

Global Warming and Microorganisms: Brief Insights to the Emerging Diseases

Rashed Noor*, Bushra E Anjum, Saffat Reaz, Farhana Farin Tasnim, Kaneez Fatima, Mohammed Fahad Alam Saeed, Md Imran Khan Masum, Mahbuba Akther, Margia Hossain Rahi and Hafsa Jarin Snigdha

School of Life Sciences (SLS), Independent University, Bangladesh (IUB), Bashundhara, Dhaka, Bangladesh

***Corresponding Author:** Rashed Noor, School of Life Sciences (SLS), Independent University, Bangladesh (IUB), Bashundhara, Dhaka, Bangladesh.

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Abstract

The consequences of global warming as well as climate changes have recently been appearing as a huge threat round the globe because of the associated decline in the environmental sustainability which in turn is noticed to evoke the mass public health deterioration. Promulgation of re-emerging diseases has been connected by several groups of scientists to one of the ghastly effects of global warming. The significance of understanding the changes in the biodiversity; i.e., the variations in disease causing bacteria and viruses, vectors and hosts is noteworthy upon the environmental perturbations caused by the global warming and by the climate change as well. Such a study would benefit the overall public health globally. Present review concisely described environmental issues raised by the global warming and about the associated vector-borne re-emerging diseases.

Keywords: Global Warming; Microorganisms; Climate Change; Emerging and Re-Emerging Diseases; Vector; Biodiversity

Abbreviations

MERS-CoV: Middle East Respiratory Syndrome Coronavirus; SARS: Severe Acute Respiratory Syndrome; CHIKV: Chikungunya Virus; DENV: Dengue Virus; ZIKV: Zika Virus

Current situation of global warming and its impact on microorganisms

Recent scientific interest into global surface temperature variability and climate change impacts led to unravel (1) the incidences of summertime warm that is associated with the raise of sea surface temperatures and (2) the wintertime cold extreme that is linked with the atmospheric warming tendency [1]. Besides, the signs and signals of climate change is another serious concern for the scientists. Extreme weather events, melting of ice, elevated sea levels, acidification of the oceans, reduced fresh-water resources,

abnormal precipitation (heavy rainfall both in spatial and temporal patterns), increase in the atmospheric carbon dioxide (CO₂), the heightening of the greenhouse gases, heat waves, disruption and depletion of stratospheric ozone, the unpredictable intense weather conditions, soil degradation and the loss of productivity of agricultural land, desertification, and most importantly the decreased trend in the biodiversity with a concomitant increased rate of infectious disease emergence and re-emergence brought the interest of the scientists working especially in life sciences. Among them, the microbiologists are now focusing on the impact of global warming/ climate change on (1) the microbial consortium in the environment, especially in soil and ocean, (2) on the host - pathogen interactions followed by (3) the global burden of infectious and re-emerging diseases [2].

Global warming and microbial activities

The global warming phenomenon has largely drawn interests of microbiologists since such a constant increase in the global temperature may be associated with the dissemination of an array of re-emerging diseases as well as with the massive changes among the microbial growth dynamics within the soil, air, and water. It has been noticed by a group of scientists that the temperature of the Arctic Ocean is increasing at a rate of two to three times higher than the normal physicochemical condition together with the accelerated ice loss which in order may result in the complete loss of ice within 2050 [3,4]. Such warming beyond a threshold of 5°C has been shown to enhance a decline in the phytoplankton biomass [3,5]. Interestingly this type of escalating warming may elevate the marine bacterial population which may trigger bacterial carbon transfer to the upper trophic levels [6]. Indeed the recent study based on the observation of the responses of phytoplankton biomass, the heterotrophic microorganisms and viruses to the contemporaneous changes in warming along the elevation of CO₂ unraveled an attention-grabbing dynamics in microbial abundance [3]. Such a cascade would really be threatening as the global warming seems to be favorable for the survival and replication of the infectious microorganisms resulting in fatal diseases causing worldwide mortality and morbidity. Along these lines a generalized model has been proposed in Figure 1 inferring the influence of climate change and global warming on the microbial activities.

Figure 1: Proposed model of global warming and microbial activities. Global warming is largely responsible for the disruption of ecosystem posing the deteriorations in the atmospheric-, lithospheric-, and the hydrologic harmony. Together with the rise of temperature and the elevated CO₂ level, the desertification/loss of land fertility with irregular precipitation may increase due to the global warming which ultimately hampers the productivity by the phytoplankton and plants that is also indicative of the defective biogeochemical cycles which involve the participation of microorganisms. Perhaps the infectious microorganisms adapt more competently applying their quorum sensing mechanisms and hence survive and replicate with a concomitant transmission of the re-emerging diseases.

Along with global warming, the elevated level of CO₂, and nitrogen (N) deposition may influence the soil bacterial density which in turn affects plant biomass as well as the biogeochemical cycles including the carbon cycle, and the nitrogen cycle [7]. In a sense, the global warming or the climate change is very much likely to impart hassle on the soil environment as well as the soil microbial community. In an early study the increases in temperature was shown to pose negative effects on the abundance, diversity, structure and physiology of soil bacterial communities [8].

Rationale of the current review

Global warming and climate changes have direct impacts on the environment through unbalancing the natural ecosystem as the temperature of atmosphere, lithosphere and hydrosphere increases together with the imbalanced biogeochemical cycles. Biodiversity; i.e., the distribution of shifts of the infectious microorganisms as well as the associated vectors occurs let alone the increased chances for the contamination of food and waters. Thus the sound state of the mass public health deteriorates along with the socio-economic condition. As has been stated above, the most dreadful part of the global warming is the distribution and dissemination of the re-emerging diseases which has been elaborately focused in the current review.

Global warming and thermal adaptation by microorganisms: Experimental approaches

Microorganisms have specialized to possess a critical high temperature that is actually the upper limit of survival as well as that is known to be the optimum growth temperature [9]. Experiments with heat shock strategies revealed various up- and down regulations of the specified genes in the model test microorganism *Escherichia coli* Eventually the exceeding limit of temperature by the global warming is may damage the microbial cells in a defined ecosystem. However, interestingly some of the microorganisms may survive by adaptation to the temperature rise if the mutations linked to the capacity of withstanding the high temperature are gained. *In vitro* analysis of the effect of global warming on microbial ecosystems would be thus interesting. Recent experiments revealed interesting phenomenon of thermal adaptation capacity by *E. coli* and *Zymomonas mobilis* [10]. Aside microorganisms, the occurrence of thermal acclimation together with the acute and evolutionary adaptation to temperatures have been also noticed in the insects [11].

Global warming and the spread of pathogenic microorganisms

Global warming as well as the climate change may cast increased environmental pollution, deposition of toxic substances along the food chain, and thereby making proper ecological niche for the microbial pathogens, which ultimately may cause the propagation of infectious and re-emerging diseases especially by raising the transmission of water-borne pathogens [12]. A rise in the atmospheric, soil or marine temperature favors the vector (like mosquitoes and

ticks) transmitting a particular pathogenic virus or bacteria; and hence elevate the rate of diseases like malaria, Chikungunya Virus (CHIKV) infection, Dengue Virus (DENV) infection, Lyme disease, Ebola virus infection, Middle East Respiratory Syndrome Coronavirus (MERS-CoV) infection, Zika Virus (ZIKV) infection, yellow fever, West Nile Virus infection, Severe Acute Respiratory Syndrome (SARS), food borne illness, etc. [12,13]. These diseases are well known for causing the global fatality since appropriate vaccination strategies against these infections are still obscure.

Onset of re-emerging diseases due to global warming

Infectious diseases are actually thought to emerge due to (1) changes in their geographic ranges and (2) by the genetic changes in microorganisms infecting animals which in turn make the microorganisms further capable of infecting humans [13]. The emergence and re-emergence of infectious diseases is principally dependent on (1) the pathogenic survival and on the vector survival and reproduction; (2) microbial contamination of water and food; and to a great extent, (3) on the abundance of hosts. All factors are influenced by the environmental changes brought up by the global warming effects (Figure 2).

Figure 2: Proposed model of Global warming and re-emerging diseases. Along with the demographic- and social changes through the environmental deregulations caused by the global warming, the alteration in biodiversity as well as the changes in specific set(s) of gene(s) within the virulent microorganisms may trigger the onset of re-emerging diseases like CHIKV infection, DENV infection, ZIKV infection, etc. Such epidemics are expected to be augmented by the survival enhancement capacity of the infectious microorganisms and the associated vectors due to the altered/ favorable environment imparted by the global warming.

Earlier reports have shown that several countries round the globe are experiencing a range of disease outbreaks principally due to the natural dissemination of pathogenic bacteria and viruses into the environment [14]. Appropriate vaccination programs, defined chemotherapy may theoretically combat these emerging and re-emerging diseases; however, the microbiologists, the environmental scientists, the health professionals, and the people working with the climate change should focus on the clinical impacts of global warming which triggers the acceleration of these diseases within different geographical locations. From the discussion put above it is clear that a methodological maintenance of the environment is quite essential at least to pause the re-emerging infections since the appropriate treatment of diseases is not possible everywhere especially in the resource poor settings.

Besides routine clinical diagnosis, the medication strategies, measuring the drug-resistance traits of the infectious microorganisms, development of new drugs and vaccines, determining the rate of global warming using systematic tools (for example, by the process-based mathematical models to scrutinize the likelihood of the arthropod vector influx) may aid to forecast the disease epidemics and hence can help mass people to be aware of these infections [15,16]. Moreover, from the microbiological point of view, a handful of wet experiments using the affected cases demand to be conducted in order to project the future distribution especially of the vectors. Along with the global carbon emission, the environmental temperature - precipitation (rainfall) co-lineage for the vector survival as well as for the growth rates of the microorganisms is also in essence [16].

Conclusion

Together with the recent reports as well as from the above write-up, it is evidently clear that the global warming strongly influences the biodiversity as well as the infectious disease emergence and re-emergence. The mechanism behind such disease epidemics generated by the natural imbalance is being thoroughly investigated by different groups in different countries. It is simultaneously interesting and scary to know that the disruption of temperature within the nature; i.e., the climate change accounts for the increase in the number and extent of the emerging and re-emerging diseases. Involvement of the health professionals with the environmental scientists and the microbiologists would be fruitful to develop the preventive strategies against these diseases caused by the climate change and the global warming. Genetic analyses of the disease causing bacteria and viruses would further aid to develop clinical counters to improve the mass public health.

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Conflict of Interest

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