Turning Waste Water Treatment Works into CO_2 Sinks: A Simple Chemistry Idea

By Rami Elias Kremesti * M.Sc. CSci, CEnv, CWEM

Kremesti Environmental Consulting Ltd.

2 Westfield Walk, High Wycombe HP123JN

Transmutare Substantiarum Basium In Aurum ™

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*rami@kremesti.com

Introduction

The problem of Green House Gas emissions is a global, urgent one as it results in climate change and global warming. One of the most recalcitrant GHG's is CO2, a linear acidic, non-polar molecule that is slightly soluble in water and forms carbonic acid, one of the acids that makes our carbonate beverages so tangy.

As we pump billions of tons of CO2 into the earth's atmosphere, more and more CO2 is dissolving in the oceans which is resulting in a decreasing trend in pH in sea water.

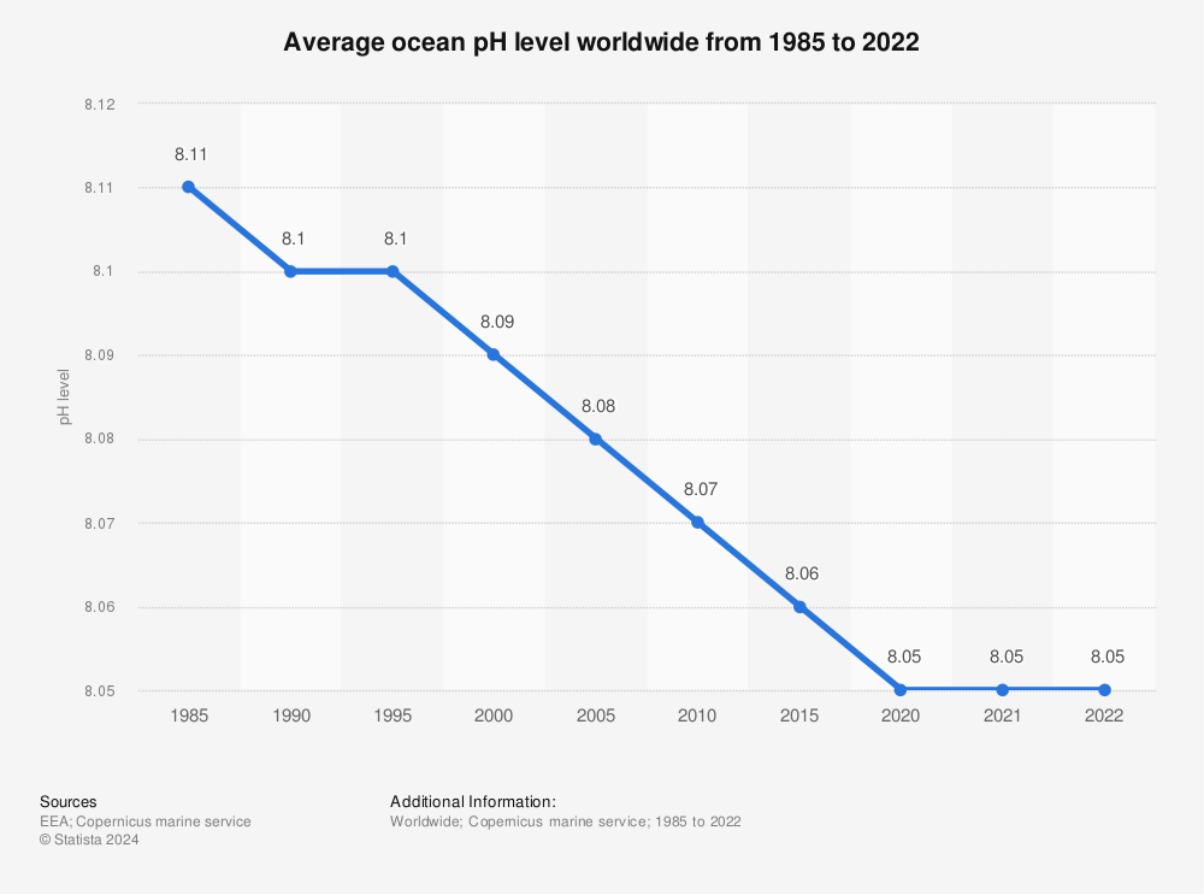

Figure 1: Average ocean pH over time from 1985 to 2022 – Source Statista

One of the ideas that is floating in the idea-sphere to counter this alarming trend in pH, which has an impact on crustaceans' ability to form tougher and thicker protective shells, is to remove CO2 from the ocean. A form of sea water CO2 capture, the water equivalent of DAC = Direct CO2 Air Capture.

The university of Exeter is working on such a pilot called SeaCURE:

https://sites.exeter.ac.uk/seacure/

The idea is a noble one but it suffers from one obvious drawback: the massive dilution factor. Billions of tons of sea water would have to be filtered to remove a tiny fraction of CO2.

Our Idea

A recent online publication caught my attention.

https://www.lex18.com/world-news/ocean-dumping-or-a-climate-solution-a-growing-industry-bets-on-the-ocean-to-capture-carbon

Pilot tests on using Magnesium Oxide to increase the pH in the ocean and capture CO2.

Figure 2: In this photo provided by the Ocean Alk-Align project, pink dye is released into Tufts Cove along Halifax Harbour in Nova Scotia, Canada, as part of a project by the company

Planetary Technologies to test whether adding alkaline minerals to the ocean can help slow climate change, Thursday, Aug. 10, 2023. (Ocean Alk-Align project via AP).

There is even a patent:

https://patents.google.com/patent/US20120291675A1/en

There is a very interesting article about this in Nature:

https://www.nature.com/articles/s43247-024-01506-4

My idea is to dose the MgO upstream in the process, before the aeration step where BOD removal and Nitrification take place: the benefits will be two fold.

First Magnesium will help with removal of ammonia as it reacts with Ammonia and phosphate to form struvite and secondly, the resulting alkalinity from dissolution of MgO in water will fix CO2 produced by the BOD oxidation process in the form of Magnesium Carbonate.

A pilot test that we conducted on a sewage treatment plant in County Donegal in Ireland in 2024 showed that the dosing of small amounts of Magnesium Chloride into the raw sewage results in perceptible sustainable decreases in ammonia in the effluent. The mechanism could be two fold: Magnesium is an essential nutrient for nitrifying bacteria and it reacts with ammonia and phosphate in the sewage to form Struvite.

According to recent estimates, the yearly emissions of greenhouse gases from wastewater treatment facilities worldwide amount to around 1.43 billion metric tonnes, with a corresponding social cost of $264.5 billion (He et al., 2023, He et al., 2023).

The cost of 1 ton of MgO on Alibaba is = High Purity Magnesium Oxide/Magnesium Oxide Price. $**145.00-180.0/ton**. Min. order: 1 metric ton.

$MgO + CO2 \rightarrow MgCO3$

Molecular weight of MgO = 40.3044 g/mol

Molecular weight of $MgCO_3$ = 84.3139 g/mol

Molecular Weight of CO_2 = 44.009 g/mol

Therefore the ratio of MgO to CO_2 removed is 40 grams to 44 grams or roughly 1 to 1 ton removed.

A simple comparison to the social cost of CO_2 emissions above shows that the economics is feasible and cost effective.

Conclusion

We strongly believe that the CO_2 GHG emission global problem can be solved using simple chemistry and this will happen in the next 10-20 years as historical lessons from solving global environmental problems teach us.

Kremesti Environmental Consulting is a small consultancy based out of High Wycombe with a passion for Chemistry and 20 years' experience in water treatment and power station chemistry. We strongly believe that the solution for Climate Change is a chemical one based on simple chemistry. The founder and managing director, Rami Elias Kremesti, is a published author and keen nature lover. He regularly hikes the Chilterns AONB and is fascinated by how plants convert inorganic chemistry to organic chemistry.

Portrait of Rami Elias Kremesti