Ocean Acidification

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Each day, the oceans absorb about a quarter of the CO_2 produced by human activities, causing a chemical modification of seawater that results in ocean acidification. The dissolution of CO_2 in seawater causes an increase in acidity (decrease in pH) and a decrease in the availability of carbonate ions (CO_3^{2-}) which are one of the building blocks required by marine plants and animals to make their skeletons, shells and other calcareous structures. Ocean acidity has increased by 30% in 250 years, and could triple by 2100. It threatens species such as oysters and mussels, and will also have an impact on marine food chains. Our understanding of the effects of ocean acidification on marine life is still only rudimentary.

OCEAN ACIDIFICATION

Every day our oceans absorb about 1/4 of all man-made carbon dioxide (CO_2). The result? Ocean acidification, with consequences for some marine plants, animals and ecosystems.

WHAT IS OCEAN ACIDIFICATION?

Most of us have already heard about climate change and global warming, caused by the greenhouse gas effect. We also know that human activities are the culprit; in particular the carbon dioxide emissions (CO_2) produced by industry and cars. But *ocean acidification* remains poorly known. This is not very surprising, as the consequences of this phenomenon were only recently discovered. Yet, the cause is once again carbon dioxide. In fact, ocean acidification is sometimes called "the other CO_2 problem".

THE CHEMISTRY

All of the CO_2 that we produce every day does not remain in the atmosphere. Instead, around one fourth is absorbed by our oceans. Without the oceans, the proportion of atmospheric CO_2 would be higher, leading to more severe global warming. We are therefore very lucky to have our seas and oceans! For a long time researchers thought that this absorption of CO_2 would remain without major consequences for the oceans and the organisms that live there. But they realized, around 15 years ago, that the dissolution of CO_2 in seawater had been changing its chemistry: leading to a reduction in pH (the measure of the acidity of a liquid) and in the concentration of carbonate ions (CO_3^{2-}), an important building block for the creation of shells, skeletons and other calcareous structures in marine plants and animals.

ACIDITY AND THE PH SCALE

You must be familiar with some acidic food such as lemon or vinegar. Well, CO_2 is an acid gas. You can see it in sodas: the small bubbles are, in fact, CO_2 bubbles. After being absorbed by the oceans, the CO_2 dissolves in seawater, leading to an acidification. This does not mean that oceans are becoming acid, only that their chemistry is progressively changing towards a higher level of acidity. The acidity of a liquid is determined by its concentration of hydrogen ions H^+ (protons). It is not practical to refer to the concentration of protons, as the numbers are very small. To simplify, we use the pH scale with values ranging from 0 to 14. The lower the pH value, the higher the acidity of the liquid. A liquid with a pH of 7 is called *neutral*, one with a pH lower than 7 is acid, and if the pH is higher than 7 it is said to be *basic*. The pH scale is a bit unusual, much as the Richter scale used to measure the magnitude of earthquakes. A liquid with a pH of 6 is 10 times more acidic than a liquid with a pH equal to 7, 100 times more acidic that a liquid with a pH of 8 and 1000 times more acidic than a liquid with a pH of 9.

THE NAME

Why is this phenomenon called "ocean acidification", even if our oceans will never actually become acidic (pH < 7)? Acidification is a process: the decrease in pH (increase in hydrogen ions and acidity). The word "acidification" refers to lowering pH from any starting point to any end point on the pH scale. This terminology can be compared to the one used for temperature: if the temperature of the air goes from -20 to -10, it is still cold, but we call it "warming".

A LITTLE BIT OF HISTORY

Ocean acidity has increased by 30% in 250 years, or since the beginning of the industrial revolution (a drop in pH from 8.2 to 8.1). Model projections have shown that at the present rate of CO_2 emissions the acidity of ocean surface water could triple by the end of this century. The current speed of CO_2 absorption is 100 times higher than has occurred naturally over the last 300 million years.

IMPACTS ON MARINE ORGANISMS

The absorption of CO_2 by seawater does not only increase the number of protons (hydrogen ions, H^+) but it also lowers the number of certain molecules - the carbonate ions (CO_3^{2-}) - used by numerous marine organisms to build their skeletons and shells (corals, mussels, oysters etc.). Many of these calcifying plants and animals will thus face difficulties when building these structures, and their skeletons and shells might even dissolve. When seawater acidity reaches a certain threshold it becomes corrosive to limestone, the material used to form shells and skeletons.

Researchers have performed laboratory studies on the process of building these calcareous structures, in organisms exposed to conditions of ocean acidification projected to occur in the future. Negative effects have been observed in some species, for instance in pteropods and calcifying algae (see pictures 1 and 2). Other organisms might benefit from ocean acidification. For example, for some plants more CO_2 means increased photosynthesis.

WHAT COULD BE THE IMPACT OF OCEAN ACIDIFICATION ON HUMANS?

Ocean acidification could have a direct impact on organisms that we consume and that form calcareous shells, such as clams and oysters. Negative effects on zooplankton, similar to those observed in pteropods, could have indirect consequences for humans. Everything is connected in the ocean. Many organisms depend on plankton or corals, for instance, as their source of food and habitat. Ocean acidification could therefore impact food chains and biodiversity in certain ecosystems. For example, in the North Pacific and Arctic oceans the tiny pteropod is eaten by salmon. Salmon is an essential food resource and salmon fisheries employ many people.

WHAT CAN WE DO TO REDUCE OCEAN ACIDIFICATION?

Seawater chemistry will remain altered for centuries to come even if we stop all CO_2 emissions right now. But it is still possible to slow down ocean acidification and reduce its impacts. More or less realistic geo-engineering techniques have been proposed to limit ocean acidification (for instance, discharging basic compounds into the oceans to counter acidification and increase the pH). However, the only proven, effective and risk-free solution is to attack the root of the problem, namely the rise in CO_2 emissions. Emissions can be reduced at several levels, in particular through political negotiations on the replacement of fossil fuels with renewable sources of energy, carried out at national and international levels. But each of us can bring a contribution. We can reduce our emissions by taking the train instead of the car, for instance, or by limiting our use of electricity, and we can talk about this problem with friends and family so that they learn how to reduce their emissions too.

FOR MORE INFORMATION

- Laboratoire virtuel – http://i2i.stanford.edu/AcidOcean/AcidOcean_Fr.htm
- Animation sur l'acidification en français – www.youtube.com/watch?v=KqtxGZKItS8
- Animation projet BNP Paribas eFOCE – www.youtube.com/watch?v=QhgQ4unMVUM
- Animation « Hermie the hermit crab » – www.youtube.com/watch?v=RnqJMlnH5yM Great Barrier Reef Marine Park Authority
- Brochures en français – www.iaea.org/ocean-acidification/page.php?page=2198
- Résumé à l'attention des décideurs – www.igbp.net/publications/summariesforpolicymakers/summariesforpolicymakers/oceanacidificationsummaryforpolicymakers2013.5.30566fc6142425d6c9111f4.html