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Removal activities under the Article 6.4 mechanism

at the University of Hamburg response to information note

The working group Aquatic Geochemistry at the University of Hamburg is developing a multidimensional approach to carbon dioxide removal based on enhanced weathering and biochar in soils.

We are grateful for the opportunity to provide feedback on the Article 6.4 Supervisory Body's Information note on Removal activities under the Article 6.4 mechanism Version 04.0.

Our main concerns with the information note follow in the sections below. In summary, they are:

- As practitioners in the biochar and enhanced weathering spaces, we disagree with the hard delineation between "land-based" and "engineered" carbon removal activities. We emphasize that all human activity, including afforestation or other land management practices, ultimately constitutes an intervention that impacts earth systems. We note that "engineered" approaches, such as biochar and ERW, may serve to enhance natural earth processes and cycles. EW itself is an acceleration of a natural process, weathering, which occurs (albeit more slowly) even in the absence of human intervention. Biochar comes with many co-benefits to natural processes, such as improving soil water and nutrient retention.
- We note that the use of these "engineered" CDR solutions may in fact reduce the need for other "human-engineered" activities which negatively impact GHG levels and natural Earth processes. As an example, the use of biochar and rock dust in agricultural lands can reduce the need for manmade chemical fertilizers
- We note that marine pathways have not been included in the Supervisory Body's note
- We strongly contest the view that carbon removal activities cannot contribute significantly to Net Zero goals. While carbon removal activity to date has been small in volume, this is the result of the nascency of the industry.

A longer discussion of our concerns follows.
General concerns:

1. As geoscientists we are concerned about the isolated view on CDR methods which fails to consider carbon storage and pathways in the Earth's system with its interconnections of atmosphere, water, soil, rock and biosphere. We propose to approach the issue of deliberate carbon dioxide removal with a holistic, multidimensional view not only in space but also in time, considering CO_2 storage in organic and/or inorganic form, carbon in its significance for climate and Earth system cycles, and the interaction with other inorganic and organic carbon pools sustaining valuable ecosystem services.
2. We would like to point out that CDR provides the opportunity to disrupt the linear economy of carbon usage in terms of releasing carbon from fossil sources for a single use and treats CO_2 as a waste product. We emphasize that CO_2 can be re-imagined as a resource in a circular economy. CO_2 capture can be a process of creating economic value in the form of an environmental service, a product or both. While biomass burial or geological storage support the single use approach of a linear economy and may disturb global nutrient cycles, the manufacturing of industrial products (CCU), soil remediation tools, ocean acidity buffer, fertilizer substitute and others are examples for an added value of carbon removal.
3. Besides the creation of materials, valuable economic, social and environmental co-benefits are the restoration through ecosystem protection, soil protection, the increase of traditional and regenerative agriculture practices, social equality, wealth, and many more.
4. We would like to point out that the feasibility and potential of CDR methods must also be evaluated in view of their regional conditions such as availability of resources, transport distances, climate conditions or others. Furthermore, environmental, societal, and economic criteria must be considered.

Framing and definitions:

5. As geoscientists we are concerned about several framings and definitions that have been made without considering current science:
6. 2.3. Definition of other terms, 34. d): biochar may be used in terms of CDR but also CCU (materials for industry, construction, electronics, feedstock, cosmetics, medicine, sanitation etc.). For CDR it can not only be used in soils but also stored in landfills or closed mines.
7. 3.1 Taxonomy of removal activities, 36. b): Weathering and chemical carbon capture should be divided. Weathering is a natural geologic process that has been occurring on Earth for billions of years. Weathering can be enhanced without human intervention by plant roots, micro-bacterial activity and mechanical destruction (e.g., via wave action) while chemical carbon capture from e.g. amine scrubbing is an artificial process based on human technology.
8. 3.1 Taxonomy of removal activities, 37. b): The storage of carbon as bicarbonate/alkalinity as an intermediate yet long-term weathering product is missing. As bicarbonate has a residence time of roughly 100.000 years (Renforth and Henderson, 2017) in the ocean, this form of carbon must be considered as an own storage method.
9. 3.1 Taxonomy of removal activities, 37. c) (i): biochar is a product of which the major part (75%) is estimated to last in soils for millennia (Schmidt et al., 2022)
10. 3.1 Taxonomy of removal activities, Table 2: The marine dissolved inorganic carbon is missing as a storage from enhanced weathering on land or ocean alkalinisation (see 3.1, 73. b)).
11. 3.1 Taxonomy of removal activities, Table 3: the pro and con arguments of engineering-based and land-based activities are not balanced, at best highly controversial, and don't seem to be based on current science. Also, marine-based CDR approaches are not considered at all. We fundamentally disagree with the dichotomy of "land-based" vs. "engineered" solutions: every human activity is a forced intervention of the environment that manipulate the biogeochemistry

and carbon cycle on local, regional or global biochemical cycles scales and therefore impact the climate. Even “non-engineering” activities like afforestation change the albedo, water and nutrient cycle, regional climate and biodiversity. Furthermore, the fact that the CDR industry currently only removes 0.01 Mt CO_2 is not due to a failure of scaling or technology but explained by the early stage of this industry while CDR from land management has been taking place since the settling of humanity. A con of “land-based” activities is clearly the competition of land use (food production, settlement) especially under rewetting of peatland and afforestation which can be avoided through, e.g., biochar, enhanced weathering, and DAC.

12. Table 4: The table is missing marine biological and geochemical CDR although these methods are described in the IPCC AR6, WGIII. Electrochemical or photoelectrochemical solutions are not mentioned at all.

A multidimensional carbon dioxide removal

13. As there is no silver bullet technology that can bring us to net zero, it must be expected that a portfolio of CDR approaches will be deployed to reach net zero emissions. At this stage of research and development, CDR approaches have to be evaluated considering their interplay with all potential positive and negative side effect. As an example, the combination of biochar and enhanced weathering provides benefits exceeding the CDR potential from the single methods and including benefits beyond such as emissions reduction, increased permanence, implementing and cultivating traditional regenerative agriculture and driving positive environmental and social impacts by, e.g., increasing food security. At the same time the single but also combined methods are not in competition to the former land use but have the potential to improve the productivity and quality of a region (Janssens et al., 2022):
    a. Single biochar deployment: the single deployment of biochar for soil amelioration and remediation as practiced by indigenous societies for soil also cover co-benefits relevant for climate and carbon management such as higher biomass yield, improved hydrological conditions and root conditions, the support of higher soil microbial biomass, soil organic carbon, nutrient availability and trace metal retention (Schmidt et al., 2021). Further, outgassing of the potent greenhouse gas N_2O is diminished. Other benefits are the sustainable energy generation from pyrolysis products and the management of biomass waste while avoiding release of greenhouse gases from biomass landfills. As a decentralized method, pyrolysis provides jobs in rural areas. The advanced certification from, e.g., the European Biochar Certificate guarantees a safe and sustainable transformation from waste to value. In terms of permanence new findings reveal a high content of polycyclic aromatic carbon persisting > 1000 years depending on pyrolysis conditions and feedstock (Schmidt et al., 2022).
    b. Enhanced weathering EW: the application of rock powder for soil fertilization yields several benefits for plant health, crop yield, nutrient supply, reduction of N_2O and NH_3 emissions, soil pH and biology and soil physics (Swoboda et al., 2022). The soil organic carbon is positively impacted by the release of minerals and formation of secondary minerals (Lavallee et al., 2020; Buss et al., 2023). As an affordable fertilizer it reduces emissions by substituting artificial fertilizers and liming and allows small farming business to benefit from this low-cost, high available and natural agricultural practice e.g. under the activities of Mati.
    c. Co-deployment of biochar and rock powder: the co-deployment as practised to produce terra preta for soil fertilization as part of traditional regenerative agriculture is proved to lead to a stabilization of the labile fraction of biochar (Nan et al., 2022). Moreover, both

methods together are able to increase the nutrient pools and their retention even more, to optimise the soil hydrology for roots and faster weathering, to stabilize the soil pH over longer periods and to increase soil biota and its activity. Due to a large surface biochar may retain trace metals from rock weathering (Amann and Hartmann, 2019).

d. Co-pyrolysis of biomass and rock powder: the co-pyrolysis of biomass and rock powder can increase the total yield of biochar and also the content of persistent biochar while the minerals protect the biochar against microbial and physical degradation (Buss et al., 2022).

e. Multidimensional carbon dioxide removal (Fig. 1): the combination of biochar and enhanced weathering on land provides a boost to yield higher CO_2 removal when combining it with other biomass-based CDR methods like BiCRS (bioenergy, carbon removal and storage) or afforestation. Habitat restoration, soil organic carbon increase and, in the longer term, ocean acidity buffering through alkalinity can be further effects that directly benefit CDR removal. Substituting emission-intensive fertilizers and using an area for above and below ground carbon removal makes CDR per area much more efficient while sustaining the land use and keeping the environmental impact low.

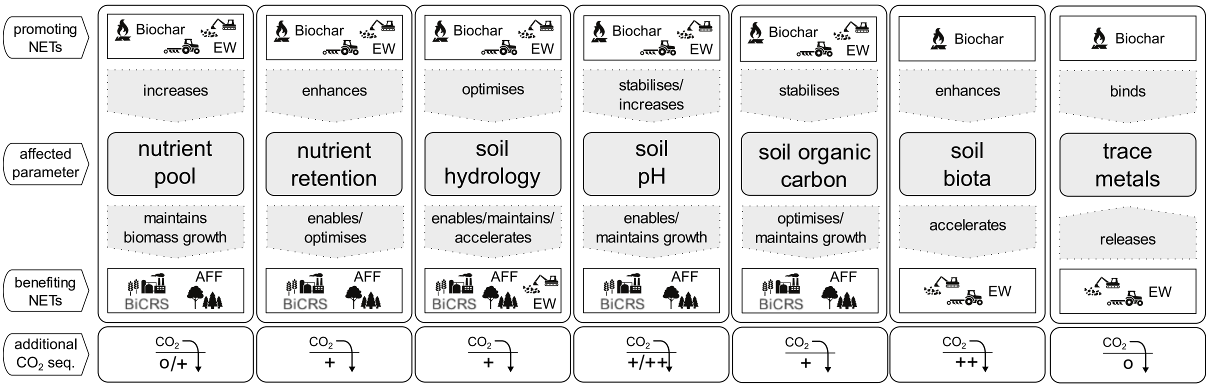

Figure 1: Overview of co-benefits from biochar and enhanced weathering for BiCRS, afforestation and EW and potential increase in CDR potential. Modified after Amann et al. (2019).

Questions of specific elements:

14. Emissions reductions: as outlined for biochar and enhanced weathering the substitution of artificial fertilizers, regional production of biochar and sustainable energy generation from pyrolysis, avoiding of methane outgassing from biomass landfills, greenhouse gas retention from biochar and replacing agricultural liming by silicate rock powder leads to reduced emissions.
15. Reducing non-permanence: by reducing the labile fraction of biochar with co-pyrolysis and/or protection of biochar from minerals the permanence of biochar is increased. Additionally, the stabilization of soil organic matter is increased through weathering products, secondary mineral formation and biochar itself.
16. Avoidance of other negative environmental, social impacts: the practice of biochar and enhanced weathering in agriculture, pasture or forest has no land use competition but offers soil remediation/amelioration effects, drought resistance and respects the traditional regenerative agriculture for a sustainable food production.

We trust that our response can be of use to the Supervisory Body as it moves forward with its work.

Yours sincerely,

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