Ocean Acidification

Introduction

Ocean Acidification may be defined as the chemical reactions which occur when the CO_2 is absorbed by seawater, thus reducing the seawater pH, carbonates ion concentration and saturation states of biologically important calcium carbonate minerals.

Since the beginning of the industrial revolution, the release of CO_2 from industrial and agricultural activities has resulted in increase of atmospheric CO_2 concentrations. The concentration of atmospheric CO_2 has actually increased from 280 parts per million (ppm) to 381 ppm. The ocean has absorbed about 430 billion tons of CO_2 from the atmosphere, or about one-third of anthropogenic carbon emissions. This absorption has benefitted people by significantly reducing greenhouse gas levels in the atmosphere. However, the ph (the measure of acidity) of the ocean surface water has already decreased by about 0.1 units (from the average of about 8.2 to 8.1), since the beginning of industrialization. Studies have predicted that by the middle of this century atmospheric CO_2 levels could reach higher than 500 ppm, and by 2100 they could be well over 800 ppm (IPCC scenario B2, 2007). This would result in an additional mean surface water pH decrease of approximately 0.3-0.4 pH units by 2100 implying that the ocean would be about 100-150% more acidic than at the beginning of the industrial revolution.

The Chemistry of Ocean Acidification

The chemical reaction involved in the ocean acidification is the reaction of atmospheric CO_2 absorbed by the ocean with seawater to form carbonic acid (H_2CO_3). Almost immediately the carbonic acid dissociates to form bicarbonate ions (HCO_3^-) and Hydrogen ions (H^+). As the concentration of Hydrogen ions increases, the water becomes more acidic.

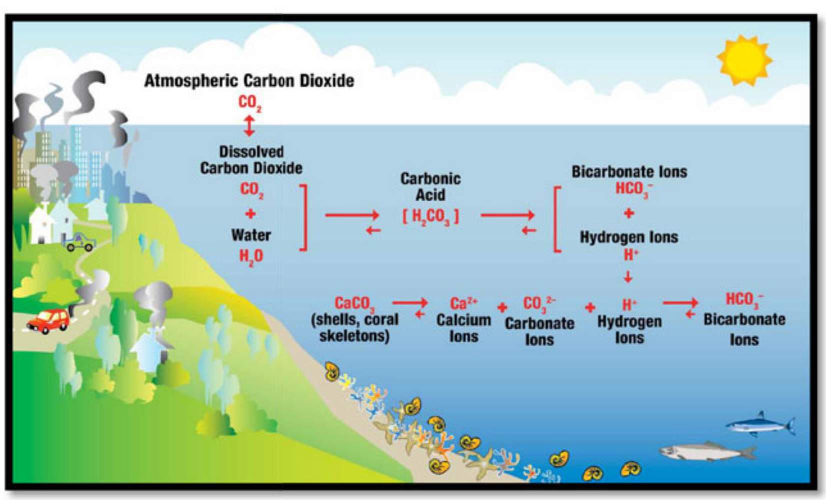

Fig No. 1: Carbonate Chemistry

Ocean Acidification & its Impacts

The decrease in ph-levels, and the subsequent increase of acidity and the decrease of carbonate ions make it difficult for many marine organisms to survive; particularly those that rely on carbonate ions for the production of calcium, which in turn is vital for the production of shells and other body structures. An increase in the acidity of the seawater, combined with environmental stressors like increasing ocean temperature and pollution, has the potential to affect the biological processes.

Building Shells: Many animals and some algae use the carbonate ions to make calcium carbonate shells and skeletons. Due to ocean acidification there is decrease in the availability of carbonate ions, hence organism's takes longer time to produce shells.

Fig No. 2: Shell Production

Maintaining Metabolism: Metabolic processes of many organisms are fine-tuned to operate within a narrow pH range. Beyond that range, the reactions may be too slow or inefficient to keep the organism healthy. Although many species can adjust to changes in their surroundings by actively maintaining a constant internal environment, this maintenance requires a significant expenditure of energy. An adult fish may be able to compensate by eating more, but fish eggs and larvae have limited energy reserves and, therefore, may have less capacity to adjust to more acidic conditions.

Fig No. 3: Side effect on fishes

Boosting Photosynthesis: Carbon dioxide can stimulate plant growth by boosting the rate of photosynthesis. Many plants, including seagrass, grow more rapidly under elevated carbon dioxide conditions. Although sea-grass provide valuable habitat, this could be too much of a good thing; if these plants overgrow the less robust species it could reduce the ecosystem's biodiversity.

Fig No. 4: Sea grasses, reduction of bio-diversity

Obtaining Essential Minerals & Nutrients: Ocean acidification could make it harder for marine organisms to absorb nitrogen, phosphorus, iron, and other elements essential for growth. For example, when seawater becomes more acidic, iron attaches to organic compounds, preventing marine life from using this essential element, which leads to unhealthy growth of the organisms.

Fig No 5: Unhealthy growth of Organisms

The Open Ocean: Open ocean ecosystems are based on plankton, a mixture of tiny free-floating plants and animals that live and grow in sunlight and surface waters and serve as the foundation of the marine food chain. A number of plank tonic species, including *coccolithophores*, *foraminifera,* and *pteropods,* need carbonate ions to build their shells. If ocean acidification increases, these carbonate-based plankton species may decline – which means that a range of species, including fish, seals, and whales, could lose their preferred foods, or have less food altogether. The pteropod, or "sea butterfly", is a tiny sea creature about the size of a small pea. Pteropods are eaten by organisms ranging in size from tiny krill to whales and are a major food source for the North Pacific juvenile salmon. The photos below show what happens to a pteropod's shell when placed in sea water with pH and carbonate levels projected for the year 2100. After 45 days the shell slowly dissolves completely.

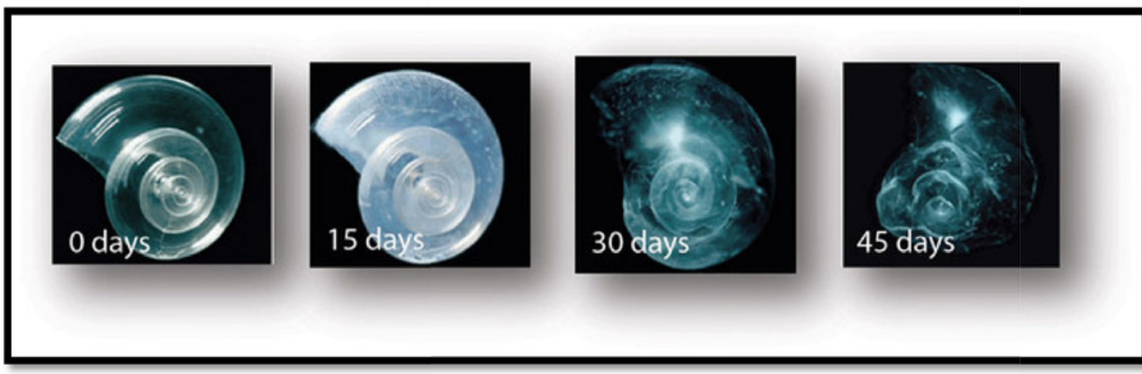

Fig No. 6: Pteropod's shell dissolved due to Ocean Acidification

Tropical Coral Reefs: In the natural world, corals must grow rapidly to outpace predation by fish and other organisms, and to compete for space with algae and sea grass. However, experiments have shown that ocean acidification prevents reef building corals from growing at an adequate rate to escape predation and competition, or to repair physical damage sufficiently. Slowed growth is not the only impact that ocean acidification could have on coral reefs – some scientists think that more acidic conditions could also contribute to coral bleaching.

Fig no 7 Coral Reefs

Polar Ecosystems: The polar waters of the Arctic and Southern ocean harbour endangered marine mammals and support some of the most productive fisheries in the world. Carbon dioxide dissolves more readily in cold water, acidifying the waters of polar region faster as compared to waters in lower latitudes. Recent studies have determined that the surface waters of the southern ocean will begin to become corrosive to some types of carbonate structures by the year 2050 if carbon dioxide emissions continue to increase at the current rate.

Fig No.: 8 Polar Ecosystems

Deep Water Coral Reefs: Corals are not only found in warm, shallow, tropical waters—these animals are also found in the deep sea, some 40 meters (about 131 feet) to 1000 meters (about 3281 feet) below the surface of the ocean, where they create habitat for many species of fish. Ocean acidification is expected to take longer to reach the deeper water, but just as for tropical reefs, over time it could reduce calcification, decreasing the rate of growth of deep-water corals. Furthermore, deep-water species may be less able to tolerate changing conditions than their shallow water counterparts. Many deep-dwelling organisms are adapted to the unvarying conditions that characterize the deep sea and may be less able to cope with change, such as increasing ocean acidity.

Fig No. 9: Endemic Mediterranean coral Cladocora caespitose showing severe skeletal damage & dissolution due to ocean acidification

Conclusion

The oceans are fast becoming more acidic. Ocean acidification may prove costly since coral reefs provide up to $30 billion a year in economic benefits, as a draw for tourists and habitat for fish. Globally, fish is the primary protein source for about one sixth of the world's population. The oceans also provide enormous benefit to humans by stashing away a large part of the carbon dioxide gas emitted in the atmosphere. This hidden service on each ton of carbon sequestered could be estimated at $600 billion a year. While advance techniques should be used to detect and mitigate the effects of ocean acidification; industries should also be encouraged to reduce CO_2 emission

References

1. http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F

2. http://www.oceanacidification.net/docs/OAA_Factsheet.pdf

3. http://www.gg.mq.edu.au/rep/websites/docs/paper.pdf

4. http://blog.nature.org/science/2013/05/20/ocean-acidification-the-next-big-threat-to-coral-reefs/

5. https://web.duke.edu/nicholas/bio217/spring2010/chang/Direct%20Effects.htm

6. http://dels.nas.edu/resources/static-assets/materials-based-on-reports/booklets/OA1.pdf

7. http://oceanacidification.net/fast-facts/

8. http://www.esf.org/fileadmin/Public_documents/Publications/SPB37_OceanAcidification.pdf

9. http://icriforum.org/sites/default/files/CLIM%20Acid%20and%20temps%20FINAL%20CH1%20%20Dec08_0.pdf