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Impact of climate change on biodiversity of microorganisms

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Climate change is one of the most important global environmental challenges, with implications for food production, water supply, health and energy. Microbes are involved in many processes, such as the carbon and nitrogen cycles and are responsible for both the production and consumption of greenhouse gases such carbon dioxide and methane. Microbes, it is safe to say are sadly neglected in most discussions of climate science, these tiny organisms are easily overlooked and there is nothing we human beings can do from one minute to the next that is not based on co-operative arrangements with our microbial partners. Global climate not only impact plants and animals but will also affect bacteria, fungi and animals and other microbial populations. Microbes have the capacity to alter the environment in profound and lasting ways as they are effective geo-engineers and biogeochemists. Life as we now know it could not have evolved without drastic rise in oxygen levels. Cyanobacteria in oceans are first organisms to produce O_2. Our respiration and digestion immune function, well being and survival depend on microbes. All our food is produced in alliance with complex community of organisms.

Why Climate change matters

Climate change affects biodiversity according to Millennium eco system assessment, climate change is likely to become dominant driven of diversity loss end of century. Microbes -bacteria, archaea, protista are crucial to biodiversity since they are part of it. In generic terms there is more variety within microbes than in other forms of life. The continuous existence of microbes is necessary for survival of everything else as they are important as decomposes and producers. Climate change is forcing biodiversity to adapt through shifting habitat, changing life cycles, developing new physical traits and attaining dormancy. Dormancy is a critical factor promoting diversity particularly in bacteria in comparison with eukaryotes. In a given ecosystem functionally diverse communities are more likely to adapt to climate change and climate variability than impoverished ones. High genetic diversity within species appears to increase their long term persistence. The ability of ecosystem to either resist or return to their former state following disturbance may depend on level of functional diversity.

IMPACT OF CLIMATE CHANGE ON MICRO ORGANISMS

Change in number and type of Microorganisms

Difference microbes occur in different places with natural changes on seasonal and longer cycle in costal sea water, greatest abundance of microbes occurs in mid summer, but greatest diversity is in mid winter, around 100000 species at single sight explains Williamson *et al.*, 2009[1]. If there is organic pollution for example by sewage, microbial number will increase, it there are temperature changes the number might fall or rise. In both cases species composition will change. It may not be necessarily good or bad but just different.

Higher temperature increases the survival of disease causing microbes that are undesirable and could be implication for biodiversity. For example during warmer and dryer conditions increased levels spore forming bacteria are observed. Such findings help scientists to determine whether a pathogen's presence is weather related or a sign of bioterrorist attack. Air - borne bacteria allow scientists to track the effect of climate change on microbial population in atmosphere. For example wind blown dust from Sahara desert of Africa that reaches North America increases incidence of asthma in CARI.

The occurrence of diseases in natural population can be detrimental to the survival of endangered species. For example amphibians suffer from infectious diseases contributing to decline in fog population worldwide. This also increases biodiversity in long term, if species reduced in number the opportunity may be provided for others to increase.

Affect on Carbon and Nitrogen contents

Microbial decomposition of organic carbon is crucial to terrestrial carbon cycle. A total of 93% of earth's CO_2 is stored in oceans. Oceans cycles about 90 billons tonnes of CO_2 per year dwarfing 6 billion tonnes or so generated by human activities. The mechanisms of this oceanic carbon cycle are dominated by micro, nano and pico-plankton, including bacteria and archaea. There is lot of frozen dead material under the snow pack, as studied in Alaskan Boreal forest and area experiencing greater warming. Treseder found in her research that an increased temperature would lead to increased decomposition by fungi. Since one by product of decomposition is CO_2 increased temperature results in greater CO_2 release from soil. Nitrogen levels increased with increase in temperature. Nitrogen tends to suppress fungal decomposition rate. So it ends up as decreased CO_2 production which inturn results in temperature increase. Thus increased temperature may provide a positive feedback to climate change affecting biodiversity through microbial activity.

Increased bacterial decomposition rates in soil in Arctic Tundra could release extra green house gases. Tundra is producing increasing quantities of methane. The main source of methane in permafrost soils is methanogenic (methane-producing) archaea, while the only known terrestrial sink is methanotrophic (methane-consuming) bacteria. Methane is a far more effective greenhouse gas than carbon dioxide.

Affect on phytoplanktons

Changes in Ocean in warmer world would reduce Phytoplankton productivity hence less uptake of atmospheric CO_2 by biological carbon pump. According to Worm rising surface temperature prevents mixing between the oceans O_2 rich upper layers where phytoplankton are present and colder more nutrient rich waters below. Studies have shown that temperature is associated with decline in phytoplanktons in 8 out of 10 regions. This decline is particularly around poles, where it seems logical that increasing warmth would drive more growth to be driven by increasing winds and ocean mixing. A decrease in plankton means less food for fish population .Temperature increases are expected to shift many species pole wards where climate is cooler. Warm water species increase in abundance affecting commercial fisheries. Many sea birds that prey on fish and plankton are likely to have their food supply reduced or relocated.

Affect on snow mold

As global temperature raises glaciers retreat, microorganisms lose their habitat. They will probably go extinct before we can study them and get a better idea of their contribution. Schmidt et al., 2008[2] studied microbial activity under the snow pack in Coniferous forests. Under snow microbial activity is especially high in the late winter as snow pack proves ideal temperature and moisture for the growth of mats of snow mold.

Snow mold may damage the lawn. They are rapidly growing at low temperature below freezing and contribute to 10-30% of year round CO_2 production. Snow mold needs a period of 1-2 months at low temperature to do the job effectively. As global temperature rises the late winter period of sub freezing temperature will shorten and snow packs will be less as well. As soil warm snow mould will have less water and will produce less CO_2 which may be good, but tree also depend on snow melt water and will ultimately die under extreme drought leading to overall decrease in CO_2 fixation.

Affect on phyllosphere

John Kelly of Loyola University in Chicago studied the effect of increased CO_2 on microbial populations on leaves of trees on land and in streams and found a distinct shift in microbial population. This could have an enormous impact on food change as microbes are a source of nutrients for small animals that feed on leaves.

Affect on Viruses

Marine viruses are estimated to be 4 x 10 ^{30} viruses in ocean waters. If stretched end to end marine viruses would span 10 million light years. Viral carbon is equivalent to 75 million blue whales.Viruses may lyse up to 50% of oceanic bacteria per day. In this way they affect geo chemistry on global scale by altering the storage and respiration of organic and in organic material.Viruses have direct dependence on host organisms for survival and hence cause animal are plant diseases.

Affect on plant pathogens

Temperate climate zones with cold average temperature experience longer periods of temperature that are suitable for pathogen growth and reproduction .For eg potato and tomato late blight caused by *Phytophthora infestans*, infects more successfully during periods of high moisture content when temperature is warm[3]. Some pathogens like apple scab, late blight and root pathogens are likely to infect plant with increased moisture. Research has shown that increased CO_2 concentration results in higher growth of stem and leaves with denser canopies in presence of high humidity. These conditions favour pathogen growth they also result in greater fungal spore production. It is also observed that increased CO_2can result in physiological changes in host plant that can increase host resistance to pathogens[4].

Affect on symbiotic relationships

Williamson explains that most plant eating animals directly depend on gut bacteria and archaea to digest cellulose.Warm water Corals directly depend on photosynthesizing micro algae within their tissues to provide them with internal energy supply. Coral bleaching occurs when algae are expelled under stress conditions, the corals die if symbiosis is not reestablished. Bioluminescence by fish, jellyfish and insects is achieved by symbiotic bacteria. Decline in pollinating insects has worrying impact in terms of biodiversity. According to Williamson decline in honeybees may be due to bacterial or viral disease involved in Varrao mite acting as an agent to increase its spread.

Concerns

⇒ Key ecosystem functions that a particular micro organism perform may be affected by global warming.
⇒ Another concern is possible increase in ability of pathogenic micro organism to cause diseases either as result of more favorable temperature for reproduction and therefore better ability to disperse into new geographic areas, where they could not previously survive well.
⇒ Micro organisms and bacteria in a particular, have amazing genetic capacity to either utilize a food source or become tolerant to many chemical that would be toxic to animals and plants including many xenobiotic compounds
⇒ In public view, micro organisms may not have the charisma as pandas, dolphins and butterflies but their communities are central to health, agriculture and play a key roll in earth's geo chemical cycle.

Hence there is a need to

⇒ Identify and conserve biodiversity components that are especially sensitive to climate change.
⇒ Preserve intact habitats so as to facilitate the long-term adaptation of biodiversity.
⇒ Improve out understanding of the climate change biodiversity linkages, and
⇒ Fully integrate biodiversity considerations into climate change mitigation and adaption plants.
⇒ Microbes are foundation of all life on earth and without them life would eventually cease to exist.

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