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Effect of Radiation on Bacterial Population During Annular Solar Eclipse

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An annular solar eclipse was observed in India on January 15, 2010, with a magnitude of 0.9190 and was most prominently seen in southern parts of Kerala. The effect of radiations especially UV light, produced during different phases of solar eclipse, on bacterial populations was investigated. The bacterial species, *E. coli*, identified from the normal water samples were inoculated in different test tubes with known aliquots of distilled water and were exposed directly to the eclipse radiations. The samples were observed to have an increased number of viable bacterial colonies in both the pre and post eclipse phases. The samples exposed at the peak hours of eclipse that is phase I (12 -13h) and phase II (13-15h) shows subsequent reduction in bacterial populations. About 51.47% and 63.21% reduction in bacterial populations were observed in first and second phases of eclipse respectively. The restoration of bacterial populations with about 77.46% increase in viability in the post eclipse phase was observed. The major observation made was the development of fluorescence by *E. coli* colonies on the nutrient agar plates after their exposure to the solar eclipse's radiations. This phenomenon could be attributed to the mutagenic effects of radiations produced during the eclipse. About 82.75% and 94.54% of the bacterial colonies among the total bacterial population developed fluorescence, after their exposure to the radiations in first and second phases of the eclipse respectively.

Key words: Annular solar eclipse; *E. coli*; Fluorescence; Radiation; Bacterial colonies.

Annular solar eclipse is the most spectacular astronomical event that most people will experience in their lives. There is a great deal of interest in watching eclipses, and thousands of astronomers travel around the world to observe and photograph them. The solar eclipse of January 15, 2010 was an annular eclipse of the sun with a magnitude of 0.9190. A solar eclipse occurs when the moon passes between earth and the sun, thereby totally or partially obscuring Earth's view of the Sun. An annular solar eclipse occurs when the moon's apparent diameter is smaller than the Sun, causing the sun to look like an annulus (ring), blocking most of the sun's light. An annular eclipse appears as a partial eclipse over a region thousands of kilometers wide. It was the longest annular solar eclipse of the millennium, and the longest until December 23, 3043.

The eclipse was visible as only a partial eclipse in much of Africa, Eastern Europe, the Middle East and Asia The path of the moon's antumbral shadow begins in Africa and passes through Chad, Central African Republic, Democratic Republic of the Congo, Uganda, Kenya,

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and Somalia.. It was seen as an annular eclipse within a narrow stretch of 300 km (190 mi) width across Central Africa, Maldives, South Kerala (India), South Tamil Nadu (India), Sri Lanka, parts of Bangladesh, Burma and China. The maximum duration of the eclipse was 11 minutes and 7.8 seconds over the Indian Ocean, thus making it the longest annular eclipse of the millennium. In India, the eclipse gets started around 11.53 a.m. and ended around 15.11 p.m.

The maximum eclipse of 53 percent was at 13.39 p.m. The eclipse was the longest of the millennium – that is between 2001 and 3000. People in most parts of India had seen the partial phases of the eclipse. Solar eclipses are useful in gathering scientific data about the atmosphere of the earth. During an eclipse there is a sudden reduction of solar radiation, which causes various effects in the atmosphere at different altitudes. It is known that the eclipse bring many atmospheric changes and its effect is a marvelous change for physics to study the diameter of the sun, gravitation, atmospheric temperature, planets and other parts of the solar system.

Biologists are also interested in observing the behavioral changes of insects, birds, animals, plants etc during this event. There have been reports on the killing effect of the radiations produced during the solar eclipse event[1]. The changes in growth of fungal populations during the eclipse and the effect of radiations emitted during the solar eclipse on the microbial population, with special emphasis on fungal populations have been reported[2].

The germicidal action of sunlight has long been recognized[3] but the ecological implications and the potentials for practical applications have to be researched more thoroughly. UV light has been shown to effectively inactivate indicator bacteria and pathogens[4-5]. The effectiveness of UV light in biological inactivation arises primarily from the fact that DNA molecules absorb UV photons between 200 and 300 nm, with peak absorption at 260 nm. The solar radiation that reaches the surface of Earth ranges from ultraviolet (UV) radiation at wavelengths longer than 290 nm to radio waves in the meter range hence they may possibly cause the lethal effects.

The main objective of the study was to find out the changes happening to the bacterial population before and after being exposed to solar radiations especially UV light produced during the solar eclipse.

MATERIAL AND METHODS

The study was conducted in the south zone of kerala at the latitude and longitude of 9° 29’ 39" N / 76° 19’ 39" E where the solar eclipse had taken place prominently in India on January 15th 2010. The time frame of solar eclipse in India was around 11:29 am to 15:15 pm. According to the Planetary Society of India, the peak of the eclipse will be approximately 77 percent around 13:32 pm when the moon will mask the sun.

Ordinary tap water was initially plated for isolation of the organisms required for conducting the experiment. Among the bacterial population that appeared in the nutrient agar plate, the major bacterial colonies that predominated in the water sample was isolated and identified using the procedures in the Bergey’s manual of systemic bacteriology. The colonies were then sub-cultured and purified. The purified bacterial cultures were later used for preparing the test samples for the experimentation procedure.

Preparation of experimental samples

Approximately 1ml of nutrient broth culture of the purified bacterial colonies was inoculated in 6 different sterile test tubes with 9ml sterile distilled water. The test tubes were placed in racks in a slanting position at an angle of 45° so that they were exposed directly to the solar radiations at the time of the eclipse. Similar set of test tubes with the same aliquots of bacterial culture broth in sterile distilled water were exposed to the atmospheric radiations before (Pre eclipse) and after (Post eclipse) the peak hours of the eclipse phase and was set as the control.

The control tubes were exposed to the atmosphere for a time period of 1h before and after the peak hours of eclipse. The test samples were kept exposed for different time intervals starting from 12:00 noon to 13:00 h (Phase I) and 13:00 to15:00 h (Phase II), which includes the peak hours of the eclipse. Both the test and the control samples were then kept for 2 h in the normal room temperature covered with a dark coloured paper for limiting light. This can avoid the photo reactivation effect on the mutation that might have

occurred in the bacterial cell due its exposure to the mutagenic radiations produced during the eclipse. The viable counts of the organisms were made at regular intervals by preparing a standard decimal dilution series of 10^{-1} and 10^{-2} in sterile distilled water. Test organisms were counted on nutrient agar medium after incubation at 37°C for 24 h. Three replications of the same samples were plated and the average values were taken as the final result.

The bacterial colonies from the nutrient agar plates were observed for their colony morphology and were identified using grams staining procedures. Individual colonies were picked up randomly from the plates and identified using the bacterial identification procedures in Bergey's manual of systemic bacteriology for reconfirmation. The total viable counts (TVC) are taken for each replicated plates and mean value was calculated.

RESULTS AND DISCUSSION

The bacterial colonies isolated from the water samples were found to contain predominately gram-negative rods and was identified as *E. coli*. The *E. coli* was most preferred microorganism for the study as it shows its extreme sensitivity towards near ultraviolet light[6-7]. Importance of *E. coli* as a test organism was also proved, indicating that when *E. coli* cells were exposed to solar radiation in estuarine water samples, their numbers were reduced from 6×10^8 to no surviving organisms per milliliter of water sample in 8 days[8]. There have been reports that the solar radiations can also inactivate fecal indicator bacteria like *E. coli* within a few hours in surface waters[9].

The total viable count of the plates from the samples exposed to the atmosphere in the pre and post eclipse phases (control) was found to be higher than those of the samples that are exposed to the eclipse radiations. The number of live organisms in the test samples was found to be much less than the control samples which prove the killing effect of solar radiations produced during the eclipse phase. The present study had observed a significant decrease in bacterial populations from an initial plate count of 16,900 cfu/ml for the samples obtained in the pre eclipse phase to a reduced level of 8,700 cfu/ml for exposed samples at the first phase of eclipse (12 -13h). The samples exposed during the second phase of eclipse (13-15h) had shown a total viable count of 5,500 cfu/ml. The solar corona that remained partially unmasked during the eclipse is the source of the ultraviolet radiations that could have attributed to this reduction in level of bacterial populations.

About 51.47% reduction in the bacterial population was observed during the first phase while 63.21% reduction in bacterial populations was observed during the peak hours of eclipse when the intensity of radiations was found to be high. The total plate count of 7,100 cfu/ml was observed for the samples exposed during the post eclipse phase. After the eclipse phase, 77.46% increase in viable colonies was observed. This clearly indicates that the decrease in intensity of UV radiations during the post eclipse phase has resulted in the increase in microbial populations. Similar observations were made by other researchers indicating that the intensity of solar radiation which kills bacteria was significantly greater during the eclipse period than in normal day[1].

The bacterial colonies obtained from the water samples, which were exposed to the eclipse radiations, after plating in nutrient agar medium, developed fluorescent colonies. The fluorescence was not observed for the bacterial colonies in the control plates (Fig. 1) while a remarkable increase in the fluorescence (Fig. 2) was shown by bacterial cultures obtained from the test samples, which could be easily observable. The total percentage of bacterial colonies that develops fluorescence is also noted more for the sample that was kept for longer time in the radiations especially at the peak hours of the eclipse (13h – 15h). Samples kept for 2h in the radiation showed the highest percentage of increase in fluorescent colonies with a value of 94.54% (for 10^{-2}dilutions). The samples show a considerable decrease in the intensity of fluorescence as the exposure time decreases. For initial exposure time (12h- 13hr) there observed a reduced fluorescence with a total percentage of 82.75% of colonies being fluorescent (for 10^{-2} dilutions). This change in the bacterial colonies can be attributed to the mutagenic effect of the UV radiations produced during the peak hours of the eclipse. There had been reports that the exposure

Fig. 1. Control plates without fluorescence

Fig. 2. Test sample with fluorescence exposed in solar radiation

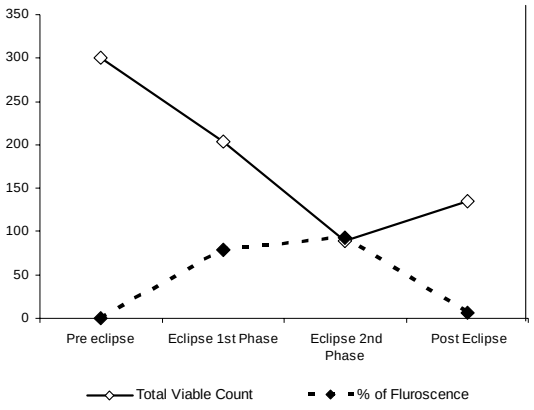

Fig. 3. TVC and % of *E.coli* colonies (10^{-1} dilution) showed fluorescence

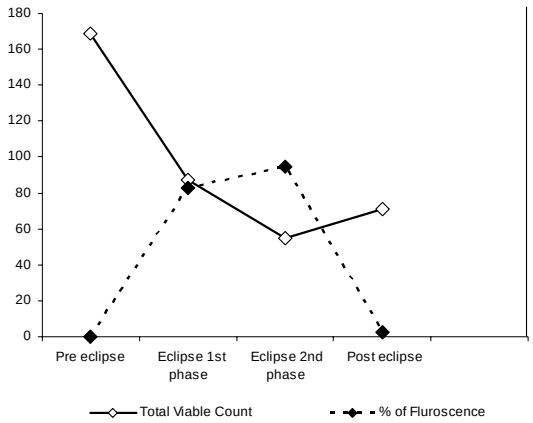

Fig. 4. TVC and % of *E. coli* colonies (10^{-2} dilution) showed fluorescence

to solar UV radiation can reduce productivity, affect reproduction and development, and increase the mutation rate in microorganisms[10], bacterioplankton and other aquatic animals[11].

The major bacterial colonies that had developed the fluorescence were observed under the UV transilluminator for ensuring their fluorescence (Fig.3 & 4). The bacterial colonies that develops fluorescence in the plates where isolated and are identified for reconfirmation and was found to be *E. coli.* The fluorescence observed in the samples collected during the post eclipse phase showed a considerable decrease with a value of 2.4%, indicating that the fluorescence had been caused due to the exposure of the samples to radiations at the peak hours of solar eclipse.

CONCLUSION

The water samples that are unexposed to radiations produced during the solar eclipse (pre eclipse phase) showed a maximum viable count (16,900 cfu/ml) and the *E.coli* colonies isolated were with no fluorescence. In the exposed water samples at the first eclipse phase there observed a considerable decrease in the viable count (8,700 cfu/ml) when compared to the unexposed samples. Due to the higher intensity of the radiations

produced during the peak hours of eclipse, the plates exposed at the second phase showed the least number (5,500 cfu/ml) of viable bacterial count. In both the cases the exposed bacterial colonies develops fluorescence with a value of 82.75 % in the first phase and 94.54% in the second phase. The post eclipse phase showed a marginal increase in bacterial populations (7,100 cfu/ml) and showed only 2.4% of fluorescence. This clearly indicates that radiations, like UV radiations, produced during the peak hours of eclipse phase have more lethal effects on bacterial populations. These results had confirmed the lethal effects of the radiations that had been produced during the solar eclipse but with a remarkable finding of the development of the fluorescent bacterial colonies. The bacterial colonies that had been non-fluorescent had developed a fluorescent property that could be attributed to the mutagenic effect of the radiations that are produced during the solar eclipse.

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