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Estimation of atmospheric CO_2 amount reduction through a decarbonation method based on seawater electrolysis, aimed to create a global-scale CO_2 capture strategy.

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Dr. Tatenuma's favorite R&D fields are chemical analysis, nuclear medicine, and related materials. Recently he is focusing on the development of innovative disinfectant and material for environmental purification based on iodine.

Dr. Spaziani's activity is focused on environmental chemistry research at ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) in Roma (Italy), and on the development of innovative materials for environmental and nuclear-fusion energy applications by joining the research group of Kaken Inc. in Japan.

9:35-10:00(GMT), 18:35-19:00(JST)
April 27, 2022

Overview

Atmospheric CO_2 has increased by 50% compared to before the Industrial Revolution happened 250 years ago.

As a strategy to globally reduce the atmospheric CO_2 surplus, which causes the global warming phenomenon, we propose a method to improve the natural CO_2 absorption capacity on the ocean surface layer by forming $CaCO_3$ through seawater electrolysis .

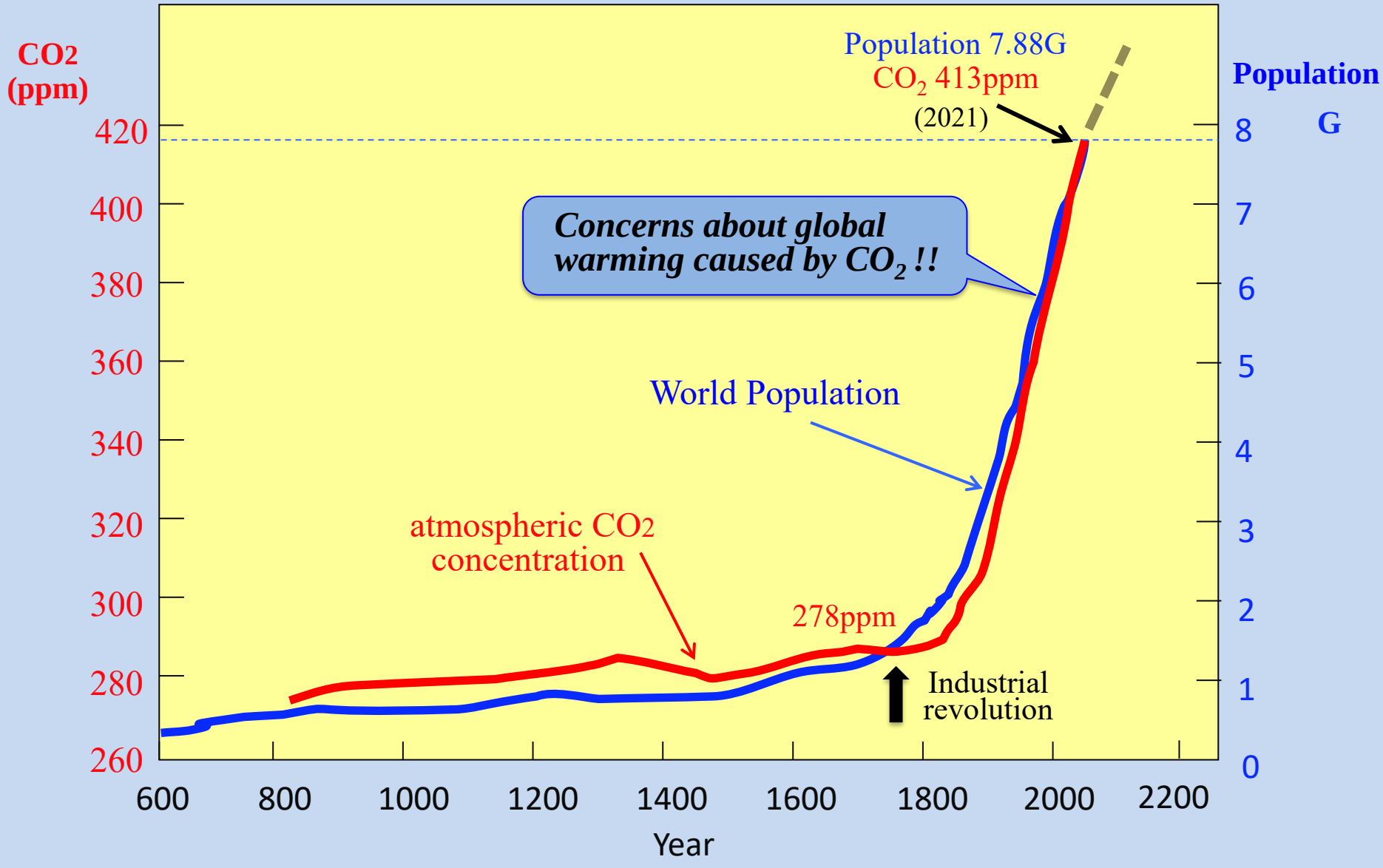
According to this approach, it is conceivable to remove up to 12 GtonCO_2 accumulated in the atmosphere every year, and it may be possible to prevent the outcomes of global warming.

Contents

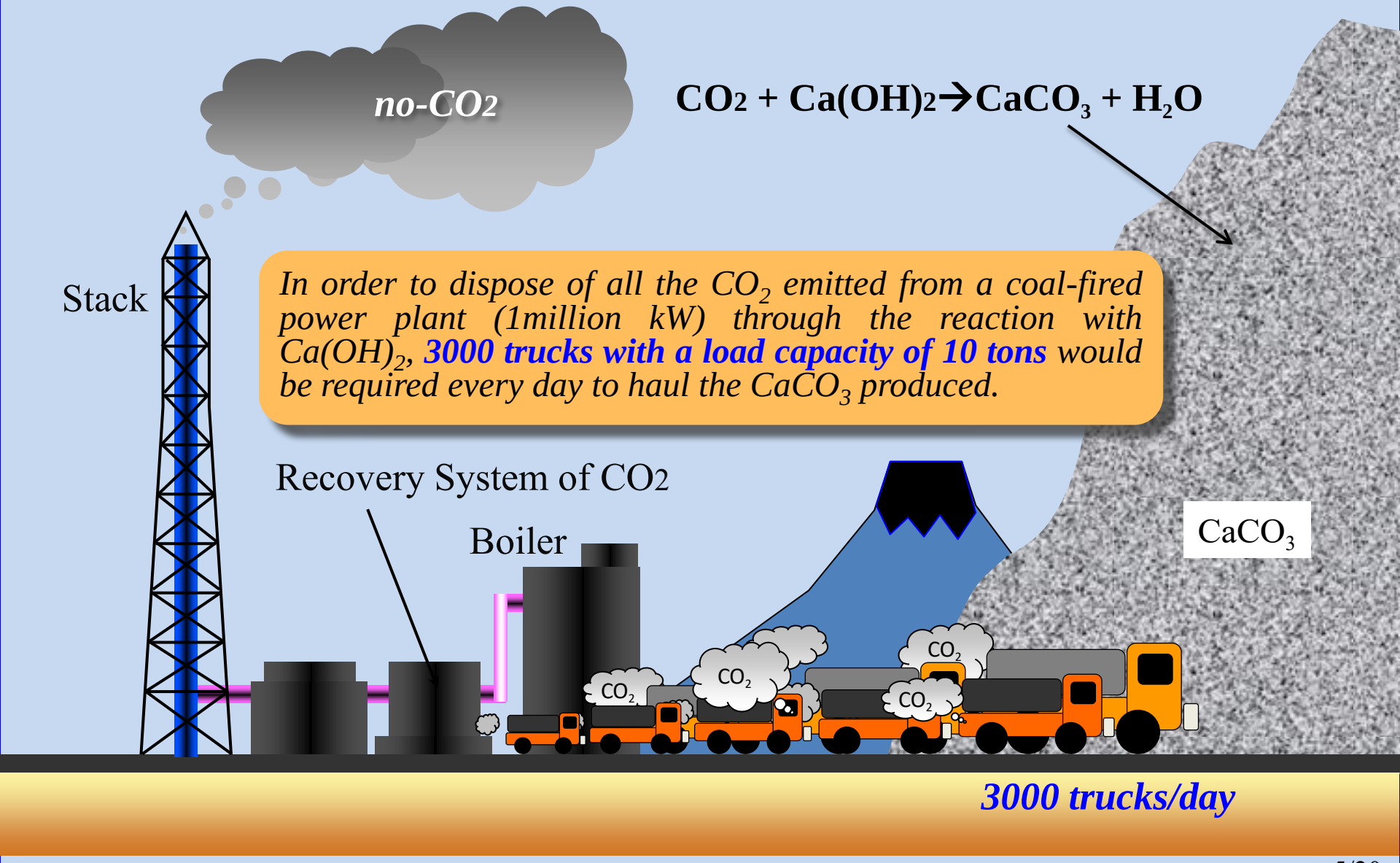
- Status of CO_2 accumulation in the atmosphere.
- Why does CO_2 accumulate in the atmosphere ?
- How to remove CO_2 in the atmosphere ?
- What amount of atmospheric CO_2 should be removed to prevent global warming ?

Status of CO_2 accumulation in the atmosphere

Population growth vs. atmospheric CO_2 concentration

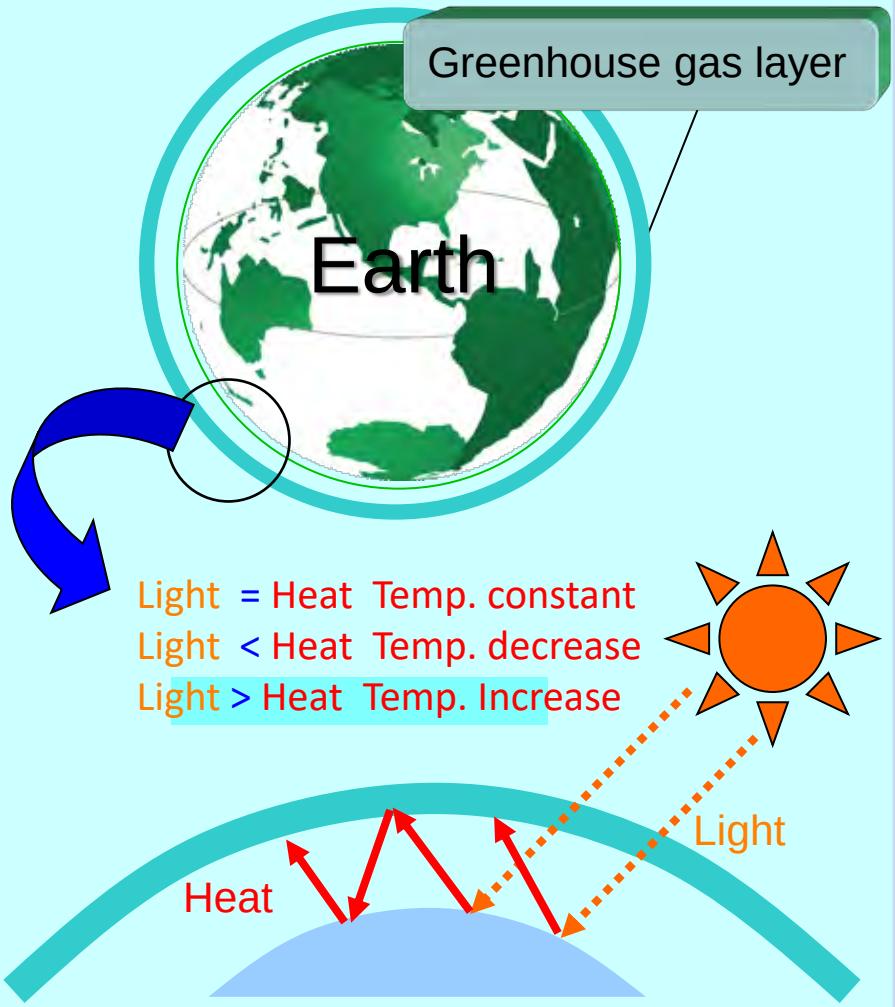


Huge amount of CO_2 emissions



Strange role of CO_2 !?

Greenhouse effect



- Greenhouse gases in the atmosphere

	in air	global warming potential
H_2O	0~7 %	-
CO_2	0.041	1
CH_4	$1{,}8\times10^{-4}$	21
N_2O	$0.\ 4\times10^{-4}$	310
O_3	4×10^{-4}	
Freons	$3\sim5\times10^{-8}$	~10,000
SF_6		23,900

Effect of greenhouse gases

without atmosphere -18 ° C
actual average temp +15 ° C

- CO_2 therapy

Self-breathing controlled by CO_2 in blood
→used as therapy for Syowa Emperor *!*

It is important to keep the CO_2 balance for Organism and the Earth !

Carbon circulation

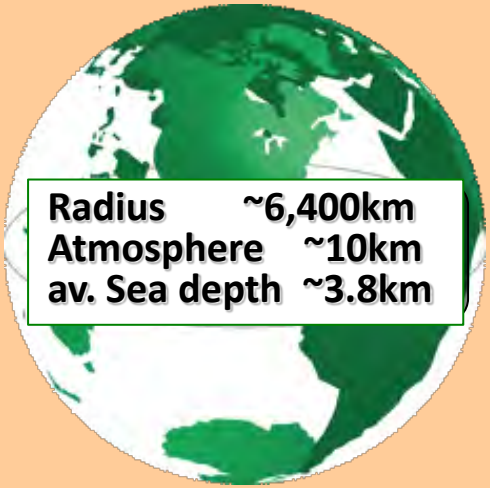
- Carbonate produced in the oceans — 1.1~1.6 GtonC/y
- Carbonate accumulated in the oceans — 0.16 GtonC/y

in atmosphere 4.5 GtonC/y

- CO_2 emission by human breath (5.7 bln) — 0.49 GtonC/y (8 % of total emitted CO_2)
- **CO_2 emission** by fossil fuel consumption — **9.3 GtonC/y (50% CO_2 remained in Air)**
- **Atmospheric CO_2** — **709.0 GtonC**

- **Inorganic Carbonate dissolved in sea water** — 38,000 GtonC

Superficial	1,100 GtonC
Intermediate~Deep	38,000 GtonC



- Carbonate exist on earth — 49,100,000 GtonC
- Total reserve of oil and coal — 5,450 GtonC
- Total reserve Ca resource (in sea water) — 600,000 GtonCa

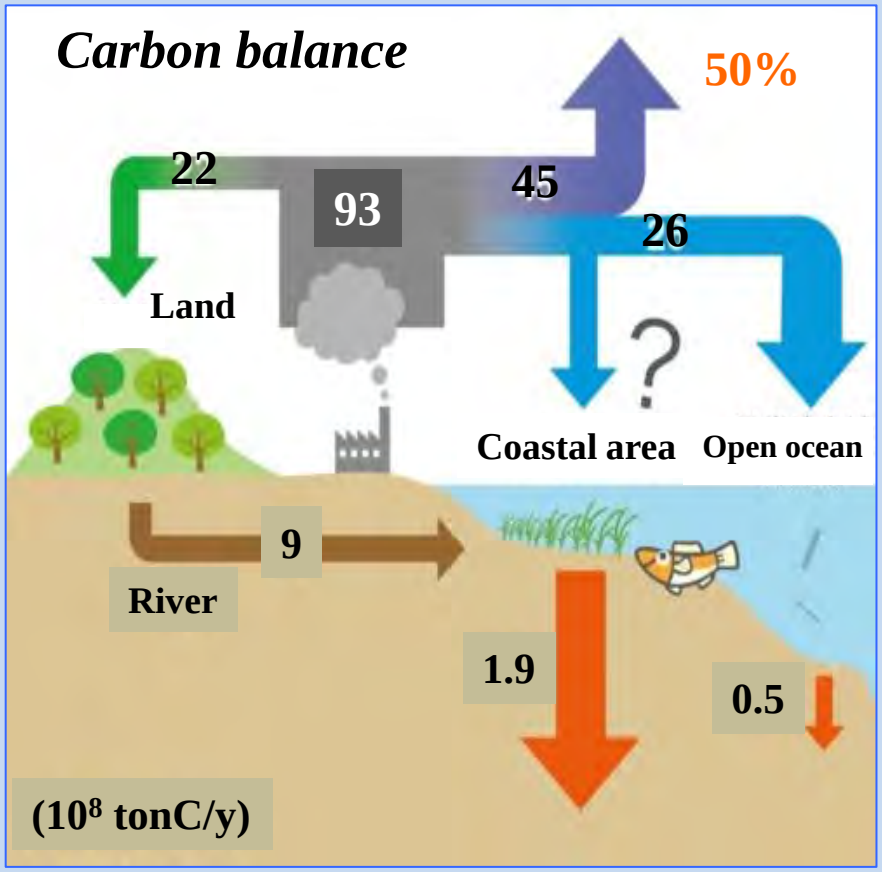
(Carbon 1: Ca 30 in sea water)

Biosphere is a thin film on the Earth's surface!
Oceans are the ideal CO_2 absorbent!

CO_2 emission by human breathing — approximately 1 kg(CO_2)/day
20~30 ton(CO_2)/life

Why does CO_2 accumulate in the atmosphere ?

Mechanism of CO_2 accumulation in the atmosphere!!



Property of CO_2

- Easily soluble in water
- Weak acidic substance

Elements in seawater

Na^+	10.8 g/kg
Cl^-	19.4
Ca^{2+}	0.41
Carbonate (HCO_3^-, CO_3^{2-})	0.14

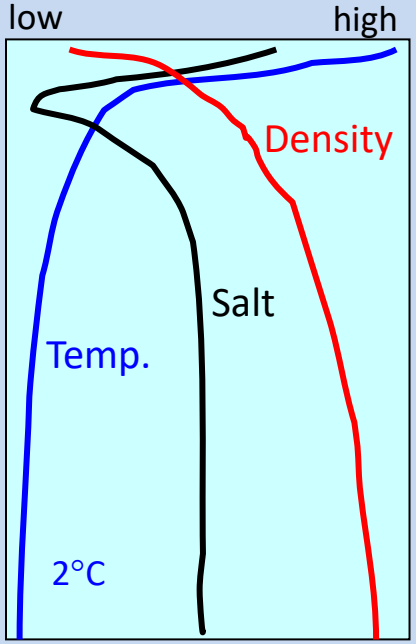
CO_2 is concentrated in seawater

CO_2 0.4cc/L in air

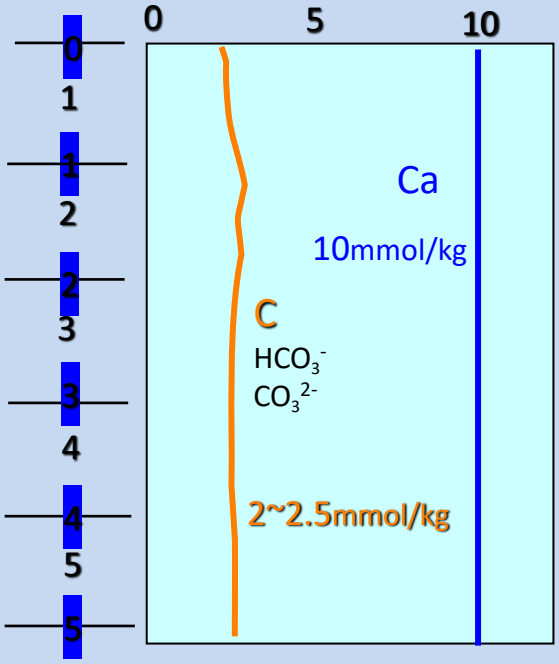
↕

50cc/L in seawater

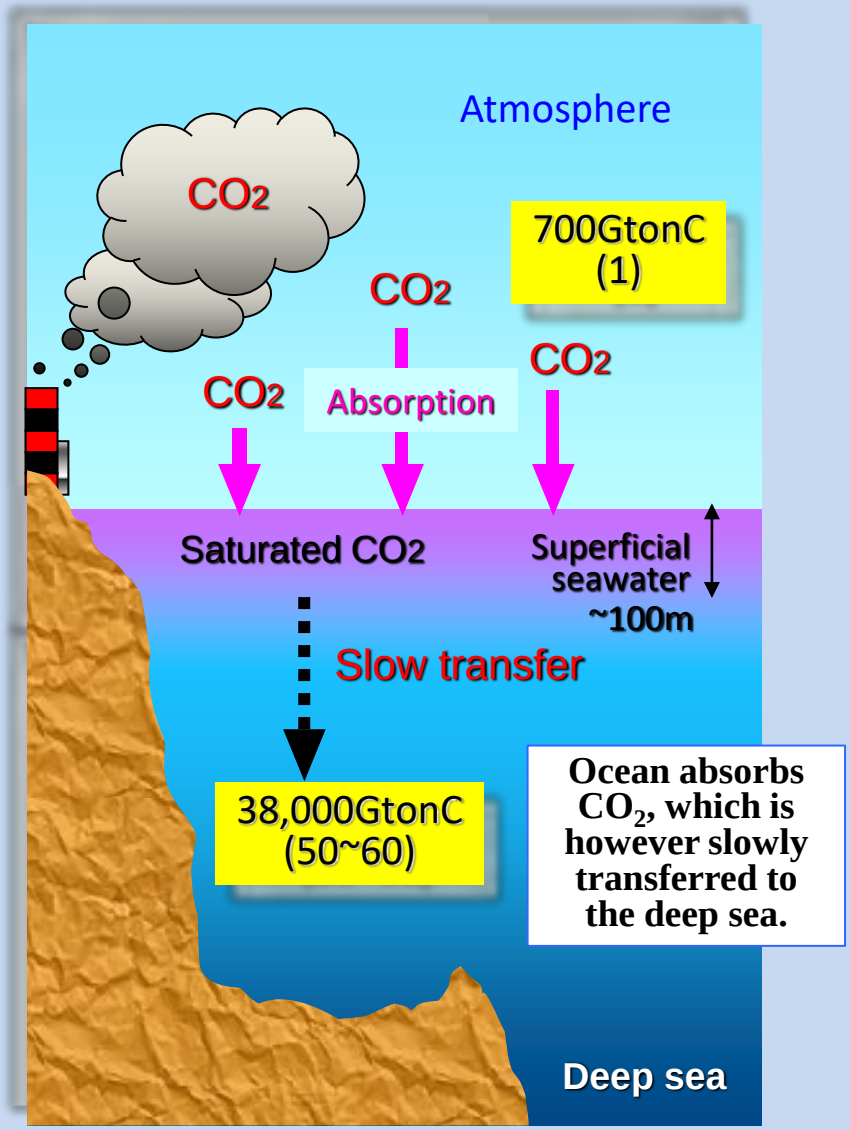
Ocean cross section



Distribution of C and Ca

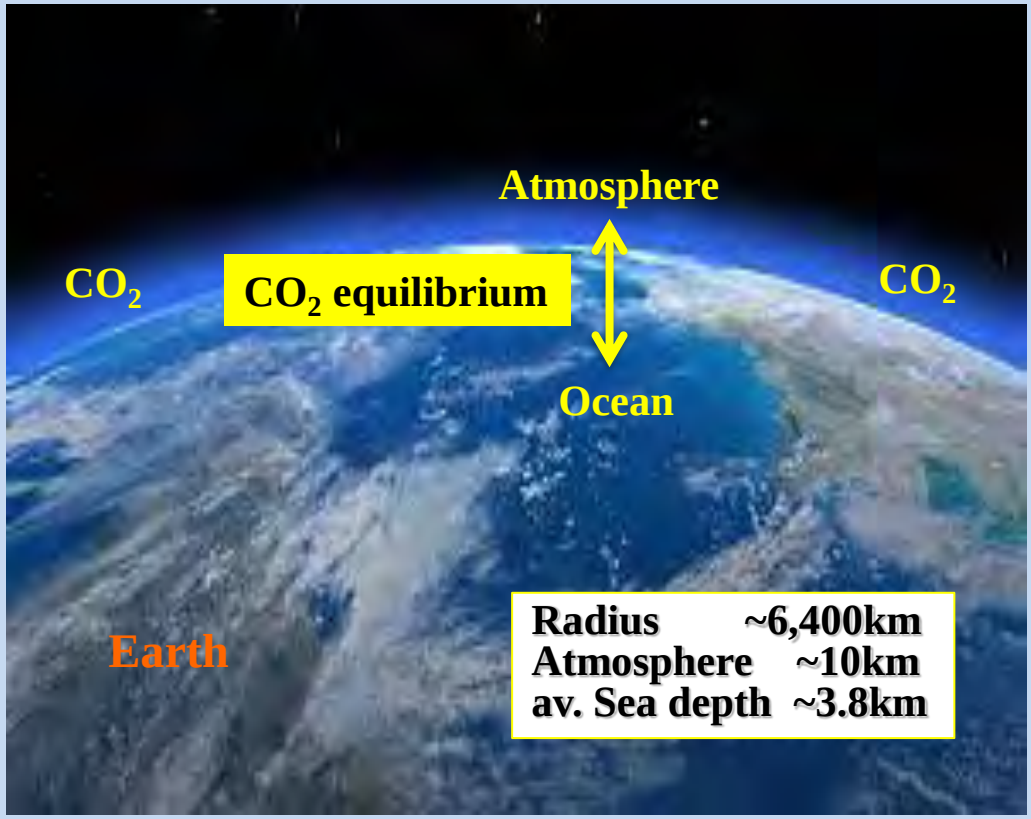


Earth is a chemical equilibrium planet !!



Ocean absorbs CO_2, which is however slowly transferred to the deep sea.

Oceans cover around 70% of the Earth's surface



The ground, the oceans, and the atmosphere maintain a chemical equilibrium of CO_2.

How to remove CO_2 in the atmosphere ?

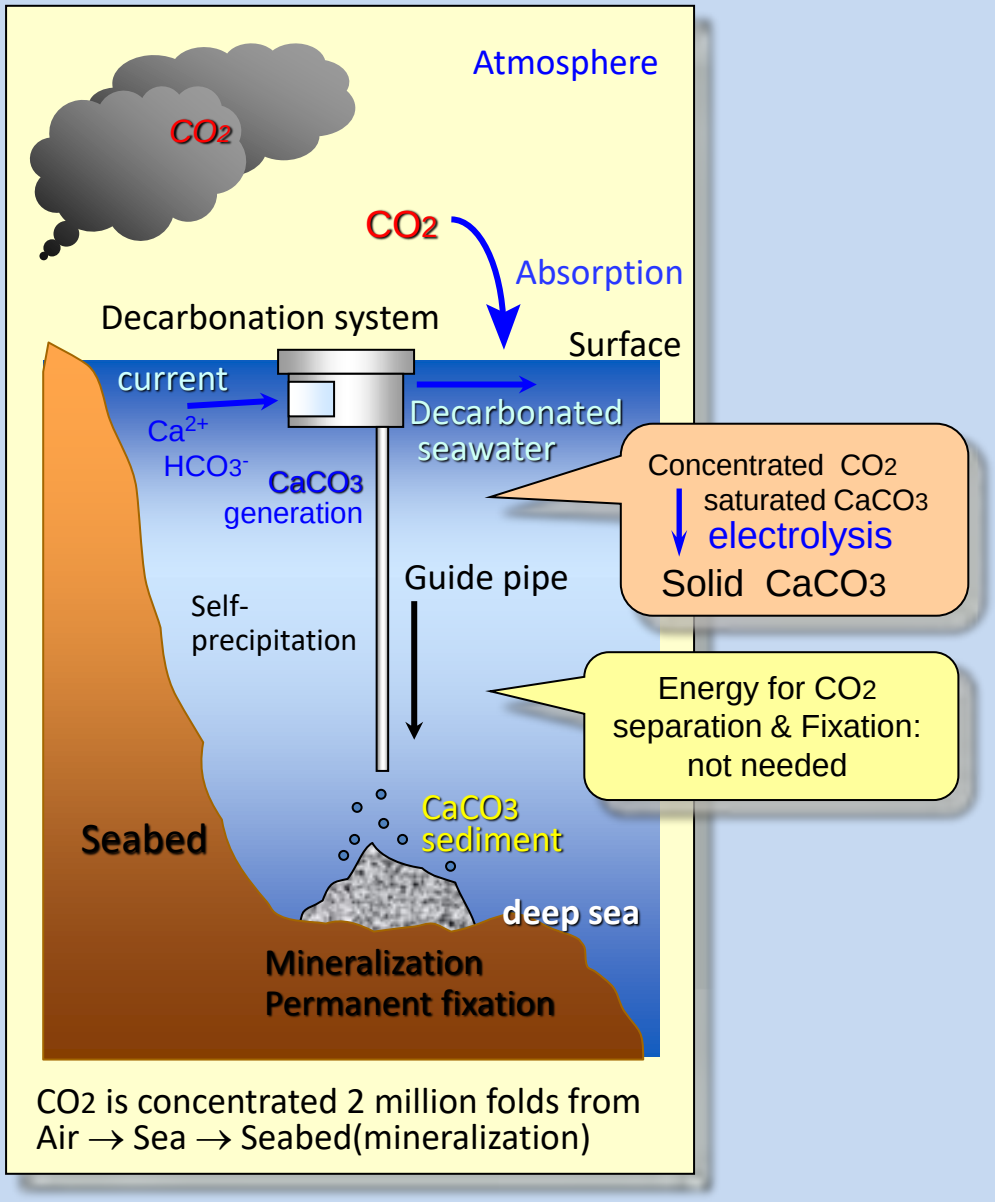
Principle of Global Reduction of Atmospheric CO_2

The ocean's natural CO_2 absorption ability can be increased through seawater electrolysis, since the process causes the decrease of carbonate concentration on the surface.

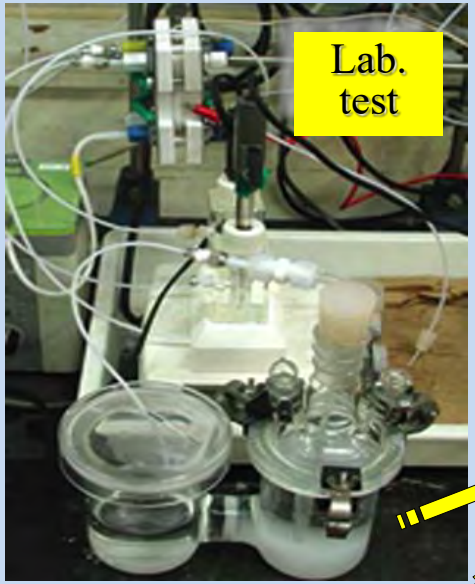
- High CO_2 reduction ability
- Huge amount of H_2 can be recovered simultaneously

- Permanent Isolation of CO_2 from biosphere !
- Simple, Controllable & Low-cost !
- Small CO_2 emission !
- Non-need Chemical & Biological Additives !
- Ecological & Natural method !

Elucidate the following mechanism;
- **Ocean circulation**
- **Biological pump**
- **Alkaline pump**

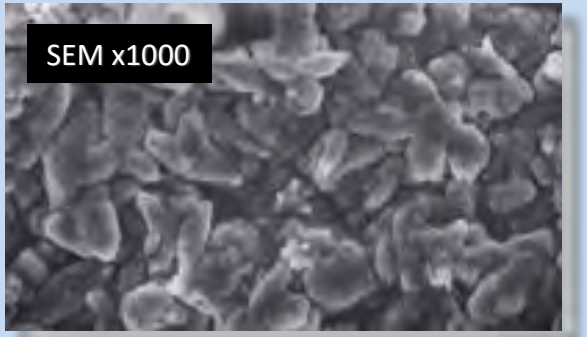


$CaCO_3$ production by electrolysis of seawater



The precipitate easily produced by electrolysis is composed of <u>Aragonite</u> ($CaCO_3$) and <u>Brucite</u> ($Mg(OH)_2$).
The amount, chemical composition and crystals shape depend on the electrolysis conditions.

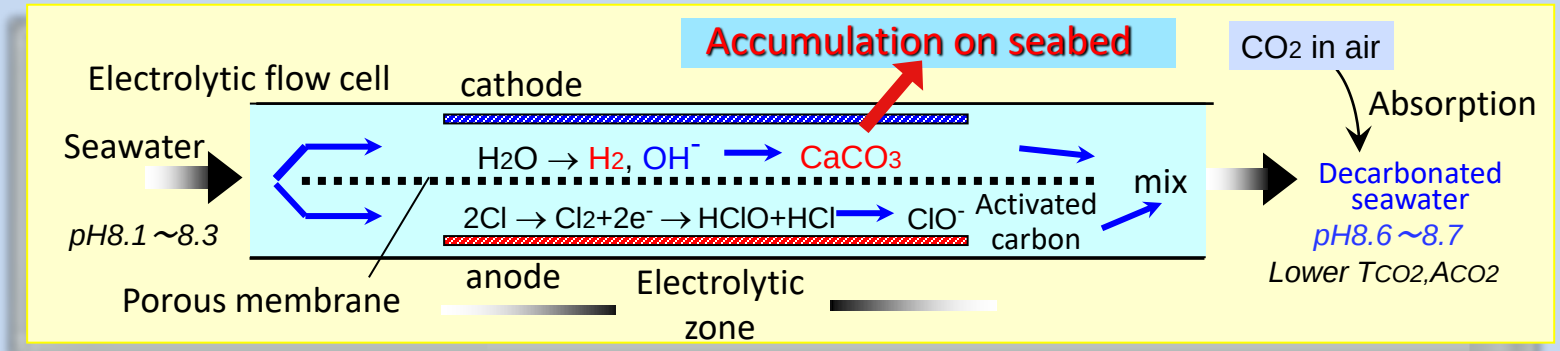
at 300 kg/cm^2 (3,000m depth)

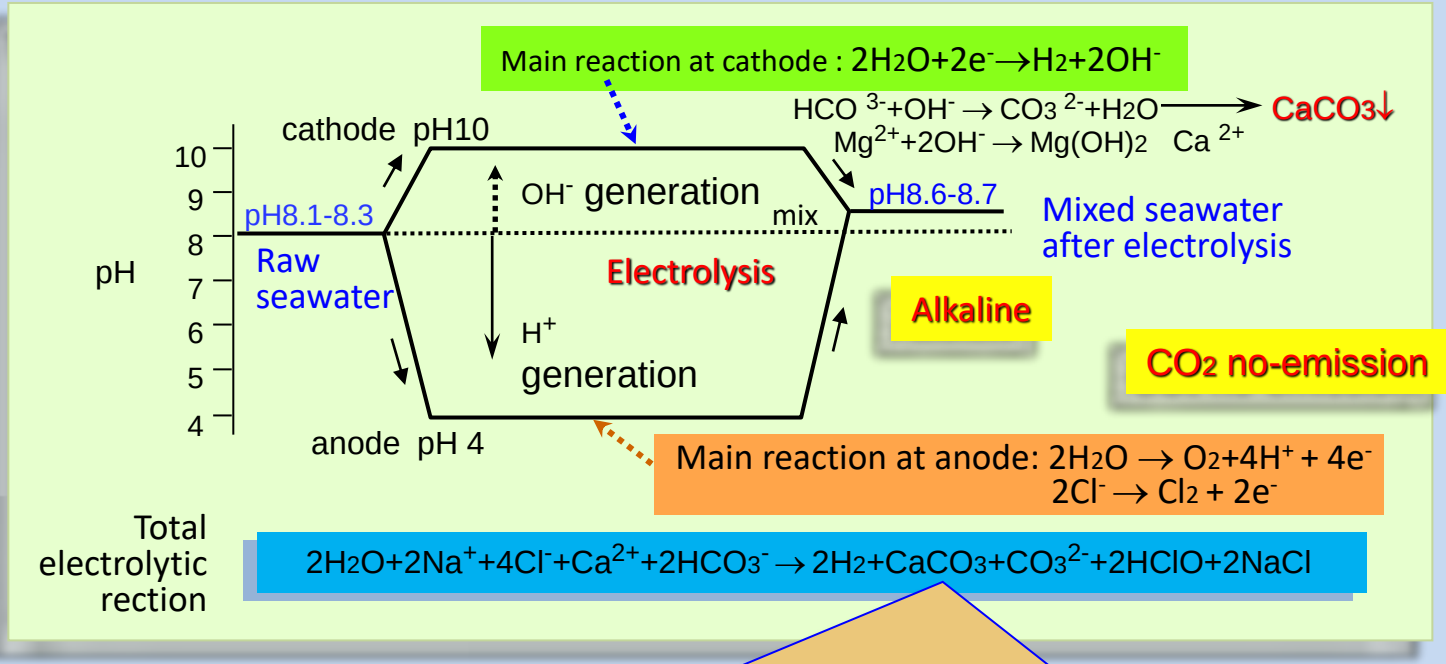


at 500 kg/cm^2 (5,000m depth)

Carbonate precipitate is stable at high pressure in deep sea.

Electrolysis Reaction of Seawater





CO2 is not emitted by this electrolysis treatment. It differs from the coral reef carbonate chemistry, characterized by CO2 emission [$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3\downarrow + CO_2\uparrow + H_2O$]

Estimation

Duty of CO_2 reduction in Japan: -6% of 1990 (actual -14%: 0.047GtonC/y)

♦ Electric Power

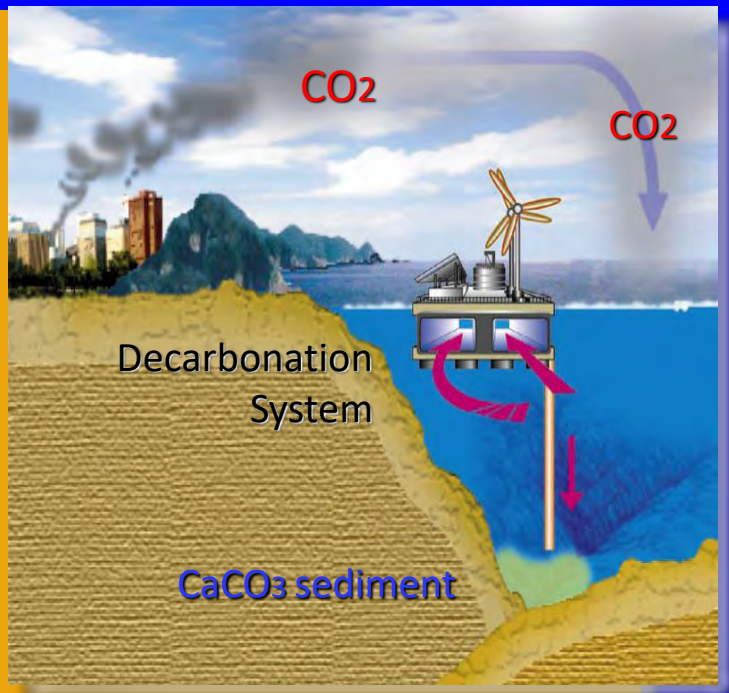
Fixation Efficiency : 0.15~0.44 kg(CO_2)/kWh
The use of clean energy is desirable

♦ Life Cycle Assessment (compared with nuclear power)

CO_2 Emission : Fixation Ratio < 1/20

♦ Size of Decarbonation System

<conditions> Sea Current Velocity of 1 m/s,
Decarbonation of 50%
Actual size of Seawater Intake
1.1×10^5 m^2 (100m-depth, 1,100m-width)
2.28×10^6 m^2 /GtonC・y^{-1} (100mx22,800m)



♦ Cost and Economy effects in the case of Japanese total duty of CO_2 reduction

Cost: System 2,000~4,000 million(M) US$

Income: CO_2 Reduction fee : 500 Million-US$/y (10 US$/tonC)
H_2 Resource : 6,000~12,000 Million-US$/y

CO_2 removal cost of every coal fired power plants with 100 million kW
Fabrication : 700~1,200 MUS$
Running : 300~700 MUS$ /y + Waste in Sea 30MC$/y

♦ Resource of Ca in sea

The Ca reserve in seawater is greater than the oil stock (5,500GtonC)

What amount of atmospheric CO_2 should be removed to prevent global warming ?

Huge amount of CO_2 to be reduced

CO_2 veil
>400ppm

Giza pyramid

Bottom length 230m
Height 146m
(138m at present)
Slope 51.51°
Volume 2.59×10^6 m^3

for comparison

excess CO_2 in atmosphere

Extra accumulated CO_2 : 260GtonC
$CaCO_3$ 2.2×10^{12} ton ≈ 6,700/vol.(Giza-pyramid)
CO_2 accumulated every year : 4.5GtonC/y
$CaCO_3$ 3.8×10^{10} ton ≈ 110/vol.(Giza-pyramid)

to remove extra accumulated CO_2

6,700 times volume of Giza-pyramid

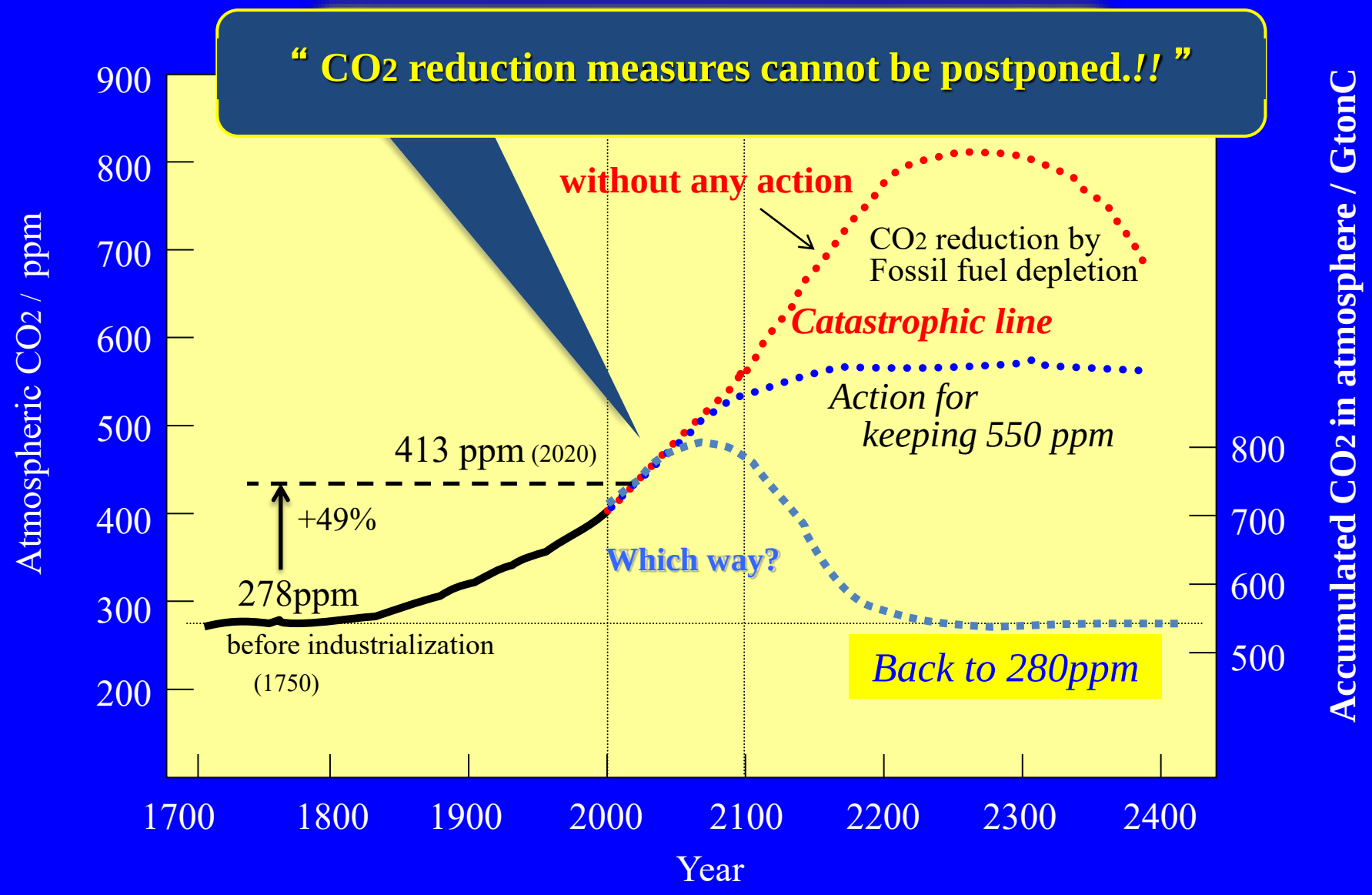
to remove CO_2 accumulated every year

110 times volume of Giza-pyramid

CO_2 ~280ppm

Return to the atmosphere in the 1700s

Possible to solve the Global Warming and our ・?



Concept & benefits of our technology developed to reduce the atmospheric CO_2 surplus

- Promoting the natural CO2 flux
- Global Reduction of emitted CO2
- Contrasting the atmospheric CO2 increase
- Simple, high performance and controllable method
- Isolation from biosphere
- No-emission of CO2 and wastes / no additives needed
- Environmentally friendly / does not disturb the ecological balance
- Does not disturb the economy growth
- Small economic stress

- **Stopping the runaway of global warming.**
- **Possibility to restore the old atmospheric environment !?**

If you have any question, please send me by email.

For more information

Our homepage
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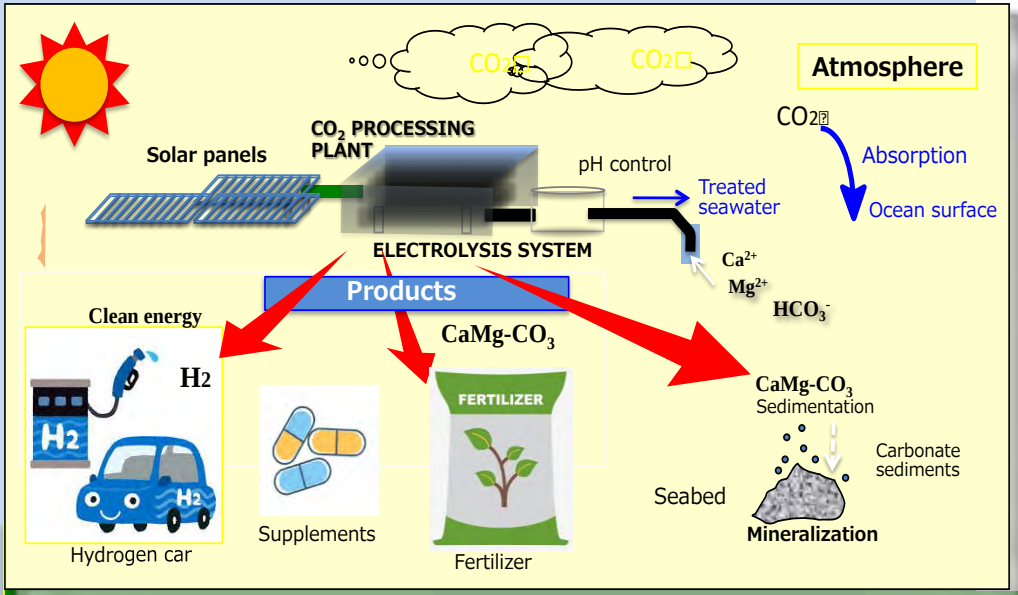
Our recent paper on this theme
Tatenuma K and Spaziani F (2022)
Adv Environ Stud 6(1):452-454



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The Challenge of Global CO_2 Reduction: The Potential of the Method Based on Seawater Electrolysis

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Keywords
Carbon dioxide, Seawater, Electrolysis, Mineralization, Climate change

Introduction

The atmospheric CO_2 concentration dramatically increased in the last 300 years, due to fossil fuels consumption and deforestation. From approximately 280 ppm before the start of the industrial revolution, about a 140 ppm upsurge was estimated. This phenomenon is understood to be responsible for a rise in global temperature, which will lead to glaciers melting and sea levels rising. Consequently, the research focused on atmospheric carbon capture and storage is fundamental for achieving the goals of the Paris Agreement concerning climate change mitigation.

A primary strategy to face these problems is to reduce the consumption of fossil fuels, by introducing, as an example, electric engines and renewable energies. Nevertheless, another essential task is the sequestration of the existing CO_2 excess in the atmosphere and its stable storage. From this point of view, for several years the most promising technique was the geological sequestration through injection and confinement of liquefied CO_2 into selected deep underground rock formations (such as saline reservoirs and depleted oil/gas fields). However, the hazard of potential CO_2 leakage is the main weak point related to this method. A more recent alternative was the geochemical sequestration, based on CO_2 injection into minerals that may drive carbonation reactions, producing stable carbonate rocks and implying a negligible risk of return to the atmosphere [1,2].

In our opinion, geochemical sequestration can be efficiently used and optimized by exploiting both seawater electrolysis and the oceans' natural CO_2 absorption feature.

Oceans CO_2 Absorption

The oceans store about 60 times more CO_2 than the atmosphere, cover over 70% of the Earth's surface, and absorb approximately 25% of the anthropogenic CO_2 emissions.

The CO_2 assimilation is achieved both through biologically-mediated and chemically-mediated sequestration: the former includes the processes that regulate the inorganic carbon incorporation into organic matter (photosynthesis by phytoplankton) and the transport to the deep sea (the portion of organic carbon not converted back to CO_2 via the food chain, sinks to seafloor sediments); the latter is based on the reaction of CO_2 with seawater to form carbonic acid, that breaks into hydrogen ions and bicarbonate (a chemical form of carbon that does not easily escape the ocean).

Background to our proposal

Our research group previously proposed, in the past, a method for reducing CO_2 in the atmosphere based on the ocean's carbonate chemistry [3,4]. According to that scheme, when seawater is electrolyzed the dissolved CO_2 (incorporated in the carbonate family ions) reacts with the calcium-magnesium components producing insoluble carbonate minerals $CaMg(CO_3)_2$. If the process is carried out on the seawater surface layer the concentration of carbonate ions on the ocean's surface will decrease and the absorption of atmospheric CO_2 should be enhanced. Moreover, seawater electrolysis produces hydrogen, which can be stored and used/sold as an energy resource. The electrolysis system must be performed using carbon-free energy (such as solar, to do not release CO_2). A similar approach was recently proposed by other researchers, confirming the validity and feasibility of the idea [5].

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