Volume 4, Issue 8

www.agriallis.com

Science for Agriculture and Allied Sector: A Monthly Magazine

Article Id
AL04148

CORAL BLEACHING

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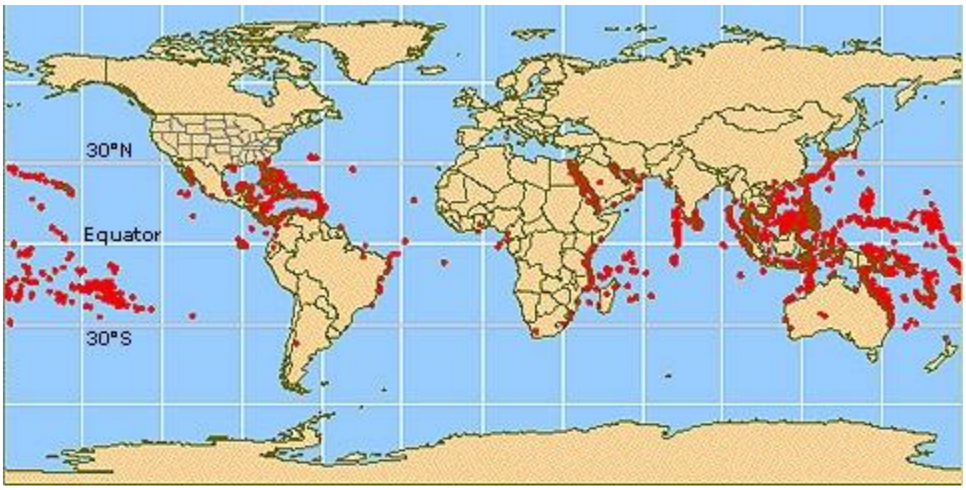
The coral reefs are distributed in the tropical regions and cover less than one percent of the earth's surface, but provide habitat for many species in the marine realm. The majority of reef building corals is found in tropical and subtropical waters and typically occurs between 30° N and 30° S latitudes. Coral reefs are greatly valued due for their beauty, biodiversity it encompasses and the products and services they provide to human society (Saravanan *et al.*, 2017). The coral reefs are made of calcium carbonate secreted as skeletal material by the coral polyp. Coral polyps live in association with intracellular algae (zooxanthellae), which provide additional nutrition to the coral in its life processes. The association of coral polyp with zooxanthellae, restrict its distribution in waters up to the depth of 100 meters where sunlight would be available for the photosynthetic zooxanthellae (Hoegh- Guldberg, 1999).

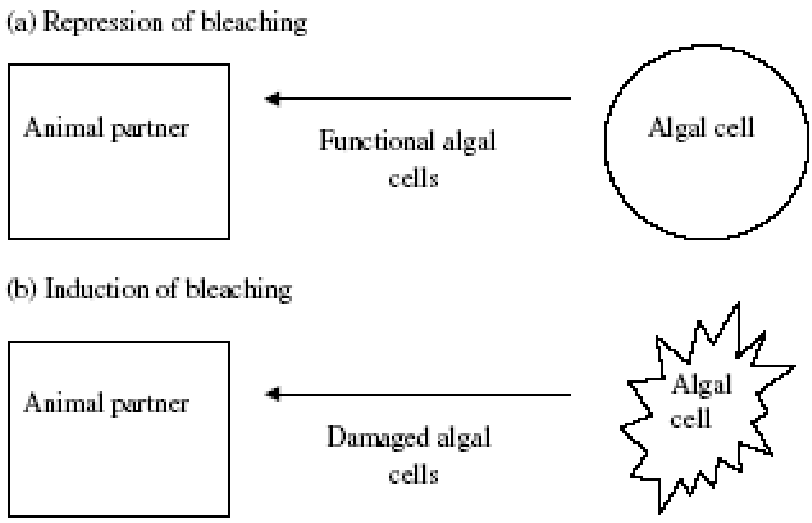


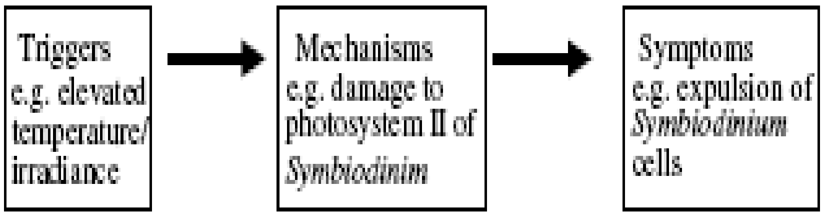
Coral Bleaching

Coral Bleaching is a stress condition in coral reefs that involves the breakdown of zooxanthellae. Bleaching is a stress response that results when the coral algae relationship breaks down. The term 'bleaching' describes the loss of colour that results when zooxanthellae are expelled from the coral hosts or when pigments within the algae are degraded. Because the photosynthetic pigments found in zooxanthellae give corals most of their colouration, the loss of zooxanthellae renders the tissue largely transparent (Hughes *et al.*, 2003).

The Causes of Coral Bleaching

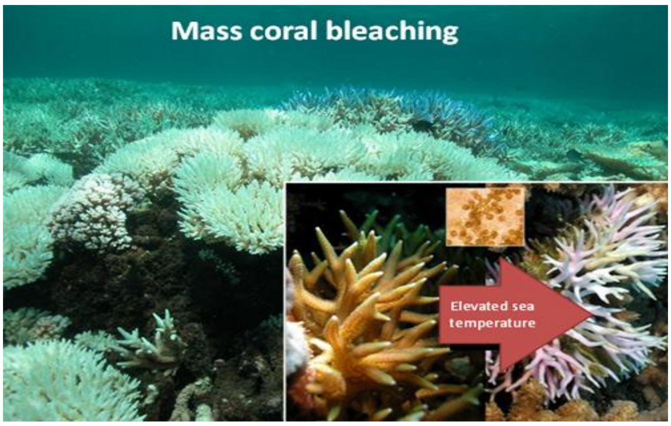
The role of temperature and light increased temperatures cause bleaching by reducing the ability of the photosynthetic system in the zooxanthellae to process light. When temperatures exceed certain thresholds, incoming light overwhelms the photosynthetic apparatus, resulting in the production of reactive oxygen species that damage cellular structures. Corals cannot tolerate high levels of these toxic molecules, and they must expel the zooxanthellae to avoid tissue damage. Because of the low tolerance of the photosynthetic process to high temperatures, even normal levels of sunlight are enough to damage the photosynthetic system of the zooxanthellae when temperatures exceed certain levels (Parry *et al.*, 2007).





Consequences of Coral Bleaching

- **Sea surface temperature** key factor for organisms associated with symbiotic dinoflagellates (zooxanthellae) or that have a narrow temperature tolerance range. Coral reefs grow in shallow areas with good light penetration where water temperature rarely declines below 18°C (Lesser, 2011).

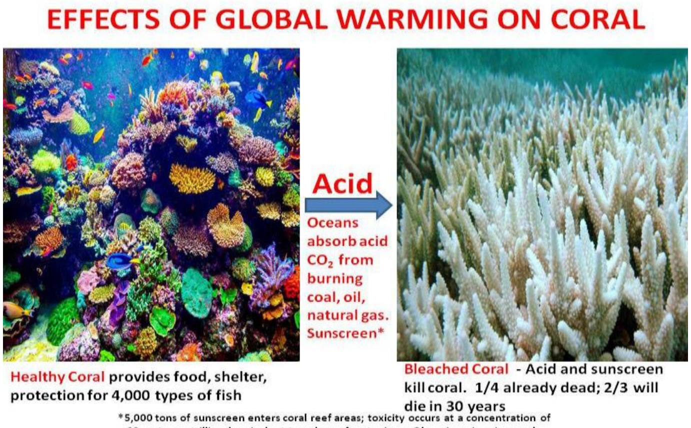


- **Salinity:** Zooxanthellae are sensitive to low salinity due to precipitation and runoff. Therefore, they tend to live near shallow, clear waters (no deeper than 100m) with plenty of sunlight.

❖ **UV radiation:** High levels of photosynthesis lead to high amounts of nitric oxide production by zooxanthellae (Gleason and Wellington, 1993).

❖ **Global Warming**

- If temperatures continue to increase to 1-2 C, for the next 20 years there will be mass coral bleaching worldwide.
- The high seawater temperature elevation will affect over 95% of the species living within the coral and lead species to become extirpated or extinct.

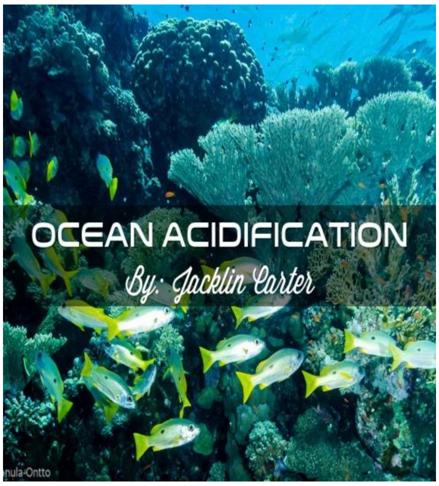


❖ **Irradiance**

Irradiance (both visible light and ultraviolet (UV) light) is a key environmental factor for coral reefs. Coral reefs need sufficient irradiance for photosynthesis, and are therefore restricted to the upper 50 metres depth in clear oceanic waters, and four metres in turbid inshore waters128. However, too high levels of irradiance during hot periods can cause permanent physiological and structural damage to photosynthetic symbiotic organisms through photoinhibition and other stress processes.

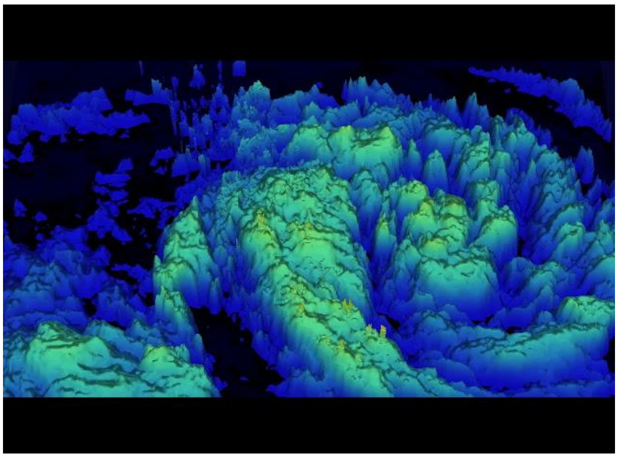
Ocean Acidification

Evidence is strong that a reduction in pH following rising CO2 will cause profound changes in the physiology of marine calcifying organisms and in reef processes. Direct effects will be greatest for calcifying algae such as crustose coralline algae and *Halimeda*. The sensitivities of calcifying and non-calcifying organisms to ocean acidification (Downs *et al.*, 2002).



❖ **Tropical storms**

Susceptibility to tropical cyclone damage varies widely between species and growth forms, and also changes across the continental shelf and with depth. In general, species with slim bases and slender branches, such as branching *Acropora* or large upright seaweeds (eg *Sargassum*), and organisms residing in shallow water are highly sensitive to cyclone damage.



- **Coral disease**

Just as in humans, corals are regularly exposed to diseases. Bacteria, viruses, protozoa, or fungi can cause coral diseases, but generally disease is isolated, patchy or not deadly in healthy coral reef systems. However, under certain conditions disease can spread through entire populations or reef communities, causing widespread damage of coral.

Consequences of Increased Bleaching

- **Increased coral mortality**

One of the most direct impacts that coral bleaching has on corals and coral reefs is that affected organisms tend to die at greater rates. Mortality estimates following mass bleaching range from close to zero in cases of mild bleaching to close to 100% as seen in some shallow water reefs. Island at the southern end of the Great Barrier Reef. Corals of some genera (e.g. *Pocillopora*). Mortality was family specific with staghorn corals (Acroporidae) being the worst affected. Bleaching affected all colonies of *Acropora hyacinthus* and *A. gemmifera* and

70–80 % were dead 5 weeks after the initial bleaching began (Schuttenberg and Marshall, 2005).

- **Decreased coral reproduction**

In addition to killing corals, increased temperature has recently been found to effect coral populations by reducing the reproductive capacity. The effect of bleaching stress on corals was dramatic. Bleaching reduced reproductive activity in most reef flat corals examined. Bleached colonies of many important reef flat species contained no eggs at all despite the fact that they were supposed to be reproducing month's later (*Symphyllia* sp, *Montipora* sp, *Acropora humilis, Favia* sp, *Goniastrea* sp, *Platygyra daedalea*. Observations during the spawning period in November revealed that these bleached corals, even though recovered, did not spawn (Douglas, 2003).

- **Reduced reef productivity and growth**

Although mortality might not always eventuate, reef-building corals that undergo bleaching have reduced growth, calcification and repair capabilities following bleaching. The primary effect of increasing the temperature is to induce the loss of zooxanthellae from reefbuilding corals and other symbiotic invertebrates. As zooxanthellae are the principal engine of primary production in these organisms, the rate of photosynthetic productivity of reef-building corals and other symbiotic organisms falls off dramatically. Reef-building corals contribute a substantial proportion of the total productivity of coral reef ecosystes (Baird *et al.*, 2009).

Mitigation Measures

- **Management of local stressors**

Local stressors includes physical damage due to diving, snorkeling and anchoring, water quality and fishing activity. In the present case, the Lighthouse Reef suffers from physical damage due to anchoring as well as effluent discharge from the adjacent shrimp farms. The local, regional and global stressors for the reef system should be analyzed as indicated in. Monitoring light, temperature and water currents is important as Palk Bay is prone to quick and longer spells of seawater warming (Brown, 1997).

❖ **Identifying resilient coral reef areas**

Identifying the healthy reef areas, which tolerate bleaching and protecting them for the reef recovery, is required. A resilient coral community might suffer significant coral mortality from a bleaching event, but reorganize so that the community composition shifts toward different coral species that require similar habitat and are more tolerant to coral bleaching. Building long term reef resilience can be achieved by identifying the resilient coral community and incorporating the area into a management plan (Loya *et al.*, 2001).

❖ **Fishermen involvement in reporting and monitoring coral bleaching events**

Identifying the fishermen for reporting the bleaching events to the state and central government agencies and monitoring the bleached coral reef sites as community management is required (Hoegh-Guldberg, 1999).

❖ **Marine Protected Areas**

Marine Protected Areas (MPAs) are considered as the best strategy to conserve coral reef habitat and biodiversity. The Great Barrier Reef Marine Park that was established in 1975 is a good example. In 2004, the park was re-zoned to increase the no-take area, which means that no fishing or disturbances such as anchoring or removal of material is allowed. Especially no-take marine reserves have resulted in positive ecological effects (Buddemeier and Fautin, 1993).

❖ **Developing a forecast model for coral bleaching**

The US National Oceanic and Atmospheric Administration (NOAA) developed a forecast system on global level for coral bleaching due to thermal stress. Operating on similar lines, the Coral Bleaching Alert System (CBAS) is a service initiated by Earth System Science Organization – Indian National Centre for Ocean Information Services (ESSO-INCOIS) since February 2011 in India. This employs a model that assesses the thermal stress accumulated in the coral environs with the help of satellite derived SST (West and Salm, 2003).

Conclusion

Climate change is emerging as the single greatest threat to coral reefs. Rising CO2 emissions into the atmosphere is taken up by the oceans and alters ocean chemistry, leading to acidification. This in turn affects coral calcification, an important determinant of the health of coral reef ecosystems. The ability of corals to deposit calcium carbonate has declined and is likely to have several consequences such as weakening of coral skeletons and reef structures. 19% of the world's coral reefs are estimated as already lost and model outputs show that bleaching and acidification will be a severe threat to continued coral survival. The current rate of increasing CO2 is worrying, because modern coral reef may not have the ability to adapt to these changes and together with direct human pressures, this may drive coral ecosystems toward domination by non-coral communities. Actions to conserve reefs are urgent and must include polices to reduce CO2 emissions. Further research is needed to fully

Understand this highly complex subject. Investments and collaboration in order to include more coral reef areas in MPA networks and to also improve other management strategies would help to protect coral reef ecosystems and increase their ability to survive.

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