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OCEAN ACIDIFICATION: A MAJOR ENVIRONMENTAL ISSUE

Jyoti Pathak*

ABSTRACT

Oceans provide a lot of benefits to the earth. Oceans transport heat from the equator to the poles, thus regulate our climate and weather conditions and patterns. oceans also play a dramatic role in global carbon cycle. Almost half of the worlds $O_2$is produced by oceans. CO_2 is absorbed by it to a greater extent, even five times more than atmosphere. CO_2 emissions have increased substantially due to fossil fuel burning and other similar human activities. Ocean acidification is the direct consequence of increased CO_2 emission to the atmosphere. Increased accumulation of CO_2 in the atmosphere over a long time period, increase acidity of ocean water. In present, ocean acidification occurs almost ten times faster than 300 million years ago. Decreased pH and hence increased acidity, elevated partial pressure of CO_2 and decreased saturation state of $CaCO_3$ making conditions corrosive for many calcifying organisms like corals, planktons and many echinoderms. Coral bleaching is another effect of ocean acidification. This paper summarizes key information on ocean acidification, including its causes, changes to carbonate chemistry and its effects on marine organisms and human beings.

Keywords: *Oceans, CO_2, Fossil Fuel, Temperature, Rainforests*.

Introduction

Oceans are the largest solar energy collector on earth. It can absorb a large amount of heat without a large increase in temperature. This amazing ability of collecting and temperature heat make oceans unique environmental component .They play a dramatic role in stabilizing earth's climate. They absorb huge amounts of heat from sun. More than 90% of earth warming has occurred in oceans . Heat is the most intense at the equator warming water nearest the surface the most . Ocean currents transport heat to the poles and cold water from the poles to the tropics. In absence of ocean currents weather would be extreme in some regions and only a few places would be suitable for living . It regulates rain, C-cycle and temperature of earth.

They provide shelter for many marine organisms . Variety of creatures living on the surface of water and underwater are much greater than on land. more than 300,000 variety of species of different organisms live here. Oceans also play a big role in the economy of nations. Millions of people earn by fisheries, offshore oil & gas, transportation, minerals, marine & coastal tourism, herbours, renewable energy production and water sport businesses etc. many antiviral drugs are obtained from marine organisms. Oceans are big sources of sea food also .

Rainforests are responsible only for 28% O_2 while oceans for the rest 72%. Independent of our distance from sea it contributes a lot in our breaths. Since the beginning of the industrial revolution, humans began burning coal in large amounts. World's ocean water has gradually become more acidic. It is a direct consequence of increasing levels of CO2 in the earth's atmosphere. Ocean acidification and global warming are different aspects of the environment but are closely correlated because root cause of both are same i.e emission of CO2 in excess amount.

Prior to industrialization and scientific era, concentration of CO2 in the atmosphere was 280ppm (Parts per million).with the increased use of fossil fuels, the concentration has been raised to 400 ppm and still the growth rate is accelerating. The current atmospheric concentration of CO2 is higher than it has been for the last 800,000 years and possibly higher than any time in the last 20 million years.

* Assistant Professor, (Chemistry), Government College, Kotputli, Rajasthan, India.

Humans have benefited a lot from the oceans' capacity of absorbing enormous amount of CO2 combined with holding carbon. The atmospheric concentration would have been raised even much more higher if oceans had not absorbed such a large portion of CO2 fromthe atmosphere. As a result of which, consequences of global warming i.e. sea level rise, shifting weather patterns would be more pronounced.

Reasons

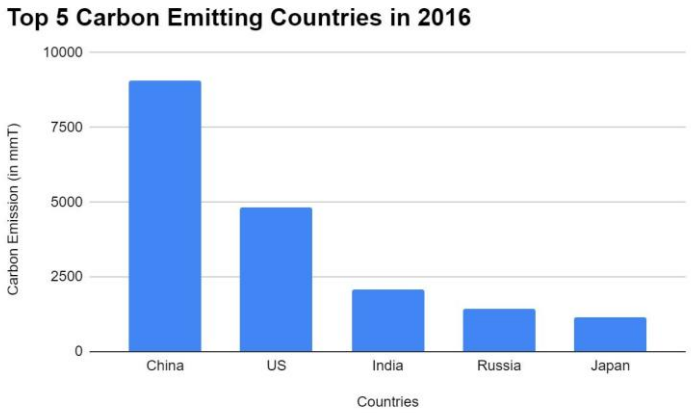
There are two major sources for the influx of CO2 in atmosphere: Fossil fuel emission and deforestation. Human activities like burning of fossil fuels have increased amount of CO2 gas emitted to the atmosphere. Fossil fuel emissions are spewed out of most vehicles, aeroplanes, power plants and various industries like cement textile etc. which use burning fossil fuels. since the industrial revolution, fossil fuel consumption has been raised changing many climate factors and affecting many environmental issues like ocean acidification .

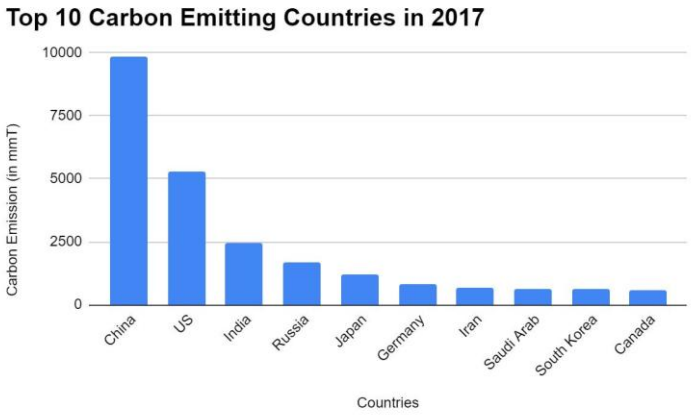
Forests which are the major carbon sinks historically have balanced

CO2 level. Deforestation creates more CO 2 and blocks its beneficial absorption. Plants on cutting if left to rot or burnt emit CO2. Our daily activities like driving, disposing wastes, consuming electricity, producing industrial fumes increase emission of CO2 and other greenhouse gases.

The rate of acidification of ocean water is reported to be fastest in northern Bay of Bengal. This region is highly acidifying. This is mainly due to pollutants mixing with sea water from Indo-Gangetic plains. This phenomenon has adverse effect on the food chain and reduces the growth of fishes, planktons and destroys shell forming marine creatures.

During winters freezes from land to sea carry pollutants and deposit it in oceans. It also carries nitrates, sulphates which also decrease the pH of ocean water. World average was 4T and Indian average 1.58 tons of CO2 equivalents in 2015.



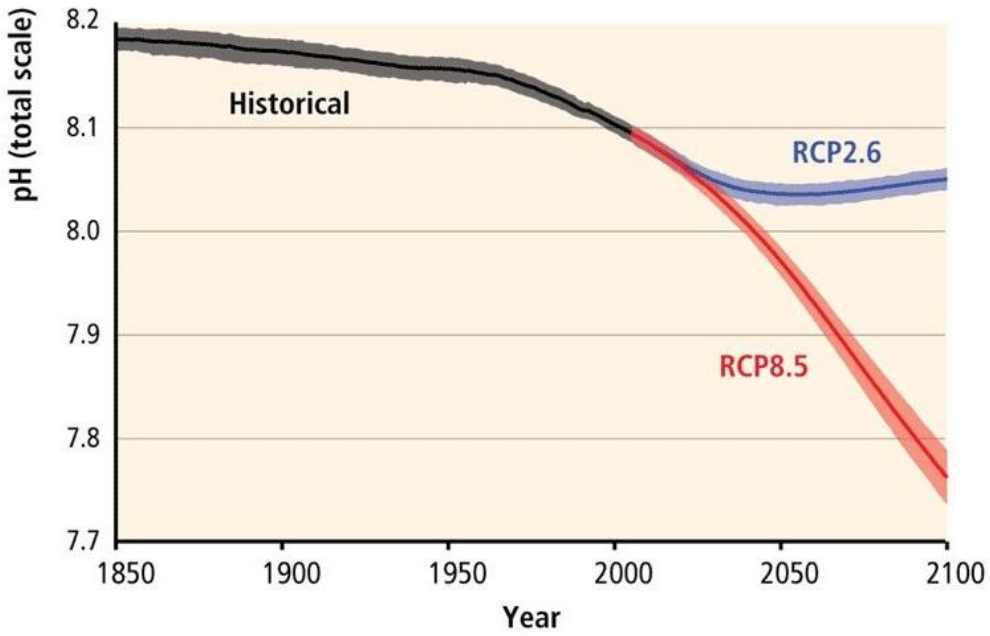


Major Causes of Ocean Acidification

- Industrial revolution
- High concentration of CO2
- Burning of fossil fuels
- Cement Manufacturing
- Deforestation
- Loss of Biodiversity
- Use of chemical fertilizers, pesticides in agriculture
- Coastal tourism
- Unawareness and of carelessness of people
- Lack of strict follow of environmental rules

Probable Future Scenario

The Degree of future ocean acidification will be closely correlated to future increases in atmospheric CO2. If emission of CO2continues at the present rate, i.e. RCP 8.5 Trajectory acidity of ocean water would increase by 0.4 units by the end of century. pH will vary depending on the ecosystems as polar seas and upwelling regions are expected to acidify faster than temperate or tropical regions. Most surface waters will be continually corrosive within decades.



As ocean acidification is occurring 30 to 100 times faster than any time during the last several million years, Intergovernmental panel on climate change (IPCC) Predict the atmospheric CO_2level to reach 500 PPM by 2050 and 800 PPM by the end of the century.

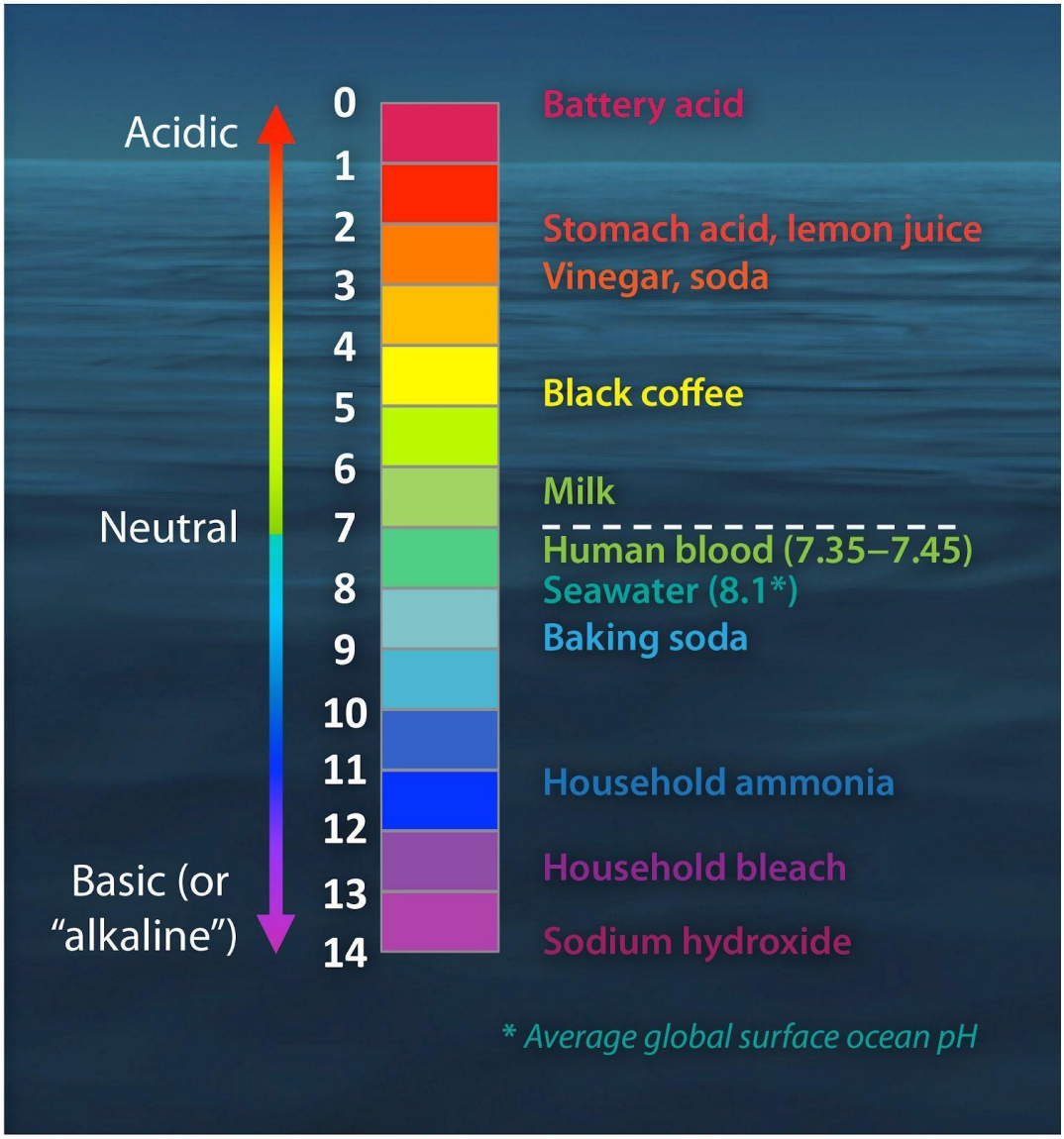
This will definitely lead to significant increase in temperature and acidity of ocean water. pH will be reduced by 0.3 to 0.4 units by 2100.

Basic Chemistry of Ocean Acidification

Ocean acidification represent a direct chemical change to global ocean chemistry in response to rising levels of CO2 in atmosphere. Ocean acidification occurs when CO2 is absorbed into the water at a high rate. It reacts with water and forms acid due to which pH changes.

Acidity or alkalinity of H2O or a solution is determined by concentration of H+ ions using pH scale.

PH = -log[H+]



Pure water has PH7.pH less than 7 shows acidity. Similarly pH more than 7 shows basicity or alkalinity. As pH scale is logarithm one unit change in it indicates 10 fold opposite change in H+ concentration. Oceans are slightly alkaline with pH 8.2 on average. CO2 absorbed by seawater reacts with H2O to form carbonic acid. This carbonic acid breaks down into bicarbonate ions.

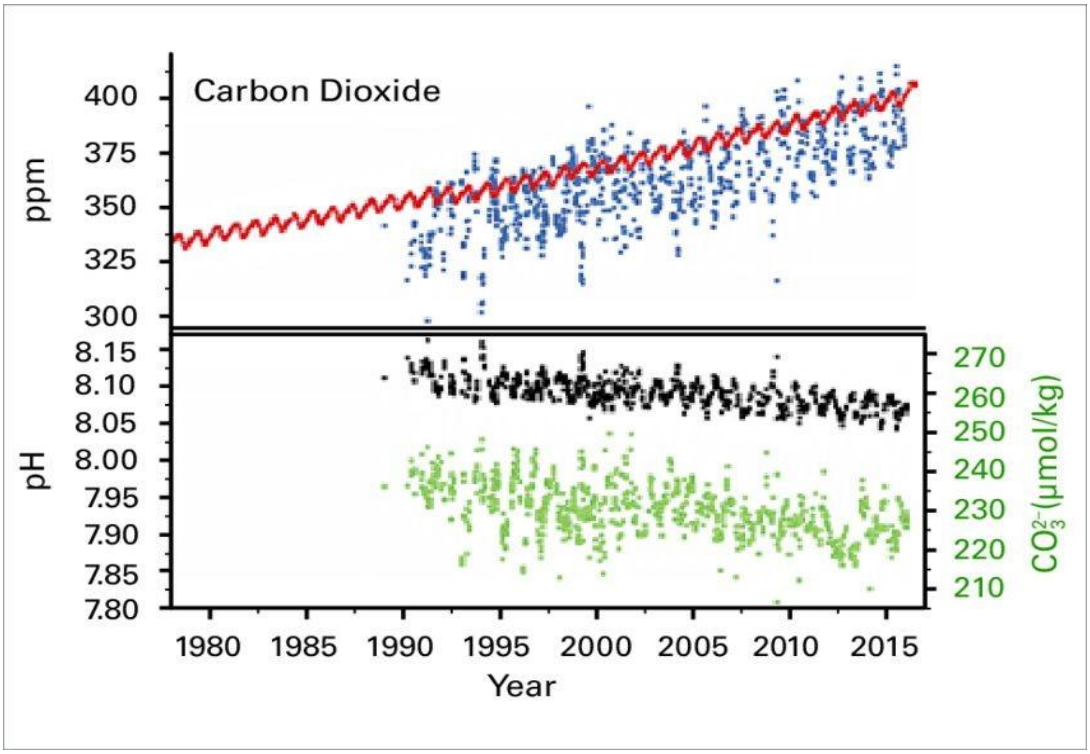
$CO2+ H2O \rightarrow H\ \ 2CO\ \ \ 3\ \ \ \ carbonic\ acid\ \ \ \ H2CO\ \ \ 3 \rightarrow H^{+} + HCO3^{-}\ \ bicarbonate\ ion$

Thus increase in concentration of H^{+} ions decrease the pH and hence increase the acidity of seawater these additional H^{+} ions released by breaking down of carbonic acid bind to new carbonates to form bicarbonate decreasing the amount of carbonate in ocean water

$H^{+} + CO3^{2-} \rightarrow HCo3^{-}$

Since industrialization, surface ocean carbonate concentrations have declined by 10 % in the tropics and southern oceans.

$CO2 + H2O + CO3^{2-} \rightarrow 2HCO3^{-}$



Decreasing Concentration of Carbonates make it difficult to form shells, skeletons for corals, mollusks echinoderms and other calcifying marine organisms. Reduced carbonate ions lower the saturation state casing all forms of CaCO3 to dissolve at shallower depths

$CaCO3(s) + 2H^{+}(aq) \rightarrow Ca^{+2}(aq) + CO2(g) + H2O$

Shells and skeletons of many marine organisms are made up of CaCO3 forms like calcite and aragonite. Both are polymorphs means have the same formula but different crystal structure.

Aragonite is produced by many tropical corals, cold water corals and some molluscs. shell building takes place more easily if there are abundant $CO3^{-2}$ ions in water.

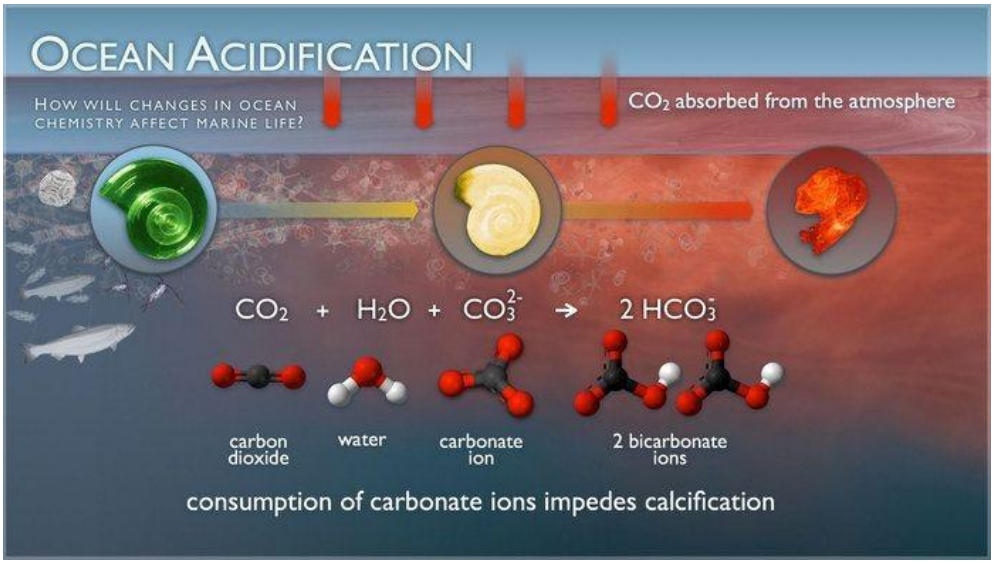
In contrast shells and skeletons begin to dissolve due to the scarcity of $Co3^{-2}$ ions this is undersaturated state . Water becomes corrosive in such case .

Aragonite has orthorhombic structure but calcite has trigonal rhombo structure. Aragonite is much denser or stronger than calcite. Aragonite makes needle like crystal but calcite makes blocky ones. These two polymorphic forms of CaCO3 in Sea water (aragonite and calcite) have different solubility which is measured by saturation state Ω. This rate is mainly dependent on the concentration of Ca^{+2} in water as well as P or the depth. Because the concentration of calcium ions in water is constant, so it the concentration of $CO3^{-2}$ ions that determine the formation of CaCO3.Surface water due to being supersaturated hence Ω>1,it favours CaCO3 formation. deeper water are undersaturated, i.e.Ω<1 and hence CaCO3 dissolves. CO 2 is more soluble in cold water so the oceans near the poles have more CO 2, less carbonate, lower saturation. Thus absorption of acid gas CO2 by Oceans Creates various chemical changes in seawater like an

increase in partial pressure of CO_2

(pCO2), dissolved inorganic carbon (DIC), increase in concentration of H^{+} and $HCO3^{-}$ ions and decrease in the concentration of CO_3^{-2} ions (Carbonate ions).

Since the preindustrial period oceans have absorbed almost 29 % of total CO2 emitted to the atmosphere. Currently Oceans absorb about 26 %of CO2 emitted by humans in atmosphere. pH of Ocean surface water has decreased by 0.1 units i.e. from 8.2 to 8.1 It shows 26% increase in ocean acidity.



Effects on Marine Life

Ocean acidification is raising serious problems like short term effects on calcifiers and long term effects on the overall health of ocean and existence of many marine species. Physiological sensitivities, reduced metabolism, reduced O2 uptake, reduced reproduction have been reported in marine and coastal organisms.

CO2 from the oceans pass into animals where it changes the internal chemistry of tissues and cells. different species have different capacities to maintain acid -base balance or to adjust a new pH.

Marine organism could also experience decreased food intake, decreased metabolic efficiency, changes in growth, development ,abundance, olfactory and visual behavior and survival due to ocean acidification many species like juvenile fish may face troubles in locating suitable habitats.

Ocean acidification affect many marine organisms especially that build shells and skeletons of CaCO3.corals, oysters, snails etc. are the major examples. These marine calcifiers face threats of dissolving their shells, skeletons in acidic and corrosive ocean water as well as the less availability of carbonate for their shell formation .

Ocean acidification causes reduced growth in both corals and coralline algae threatening reef structures and loss of habitat. fewer and weaker reefs mean less coastal protection from storms, lost income and food.

The reduced growth of molluscs could lead to fewer bivalves like clams, oysters reducing bivalve eating mammals and organisms.

It lies adverse effect on fisheries.

The catastrophic changes may be worsened by the combined effects of ocean acidification, decreased O2 levels in ocean water, increased concentration of toxic chemicals in it through rivers.

Effects on Humans

Substantial revenue declines, loss of employment and livelihoods are the major consequences on human societies. Sea food security is at risk . Global annual costs of molluscs loss by OA could be over US $100 billion. Marine ecosystems e.g.coral reefs protect shorelines from storms, cyclones. Protective function of reefs prevent loss of life, erosion and property damage. OA is having catastrophic impact on coral reefs. There appears to be a danger on coastal life.

Solution

We are responsible for the present dangerous scenario of environment. only we can change it by slowing down of CO2 emission.

We have to work to solve the problem of accumulation of atmospheric CO2. efforts should be done individually as well as collectively on local , community, national and global levels. we have to move forward in the direction of green or eco friendly option.

Efficient uses of energy, uses of efficient fuels are the best remedies. Using public vehicles, pool instead of individual vehicles would reduce the emission of CO2.

C-footprint calculator is user friendly providing us another option in different aspects of daily lives. Similarly ocean & climate defender provides ideas how to lessen C-footprint.

Conserving electricity is another solution by which we can lower the amount of energy needed to produce electricity . reduce ,reuse , recycle and refuse rule also applies here. Reducing the use of excess products and materials would reduce its demand and materials in turn reduced energy for its manufacture . we must reduce our needs and deeds. We must prefer eco friendly products. Saving water reduces greenhouse gas emissions. Pumping and treating water also emits CO_2. Plastic consumption and single use plastics must be strictly decreased and stopped respectively. coral products must never be purchased. Energy conservation must be encouraged. Univ. of central Florida started campus competition among students to encourage them to conserve energy providing simple and cheaper ways of energy .

We have to discover new efficient ideas of energy production so that less CO_2 can be accumulated in the atmosphere.

We have to conserve existing habitats. Marine habitat and wildlife needs to be protected so that oceans may be resilient and the damage caused earlier, can be compensated. Regular climate training programmes & activities must be organized.

Some coastal challenging decisions and actions have to be taken. Increasing coastal protection, establishing, maintaining and protecting endangered marine ecosystems, improving water quality of rivers, regulating chemicals, pollutants, industrial wastes in it implementing new technologies are the major efforts which should be done on community and national level.

There is very little agreement among countries on largest global temperature rise less than $+2^0$c . There should be agreement & combined efforts on a global level.

Remedial Solutions of Ocean Acidification

- Reducing energy consumption
- Reducing electricity consumption
- Educating people
- Geo engineering and technologies
- Reducing individuals' C-footprint
- Local, state, national regulations and international collaborations.

Conclusion

Acidification of Oceans is the major problem that needs to be remedied . Due to Ocean acidification, not only marine lives but we also suffer. This problem influences every species, non biotic factors of environment and climate. We are directly or indirectly influenced by ocean acidification independent of the fact whether we live near or far from oceans. We all have the potential to offer solutions.

Contacting federal leaders, beginning recycling centers, planting trees, caring parks, starting climate training programmes are the basic efforts to be successful . Beginning is the first step towards a healthier environment. Unless action is taken to stop CO2 levels, oceans will continue to be more acidic, more toxic, more poisonous if we all are well determined to reduce CO2 in the atmosphere and oceans. the goal is not as large as unachievable .

We will live happily , if and only if our oceans and environment is happy .

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