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Opinion

Ocean acidification: A weapon against the sea life

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The term ocean acidification (OA) is known as the lowering in the pH of the ocean by absorbing carbon dioxide (CO_2) from the atmosphere over a continued period of time. Various factors such as land use change and the burning of fossil fuels increase the concentration of CO_2 which was absorbed by the ocean at a factor of 30% which causes many chemical reactions [1]. The hydrogen ion generated during the chemical reaction and acidity of seawater increases and less availability of CO_3^{2-} ion. At the stage of OA, the $CaCO_3$ minerals which are very important biologically come into the saturation site. A regular decline in the concentration of carbonate ions creates difficulties for calcifying organisms such as deep-sea corals, clams, calcareous plankton, etc. in making and maintaining shells and other $CaCO_3$ structures. The disturbance of the pH of the ocean has changed whole ocean chemistry even in the non-calcifying organisms, coastal estuaries, and waterways. Our ocean food web is very complex and small ongoing pH enhancement of seawater is recognized by the ecosystem and immediately adverse effects are seen. The most remarkable impact of OA is the harm to the coral reef creates ripple effects on the entire ecosystem. Coral reefs are the site of the habitat and food for a large variety of marine life. It was depicted that over 4000 species of fish and 25% of all marine life are dependent on coral reefs. The coral builds their stony skeleton from $CaCO_3$ which was affected by ocean acidity and under harsh acidity conditions, the skeleton of coral can dissolve [2] Figure 1.

Various shelled animals face trouble in building their shells from high magnesium calcium which is a type of weaker shell and face challenges of being crushed or eaten in the OA conditions. Various zooplankton such as foraminifera cannot bear higher acidity and their shells dissolve rapidly so the extinction of foraminifera is seen in some tropical areas. A recent discovery described that approximately by 2080 ocean conditions will become so acidic that the erosion of healthy coral reefs will be seen rather than their rebuilding. Ocean acidification not only affects the coral reefs but is inhospitable to food security, tourism, biodiversity, and shoreline protection. Figure 2 depicted the effect the ocean acidification on human beings.

Sea water carbonate chemistry is stressed by ocean acidification and imposes negative effects on many calcifying organisms such as corals and bivalves. A study discovered

Figure 1: Marin Science Seminar: Ocean Acidification and Exoskeletons [3].

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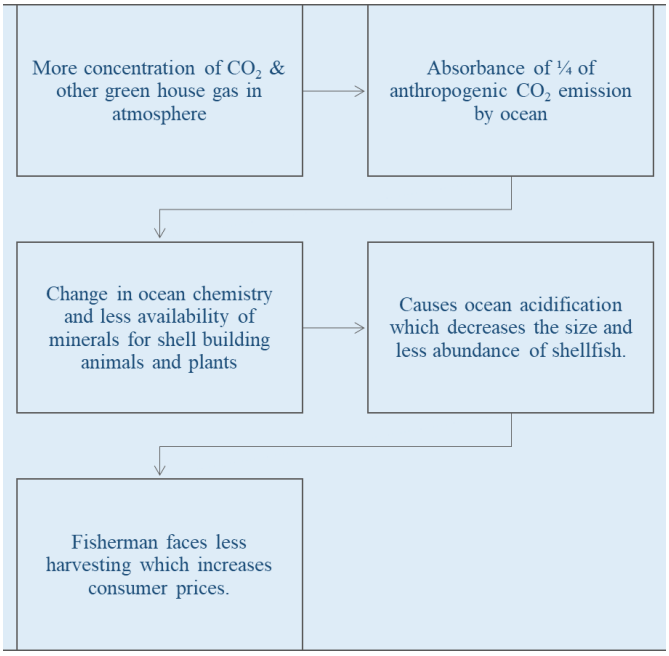

Figure 2: How CO_2 concentration in the ocean affects the economy [4].

the impact of acidification in *Mercenaria mercenaria* with the exposure to *Vibrio* spp. and their overall immune performance. *Vibrio* spp are important ubiquitous pathogens and create disease outbreaks in a large variety of shellfish especially in larval and juvenile stages [5]. In ocean acidification conditions the *Vibrio* spp is more susceptible to infection which automatically affects the health, restoration, and aquaculture operations of shellfish. It was investigated that the larval and juvenile clams showed the greatest mortality under the condition of low pCO_2/high pH to high pCO_2/low pH conditions [6]. In the northern South China sea, a dominant *scleractinian* coral species namely *Galaxea fascicular* found on inshore fringing reefs. The various strains of coral-associated bacteria found in *G. fasicularis*'s gastric cavity have been isolated using the approach of noninvasive sampling. Out of 101 representative bacterial strains, the *Vibrio coralliilyticus* strain SCSIO 43001 was found in *G. fasicularis* as temperature dependent opportunistic pathogen. The results of the antagonistic activity between the *Vibrio coralliilyticus* strain SCSIO 43100 and 100 strains showed the inhibition in the growth of *Erythrobacterflavus* and *Sphingomonas yabuuchiae*. Many other coral-associated gram-negative bacterial strains and *Vibrio coralliilyticus* SCSIO 43100 showed moderate to high anti-bacterial activity against three Pseudoalteromonas strains [7]. High altitude regions are the main focal point for the research of ocean acidification due to the greatest changes observed in carbonate chemistry. Another region is the coastal region where ocean acidification driven by both anthropogenic and eutrophication creates less oxygen zone and is untouched at the global level of marine research. The coastal area is full of fisheries and other marine resources and services so these should be the target regions for giving immediate solutions to ocean acidification. The most important and remarkable aspect of Ocean acidification is global climate change. Currently, researchers are paying much attention to the ocean science community to get the potential solution for the situation of ocean acidification. Various ocean acidification programs by NOAA help to maintain the relationship between policymakers, resources managers, scientists, and, the public to monitor the impact of varying ocean chemistry on economically and ecologically supreme ecosystems such as coral reefs and fisheries. A new aspect of the impact of ocean acidification on crustacean sensitivity was reported. The low pH of the ocean damaged the hair-like bristles called mechanoreceptors which stick out from the shell of the crab and are a good receptor to transmit the sensation and help them to navigate their environment. The common observation seen in crustacean species due to OA is slower movement, impaired swimming, less tactile recognition, and prolonged searching time. The NOAA's scientists first time reported this type of above impact of OA on crab larvae in this century [8]. The interesting thing about the OA is that its impact of it is not uniform across all species e.g. algae and seagrass may take the benefit of high pH in the ocean and show improved photosynthetic and growth rates. Overall it can be said that the positive or negative responses are seen within and between the marine groups and showed substantial changes in the ocean ecosystem in this century. Eradication of the problem of ocean acidification is currently at the drawing board stage and needs more attention. During the corona pandemic hit, the knowledge about the OA shifted to relying on available data, and the original plan to study the pH level of marine life would get stopped and researchers relied on existing literature data. Now, is high time to speed up the research about the OA as it creates a short-term impact on marine species and a long-term impact on the health of the ocean. Various new technologies such as the aquaculture industry and new forecasting systems have been developed for seasonal upwelling that creates low pH in sea waters and causes massive shellfish die-offs. The role of nuclear science to understand ocean acidification is the new concept where the use of radioisotopes such as calcium-45 and carbon-14 is used to get the rate and impact of OA. This type of nuclear technique facilitates global communication and international activities to understand the severity and impact of OA. Sustainable management of habitats and the establishment and maintenance of Marine Protected areas is the best way to protect the highly vulnerable and endangered marine ecosystems from OA. The ocean acidification community provides essential metrics for rational discourse on how to recognize the harm of CO_2 leakage after sub-seabed CO_2 sequestration.

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