CALCUTTA INTERNATIONAL SCHOOL
SCIENCE CLUB

Quarterly Issues

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The Evidence

Global Temperature Rise

The planet's average surface temperature has risen about 1.62 degrees Fahrenheit (0.9 degrees Celsius) since the late 19th century

Warming Oceans

The oceans have absorbed much of this increased heat, with the top 700 meters of ocean showing warming of more than 0.4 degrees Fahrenheit since 1969

Shrinking Ice Sheets

Antarctica lost an average of about 127 billion tons of ice per year between 1993 and 2016. The rate of Antarctica ice mass loss has tripled in the last decade.

Glacial Retreat

Glaciers are retreating almost everywhere around the world — including in the Alps, Himalayas, Andes, Rockies, Alaska and Africa.

Decreased Snow Cover

Satellite observations reveal that the amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades and that the snow is melting earlier.

Sea Level Rise

Global sea level rose about 8 inches in the last century. The rate in the last two decades, however, is nearly double that of the last century and is accelerating slightly every year.

Declining Arctic Sea Ice

Both the extent and thickness of Arctic sea ice has declined rapidly over the last several decades.

Extreme Events

The number of record high temperature events has been increasing, while the number of record low temperature events has been decreasing, since 1950

Ocean Acidification

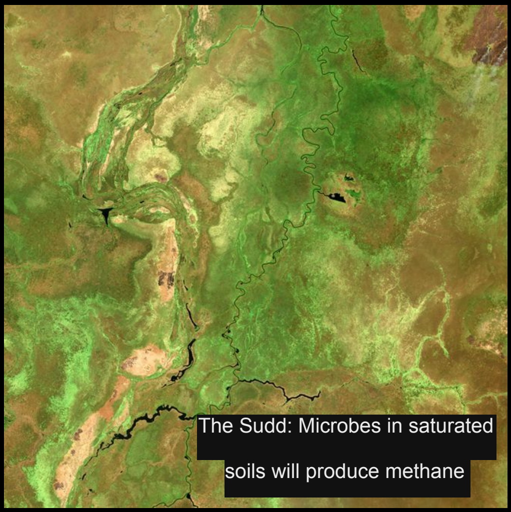
The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion tons per year.

A surge in Methane Levels

Since late 1980, the world has witnessed a drastic change in industrial processes making them much more efficient. However, these processes have taken a toll on the environment. A simple way to understand the gravity of this situation is to assume that climate change is an iceberg, the earth is the Titanic and well you know what happens after that. Climate change questions the very survival of the human race. Even though various industrial processes contribute to climate change, we must understand that some natural processes also lead to climate change.

Recent developments have shown that wetlands contribute heavily to the emission of methane. Natural wetland emissions currently contribute up to approximately 40% of the global CH_4 emissions. Of all the greenhouse gases, methane is one of the most dangerous because of its ability to absorb heat efficiently in Earth's atmosphere. Studies show that over 20-years a kilogram of methane heats the planet 80 times more than a kilogram of carbon dioxide.

Wetland methane is created through a method known as methanogenesis.Wetlands are anaerobic environments where microorganisms break down organic matter in a process that leads to the production of the gas.They are the world's biggest natural supply of methane. Research published in the PNAS (Proceedings of the National Academy of Sciences of the United States of America) in 2017 showed that these areas played a much bigger role in emissions than what was thought before.



The Sudd: Microbes in saturated soils will produce methane

Incidents reported in the news has been about the methane pulse which has been detected from the South Sudan wetlands. A group of researchers from the University of Edinburgh have pointed out a rapid climb in the levels of methane and believe that a region called the Sudd (a vast swamp formed by the White Nile in South Sudan) could be the culprit. The group has been using the Japanese GOSAT spacecraft to watch the greenhouse-gas behavior over peatlands and wetlands in the continent and have located important rises in methane emissions above South Sudan centered on the years 2011-2014.

“The levels of the East African lakes, which feed down the Nile to the Sudd, increased considerably over the period we were studying. It coincided with the increase in methane that we saw and would imply that we were getting this increased flow down the river into the wetlands,”explained Dr Mark Lunt. He continued, "It's a huge area so it's not surprising that it's pumping out a lot of methane. To give context - the Sudd is 40,000 sq km: two times the size of Wales. And being that big we expect to see the emissions from space.”

-Neel Narayanan (IB-1)

How Climate change affects Biodiversity

A number of species will be affected physiologically by climate change. There is evidence that some species are physiologically vulnerable to a temperature spike. For example, desert-living species could be particularly vulnerable to climate change as they may already live at their physiological limits.

Rising temperatures already affect the world's polar regions. Diminishing ice packs reduce the habitats of polar bears, penguins, puffins, and other Arctic creatures.

Changes in temperatures will also cause shifts in mating cycles, especially for migratory animals that rely on changing seasons to indicate their migration and reproductive timing.

Warmer sea surface temperatures are blamed for an increase in a phenomenon called coral bleaching. This is a whitening of coral caused when the coral expels their zooxanthellae , symbiotic photosynthesising algae that live within the coral tissues and provides it with essential nutrients. Since the zooxanthellae help coral in nutrient production, their loss can affect coral growth and make coral more vulnerable to disease.

As the ice melts, it increases the sea level, which will affect and perhaps destroy ecosystems on coastlines. Rising sea levels will also cause changes to ocean temperatures and perhaps even currents. Such changes would have a strong impact on zooplankton, an essential part of the food chain in the ocean. Shifts in where plankton live and how big the size of their populations could upset the biodiversity in the Earth's waters. Whales, especially, could bear the brunt of this, as many whale species require mass amounts of plankton to survive.

In conclusion, as biodiversity decreases, there will be far-reaching effects. Disruptions in the food chain may greatly affect not only ecosystems but also humanity's ability to feed an ever-growing population. For example, losing diverse insect species will decrease plant pollination. Additionally, this may decrease humanity’s ability to produce medicine, as extinction claims more and more key plant species. Biodiversity also protects against natural disasters, such as grasses that have evolved specifically to resist the spread of wildfires.

Some of the impacts of climate change may be sudden, but in many cases, societies will have some years to adapt their management of biodiversity as conditions change. Increasing our understanding of the effects of climate change on biodiversity, and developing practical ways of mitigating such effects, are critical to limit the damage. Even so, the dangers are great—for humans as well as our native plants and animals.

-Kaavya Agarwal (IB-1)

Oxygen Production

It has been found that not only creatures like planktons but also microscopic organisms like cyanobacteria have dominated the earth's oxygen production.

Victor Smetacek, a marine biologist, has been studying planktons and microorganisms in the southern ocean. Planktons happens to be our planet's most prolific life form, providing the base layer of the global food chain. Much of the oxygen we breath comes from just the one species of cyanobacteria and prochlorococus, which has dominated earth's production for the last 2.4 billion years. These minuscule marine plants produce more oxygen than all of the planet's forests combined. Their steady breathing is only limited by a lack of key nutritional elements . If enough of these elements are supplied by dust off a continent or fertilizer run off from farm fields , the ocean can produce blooms that can be seen from space.

These plankton pastures depend largely upon iron. However, there are many places, especially those that are cut off from the continental dust and dirt, that do not have abundant iron supply. With access to more iron, the plankton would proliferate and siphon more and more planet heating carbon dioxide from the atmosphere.
Statistics show that iron fertilizer could potentially sequester as much as one billion metric tons of carbon dioxide annually, and keep it deep in the oceans for centuries . These statistics are staggering and really prove a point but I would still like to explain certain observations made by Mr. Smetacek based on an experiment he conducted in the year 2004.

Using an iron sulphate waste sold as a lawn treatment in Germany, Smetacek and his colleagues supplied the plankton with the nutrients they needed.They hoped that fertilizing the waters would promote blooms to help sea life thrive all the way up to the food chain. More importantly, the uneaten plankton could suck out carbon dioxide from the air until they died and sank to the sea bed, thereby providing natural carbon sequestration.
Smetacek's ship dumped enough of iron sulphate to raise the iron concentration by 0.01 gram per square meter in a 167 square kilometer self contained swirl of water that could maintain its shape for weeks, even months. Over the course of 2 weeks,13 species of diatoms bloomed down to depths of 100 meters. Then the bloom began to die in large numbers leading to a 'snowfall' kind of scenario with depths of 500 meters. About half of them continued on even further, sinking more than 3000 meters to the sea bed.
For 2 weeks, Smetacek induced carbon to fall to the sea bed at the highest rate ever observed - 34 times faster than normal. This marine tinkering could help buffer the ever increasing concentrations of carbon dioxide in the atmosphere, concentrations have touched 400 parts per million, levels never before experienced in the history of the species.
Apart from the ethical issues in this experiment-iron could lead to a toxic legal algae bloom or a "dead zone" causing fish to flee and suffocating crabs and worms-the results of the study were very clear and indicated an alternative solution for survival on earth.
The proceedings of this study were also taken into consideration for regular practice in order to purify the air. However, seeing the potential damage that large amounts of iron could inflict on marine life, the method was discarded.

-Aryan Saraogi (IB-1)

ICE CORES

Ever wondered how scientists measure CO_2 levels, methane levels and atmospheric temperatures from hundreds of thousands of years ago? It seems impossible as we had no equipment 800,000 years ago to measure the climate conditions, however ice cores allow scientists to measure and calculate these conditions.

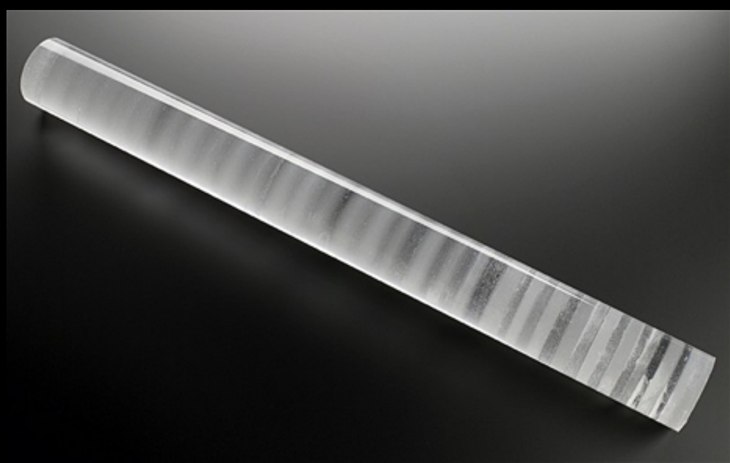
Ice sheets allow us to go back in time and sample accumulation, air temperature and air chemistry from another time. Ice core records allow us to generate continuous reconstructions of past climate, going back at least 800,000 years. Ice cores are cylinders of ice drilled out of these ice sheets. Most ice core records come from Antarctica and Greenland, and the longest ice cores extend to 3km in depth. The oldest continuous ice core records to date extend 123,000 years in Greenland and 800,000 years in Antarctica. Ice cores contain information about past temperature, and about many other aspects of the environment. Crucially, the ice encloses small bubbles of air that contain a sample of the atmosphere – from these it is possible to measure directly the past concentration of gases (including carbon dioxide and methane) in the atmosphere. The ice forms through incremental build-up of annual layers of snow, which compresses to form ice. The newer layers form on the top, and therefore the deeper the core, the older the ice.

Shallow ice cores (100-200 m long) are easier to collect and can cover up to a few hundred years of accumulation, depending on accumulation rates. Deeper cores require more equipment, and the borehole must be filled with drill fluid to keep it open. The drill fluid used is normally a petroleum-derived liquid like kerosene. It must have a suitable freezing point and viscosity. Collecting the deepest ice cores (up to 3000 m) requires a semi-permanent scientific camp and a long, multi-year campaign.

Layers of ice

If we want to reconstruct past air temperatures, one of the most critical parameters is the age of the ice being analysed. Fortunately, ice cores preserve annual layers, making it simple to date the ice. Seasonal differences in the snow properties create layers – just like rings in trees. Unfortunately, annual layers become harder to see deeper in the ice core. Other ways of dating ice cores include geochemisty, layers of ash (tephra), electrical conductivity, and using numerical flow models to understand age-depth relationships.

Although radiometric dating of ice cores has been difficult, Uranium has been used to date the Dome C ice core from Antarctica. Dust is present in ice cores, and it contains Uranium. The decay of ^{238}U to ^{234}U from dust in the ice matrix can be used to provide an additional means to find the age of the ice



This is a 19cm section of the GISP ice core at 1,855m showing "annu layers. This section contains 11 layers with the lighter "summer" layers sandwiched between the darker "winter" layers.

Information from ice cores-

Accumulation Rates

The thickness of the annual layers in ice cores can be used to derive a precipitation rate. Past precipitation rates are an important palaeoenvironmental indicator, often correlated to climate change, and it's an essential parameter for many past climate studies or numerical glacier simulations.

Melt layers

Ice cores provide us with lots of information beyond bubbles of gas in the ice. For example, melt layers are related to summer temperatures. More melt layers indicate warmer summer air temperatures. Melt layers are formed when the surface snow melts, releasing water to percolate down through the snow pack. They form bubble-free ice layers, visible in the ice core. The distribution of melt layers through time is a function of the past climate, and has been used, for example, to show increased melting in the Twentieth Century around the NE Antarctic Peninsula

Past air temperatures

It is possible to discern past air temperatures from ice cores. This can be related directly to concentrations of carbon dioxide, methane and other greenhouse gasses preserved in the ice. Snow precipitation over Antarctica is made mostly of $H_2{}^{16}O$ molecules (99.7%). There are also rarer stable isotopes: $H_2{}^{18}O$ (0.2%) and $HD^{16}O$ (0.03%) (D is Deuterium, or ^2H). Past precipitation can be used to reconstruct past palaeoclimatic temperatures. D and ^{18}O concentrations are related to surface temperature at middle and high latitudes. The relationship is consistent and linear over Antarctica.

Snow falls over Antarctica and is slowly converted to ice. Stable isotopes of oxygen (Oxygen [^{16}O, ^{18}O] and hydrogen [D/H]) are trapped in the ice in ice cores. The stable isotopes are measured in ice through a mass spectrometer. Measuring changing concentrations of D and ^{18}O through time in layers through an ice core provides a detailed record of temperature change, going back hundreds of thousands of years.

-Ethan Hugh (A2)

Climate change and plastic

Every year, humanity manages to produce the amount of plastic weighing an equivalent of 1000 Empire State buildings (300,000,000,000 kg). It's the most widely used chemically synthesised industrial material and practically constitutes the entirety of the use and throw industry. Whats more? Despite this, only about half the mass of annually used plastic is use and throw plastic.

Plastic is made from fossil fuels and their production uses up already strained supplies of coal and oil. This is extremely uneconomic and expensive when you look at a scale large enough to account for the usage by all 7 billion of us. Additionally, because fossil fuels are an integral part of they production, manufacturing plastics emits a significant carbon footprint. As a result, the world is looking to quickly replace the use of plastic.

Other than these already known detrimental effects of plastic, recent studies show that the degradation of plastics further emits greenhouse gases such as methane and ethylene. Even though they constitute smaller volumes than carbon dioxide, these gases are just as dangerous if not more. For instance, methane is known to be 21 times more reactive as a greenhouse gas than carbon dioxide. This rate of emission increases as the surface area of the plastic increases and as the plastic degrades, the surface area increases. Hence, the rate of emission occurs at an increasing rat making it even more significant.

Plastic is one of the few such banes man has given this Earth that manages to perpetrate a large portion of three of the worst forms of pollution identified by scientists. The low rate of biodegradation makes it very easy for plastic to accumulate as litter causing major land pollution. The emissions into the atmosphere caused by plastic are a major part of air pollution. Water pollution, too, is just as prevalent. The great pacific garbage patch is a patch of plastic accumulated in the pacific ocean and stretches across an area of 1.6 square kilometres with concentrations upto 100 kg plastic per square kilometre. Causing severe damage to aquatic life and killing out entire populations, the “plastic vortex” is one of the biggest symbols of pollution in the world.

However, despite their adverse effects on the environment, plastics are cheap and they have several characteristic traits making them perfect for whatever they’re used for. Thus, removing them directly would be an economic catastrophe. Instead, an alternative form of plastic was developed: bioplastics. Bioplastics exhibit all the positive characteristics that plastics do, making them perfect for industrial use in place of plastics, but they have a few added advantages. They are made of waste organic material and thus are much more easily biodegradable and environment friendly than normal plastics. These aren’t a permanent solution to the plastic paradox but they are our best shot at starting. As a matter of fact, most big companies (cocacola, heinz, dasani, etc.) have started avidly using bioplastics to replace their use and throw packaging.

For more on bioplastics, follow @bioplastorg on instagram or visit the Facebook page

-Yashvardhan Pansari (AS)

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