Multiple Studies Approach: Solution to Ocean Acidification

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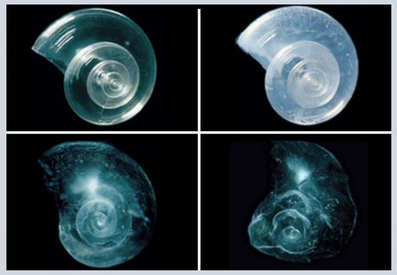
Background

Ocean Acidification (OA) is a global issue caused by increased anthropogenic carbon dioxide diffusing into the ocean and lowering the pH of the ocean. As a result, many marine organisms, mainly the shelled organisms with calcium carbonate shells, are being negatively impacted, and it is hypothesized that, at this rate, it will cause a huge loss in marine biodiversity. Many studies have been done to resolve the issue but every proposed solution has a major flaw or side effect, thus there are no truly viable solutions available yet.



Ocean Acidification Chemistry

1. Atmospheric CO_2 dissolves into the ocean water

   $CO_{2(g)} \rightarrow CO_{2(aq)}$
2. Dissolved CO_2 reacts with water and produces carbonic acid

   $CO_{2(aq)} + H_2O_{(l)} \rightarrow H_2CO_{3(aq)}$
3. Carbonic acid is very unstable and easily breaks down

   $H_2CO_{3(aq)} \leftrightarrow H^+_{(aq)} + HCO_{3(aq)}$
4. The hydrogen ion attacks and breaks down calcium carbonate used in shells

   $CaCO_{3(s)} + H^+_{(aq)} \rightarrow Ca^{2+}_{(aq)} + HCO_{3(aq)}$

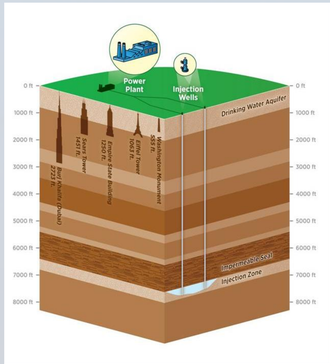
Carbon Capture and Sequestration (CCS)

(MIT 2007)

Carbon Capture and Storage/Sequestration (CCS) focuses on preventing the first step, capturing the CO_2 before it is released into the atmosphere. Some studies show that it may be possible to reduce the CO_2 emission from burning fossil fuels in industrial grade factories and power plants by 80-90%. The process consists of building special machines on these sites to capture the CO_2 before it is released into the atmosphere, compress the gas, and transport the gas into different sites where the compressed gas is injected deep underground. The injection will be under porous rocks that are able to store gas, and sit under a impermeable layer of non-porous rocks that will inhibit the gas from being returned back above the ground.

Pro

- Cut CO_2 emission from burning of fossil fuels in factories and power plants by 80-90%
- Greatly reduce the amount of CO_2 that will be dissolve into the ocean



Con

- Very expensive
- Counter-intuitive as it requires more fossil fuel to mitigate the CO_2 emission from usage of fossil fuels
- Concern for human health
- Concern for run-off leading into eutrophication
- Not supported by public acceptance
- May give false sense of security that anthropogenic CO_2 is no longer a problem.

Marine Carbon Capture

Unlike CCS , marine carbon capture deals with the CO_2 that has already been dissolved into the ocean, past equation 1. The two major studies done thus far are mineral carbonate scrubbing (Rau 2010) and olivine weathering (Schuiling and de Boer 2011). Mineral carbonate scrubbing adds carbonate directly into the water to convert most of the CO_2 into calcium carbonate ($Ca(CO_3)_2$). This is a natural phenomenon but lab scale experiments have shown that it can be sped up to lower the pCO_2 at a faster rate. Similarly, olivine weathering is also a natural process that was initially thought to be too slow to have a viable effect on this problem, but has been proved otherwise through laboratory experiments. When weathered, olivine ((Mg,Fe)2SiO4) will capture the dissolved CO_2 and convert it to bicarbonate.

Pro

- Very inexpensive compared to CCS
- Less public resistance as it is a natural process
- Does not require more fossil fuel
- The byproduct, magnesium (from olivine weathering only), can be used as fertilizer for crops

Con

- Spatially bound to the coastal region
- Does not account for the difficulty for shelled marine organisms to make their shells

Conclusion

Each of the proposed solutions (ocean fertilization, CCS, and marine carbon capture) has great potential but each lacks in viability due to its uncertainty, potential to cause more harm, cost, or spatial limitations. Because of the nature of each proposal, combining two more of these methods will not counterbalance the respective cons and thus would not be a viable compound solution to ocean acidification. Further research both globally and for this project must be done to find a more viable solution.

Ocean Fertilization (Aumont and Bopp 2006) and (Zeebe and Archer 2005)

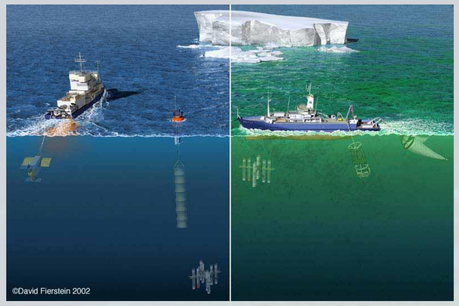
This is the most famous and oldest attempt tackle the issue. In this method, fertilizers such as nitrate, phosphate, or iron are put into the ocean to promote phytoplankton (photosynthetic microbes) to grow. This increases the rate of photosynthesis to convert the dissolved CO_2 into oxygen used by marine organisms.

Pro

- Potential to greatly reduce dissolved CO_2
- Very simple
- Not spatially bound

Con

- Potential to cause massive algal blooming
- Effectiveness decreases over time
- Benefits could be lost easily if the fertilization is not performed continuously
- Many uncertainties that may trigger other issues



Contact Information

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Resources

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