DISCOVER

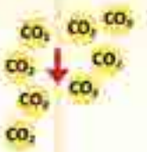
OCEAN ACIDIFICATION

By Tejas Joshi

Start here!

1 The surface of an ocean is its connection to the atmosphere above. It is here that the two constantly exchange gases. Many of you are aware of water vapour evaporating from the oceans into the atmosphere as part of the water cycle. Similarly, various gases from the atmosphere such as carbon dioxide (CO_2), nitrogen (N_2) dissolve into the water.

2 How is this connected to the increasing amount of CO_2 gas that we release into the atmosphere?



3 The higher the concentration of CO_2 in the atmosphere, the greater is its absorption by the oceans!

So what happens to all this CO_2?

4 The absorbed CO_2 combines with ocean water (H_2O) to form carbonic acid (H_2CO_3).

$CO_2 + H_2O \rightarrow H_2CO_3$

5 So, the more the CO_2 we release into the atmosphere, the more the concentration of carbonic acid in our oceans. The carbonic acid rapidly breaks down into hydrogen ions (H^+) & bicarbonate (HCO_3^-) ions.

$H_2CO_3 \rightarrow H^+ + HCO_3^-$

6 The concentration of hydrogen ions is a measure of acidity. Thus its increase means the oceans are now more acidic.

7 A significant and sudden change in acidity can be problematic! Like in our own bodies, there are innumerable delicate processes and systems in oceans which are inter- dependent and rely on specific environmental conditions.

Many of these processes are already showing signs of being adversely affected.

8 Organisms like bivalves (eg. *Mercenaria species*) with hard shells are unable to cope with the more acidic conditions in oceans, and actually die because their shells dissolve—a result of the changing carbonate chemistry...

Clam Shells (*Mercenaria sp.*) Image by Ken Hammond

9 Researchers have identified peculiar changes in the physiology, behaviour and reproduction of marine organisms. For example, high acidity has reduced growth of the Norwegian algal species *Emiliania huxleyi*.

Microscopic image of Emiliania cell by Alison Taylor

10 Imagine you were building your home, but did not have sufficient bricks and cement with you: difficult, isn't it? researchers have found something similar to be happening in the oceans because of increased CO_2 concentration. Coral reefs and many marine organisms rely on a process called **calcification** to build their protective exoskeletons. During this process, the calcium and carbonate ions in ocean water combine to form calcium carbonate.

$Ca^{2+} + CO_3^{2-} \rightarrow CaCO_3$

When the CO_2 concentration is higher, another reaction between the carbonate ions, CO_2 and water occurs instead. This uses up the carbonate which would otherwise be available for calcification.

$CO_2 + H_2O + CO_3^{2-} \rightarrow 2HCO_3^-$

As the concentration of carbonate ions reduces, the exoskeletons of marine organisms become weaker. The reduced survival of these small shelled organisms affects the survival of other species (eg. fish) that depend on them for food/ shelter.

11 Gradually, this effect is felt by an increasing number of marine species, as they are all part of an inter-connected food web.

But this is not all.
Ocean acidification poses a serious threat to the lives and livelihoods of coastal human communities who depend on the oceans for fish and shellfish (for food and trade).

? These apart, we are still trying to understand all the global impacts of this phenomenon.

Good to know!

1. The United Nations (UN) has dedicated one of their 17 Sustainable Development Goals towards ensuring the good health and protection of oceans and marine resources.
2. What activities are helping contribute to this global aim, and what are the other goals?
   Visit: http://bit.ly/XPA1ZSDG
3. Would you like to explore the oceans in more detail, and learn more about ocean acidification? Or watch some oceanographers in action?
   To learn more visit:
   http://bit.ly/1echemalocean

Become an oceanographer!

The above scheme presents a flavour of how vast, dynamic and inter-dependent life under the oceans is! In fact, ocean acidification is only one of the many emerging areas of research today.

And for the "oceanographers", who choose to research oceans, every day is an exploration into a less understood and challenging world. Would you like to become an oceanographer yourself?

A study of the oceans demands knowledge and interests in multiple fields such as biology, chemistry, physics, ecology and mathematics! It also requires perseverance, hard work and the readiness to work in less friendly environments and climates.

No doubt it is becoming a popular choice of profession; you might just be our next ocean explorer!

With your friends, search for recent topics of research in the oceans: are they connected to ocean acidification in any way?

How do we respond to the challenge of ocean acidification, locally and globally?

What is the life of an oceanographer like? Search for some oceanographers online, and try piecing together their work experiences.

What would you think are some of the greatest challenges in studying oceans?

i wonder...
Rediscovering school science

Tejas Joshi is a 2016-17 Bayer Science and Education Foundation Fellow in Germany, and has an M.A. in Science Education from the University College London Institute of Education. This follows a sustained stint at the Homi Bhabha Centre for Science Education since 2009, where Tejas first worked on a multi-component organic reaction and later on creating visual learning resources for chemistry. His recent projects have been on chemistry education for sustainable development, context-based learning and the development of open educational resources in chemistry. In his free time, Tejas enjoys painting, illustrating and gardening. He can be contacted at tejasjoshi@gmail.com

Azim Premji University