the Ampera Bridge. The Musi River water samples were taken using SNI 6989.59:2008 to obtain water samples. The grab sampling method is used to take water samples. HDPE (High Density Polyethylene) containers were used to store water samples and were stored at 4 Celsius in the freezer.

Slow Sand Filter Process

A Silica Sand with diameter ϕ 0,015 - 0,35 mm, height of Column of Sand: 70 cm. Then, Gravel with diameter of the Gravel ϕ 2 - 30 mm, height of column of gravel 10 - 30 cm. The sampling campaign was carried out during three layers. The first was filled with silica sand which was used to filter the Musi River water samples. The second and third layers were filled with the gravels in the small and big sizes. The equipment has been done is gallon with diameter ϕ 25 cm and height 150 cm. Slow sand filter was using a gallon which will be filled with three layers of silica sand, small and large gravels. The function of the silica sand was to filter out impurities while gravel was used as a filtering and a buffer medium so that the sand did not fall down. Added equipment are: 1) PV Module with length 115,3 cm, width of the Module 68 cm, and height of the Module 0,35 cm, with capacity 100 wp. PV modules were used to absorb the sunlight which was part of the solar cell equipment. 2) Inverter with power 500 Watt. The inverter is used to convert the DC current into AC current, which is part of the solar cell equipment. 3) Storage Battery is used to save electrical energy. 4) Ultraviolet Lamp with Power UV 10 Watt; length of the UV is 30 cm, Brand F10T8 Evaco Germicidal Lamp, Type UV-C with wavelength 254 nm. UV lamps were used to kill bacteria on the Musi River Water Samples. . 5) Pipe Parallon with diameter of the Pipe Parallon ϕ 8 cm, length of the PipeParallon 40 cm, PVC pipe was used as the containers of UV-C light. 6) Sprinkler with diameter of the Sprinkler ϕ 1,27 cm, length of the Sprinkler 4 - 5 m. Sprinklers were used for the water flow in and out of the UV-C tube. 7) Bottle and 8) Pump. The pump is used to raise the pressure and drain of Musi River water sample to ultraviolet radiation.

Figure 1. Slow Sand Filters

Pollutant Parameter Analysis and Treatment Analysis

Musi river water was analyzed before the filtration process and after the filtration process. SNI 06-6989.2-2009 using the Spectrophotometric Method is used to analyze chemical oxygen demand parameters. SNI 06-2503.2-1991 using the Winkler Method is used to analyze biochemical oxygen demand parameters. SNI 06 6989.14-2004 using the Iodometric Titration (Azida Modification) is used to analyze oxygen demand parameters.

III. Result and Discussion

This research used a simple of the Musi River water where the processing was done using a slow sand filter and UV lamp. In the processing of the slow sand filter, it used the sand height variation of 50 cm and 70 cm. While on treatment with UV irradiation to eliminate pathogens such as *E. coli*, it used the irradiation time for 15 minutes, 30 minutes, 45 minutes and 60 minutes. Based on the results of the analysis carried out in the Laboratory of Environmental Health and Engineering Center for Disease Control (BTKL PP) Musi River Water samples before experiencing the treatment process through a slow sand filter can be seen in Table 1 below this.

Table 1 Analysis Results of the Sample of Musi River Water Before Being Processed

Parameters	Unit	Maximum River Water Levels on the Grade III	Results	Methods Of Examination
pH	-	6-9	6.69	SNI 06-6989.11-2004
NO3	mg/L	20	0.05	SNI 06-2480-1991
BOD	mg/L	4	**12.5**	SNI 06-2503-1991
COD	mg/L	50	47	SNI 06-6989.2- 2009
DO	mg/L	3	5.08	SNI 06-6989.14-2004
Cu	mg/L	0.02	0.01	SNI 06-6989.6- 2009
PO4	mg/L	1	0.12	SNI 06-6989.31-2004
E.Coli	Number / 100 ml	-	not detected	membrane filters

*Source :*Regulation of South Sumatera Governor No.16 in 2005 about the quality standards of Musi River Water*

The Musi River Water sample filtration was done using a slow sand filter in the sand height of 50 cm and a laboratory test which was done in the State Polytechnic of Sriwijaya through several parameters can be seen in Table 2 below this.

Table 2 Analysis Results of Slow Sand Filter in the Sand Height of 50 cm

No	Parameters	Unit	Maximum River Water Levels on the Grade III	Results
1	BOD	mg/L	4	2.2
2	COD	mg/L	50	3
3	DO	mg/L	3	2.8

The Musi River Water sample filtration was done using a slow sand filter in the sand height of 70 cm and a laboratory test which has been done in the BTKL PP through several parameters can be seen in Table 3 below this.

Table 3 Analysis Results of Slow Sand Filter in the Sand Height of 70 cm

No	Parameters	Unit	Maximum River Water Levels on the Grade III	Results
1	BOD	mg/L	4	2.15
2	COD	mg/L	50	3
3	DO	mg/L	3	5.222

Lighting using UV lamps through the variation of times (15 minutes and 30 minutes) was done after the filtration using a slow sand filter in order to do the physical inquisition of the Musi River Water samples. Previous analysis of *E.Coli* test for sample Musi River Water was conducted. *E. Coli inquisition* was conducted in the laboratory in State Polytechnic of Sriwijaya and the results can be seen in Table 4 below this.

Table 4 Analysis Results of E.Coli bacteria in the Musi River Water Samples

No	Sample	Results	Methods of Examination
1	Musi River Water after Being irradiated by an UV lamp for 15 minutes	56/100 ml	Identification Biochemical
2	Musi River Water after Being irradiated by an UV lamp for 30 minutes	46/100 ml	Identification Biochemical

Lighting using UV lamps through the variation of times (45 minutes and 60 minutes) was done after the filtration using a slow sand filter in order to do the physical inquisition of the Musi River Water samples. Previous analysis of *E. Coli* inquisition was conducted in the laboratory in BTKL PP and the results can be seen in Table 5 below this.

Table 5 Analysis Results of E.Coli bacteria in the Musi River Water Samples

No	Sample	Results	Methods of Examination
1	Musi River Water after Being irradiated by an UV lamp for 45 minutes	37/10 ml	Membrane Filters
2	Musi River Water after Being irradiated by an UV lamp for 60 minutes	29/100 ml	Membrane Filters

*Source :*Regulation of South Sumatera Governor No.16 in 2005 about the quality standards of Musi River Water*

Slow sand filter is a filter which uses a sand bath as a filter media with a very small grain size but has a high quartz content. Slow sand filters contain very fine sand and usually function without chemical pre-treatment, such as chlorination or flocculation. The filtering process is a combination of physical processes, namely filtration, sedimentation and adsorption. Slow sand filter is more suitable to process the raw water, which has a moderate to low turbidity, and dissolved oxygen concentration from moderate to high. The filtering process performance will be reviewed in the water filtration. The thicker the layer of sand, then the surface area of the larger particles and the distance which must be taken by the longer of the water surface so that the water produced a better quality. The thickness of the sand for filtering media varies greatly. It can be seen from table 6 below that the processing of a slow sand filter before and after the change of the parameter value. Before the initial sample processing of Musi River Water, the BOD5 value was 12.5 mg/L and the value of DO was 5.08 mg/L. So that the research was conducted Musi River Water treatment with sand height variation of 50 cm and 70 cm to lower the BOD value and increase the value of DO.

Table 6 Analysis Results of Slow Sand Filter

No	Parameters	Unit	Maximum River Water Levels on the Grade III	Musi River Water Sample	Sand Height of 50 cm	Sand Height of 70 cm
1	BOD	mg/L	4	12.5	2.2	**2.15**
2	COD	mg/L	50	47	3	**3**
3	DO	mg/L	3	5.08	2.8	**5.22**

Based on the figures 1 and 2 below, it showed that in the analysis parameters such as BOD, COD and DO increase and decrease in the value resulting from variations in the sand height of 50 cm and 70 cm. At a height of 70 cm, sand for BOD5 decreased by 2.15 mg/L, while the height of sand 70 cm DO increase by 5.22 mg/L. This showed that the higher the sand, diminishing levels of BOD5 and content of the DO increased which determined the survival of aquatic fauna. BOD shows the amount of oxygen that is needed by microorganisms for spreading organic matter in the water biologically. Contaminants are removed from the influent water through the processes of “straining, sedimentation, inertial impaction, interception, adhesion, flocculation, diffusion, adsorption, and biological activity “. Straining involves a mechanical sieve action as well as the lodging of particles in crevices. Sedimentation occurs as gravity settling takes place in the interstices of the media. Inertial impaction, interception, and adhesion occur as particles moving through the filter strike media granules and are removed. Particles moving through the pores will also collide and flocculate causing subsequent removal by other mechanisms. Diffusion is important in the removal of very small particles such as viruses and occurs because of the small interstices in porous media and the fact that laminar flow exists

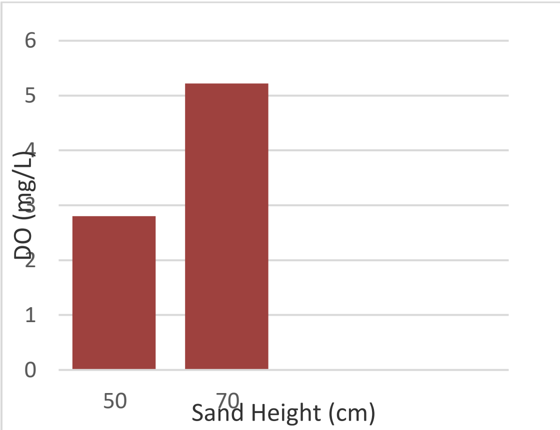

Figure 2. Effect of sand height on BOD concentration

The flow through the filter must be continuous. The Schmutzdecke is an aerobic ecosystem, and its primary source of oxygen is dissolved in the water as it moves through the top surface of the filter bed. If the flow is stopped or is too low the Schmutzdecke receives too little oxygen and the organisms that need the oxygen to survive either die or go dormant. The ability of the filter to remove bacteria immediately drops to pre- schmutzdecke levels. Once the flow through the filter is resumed, the aerobic microorganism in the Schmutzdecke recovery and the ability of the filter to remove bacteria recovers to maximum capacity. The oxygen dissolves by diffusion from the surrounding air, aeration of water that has tumbled over falls and rapids and as a waste product of photosynthesis. The presence of dissolved oxygen in the water is very important for the sustainability of fish and other aquatic organisms for the process of respiration. The ability of water to clean the pollution with natural processes depends on adequate levels of dissolved oxygen. So, the higher the BOD indicated the higher organic matter and water quality which was getting down and the greater the dissolved oxygen, it shows a relatively small degree of fouling. Thus, the silica sand contained in the slow sand filter at the height of 70 cm has succeeded in reducing the levels of pollutants BOD with the value of 2.15 mg/L, while DO increases with the value of 5.22 mg/L. In this study, the

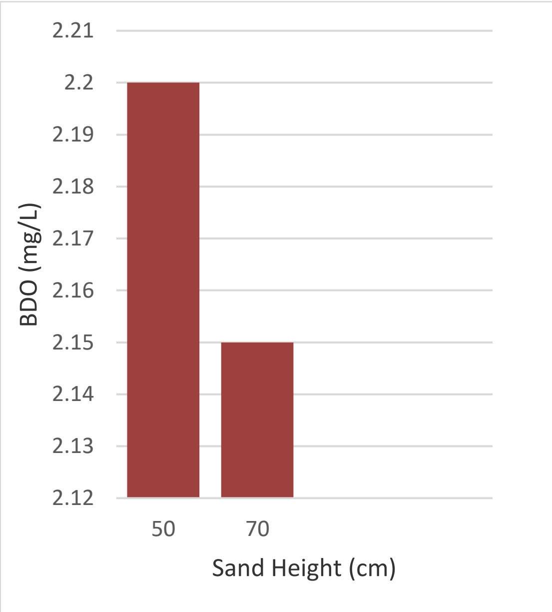

Figure 3. Effect of sand height on DO concentration

researcher used sand layer thickness of 50 cm, 75 cm, and 100 cm to filter the water of the river. BOD degradation of 85.31% with a height of 100 cm sand was obtained and COD degradation of 59.66 % with a height of 100 cm sand was obtained. This showed that the silica sand which was found on the slow sand filter is useful to filter the small impurities contained in the water. So that the higher the silica sands, the better absorption in the water filtration due to the height of 70 cm. The ability absorption at a slow sand filter can reduce levels of BOD, COD, DO contained in the water of the Musi River. *E. Coli* is the name of germs or bacteria that live in the digestive tract of humans and animals.

Infection of E. *Coli* obtained from human or animal feces. *E. Coli* could be killed by boiling water or treatment with chlorine. Suharyono (2015) , who conducted research on the effect of ultraviolet microbes total number and vitamin C lime juice that *E.coli* bacteria with the highest total irradiation time of 15 seconds while the *E. Coli* bacteria with the lowest total irradiation time of 75 seconds. In
this study, the best treatment is the lemon juice ultraviolet irradiation time of 75 seconds that can reduce *E. Coli* bacteria. From the figure 3 below, the comparison analysis results of the *E. coli* bacteria to UV light irradiation with a variation of 15 minutes, 30 minutes, 45 minutes, and 60 minutes. Before processing, *E. Coli* could not be detected in 100 ml Musi River Water sample, it was contained with too much *E. Coli* which was difficult to detect. While at the time after irradiation of UV light for 15 minutes, the *E. Coli* number of 56 could be seen in the Musi River Water sample which contained 100 ml of water. For 30 minutes, the *E. Coli* number of 46 could be seen in the Musi River Water sample which contained 100 ml of water. For 45 minutes, the *E. Coli* number of 37 could be seen in the Musi River
Water sample which contained 100 ml of water and for 60 minutes, there was the *E. Coli* number of 29 contained in the Musi River Water sample which contained 100 ml of water. Biochemical and membrane filtration are the method of choice for the analysis of *E. Coli* in water. Based on data of water conducted by BLPH water quality standards that can be used for recreation, freshwater fish farming, livestock, agriculture and other uses that quality for 1000 MPN/100 ml. It showed that the longer the irradiation of UV light, the more the bacteria *E. Coli* dies. This is due to the time when the Musi River Water sample is contacted directly against the UV light and allowed to stand for 60 minutes which results in bacteria killed by the UV light. It is because of its electromagnetic waves from the types of UV-C lamp which made the length of the UV light short-wave was correlated with the high rays energy, where the energy could kill *E. Coli* bacteria. Therefore, it was very effective to eliminate the pathogens.

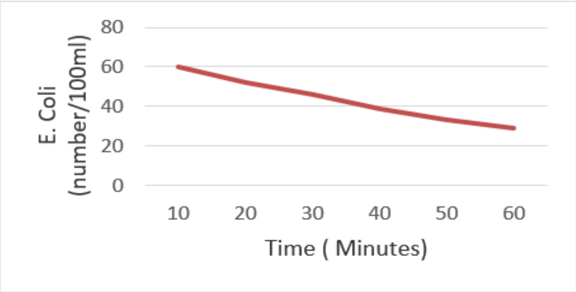

Figure 4. Effect of UV radiation time on E.Coli concentration

Figure 5. Solar Cell Photovoltaic and UV Lamp

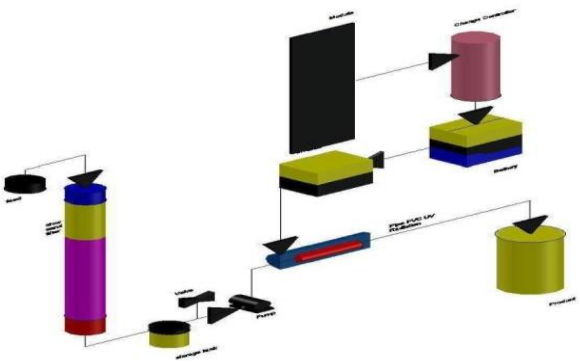

Figure 6. Experimental Equipment Set Up

IV. Conclusion

From the result, it can be concluded that the higher the silica sand, the higher BOD and COD degradation of water filtration. In this filtration, the best condition for Musi River water filtration is at a height of 70 cm. The longer irradiation time with UV light for *E. Coli* bacteria, the less bacteria found in the Musi River water sample. In this irradiation, the best condition for UV irradiation in *E. Coli* is 60 minutes. Musi River water treated using slow sand filter with a sand height of 70 cm and irradiation with UV light irradiation time of 60 minutes using electrical energy from solar cells meet the standard quality of river water grade III, with the levels obtained in BOD5 2.15 mg/L, COD 3 mg/L, DO 5.22 mg/L.

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