LOW COST SOLAR POWERED ULTRA VIOLET PURIFICATION SYSTEM FOR RURAL COMMUNITIES

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ABSTRACT
Identification of the need to solve the acute problem of affordable and efficient water purification system in most rural communities in developing countries prompted the research into the use of solar powered ultra violet purification system. Nigeria, a country in west Africa is used as a case study with an abundant solar radiation estimated to be an average of about 3.5Kwh/m^2 daily. Nigeria is faced with a lot of environmental issues with majority occurring in the Niger delta area as a result of oil spillage and other contaminations. Review of existing water purification systems was carried out and its various limitations identified. The advantages and possibilities of providing safe and potable water through the use of a locally designed model of a solar powered ultra violet water purification system was carried out.Results from the model shows in addition to its efficiency, a highly reduced and affordable cost, thereby making its adoption cost effective.

Keywords: *Water purification, Ultra violet, Oil spillage, rural communities, Niger Delta. Potable water and Solar radiation*

INTRODUCTION
Water is said to be the most common mineral on the earth with approximate volume estimated at 1370 million cubic kilometres, with the volume of fresh water distributed in rivers, lakes and ground water to be approximately 500.000 and one million cubic kilometres. (Water treatment handbook page 2.)"*Water security is therefore defined as the ability to access sufficient quantities of clean water too maintain adequate standard of food and goods production*" (Allan Hoffman 2005)

The problems of water and general sanitation had led to over 73 million hours lost every year in India because water related diseases (Turnwine, 2006). This is a common pattern that exists in developing countries. The lost hour not only reflect the loss of manpower alone, the cost on health is also in the range of RS 1000 crores a year (Tumwine, 2006) Inhabitants of the developed countries have become so used to the presence of water that it has become a part of the normal daily activities for clean water to flow from the network. With this as a norm the inhabitants of the developed economy has become accustomed to this evolution, cleaning of gutters are no longer considered as luxury but a necessity this luxury include the connection of water to the washing machines and for sanitary use. The author claimed that "More than 1 billion people lack access to clean water supplies and more than 2 billion lack access to basic sanitation. These shortages have significant health effects."(*Water to the World," Aug. 6-12 in Orlando, Fla.)*

In Diammant (Diammant,1985) publication he pointed out how the developing countries were classified and claimed that "The developing countries have been further classified in

recent years into 89 developing countries and 31 poorer countries belonging to the group of least Developing countries. 21 out of these 31 least developed countries are located in Africa accordingly. In the identified developing countries, water shortage and sanitation problems are common in the United States of America. 80% of the population turns tap on every day and are safe to drink from the tap water supplied via the public net work. The fact that developed countries such as United States, and Great Britain have a good record is not an accident according to (Cornwell &Davis 1998) Cornell said that United States sanitary engineers have been working to reduce waterborne diseases since early 1900. In Britain universal chlorination was introduced after the outbreak of Croydon typhoid outbreak of 1936 (Diammant, 1985.)

It is therefore essential and important to find a way to provide clean and safe water to the affected area. Dan Nover (2003) said that estimated 15 million children under the age of 5 die each year due to water borne disease. The World Health Organization (WHO) in 2002 decided to investigate and conduct necessary research that will lead to the improvements in the quality of life reduction of child mortality to mention few.

Background Theory

Water purification generally means freeing water from any kind of impurity. It contains contaminants or micro organism which can be harmful to Human lives (Ashok, 2000). Water purification is not a one sided process. The process contains many steps, these depends on the kind of impurities that are found in the water.UV involves the treatments of water into a potable state using ultra violet rays that is provided by a special germicidal light. It is believed and proven that when ultraviolet energy is absorbed by the reproductive mechanisms of bacteria and viruses, the genetic material (DNA/RNA) is rearranged and they can no longer reproduce. They are therefore considered dead and the risk of disease has been eliminated. (fallingrain.com 2006). The UV as with every system tend to have it own limitations. The use of UV germicidal lamp reduces iron in water to less that 1 part per million (Robert Rau, 2003) but the Iron present could be removed by the use of slow sand filtration process

Model Design

UV Ultra violet water purification system can be expensive to construct, with most of the reasons attributed to possible cost of necessary raw material as part of the draw backs. It is however possible to construct a simple water UV purifier as an alternative and this is the essence of this work.The basic design requires passing the UV lamp over the water instead of submerging it in water, which is better effective if it is used for non commercial or large quantity, this construction is cheap and does not require seal, intricate structure and constructions. As with every system, the uniqueness with these arrangements is that the flow is based on gravity flow.

Fig 1.1: Constructed 12watt UV purifier with a 12v, 100AH battery

Performance Evaluation

The constructed UV water treatment unit was tested over a time frame of 3months, 4 litres/minute of water flow exposed to 15 seconds of UV radiation by an 12watt powered UV light was obtained. The low power rating of the light source allows for energy efficiency and makes the unit compatible for powering by alternative energy sources like the Photovoltaic (PV) system. The UV germicidal lamp used reduces the iron content in water. This is particularly useful in the treatment of water in the riverine areas of the Niger – Delta in Nigeria where studies have shown a relatively high iron content in the water from this area. The constructed unit runs on a rechargeable 12V, 100AH deep – cycle battery connected to a charging system principally a 130watt solar PV cells with a 12 volt, 7amp charge controller which controls the rate at which the battery is charged. The constructed UV water treatment unit was tested with 10 litres of well and borehole water exposed for 18 seconds to ultraviolet radiation produced by 4 UV lamps of 3watt each.

The low power rating of the light source allow for energy efficiency and makes the unit compactable for powering by alternative energy sources like photo voltaic (PV) system. The UV germicidal lamp used reduces the iron content in water. This is particularly useful in the treatment of water in the riverine areas of the Niger-delta in Nigeria and other part of the world where studies have shown a relative high iron content in the water from the area. Also, the PV application allows the system to be useful in rural areas where there is little or no adequate electricity supply. Each of the four watt light bulbs draws about 330milliamps during the test period. The study area used is the Iwo community, located in Osun state, Nigeria. The community as a whole depend majorly on borehole water supply and partially on well water as their source of water.

Water samples were taken from the two sources of water to the community .The water samples were collected in a bottle and taken to the laboratory for analysis and the samples were labelled as: Sample A: Well water and Sample B: Borehole water. Additional samples from the same source (Sample C: Purified well water Sample D: Purified borehole water) were also collected and purified using the ultraviolet purification system and then taken to the laboratory for analysis.The four samples were taken to the laboratory and microbial test was carried out on the water samples as regards the bacteriological investigation i.e. the microbial load in the water sample namely: PCA (Plate Count Agar): This is a non-selective medium and is responsible for the isolation of the total variable bacteria in samples. It helps to observe bacteria growth in the water sample, and Total plate count which is the approximate number of observed micro

organism in a plate and it is related to the dilution co-efficient. The total plate count is the number of colonies observed multiplied by the dilution factor.
TOTAL PLATE COUNT= NUMBER OF COLONY * DILLUTION FACTOR..... (1)

1ml of each water sample was diluted with 9ml of sterile water then 1ml was taken from the first diluted sample and also diluted with 9ml of sterile water. The dilution was repeated until four samples were obtained. This dilution process is known as serial dilution. After the serial dilution of the water samples, 1ml from the second dilution and forth dilution was ascetically put into sterile plate and thereafter 10ml of melted PCA (Plate Count Agar) was added to the samples which was equally mixed with the Agar and later allowed to solidify. Two plates were poured for each of the samples A,B,C,D making the total number of samples eight,A_1,A_2,B_1,B_2,C_1,C_2,D_3,D_4 which were inverted and incubated AT 37° C for 48 hours. Tables below show the result of the morphological characterization of bacteria isolated in water sample A, B, C, D.

Table 1. Observation in Sample A

SAMPLE	MEDIUM	DILUTION	COLONY DESCRIPTION	NO OF COLONIES	TOTAL PLATE COUNT(cfu/ml)
A_1	PCA	10^{-2}	CIRCULAR EDGE SEPARATED EDGE WRINGLED SURFACE	10	$10 X 10^{-2}$
A_2	PCA	10^{-4}	RADIATED SURFACE WRINKLED SURFACE	5	5×10^{-4}

Table 2. Observation in Sample B

SAMPLE	MEDIUM	DILUTION	COLONY DESCRIPTION	NO of Colonies	TOTAL PLATE COUNT (cfu/ml)
B_1	PCA	10^{-2}	SMOOTH SURFACE SERATED EDGE RADIATED SURFACE	7	7×10^{-2}
B_2	PCA	10^{-4}	SMOOTH CIRCULAR SURFACE FILAMENTOUS EDGE CONTOURED SURFACE	6	6×10^{-4}

SAMPLE	MEDIUM	DILUTION	COLONY DESCRIPTION	NO OF COLONIES	TOTAL PLATE COUNT
C_1	PCA	10^{-2}	SMOOTH CIRCULAR SURFACE	1	1×10^{-2}
C_2	PCA	10^{-4}	NG	NG	NIL

Table 3 Observation in Sample C

Table 4 observation in sample D

SAMPLE	MEDIUM	DILUTION	COLONY DESCRIPTION	NO OF COLONIES	TOTAL PLATE COUNT (cfu/ml)
D_1	PCA	10^{-2}	SMOOTH CIRCULAR	1	1×10^{-2}

CONCLUSION

The constructed model is particularly recommended for usage in homes and small scale industries where potable water is not readily available. It is affordable and with a very high possibility of sourcing for its raw materials locally. The UV purification germicidal effectiveness in general tend to be reduced in cold weather (Rau, 2008) and therefore use in a place like Nigeria that enjoys a relatively warm weather is ideal, especially for domestic usage. However, care should be taken when using ultra – violet rays because of its possible health risk to the human eyes and skin.

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