

The Chain Reaction

Humanitarian Solutions Worldwide

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An Alternative Approach to the Climate Change Problem

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The Earth is heating up.

Since the time before the Industrial Revolution, around 1760, the average temperature on Earth has increased by about .9 degree Celsius (1.5 degree Fahrenheit). This seems like a small amount considering the wide variations of temperature around the globe and over the course of a day. However, the climate results of this temperature increase are clearly seen: from receding glaciers, earlier springs, territorial movements of animal, insect and plant species, and increase in extreme weather, such as hurricanes and forest fires.

What is the cause of this warming?

In the late 1700s, humans began to burn fossil fuels, such as coal, oil and natural gas for power. This, coupled with the expansion of agriculture, caused large amounts of CO₂ (carbon dioxide) to be emitted into the atmosphere. The concentration of CO₂ in the Earth's atmosphere has increased from about 280 parts per million (ppm) in the 1700s to over 400 ppm today.

This also seems like a small amount, still less than one part in a thousand. However, CO₂ plays an important role in determining the Earth's temperature. Earth receives light and heat from the sun and then re-radiates some of that energy back into space as heat or infrared radiation. CO₂ interferes with that process, blocking some of the radiation emitted from the Earth's surface. Because of this, the Earth receives more energy from the sun than it emits into space. That imbalance causes the Earth's temperature to gradually increase.

Why is this small warming a concern? It seems like it might be good for the Earth to be a little bit warmer.

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Our Mission

Chemists Without Borders solves humanitarian problems by mobilizing the resources and expertise of the global chemistry community and its networks.

Our Vision

A global support network of volunteers providing mentoring, information and advice to ensure every person, everywhere, has affordable, consistent and persistent access to:

- Essential medicines and vaccines
- Sufficient safe water
- A sustainable energy supply
- Education in green chemistry and business which people can apply in their daily lives and teach to others
- Safe processes in work environments where chemical hazards exist
- Emergency support, including essential supplies and technology

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To get an idea of how CO₂ buildup and its affect on planetary temperature can change a planet's climate, take a look at the planet Venus.

Venus is the second planet from the sun, after Mercury. Earth is the third planet

from the sun; Venus is about the same size as the Earth. The similarities end there. Venus has an atmosphere composed mainly of CO₂, which is about 90 times the density of the Earth's atmosphere. The temperature of the surface of Venus can reach 465 Celsius (870 Fahrenheit). Venus is a planet where global warming has gone wild. The CO₂ has been trapping the energy from the sun. The surface of the planet is no longer habitable as some scientists think it was a few billion years ago.

But CO₂ in the Earth is still less than one part in a thousand, and the temperature has risen only one degree Celsius. We are nowhere near the state of Venus. What is the concern?

If we were certain that the Earth's temperature would continue to just rise slowly, we could eventually work to slow it down and reverse it at our convenience. The actual issue involves phenomena that we call tipping points.

If we push against a floor lamp gently, it will rock back to its upright condition when we stop pushing on it. Push a little harder, and the lamp tips more, but it still rocks back when we stop pushing. At a certain point, a tipping point, the lamp becomes unstable and crashes to the floor.

What are the Earth's tipping points?

We may not know all of them, but here are a few:

- There are huge amounts of carbon (estimated by scientists to be twice as much as the carbon in the atmosphere) buried in the permafrost in the arctic.

A global increase of only one degree Celsius is already causing permafrost to melt in some places. The release of this carbon in the form of CO₂ or methane (up to 154 times more effective than CO₂ in trapping heat from the sun) could accelerate global warming beyond humans' capability to reverse it.

- There are also huge amounts of methane hydrates buried at the bottom of the oceans. It is thought that they may begin releasing methane into the atmosphere as the ocean temperature rises, which would also drive global warming.
- Light from the sun reflects from the ice on the Arctic Ocean. We are perhaps only a few years away from the Arctic Ocean melting in the summer. The open ocean would absorb that energy that is now reflected by the ice. Now we have an additional mechanism for heating the Earth.



Melting permafrost in Northern Canada
(Credit: Wikipedia)

The real danger is not so much the forest fires, hurricanes, or even the small sea level rise we now see as a result of the Earth's warming.

It is the tipping points that we may soon reach that will cause the Earth's temperature to rise quickly beyond our ability to stop it. Here's how it could happen:

- Large quantities of CO₂ from permafrost and methane from the ocean floor are released as Earth temperature increases.
- Temperatures rising drives more CO₂ and methane release.
- At a critical temperature, plants cannot survive, at least in some regions.
- As plants in some regions die, the local people lose their food supply and become climate mi-

grants. The loss of regional plants also reduces the only mechanism that can remove large quantities of CO_2 from the atmosphere.

- As atmospheric CO_2 and Earth temperature increase, polar ice melts and some water evaporates from the oceans.
- The additional water vapor in the atmosphere traps heat from the sun like CO_2 does.
- The Earth will not reach the state of Venus, since it is farther from the sun, but it may no longer be a planet where humans can survive.

The time for humans to react to the warming that has already occurred is now. What should we do?

We should stop burning fossil fuels, since they are the primary cause of the CO_2 build up in the atmosphere that in turn causes the Earth's temperature to increase.

Unfortunately, stopping the burning of fossil fuels is easier said than done. Our economies are tied to fossil fuels and the fossil fuel industry is powerful financially and politically. Switching to environmentally friendly power sources cannot practically happen overnight. Years of planning and implementing of engineering changes would be required. Many governments and environmental organizations are focusing their efforts on transitioning away from fossil fuels, which they should continue to do.

Thankfully, there is another approach we can take in parallel while we are opposing the use of fossil fuels.

There are devices all over the Earth that absorb CO_2 from the atmosphere at a rate that is about four times the rate of emission by the burning of fossil fuels. These devices are called "plants". They include agricultural crops, forests, grasses, jungles, basically all vegetation on Earth. The plants absorb CO_2 and use the carbon and oxygen to build their leaves, stems, fruit, seeds, etc.

When the plants die and decay or are burned, they release all the carbon they have absorbed during their lifetimes. The carbon combines with oxygen and returns to the atmosphere again as CO_2 . As a result, the CO_2 absorbed by living plants is canceled out by the CO_2 emitted by the dead and decaying plants.

However, if we could interrupt this cycle by preventing the dead plants from releasing CO_2 , we could gradually reduce and eventually cancel out the build-up of CO_2 caused by the burning of fossil fuels.

If we heat the dead plants (or crops, trees, grasses, etc.) in the absence of oxygen, the carbon will be unable to form CO_2 and will be extracted in a form of charcoal called biochar. Produced in the right way, biochar can remain stable for centuries, while providing a significant drawdown of atmospheric CO_2 .

When we produce a pound of biochar, it is a pound of carbon that will not return to the atmosphere as CO_2 . Producing biochar is equivalent to combating the buildup of CO_2 in the atmosphere, provided that other greenhouse gases, such as methane (CH_4) are not released in significant quantities during the process.

How do we raise the money to pay for the processing of dead plants to produce biochar? As it turns out, biochar is a useful product that can be sold to pay for the cost of its production.



Biochar without fertilizer compared to plain soil
(Credit: Biochar.info)

Biochar can be used as a fuel to replace coal in steel-making and other applications. It can be used as a filter to provide clean water. However, its most important application may be in agriculture.

Biochar is very porous and has microscopic channels that can capture water, fertilizer and plant nutrients, which the plants can access later through their fine root fibers. Therefore, it enables plants to thrive in drought plagued areas where water is not plentiful.

How can you be sure this isn't some crazy untested geo-engineering scheme that will backfire and ruin all our agricultural soils, leaving us to starve or worse?

The answer is that biochar already exists in nature and in our farmlands. It has existed for a long time, with and without humans around.

Considerable research has been done at agriculture departments in universities in many countries on the use of biochar in agriculture. However, its use on farms has so far been very limited, since the farmers are often not aware of the research advances.

Chemists Without Borders proposes to combat climate change by promoting the production of biochar and its use in agriculture.

We intend to help publicize the knowledge gained by the researchers of biochar production and its use in agriculture. We will pass on that knowledge to both the biochar producers and the farmers who can apply that knowledge.

We already have volunteers who are ready to talk with biochar producers and farmers about biochar in the following locations: India; Taiwan; Mali; Missouri; Georgia; San Jose, CA; San Diego, CA and Vancouver, B.C., Canada. We plan to ramp up our team of volunteers globally.

How do we propose to help the biochar producers?

With the biochar producers, we seek to learn from them about their production process. Not all production processes are equal. Two major problems can occur:

1. Methane, which is a much more powerful greenhouse gas than CO₂, can be produced in the process and be emitted in the atmosphere.
2. Some processes will produce a biochar which is not stable for a long time, defeating our efforts to keep the carbon out of the atmosphere as CO₂.

We propose to help biochar producers avoid these problems and to promote only the biochar that is produced without methane and with a long lifetime.

How do we propose to help the farmers?

We will seek to learn about the farmers' soils. Many farmers will have already characterized their soils and know the parameters that describe the soil. We will also work with soil testing laboratories which will be able to do additional tests.

When we have information about each farmer's soil, we will be able to pass on the researchers' advice on how biochar can improve the fertility of the soil and reduce the costs of water and fertilizer. As a result, the quality of the farmer's crop and their profitability will improve.

If you would like to join us as a CWB volunteer or if you are a member of an organization interested in the environment or improved agriculture that would be interested in partnering with us to solve this global crisis, please contact me:

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AIDSfreeAFRICA: Exciting Updates on the Malaria Free Zone Program

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Malaria, a disease transmitted by the bite of an infected mosquito, is a serious public health problem in Cameroon, especially for children younger than five. To combat this problem, AIDSfreeAFRICA launched the Malaria Free Zone (MFZ) program in 2015 in Cameroon (for more information visit <http://aidsfreeafrica.org/our-programs/malaria-free-zone-mosquito-nets/>). The goal of the program is to reduce the malaria infection rate while educating the residents on how malaria can be transmitted and prevented. As a part of the MFZ program, bed nets are permanently affixed to windows to make the entire structure a malaria-free environment. A behind-the-scenes look at this program was first introduced in the Chemists Without Borders Newsletter 27 (http://www.chemistswithoutborders.org/downloads/newsletters/Newsletter_27.pdf).



Since the inception of the MFZ program, AIDSfreeAFRICA has equipped over 150 homes/structures and over 700 individual windows throughout Cameroon. The initial phase of the MFZ program began in Bamenda in the Northwest Region of Cameroon and Yaounde, which is in the Central Region. In the next phase of the MFZ program, AIDSfreeAFRICA is looking to expand to the Littoral Region, which includes the port city of Douala. Douala's population is over 2.5 million. The MFZ program has the potential of making a vast impact on malaria-infection rates in such a densely populated region. Recently, AIDSfreeAFRICA formed a partnership with the Health District in Garoua in the North Region of Cameroon. The government in Garoua has provided 50 bed nets to spearhead the MFZ program efforts in this area. Great strides are being made so far and AIDSfreeAFRICA hopes to expand the MFZ program to all 10 regions of Cameroon.

To accomplish the goal of reaching all regions of Cameroon, the MFZ program will need additional volunteers and monetary support. Currently, there are almost 20 AIDSfreeAFRICA volunteers in Cameroon that are gathering supplies, coordinating installations, and affixing bed nets to windows. There are also short-term volunteer opportunities for individuals from overseas that would like to support the MFZ program's mission.

To contact us directly, please visit the AIDSfreeAFRICA website (<http://aidsfreeafrica.org/our-story/contact/>) and send us a message letting us know how you would like to partner with our organization to help Cameroon!

Next Generation Toilets: Sanitation without the Sewer

BY HEIDI DOAK

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UN Sustainable Development Goal 6 calls for sanitation to be available to all people. New toilet technologies can help achieve this goal and chemistry plays an essential role.

Billions of people lack access to sanitation and this puts their health and the health of their communities at risk. Safe, clean toilets, with effective waste treatment, improve health by preventing human contact with pathogens which cause disease.

Typical sanitation systems need large quantities of water and a connection to sewer infrastructure, making this model of sanitation unsuitable for many communities. However, merging technologies offer new ways to achieve the same benefits.

The Bill and Melinda Gates Foundation began investing in reinvented toilet research in 2011. Researchers have taken up the challenge to develop a variety of novel toilets which reproduce the safety and convenience of waterborne sanitation systems. A number of these technologies were shown at the recent Reinvented Toilet Expo (RTE), held in Beijing in November 2018.

The new paradigm in toilets is stand-alone, on-site treatment of waste. Some use renewable energy to power the treatment process; some are waterless; and in some cases the products of the treatment are also usable and valuable. This next generation of toilets uses chemistry, biology, and engineering to reinvent onsite waste treatment.

At the RTE, technologies were combined in different ways to treat human waste. Combustion, membrane filtration, electrochemical, and biological disinfection are some of the strategies used to provide effective sanitation in stand-alone systems.

One new system, the Blue Diversion Autarky Toilet, was developed by Eawag - Swiss Federal Institute of Aquatic Science and Technology. It combines several treatment technologies to collect water, urine and faeces separately. Faeces are heated in air at high pressure and above 400°C so they undergo hydrothermal oxidation, which inactivates the pathogens. Hand-washing water and flush water are collected and treated using biological treatment, ultrafiltration, and activated carbon filtration. Electrolysis produces chlorine to limit further pathogen growth. Calcium hydroxide is added to the urine to raise the pH to 12, preventing pathogen growth and odors, as well as preventing the loss of nitrogen as ammonia. Nitrogen can then be recovered for fertilizer.

A group at the University of Toronto has designed a toilet that separates solids and liquids, before the solids are dried to ash and liquids are disinfected by heating. Heat from the smouldering solids dries new waste entering the system. Additional energy requirements are low enough that they can be supplied by a household solar system.

The system developed by Cranfield University uses a nano-membrane. This waterless toilet uses a rotating mechanism to move the waste and block the odors. Solids and liquids are separated by sedimentation. Filtration through nano-filter hollow fibre membranes removes pathogens and some odor causing compounds from the liquid. The recovered water is suitable for washing or irrigation. The solids are combusted, producing ash and

energy to power the membrane filtration process.

These three inventions were just a few of the many shown at the RTE. All of them reimagine the toilet as sustainable, safe and decentralized. By using clever chemistry, biology, and engineering, next-generation toilets remove the need for infrastructure over long distances and offer the potential for improved health and safety for billions of people.

Further information about Sustainable Development Goal 6, stand-alone sanitation systems, and the Reinvented Toilet Expo can be found at the following links:

- <https://sustainabledevelopment.un.org/sdg6>
- <https://www.gatesfoundation.org/Media-Center/Press-Releases/2018/11/Bill-Gates-Launches-Reinvented-Toilet-Expo-Showcasing-New-Pathogen-Killing-Sanitation-Products>
- <http://stepsforsanitation.org/wp-content/uploads/2018/11/The-Reinvented-Toilet-Exhibitor-Guide-FINAL.pdf>
- <https://www.eawag.ch/en/research/humanwelfare/wastewater/projekte/autarky/>
- <https://news.engineering.utoronto.ca/reinventing-the-toilet-u-of-t-engineering-team-presents-sustainable-prototype-in-beijing/>
- <https://www.cranfield.ac.uk/case-studies/research-case-studies/nano-membrane-toilet>

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