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Effect Of Volume On Convergent Rays Disinfection Of Water

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Abstract: The effect of volume on convergent rays' disinfection of water was studied using groundwater derived from wells in Choba and Aluu communities of Rivers State Nigeria. Bacteriological parameters such as total coliforms, *faecal* coliform, total culturable heterotrophic bacteria count were examined. Results showed that the total coliform population in the 4,10 and 15 L of water samples examined had a uniform baseline data of 3.3 log MPN index/100 ml but no growth was observed after exposure to converged rays for 8 hours. Treatment with convergent rays reduced the faecal coliform population from 1.7 to 1.8 Log CFU/ml in all the aliquots of water exposed. Their population was reduced to 1.0 for 4 L, 1.3 Log CFU/ml uniform count for 10 L and 15 L while 8-hour exposure showed no growth. The total culturable heterotrophic bacteria count (TCHBC) of the water also decreased with an increase in exposure time for all the aliquots the values recorded ranged from 1.2 to 1. 3 log CFU/ml. The physicochemical analysis showed that pH was in the range of 6.9 – 8.9 while the conductivity levels ranged from 8.0 to 11 (SCM). Turbidity was in the range of 8.0 - 14.2 (NTU), the temperature before exposure was in the range of 27 – 29 ^{O}C and increased to 44 to 53 ^{O}C after 8 hours of exposure. The data obtained after the treatment process confirmed the use of convergent rays for water disinfection.
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Keywords: Volume, Disinfection, Water, Convergent Rays, Total culturable heterotrophic bacteria, Rivers State Nigeria.

Introduction

Water and its usage form the pivot of the world's economy because of its importance in all man's activities apart from its physiological function (Ojo *et al.,* 2015). The examination bacteria species in water has thus become a pertinent and ultimate approach to detect the occurrence of microbial populations which may become a problem to health. This, however, forms the basis for quality studies on water (Omeleke, 2004).

The level of pollution is, however, a function of the water source (EPA, 2003). Water that moves below the ground at a level where the pressure is atmospheric and known as the pyritic surface or water table, for instance, undergoes a filtering process that tends to remove bacteria (Dorola *et al*., 2005). The most critical pollution of water is from human faeces entrance to water flow systems. Several common sources of water pollution have been identified in Nigeria (Eja, 2002). Domestic sewage and other oxygen demanding wastes poise a universal problem while pit latrines and open fewer pools for human, animals and domestic waste pollute streams pond and river create biological oxygen demand (BOD), as the microbes which decompose them require oxygen to do so (Fakayode, 2005).

This technology of sun rays water treatment is a cheap technology that improves the quality of drinking water for human consumption. This technology uses solar energy to kill the etiologic agents of water-borne diseases. It is efficient in treating volumes of water for small scale (Droste and Mcjunkin, 2002). Polluted source of water is filled into visible containers and allowed for 6 hrs (or 2 days in an atmosphere that is about 50% cloudiness (Cowel, 1996).

Sunlight reaching surface water system can be absorbed by photo-sensitizers. The combined effect of sunlight can cause a disinfecting effect on the DNA of microbial populations in the water. The amount of solar energy for the inactivation of bacterial cells depends on the UV-A dose. Thus, we have 1.12 kJ m^2 of optical energy available in each second to inactivate every microbial pathogen are present in exposed water to sun-light. This value reduces in a cosine fashion as latitude increases away from the equator (Kevin *et al*., 2012).

The efficiency of this process as revealed by flow cytometry shows the disruption of cellular activities (Berney *et al.,* 2006), shortly after exposure, the

synthesis of ATP and efflux pump activities ceased (Berney *et al.,* 2006). Followed by a gradual loss of membrane integrity and glucose uptake. This process is dependent on wavelength, salt concentration and dissolved oxygen concentration (Berney *et al.,* 2006). The inactivation dose differs from organism to organism. Bacteriophage and rotavirus have shown complete inactivation (3log unit decreased) within 3hours of strong sun. Viruses can be more resistant and require more exposure time for inactivation (Berney *et al.,* 2006).

Materials And Method

Study Location

This study was conducted with water samples collected from Choba river located in latitude 4°53'53.16'N to latitude 4°53'52.50'N and longitude 6°54'05.63'E to longitude 6°54'04.69', Hassan well located in latitude 4°54'23.20'N to latitude 4°54'23.59'N and longitude 6°54'29.88'E to longitude 6°54'30.41'E and Omoukiri borehole located in latitude 4°55'29.38'N to latitude 4°55'29.03'N and longitude 6°55'24.70'E to longitude 6°55'24.43'E all within Rivers State, Nigeria.

Sample Collection And Description

Samples were collected very early in the morning from sample location in white transparent containers and transported aseptically under controlled conditions to the laboratory for immediate analysis.

Treatment Process

Water samples for this treatment process were dispensed into transparent bottles containers and exposed in a circular-dish ray concentrator covered with Mirror and Aluminum foil paper as the reflecting material. Bottles with different volumes of water were exposed for 0, 2, 4, 6 and 8hours intervals. The difference between the environmental temperature (Ambient) and water temperature at each interval of exposure in degree Celsius (°C) was recorded; the pH reading was noted for each sample.

Measuring Of Convergent Rays

The converged or incident solar rays were measured by calculating the difference between the temperature of the environment (Ambient) and water temperature at different times of exposure in degree Celsius and were compared to readings of a photometer.

Numerical Estimation Of Bacterial Growth

The numerical estimate of the bacterial load was obtained using the spread plate method with Nutrient Agar. This was based on the 10-fold serial dilution of samples. The samples were pipette into the surface of each sterile plate. About 20ml of molten Nutrient Agar was cooled to 45°C and 0.1ml of the sample was spread, after 24hr of incubation at 35^{O}C. Each plate was physically observed and colonies were then numbered and recorded in the colony-forming unit (cfu/100ml). The most probable number multiple tube method was used for coliform determination (MacConkey broth, Eosin methylene blue Agar). Presumptive tubes were confirmed with Gram staining and biochemical tests (Cox, 2006).

Results And Discussion

The efficacy and reliability of convergent ray's disinfection process were studied using different volumes of water samples exposed to convergent rays at various intervals. The total coliform population in the 4,10nd 15L aliquots of water samples examined indicated a uniform baseline data of 3.3 Log MPN index/100ml. After 2 hours of exposure, the count decreased in all aliquots of water samples to 1.9, 2.0, 2.1 LogMPN index/100ml.

There was a further decreased in population count after 4 hours exposure to 0.9, 1.3 and 1.5 Log MPN index/100ml. After 6 hours, 4L aliquot had 0.7, 10L recorded 0.9 and 15L had 1.2 Log MPN index/100ml. However, no growth was observed after 8 hours of exposure to converged rays.

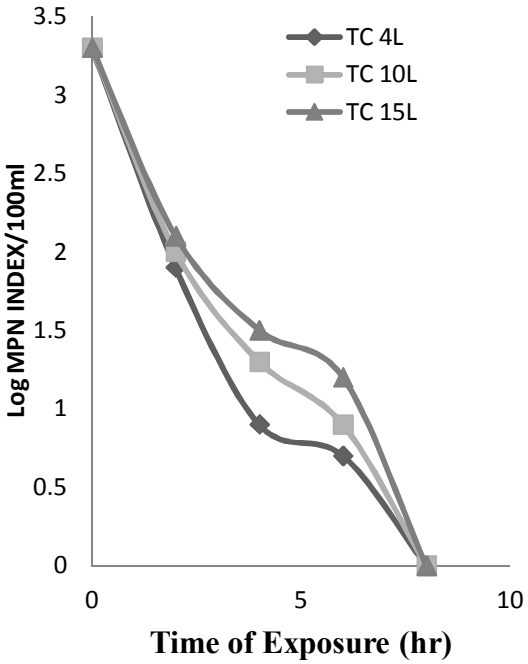

Figure 1. The Response Of Total Coliform Population In 4, 10 And 15 Litres Of Water
Key: TC = Total coliform

A significant difference was observed in population changes between the times and volumes of exposure (P-values>0.05). This finding was in support of the report of Alejandra *et al*., (2004) and Kevin *et al., (*2012). The authors examined the efficiency of

bacteria cells destruction of the reactor using 7months research on *E. coli*; K12 cell damage with 25L quantity of well water sample and water with high turbidity (Kevin *et al.,* 2012). They reported a significant decreased of coliform population and total elimination after 6 hours of solar disinfection.

The response of the *faecal* coliform population in 4, 10 and 15Litres water to converged rays is represented in figure 2. Results of 0 hours formed the baseline data of 1.7 - 1.8Log. CFU/ml for all the aliquots of samples (water) exposed, after 2 hours of exposure, the was a population change to 1.5 and 1.6 Log CFU/ml. A further decrease was observed after 4 hours of exposure to 1.3, 1.5 and 1.4 Log CFU/ml, as the time of exposure increased to 6 hours, the population reduced to 1.0, 1.3 Log CFU/ml while 8-hour exposure showed no growth.

A significant difference was in population changes between the times and volumes of exposure as indicated by the P-value. Acra in (1990) reported that with 95 minutes duration of sun rays in Beirut, for about 0900 to 1400h, over 99.9% decrease in population of *faecal* coliforms with sun ray's inactivation of the faecal coliform population in water.

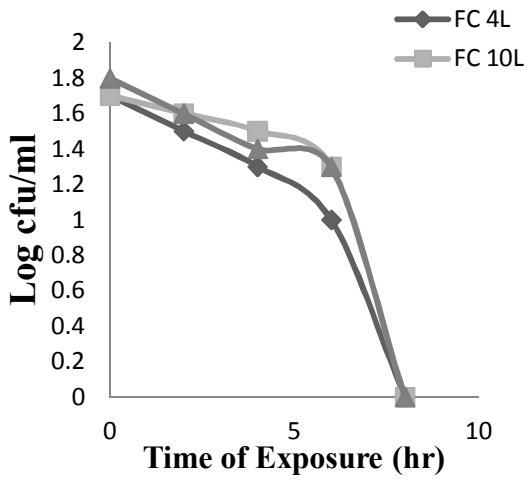

Figure 2: Response of faecal coliform population in 4, 10 and 15Litres water
Key: FC = *Faecal* coliform

The total culturable heterotrophic bacteria count (TCHBC) of the water samples showed that at 0 hour i.e. before exposure to converge rays, the water samples had a count of 2.2 to 2.3 log CFU/ml forming a control for the study. After 2 hours, the count decreased to 1.7, 1.9 and 2.0 log CFU/ ml. There was a progressive e reduction in population as the time of exposure increases for all aliquots of water samples from all litres to 1.2 and 1.3 log CFU/ml respectively.

However, Significant difference was observed in population changes between the times and volumes of exposure (P-values>0.05) as indicated by the P-value. This was in agreement with the report of (Acra 1990). He reported that 5hours exposure is needed for 99.9% elimination of total heterotrophic bacterial. While 0.0 log CFU/ml after 8 hours of exposure also agrees with the WHO (1993) and EPA (2003)1.0×10^2 standard for water.

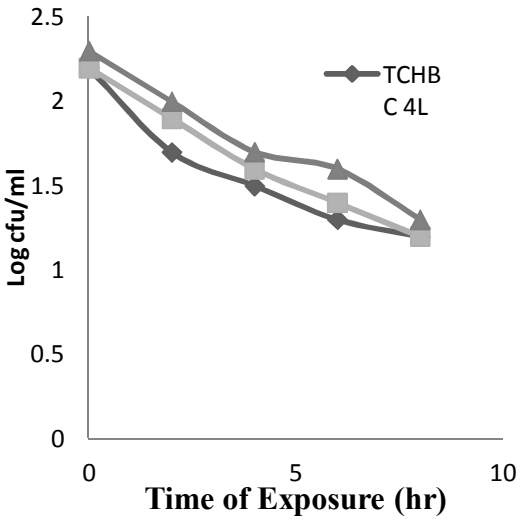

Figure 3: Response of TCHBC population in 4, 10 and 15 Litres Water
Key: TCHBC = Total culturable heterotrophic bacteria count

Results of the pH analysis show that pH was in the range of 6.9 – 8.9, conductivity values were between the ranges of 8.0 – 11 (SCM). Turbidity was in the range of 8.0 -14.2 (NTU), the temperature before exposure was in the range of 27 – 29^{O}C but increased to 44 to 53 ^{O}C after 8 hours of exposure.

The efficiency of convergent ray's disinfection of water is dependent on the time under a clear sky, the influence of containers (Their loss of high transmittance with extended use), using sun rays treatment (for over 35^{O} of latitude North or South), (which varies with the time of the day, date and geographic location), and the nature of reflecting materials and depending on the size of the concentrator, batch volumes disinfection are most effective.

Conclusion

Bacteriological parameters responded with a decrease in population with increased in exposure time. It is therefore rational to conclude that, exposure with small volumes of water samples in a circular dish ray concentrator for 6 hours and above can be appropriate for the treatment process, the volume of water exposed to sun rays is however dependent on the size of the concentrator used in the treatment. Finally,

this study has attempted to capture and address the global water scarcity and justifies the efficiency of convergent rays' disinfection technique.

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