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Effect of Convergent Rays on Coliform and Total Culturable Heterotrophic Bacteria in Water

Anafe Michael Ugbong[1*], Abiye Anthony Ibiene[1], Chioma Nkeiruka Onuoha[1] and C. Okorie Iheanyichukwu Patrick[2]

[1]Department of Microbiology, University of Port Harcourt, Nigeria.
[2]Department of Physics, University of Port Harcourt, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author AMU designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript, author CNO managed literature searches. The convergent rays concentrator was designed and it rays intensity was monitored by author COIP while author AAI managed the analyses of the study and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Verification of the effect of convergent rays on coliform and total culturable heterotrophic bacteria counts (TCHBC) in River (surface water), well and borehole (underground) water bodies around Choba and Aluu communities.
Place and Duration of Study: The efficiency of convergent ray's disinfection of surface (Rivers) and underground (well and Borehole) water bodies was conducted on Choba and Aluu communities water samples in River State, Nigeria in the Department of Microbiology laboratory, University of Port Harcourt between November, 2012 to December, 2013.
Methodology: Different volumes of water samples were exposed to converged rays for 0, 2, 4, 6 and 8 hours intervals using a circular-dish ray concentrator covered with Aluminum foil paper as the reflecting material. The TCHBC was determined using bacterial plate counts while the coliform population was determined using the most probable number multiple tube technique.
Results: The study showed that coliform and TCHBC population had the same logarithmic values at 0 hour and after 2 hours of exposure (1.2 logMPN/100 ml and 2.2 log cfu/ml). The coliform

**Corresponding author: E-mail: ugbongmichael@gmail.com;*

population of the 2 and 4 Litre aliquots decreased from 1.2 and 2.2 to 0.0 log MPN/100 ml after 8 hours while the total culturable heterotrophic bacterial population decreased from 2.1 and 2.2 for 0 hour to 0.9 and 1.2 log cfu/ml after eight (8) hours of exposure. The pH of water samples were as follows; River water 5.0, Well 6.4 and borehole 7.0 respectively.

Conclusion: The research was able to provide satisfactory and dependable results compared to World Health Organization and Environmental Protection Agency WHO and EPA drinking water standard with MPN/100 ml to be 0.0 log MPN/100 ml and 0.9 and 1.2 cfu/ml total culturable heterotrophic bacteria count after 8 hours of exposure compared to 1.2 log MPN/ml and 2.2 logcfu/ml before the convergent rays exercised; thus, the study justifies the use of convergent rays for water disinfection.

Keywords: Water; convergent rays; disinfection; coliform; heterotrophic bacteria; river state.

1. INTRODUCTION

The presence of coliforms and total culturable heterotrophic bacteria in water is of public health significance. The quality of drinking water is of highest importance and this depends on source and level of contamination. About 80% of diseases in the tropics for example, cholera, typhoid, diarrhea and dysentery are as a result of water source contamination [1].

In Nigeria, majority of the rural populace do not have access to potable water and therefore depend on well, streams and rivers for domestic use [2]. The bacterial quality of ground water, pipe borne water and other natural water supplies in Nigeria, have been reported to be unsatisfactory, with coliform counts far exceeding the level recommended by World Health Organization W.H.O [2].

Underground water is believed to be the purest source of water known because of the purification properties of the soil, however, it can be contaminated due to improper construction, shallowness, animal wastes and proximity to toilet facilities, sewage, refuse dump sites and various human activities around the water body [2]. Environmental Protection Agency (EPA) establishes heterotrophic plate count as a primary standard, which are based on health considerations [2,3].

The use of solar radiation for water disinfection has proven to be an efficient technique for the inactivation and destruction of pathogenic bacteria [4]. This technology is very well suited for rural communities of low income which do not have access to standard water purification systems, do not boil or chlorinate the water and are only interested in treating the water required for their daily consumption [4]. The minimum exposure time vary with location for reasons related to solar intensity, season and geographical location [1,5]. It was observed that with 95 min exposure to sunlight in Beirut, between 0900 and 1400 h, a 99.9% reduction of coliform was achieved with 300 min being required for 99.9% inactivation of total bacteria [6]. The objective of this study was to verify the effect of convergent rays on coliform and total culturable heterotrophic bacteria in River (surface water), well and borehole (underground) water bodies around Choba and Aluu communities in River states, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Location

The research was conducted on Choba river water located in latitude 4°53'53.16'N to latitude 4°53'52.50'N and longitude 6°54'05.63'E to longitude 6º54'04.69', 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 (underground water) 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, respectively, in Rivers State, Nigeria.

2.2 Sample Collection and Description

Water samples were collected very early in the morning from sample location in white transparent containers aseptically and transported to the laboratory for bacteriological and physiochemical qualities analysis.

2.3 Convergent Ray Experiment

Water samples were dispensed into transparent bottles containers, placed in a circular-dish ray concentrator covered with Aluminum foil paper as the reflecting material. Containers with

different volumes of water sample were exposed for 0, 2, 4, 6 and 8 hours intervals [6]. The difference between the environmental temperature (ambient) and water temperature at each interval of exposure in degree Celsius (°C), the pH reading was noted for each water sample.

2.4 Enumeration of Coliform and Total Culturable Heterotrophic bacteria

Determination of bacterial load in the water sample was done in triplicates. Bacterial plate counts were carried out using spread plate method with Nutrient Agar. This method was based on the serial dilution of water sample which were then pipetted unto + the surface of each sterile plate. About 20 ml of molten Nutrient Agar was cooled to 45ºC and 0.1 ml of water sample was spread. After 24 hours of incubation at 35ºC, colonies in the plates were counted [6]. The most probable number multiple tube technique was used for coliform enumeration (using MacConkey broth, Eosin methylene blue Agar). Presumptive tubes were confirmed with gram staining and biochemical tests.

3. RESULTS

Coliform and total culturable heterotrophic bacterial (TCHB) population in the 2 and 4 Litres aliquots of river water decreased as the time of exposure increased from zero (0) to eight (8) hours. The coliform population of the 2 and 4Litre aliquots decreased from 3.3 and 3.4 to 0.0log MPN/100 ml after 8 hours while the total culturable heterotrophic bacterial population decreased from 2.2 and 2.4 for 0 hour to 0.9 and 1.3 log cfu/ml after 8 hours (Fig. 1). Statistical analysis showed that there was significant difference in population changes between the times of exposure (P = .05) while the volumes of water exposed showed no significant difference in the change in population (P = <.05).

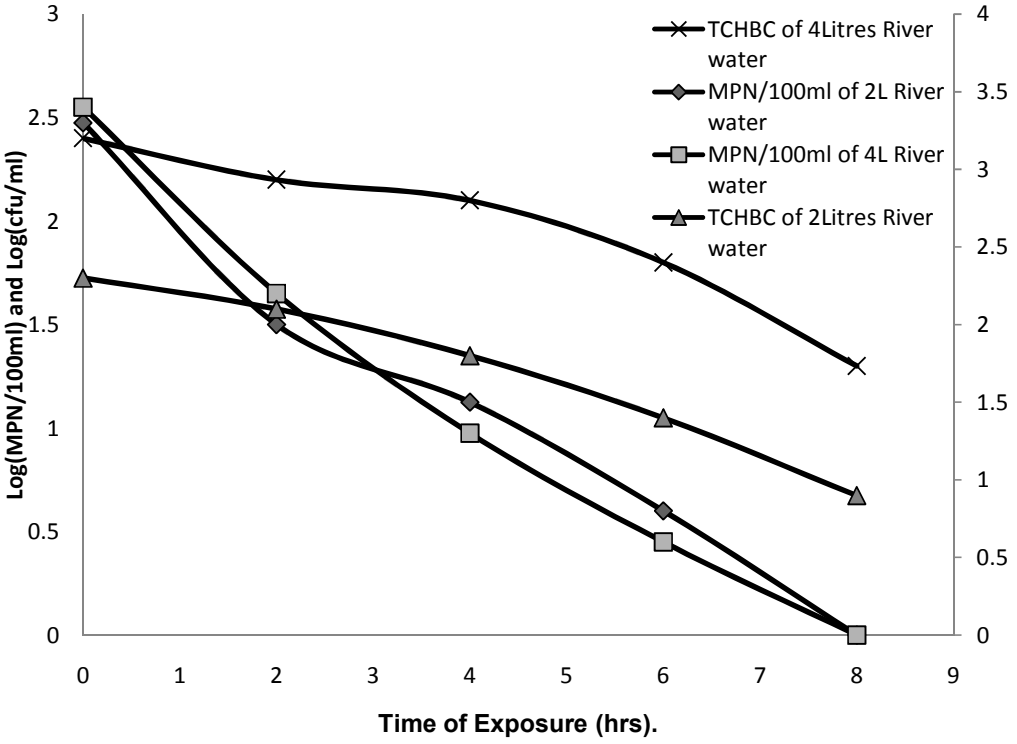

Fig. 1. Response of coliform and total culturable heterotrophic bacteria count (tchbc) in river water exposed to light rays

KEY; MPN = Most probable number; TCHBC = Total culturable heterotrophic bacteria count

The logarithmic populations of coliform and total culturable heterotrophic bacteria in both test water volumes decreased with increased time of exposure. The coliform population of the 2 and 4 Litres aliquots decreased from 3.2 and 3.2 to 0.0 log MPN/100 ml after 8 hours while the total culturable heterotrophic bacterial population decreased from 2.2 and 2.4 for 0 hour to 1.0 and 1.2 log cfu/ml after eight (8) hours of exposure (Fig. 2). There was significant difference in population changes between the times of exposure (P = .05) while the volumes of water exposed showed no significant difference in the change in population (P = <.05).

The logarithmic values of coliform and TCHB population of the 2 and 4 Litre aliquots decreased from 1.2 and 2.2 to 0.0 log MPN/100 ml after 8 hours while the total culturable heterotrophic bacterial population decreased from 2.1 and 2.2 for 0 hour to 0.9 and 1.2 log cfu/ml after eight (8) hours of exposure (Fig. 3). Statistical analysis showed that there was significant difference in population changes between the times of exposure and the volumes of water exposed (P = > .05). The pH of some water samples (Well 6.4 and borehole 7.0) were in agreement with World Health Organization and Environmental Protection Agency (WHO and EPA) standard while River water (5.0) did not meet the 6.5-8.5 pH standards for water (Fig. 4).

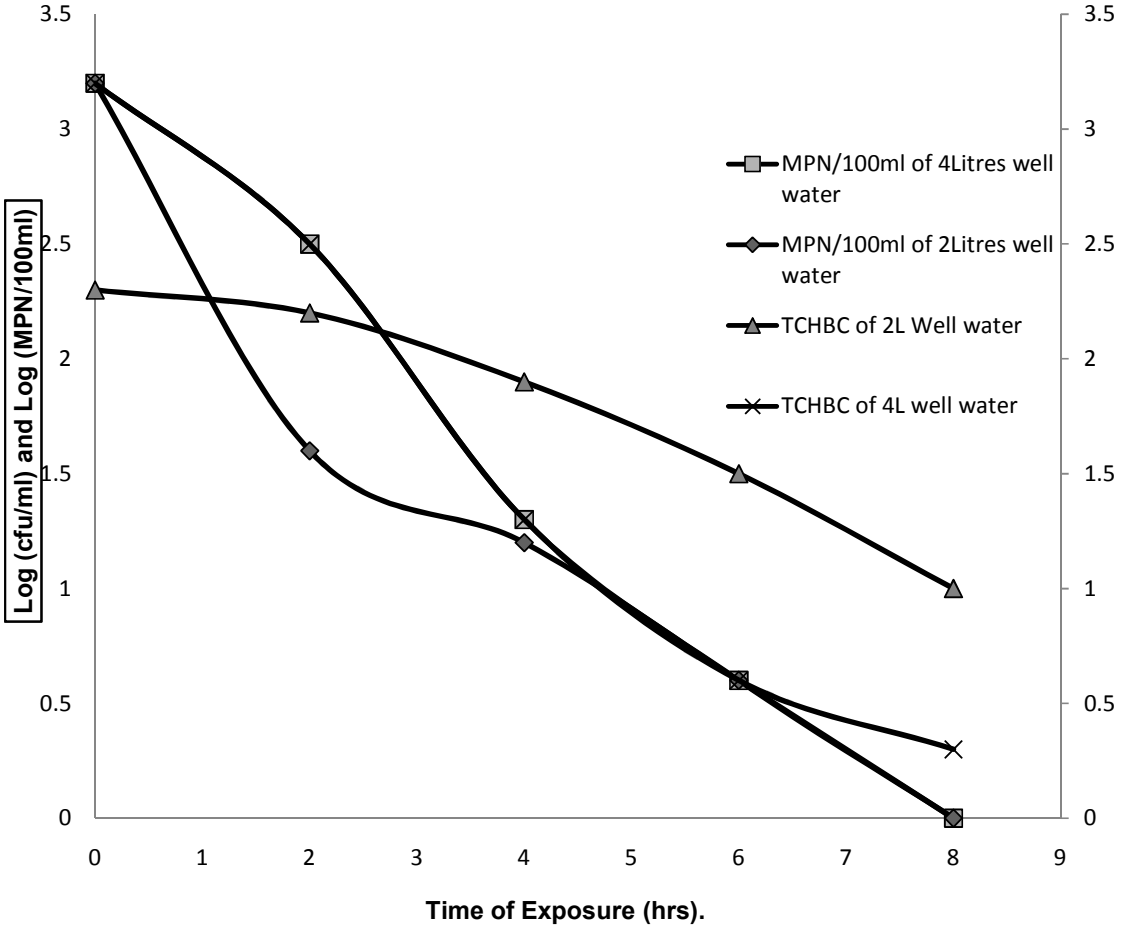

Fig. 2. Response of coliform and tchb population in well water exposed to light rays
KEY; MPN = Most probable number; TCHBC = Total culturable heterotrophic bacteria count

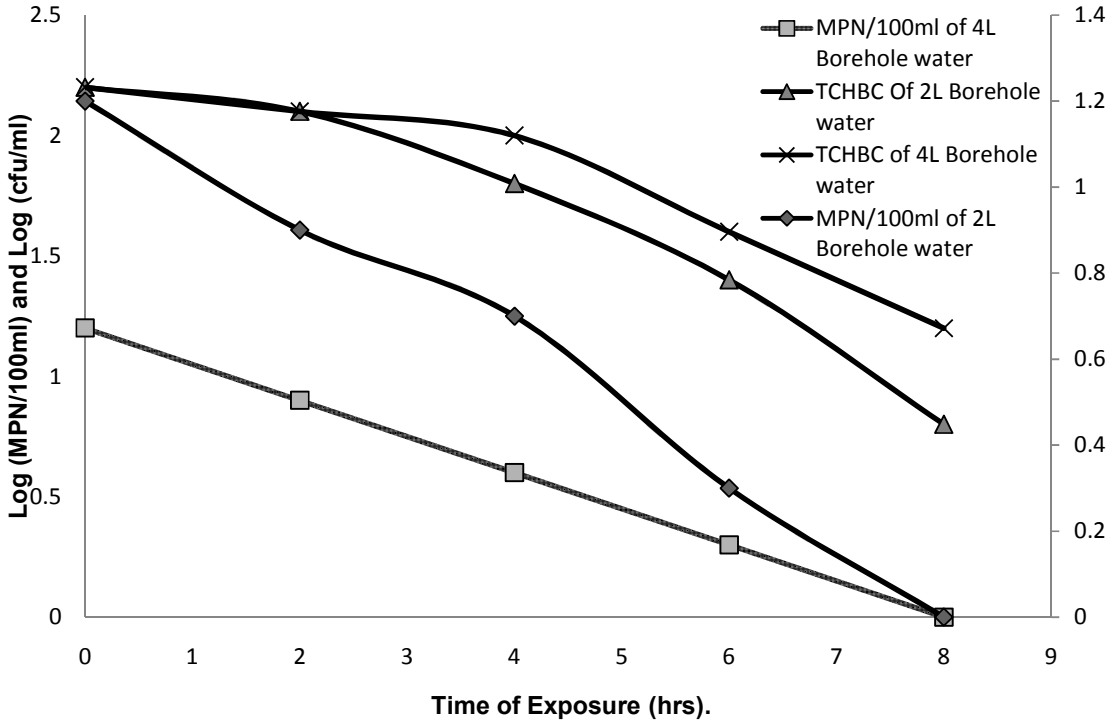

Fig. 3. Response of coliform and total culturable heterotrophic count (tchb) population in borhole water exposed to light rays

KEY; MPN = Most probable number; TCHBC = Total culturable heterotrophic bacteria count

4. DISCUSSION

Water samples around Choba and Aluu communities of River State, Port Harcourt were used during this study. The efficiency and reliability of convergent rays disinfection process was studied using different volumes of water sample exposed to convergent rays at various intervals. Bacteriological parameters such as coliforms and total culturable heterotrophic bacteria count, (Figs. 1 - 3) were performed. Result obtained indicated that the quality of all the water samples exceeded the standard defined by WHO before exposure.

Both coliforms and TCHB populations decreased as the time of exposure increased from zero (0) to eight (8) hours. Statistical analysis showed that there was significant difference in population changes between the times of exposure (P =.05) while the volumes of water exposed showed no significant difference in the change in population as indicated by the P =< 0.05. The coliform population of the 2 and 4 Litre aliquots decreased from 3.3 and 3.4 to 0.0 log MPN/100 ml after 8 hours while the total culturable heterotrophic bacterial population decreased from 2.2 and 2.4 for 0 hour to 0.9 and 1.3 log cfu/ml after 8 hours. These results are in agreement with the work of Alejandra [4]. He reported that 10^5 microbial populations can be eliminated after 4 hours of solar exposure. Most microbial death was possibly due to the thermal death point.

The logarithmic populations of coliform and total culturable heterotrophic bacteria in both test water volumes decreased with increased time of exposure. There was significant difference in population changes between the times of exposure (P=.05) while the volumes of water exposed showed no significant difference in the change in population as indicated by the P = <.05. The coliform population of the 2 and 4 Litres aliquots decreased from 3.2 and 3.2 to 0.0log MPN/100 ml after 8 hours while the total culturable heterotrophic bacterial population decreased from 2.2 and 2.4 for 0 hour to 1.0 and 1.2 log cfu/ml after eight (8) hours of exposure. These results strongly agree with Ojo [1]. They

reported that 99.6% and 99% reduction of bacterial load of water sample was achieved with 2 and 4 litres volume after 8 hours of exposure at temperature of 48°C. It was assumed that thermal denaturing of bacterial DNA occurred at temperatures of 45°C and above.

Coliform and total culturable heterotrophic bacteria in both test water volumes decreased with increase time of exposure. Statistical analysis showed that there was significant difference in population changes between the times of exposure and the volumes of water exposed as indicated by the *P* =.05.

Both coliforms and TCHB had the same logarithmic values at zero hour and after 2 hours of exposure. Log MPN/100 ml was 1.2 and log cfu/ml was 2.2 at zero hour and 0.9 MPN/100 ml and 2.1 cfu/ml after 2hours. The population decreased as the time of exposure increases. After the final exposure time of 8 hours, the logarithmic population of MPN/100 ml was zero while the log (cfu/ml) was 0.9 and 1.2 for both test volumes. The populations decreased with increase in exposure time. The complete disinfection of coliforms after eight [8] hours of exposure at 48°C also agrees with Alenjadra [4]. They reported that with solar concentrator equipment, 10^5 coliform for each 100 ml of water can be eliminated after 4 hours of solar exposure while the 0.9 and 1.2 cfu/ml also conform to World Health Organization [7] and Environmental Protection Agency [3] 1.0×10^2 standard for water. The germicidal action of convergent rays was assumed to be a reflection of the concentration and intensity of light rays.

Generally, underground water (borehole) is believed to be the purest known water because of the purification properties of the soil [2]. However, it can be contaminated due to improper construction, shallowness, and proximity to toilet facilities or sewage [2]. Borehole water had the least level of contamination from results obtained (Fig. 3). Total disinfection was achieved after eight (8) hours exposure with 48°C temperature, this strongly agrees with Acra [4].

The limitation of detecting pathogens like *Salmonella-shigella* and *Vibrio* sp may be a reflection of the depth of the borehole among several other contributing risk factors [2,8]. The pH of some water samples (Well 6.4 and borehole 7.0) were in agreement with World Health Organization and Environmental Protection Agency standard while River water (5.0) did not meet the 6.5-8.5 pH standards for water (Fig. 4).

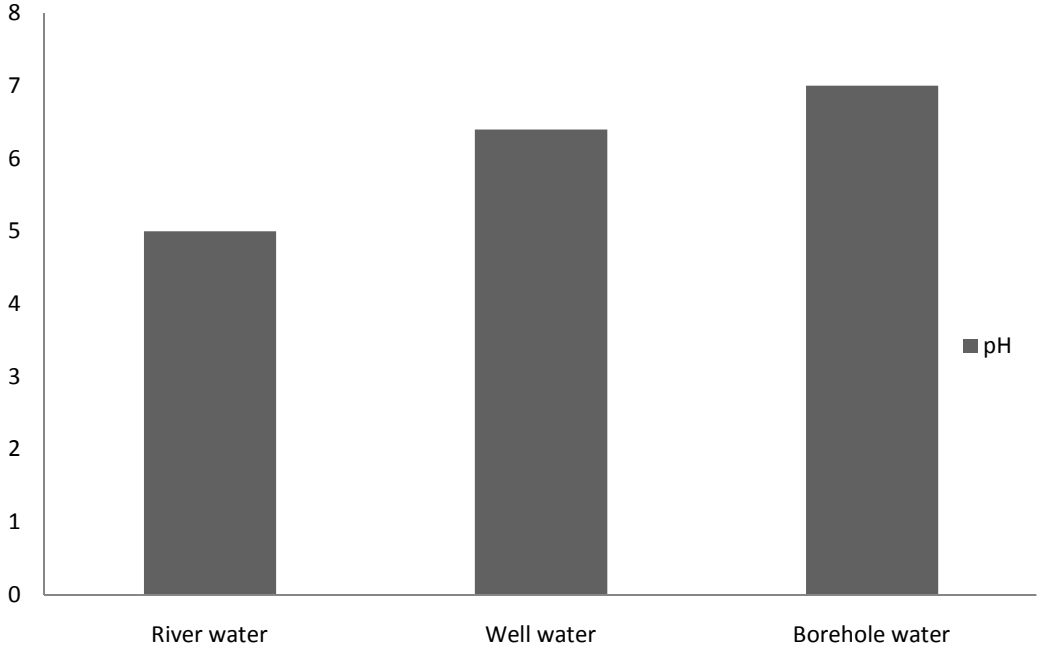

Fig. 4. pH range of water samples

Other bacteria isolated from the water samples such as *Escherichia* sp, *Staphylococcus* sp, *Bacillus* sp, *Proteus* sp and *Enterobacter* sp are also a big concern for public health. *Staphylococcus* sp is known to produce enterotoxin [2]. *Proteus* sp belongs to intestinal flora but is also widely distributed in soil and water [2,8]. *Enterobacter* sp isolated from the water samples are example of non-faecal coliforms found in vegetation and soil which may serves as a source by which pathogens enters the water bodies [2,8]. The presence of coliforms and total culturable heterotrophic bacteria count parameters have been documented as national primary drinking water regulations (NPDWRs) or primary standards which protect public health by limiting the levels of contaminants in drinking water [9].

5. CONCLUSION

The efficiency and reliability of convergent rays as a water disinfection technique or method cannot be over emphasized. The effectiveness of the treatment process can be achieved after 6 hours of exposure and above when using a ray concentrator with a wide area. Bacteriological parameters responded with a decrease in population with increase in exposure time. It is therefore rational to conclude that exposure of 2 or 4 litres volumes of water samples in a circular dish ray concentrator for 6 hours and above can be appropriate for the treatment process. Finally, this research work has attempted to capture and address the global water scarcity.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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